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Architecture, Construction, Construction Mechanics, Environmental Engineering, Engineering Maintenance of Buildings and Structures, Geodesy

Edited by

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11th International Conference on Contemporary Problems of Architecture and Construction

I'm honored to present the conference proceedings that collect contributions of local and international researchers on the topic "Contemporary Problems of Architecture and Construction" submitted in the form of research papers.

I would like to thank all authors of submitted papers, researchers, guests, partner universities for their participation. I appreciate the Scientific Committee, Organizing Committee members, Editorial Board and others for their contribution in publishing process of this book.

Coordination of up-to-date issues in the field is one of the most important activities in the sphere of science, which unites representatives of different countries, exchange their best practices. 11th International Conference on Contemporary Problems of Architecture and Construction is a vivid example of this activity.

Hence we are proud to guest in Yerevan (Armenia) the "11th International Conference on Contemporary Problems of Architecture and Construction", held from October 14 to 16, 2019 in cooperation with the partner universities:

- National University of Architecture and Construction of Armenia
- Beijing University of Civil Engineering and Architecture
- Czestochowa University of Technology
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This conference is a platform to reflect the values and missions of our universities in the best way and where the close, friendly relations and traditions between countries are getting stronger. It gives an opportunity to numerous scientists from Armenia, China, Poland, Russia, Italy, USA, Georgia, Italy, etc. to submit their contributions and open the space for discussions, scientific exchanges.

I'm hopeful that each of us would stay engaged, keep proactive, continue to meet the challenges in our fields and help us to shape the future of International Conference on Contemporary Problems of Architecture and Construction more comprehensive and ongoing.

Gagik Galstyan, Doctor of science (engineering), Professor

Rector of the National University of Architecture and Construction of Armenia

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1. ARCHITECTURE

TYPOLOGICAL FEATURES OF ARCHITECTURE OF TEMPORARY FUNCTIONING PUBLIC FACILITIES IN URBAN ENVIRONMENT OF YEREVAN

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Keywords: Urban space, temporary structures, public facilities, ecology, mobility, dynamism

Abstract. The problem of formation of temporary architecture objects in the urban environment is studied, historical experience of their usage is presented, based on the analysis of foreign practice of development of this new element in the construction of modern cities, its typological, functional, constructive and town-planning solutions are studied, the features of their appearance and distribution in the city structure of Yerevan are revealed.

1. Introduction

The problem of organizing urban environment at the present stage has become the subject of intent attention of the architectural community and a number of specialists in such fields as sociologists, economists, engineers, ecologists, designers, etc. The period of the late 20th and early 21st centuries was marked by a new approach to the development of urban areas associated with the growth of employment in the administrative, service and trade sphere, which caused a continuous stream of public institutions in the urban environment, seeking to occupy all sorts of free plots as in open street spaces, squares, public gardens and parks, intra quarter territories, and within the constituent construction of buildings at almost all levels.

The mentioned process was accompanied by the construction of a variety of temporary structures in the form of stand-alone stalls, kiosks, tents and even tables that filled all urban voids. Among the huge number of small, often 3-5 square meters of retail outlets, no exception were structures of large volumes, having an area of several hundred square meters. Temporarily functioning small and large structures cause significant damage to the ecology and aesthetics of the urban environment, causing a number of negative phenomena, such as violation of sanitary and hygienic indicators, increased background noise, pollution of the air basin and urban areas, landscape destruction, etc. The current situation is relevant for all large cities: spontaneous bazaars, commercial buildings with constantly changing functions have long been an integral part of the urban landscape.

Yerevan is not an exception with the peculiarity of the natural landscape, originality of national traditions. In connection with the spontaneity and inevitability of the problem, the absence of regulatory documents that meet the requirements of the land code, energy conservation, conservation of green areas and recreation, it becomes necessary to analyze the causes of temporary objects in the urban environment, to study their architectural potential in order to develop a strategy for their further development and possible ways of implementation in urban development, taking into account the specifics of the development of each city.

Up-to-dateness of the problem consists in identifying the spectrum of typological features in the formation of objects of temporary functioning, determining their location in the structure of the urban environment, development trends in accordance with the needs of the population for a given period of time.

The given work is aimed at studying the patterns of development of contemporary architecture forms of temporary structures and the development of their perspective use in the planning structure of the city of Yerevan.

2. Methodology

The concept of temporary structures is represented as short-lived buildings constructed of light materials, having a lightweight construction without buried foundations [1, 2]. In various research works, along with the concept of a temporary structure, temporary architecture, temporary buildings or objects can be found. In this work, temporary architecture refers to a temporary functioning public facilities (TFPF) with limited functions, the simplest constructive solution, a given period of use (up to 10 years). Examples of the TFPF (temporary functioning public facilities) use have been known since ancient times (tent over the arena of the Coliseum, various mobile vans, musical barrel organs, etc.), their further development was observed in all architectural formations, at the end of the 20th century their growth began.

The period from 1990s to 2000s are characterized as the most active in the development of TFPF, when they have been rapidly spreading in the urban area, at first with limited function and small size, then in the form of capital structures with a large area, developed function and its primary location in the historic center of cities. The widespread use of TFPF in the early 21st century also contributed to the development of technologies and materials that allowed architects and engineers to implement incredible complexity projects in all areas of architecture.

Attention to temporary architecture was manifested among almost all contemporary architects: V.L.Gazycheva, A.E. Gutnova, F.Geri, J.Nouvel, Z.Hadid, Shigeru Ban and others, on the relevance of the placement of these types of buildings in the urban environment is indicated by the presentation of the Pritzker Prize to the author of many temporary structures, Shigeru Ban in 2014, to the author of awning, mesh, membrane structures implemented in many structures with the possibility of their temporary use - Frey Otto in 2015. Well-known architects and bureaus consider it prestigious to participate in the works of the "Serpentive" London gallery on the construction of temporary pavilions. Japanese architect Shigeru Ban is sure that there is nothing more permanent than temporary structures if you love them and take care of them properly, and the English architect Charles Lendrin believes that temporality should be defined as a parameter of sustainable development [2].

The advantages of TFPF include: fast production, speed and ease of construction, mobility, minimization of funds, constructive simplicity, multifunctionality, the ability to work with a variety of materials and forms, dynamic composition [3]. However, the spontaneity of the allocation of TFPF in urban space, uneven placement, the frequency of their functional content contributed to the formation of a negative attitude towards this element of the urban environment, while with its targeted management and control they can serve as a mobile filler for urban development, participate in the creation and reconstruction of various public spaces, improve processes in urban development. The scope of application of TFPF in architecture is quite extensive:

- while preserving the archaeological and cultural heritage in the natural and urban environment;
- during the development of abandoned areas, voids, depressive areas of the city
- at protection against the extreme natural phenomena
- during the reconstruction of a significant part of the city center, when its construction is planned for a long period and the need arises to locate service facilities;
- with social and political changes in society;
- at mass cultural events, city processions, political meetings.

The functional purpose of TFPF can be classified according to a number of grounds: facilities of commerce, food, service; festivals of historical events, commemorations of creative figures, objects of a seasonal nature, recreation, occasional use, landscape gardening, exhibition, cultural, educational, etc. The diversity of the functions of TFPF, their number and frequency of operation depends on the demand of the population and the control of municipal bodies.

According to the design and technological characteristics, TFPF are divided into prefabricated, block, container, planar, linear, panel, pneumatic, (mobile, without foundations, transformable and permanent with recessed foundations); according to construction material: from cardboard, reed, straw, wood, metal, glass, cloth, water, light, plastic, recycled materials and even debris and other light, translucent, non-durable materials that can collapse in a short time or for a long period depending on functional purpose of objects. When using color and light effects, temporary objects from various materials can represent original kinetic compositions that actively influence the design of the urban space.

By location in the city structure, TFPF are most common on street spaces, squares, intersections, can serve as inserts, walls - fences, linear along street facades, in the form of spatial sculptures, large accumulations in the inner blocks, landscape-park zones. By volumetric forms are solved as sheds, kiosks, tents, pavilions, mobile shops; for the duration of usage - disposable for daily use (only at night or during the day, Sunday bazaars); reusable with the possibility of their assembly for recurring urban festivities; seasonal (fairs, eastern markets, Christmas and city events); year-round, permanent with a certain long term of usage (halls for exhibitions, entertainment, offices or without any specific functions - lofts).

The review of the TFPF parameters indicates a developed spectrum of their architectural potential to solve new dynamic approaches in the formation of the urban environment, dictates the constant demand for their use in the urban structure, since it largely converts the urban space to the rapidly changing needs of the population and can replace capital structures; to compensate for the underdeveloped urban infrastructure, to overcome the monotony of the city.

In the planning structure of Yerevan, temporary facilities were mostly in the form of ice-cream, newspaper and magazine kiosks, advertisement booths, but with the change in the socio-economic situation, there was a sharp increase in the number of TFPF initially as primitive tables linearly arranged along the sidewalks of the streets squares, near metro stations, in the inner territories, passages between houses and other voids of the city.

Since 2000, temporary facilities began to be located everywhere, their considerable accumulation covered recreational zones, in particular, the green zone of Theater Square, part of parks and public gardens in the city center.

Their functional purpose was limited by the trade in scarce products, cosmetics, souvenirs, flowers, the number of cafeterias and other food outlets increased. For the most part, these facilities were carried out by light prefabricated structures with no or slightly buried foundations, were used in the summer season, did not have sophisticated equipment. In the future, in their development, the emergence of permanent capital structures with a deep foundation and a long service life was noted. The overall picture of the use of TFPF is characterized by spontaneity in placement and functional purpose, the desire to increase the volume and area of facilities, to ensure capital operation (Fig.).

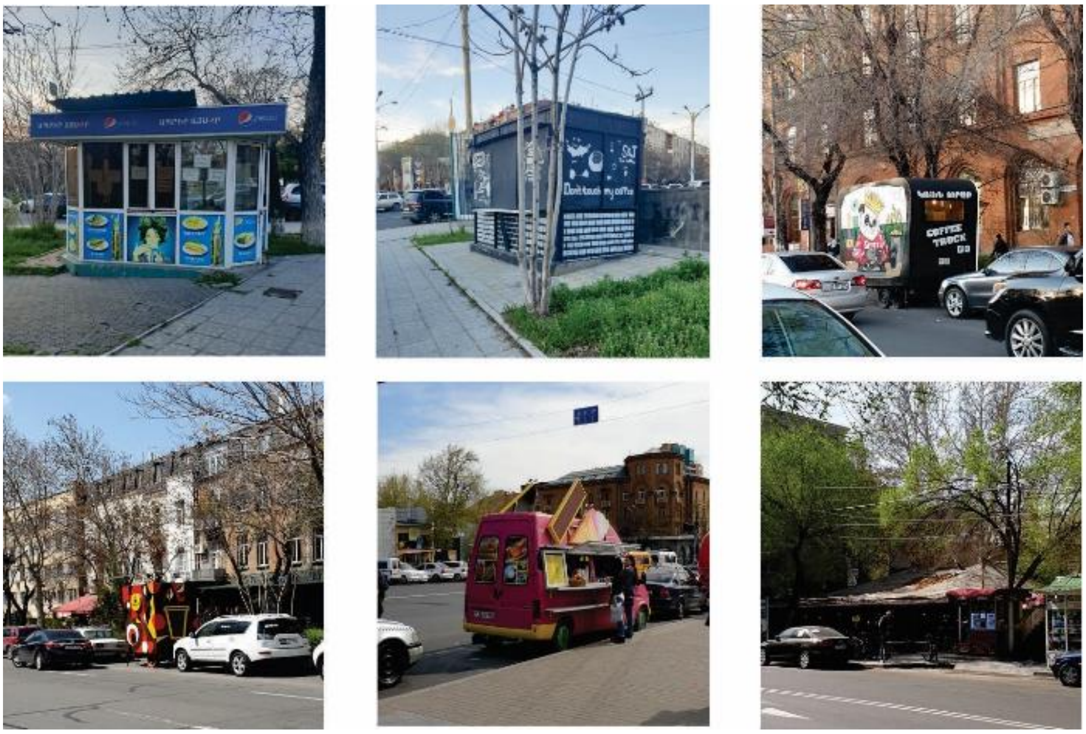

Fig. Examples of temporary structures in the urban environment of Yerevan

In recent years, there has been a trend towards the mobility of temporary facilities in the form of mobile shops, the number of which has increased so rapidly that it required radical measures by local authorities to limit their distribution in the urban environment. Similar measures were taken in relation to public catering facilities in the green area of the Opera Theater: as a result of the seizure of a vast territory in this area, the authorities eliminated some of them, and this process will be further developed. Thus, the uncontrolled location of a TFPF in the urban environment of Yerevan led to the discrediting of a temporary architecture that has a number of advantages, while the international experience of their construction indicates the prospects of its development in modern architecture. The problem of using CFs in the urban planning practice of the Republic of Armenia is practically not developed: their nomenclature is missing, requirements for architectural and compositional solutions, theoretical and practical justifications for their use, which require an analysis of their causes, development of a regulatory framework and recommendations for use and design in urban areas environment of Yerevan.

3. Results

Based on the analysis of the theoretical and practical experience of international use of TFPF, the relevance of their development in the urban environment of large cities, in particular, in Yerevan, has been substantiated, typological, functional, city-forming features of the organization of temporary architecture in modern conditions have been revealed, and a range of potential possibilities of composite solutions has been shown.

4. Conclusions

Temporary functioning public facilities (TFPF) perform the role of adaptation to the ever-changing demands of the urban population in the field of trade, leisure, recreation, have the ability to fill empty, underutilized territories, i.e. increase the efficiency of urban land development; they are able to replace capital structures in view of the diversity of typological characteristics, ensure the availability of public services, create a platform for the implementation of up-to-date principles of flexibility, ease and mobility of the urban environment. Further research on TFPF should be aimed at determining their development strategy in terms of the impact of history, climate, mobility, construction and dismantling, psychological impact during operation.

Acknowledgement

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SELF-PORTRAITS IN THE PAINTINGS AND GRAPHIC WORKS OF ARCHITECT AND ARTIST ALBERT SOKHIKYAN

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Keywords: Artist, architect, Albert Sokhikyan, self-portrait

Abstract. Albert Sokhikyan is a talented architect, who along with his practical activities, acted as a mature and successful artist. Moreover, it can be said that he was shaped as an architect thank to his creative knowledge consecutively accumulated in his early years. Achievements recorded in Sokhikyan`s art during his creative life are obviously seen especially in his great number of self-portraits. These portraits are already enough to see clearly the artist`s creative growth and achievements, artistic and compositional searches, the gradual modification of handwriting from manner of realistic painting into surrealistic way of thinking and finally the long lasting and hard way, only after passing which could be formed the artist called Albert Sokhikyan. He remained faithful to the genre of “Self-portrait” in all the periods of his creative life. Within its frameworks the already definitely found “image” of his own character each time was presented in a new way, continuously undergoing changes not only from the point of view of colour-plastic solutions, the choice of artistic ways of expressions but also his own psychological, emotional and spiritual state.

1. Introduction

The genre of “Self-portrait”, starting from school years, played a big role in the architect, artist Albert Sokhikyan's works. In graphic works, paintings created in this context, even if they were unfinished, low-volume or finished works, they were vividly expressing his artistic thinking, creative searches and the rise that the artist had experienced for many years.

2. Analysis

Both among world and armenian architects, very few people worked in parallel in their work activities, applied their own artistic skills and developed them also in the field of art. If there are such examples, in most cases they are of an amateur nature. Albert Sokhikyan is one of those unique personalities for whom painting has become not only a unique means of self-manifestation, experimentation of one’s own artistic abilities, a flight of fancy, but one can even argue the second specialty. Despite this, speaking of him, it is difficult, even impossible, to separate the “artist” from the “architect” or vice versa, because they appear together as one whole, nevertheless, it seems to me that painting prevails within his activities. This is due to the fact that from the very beginning the artist “Albert Sokhikyan” was created precisely in the context of art, "aesthetics", in terms of its active, productive participation. His first "steps" in art, he made bewitched "painting" and always hand in hand with it. Consequently, his path to architecture was laid precisely thanks to art, the knowledge and skills that were founded independently at an early age.

The young artist began to create in all genres, portrait, landscape, still life and thematic genre, also created animalistic images, collages. These his small works depict everything that Sokhikyan`s eyes saw in Lori’s nature lap, in homeland Alaverdi, in it`s streets. But in this genre diversity, Sokhikyan preferred mainly self- portrait. It was always in the center of artist`s interests. From his school years, Albert Sokhikyan often depicted many of his peers, family members, neighbors, in general, his contemporaries, ordinary people. In the portraits that make up most of his creative heritage, there is no gender or age discrimination. In this genre, the artist has always conquered by self-portrait. And it is not surprising that self- portraits reaching over five hundred give us a clear idea of his development as a competent young artist and art lover. Depicted in the state of mind characteristic of a particular age, environment, these portraits are amazing in terms of the specific mood of the moment, in the lively immediacy. Only by their example, one can get acquainted with the preferences of Albert Sokhikyan, with his artistic preferences, closely follow his process of improving them and clearly see the “gaps” and achievements of the young artist, “failures” and victorious exits. This genre direction creates the basis, on the one hand, to pose, as far as possible, to acquire skills in the started work, to make new experiments and, according to acquired new skills, to enrich their own arsenal. On the other hand, the long process of creating a detailed portrait of one’s own allows the artist to properly study and identify his own Self, the human “image”, both from physical and psychological point of view. Perhaps, this are the main motives according to which many eminent artists of world and armenian art were guided, creating their famous self-portraits, thus devoting a large place to this genre in their artistic heritage. Among them are: Martiros Saryan, Eduard Isabekyan, Albrecht Durer, Rembrandt van Rijn, Vincent van Gogh, Amadeo Modigliani, S. Dali, Frida Kahlo, Pablo Picasso, E. Schiele and others. Speaking about Albert Sokhikyan`s self-portraits (as well as about all artistic heritage) it is interesting to study his early work in detail. The study and analysis of the Sokhikyan's portraits created during this period makes it possible to understand the important fact that the fundamental achievements of the artist’s knowledge, creative growth were noted precisely in these years. This becomes known to us from the master`s works concerning his school years /1960-1965/, in which, although, there is a childlike spontaneity, simplicity, but at the same time, they have a delicate aesthetic taste, "scent" and literacy inherent in a mature person.

These newly brought to light works, created by ink, chalk, watercolors, tempera, pen, different techniques, combining different materials and just ordinary pencil, and which were not intended for a wide audience, argue about the great gift of the young man. It goes without saying that this is not about completed works, but about sketches, etudes, attempts and searches. But, of course, this does not diminish their artistic value. Just at this stage, they were exclusively aimed at identifying and finding their own artistic skills. On this path, Sokhikyan’s main “comrade-in-arms and friend” was his own person, whose many years of experience in depicting helped him to discover new skills and knowledge, develop and improve them. These works, distinguished by sincerity and liveliness, ensured the darting stable growth of a young man in this field. It was at this stage that the master could choose the types of self-manifestation, and solve them in an interesting “game” in a new way. Portraits of this period were created on cardboard, silk, wood, plaster and other materials, confirming again and again the important fact that Sokhikyan tended to a more experimental free way of pictography. Starting each new work, he applied new plastic forms of expression, experimented with artistic new, not previously applied tricks. We can say that he worked so freely most of all in these years. In the works created during this period the painter`s creative, wide diapason, promotion of style and formal thinking is clearly visible. It is not surprising that the portraits belonging to the same year are different in their plastic forms, color thinking and execution.

The surge growth of the artist is not seen from a decade to a decade, not from year to year, but, it seems, day by day. Thus, in the portraits of the beginning of 1962 (Fig. 1), young Sokhikyan simply "argues" his facial features, specially chosen posture, clothing, which makes the image artificially solemn.

Considering himself only as a model, he diligently tries to achieve portrait accuracy. In terms of color, the young artist is a bit constrained; the strokes are small, broken. This is probably also due to the choice of a small brush (which, as a rule, is inherent in young artists taking their first steps in art). Nevertheless, it is obvious Sokhikyan’s preference towards pictorial thinking. In the self-portraits created at the end of the same year and only a year later (Fig. 2, 3), Sokhikyan is more free, confident and bold, both in terms of lines and colors.

In the framework of decorative thinking, was created a self-portrait collage, which also resembles a competently designed mosaic (1963, Fig. 3). As a material, the author uses colored papers, gives them a certain shape, size, and glues them onto the selected tonal surfaces. Of course, these pieces of paper are not simply glued. The author studied the characteristic features inherent in his appearance, noted its structural large and small formes, took into account the light-shade and color-plastic features of the image, and only then combined papers of appropriate size, shape, color and tone.

Fig.1 Albert Sokhikyan, Self-portrait, 1962

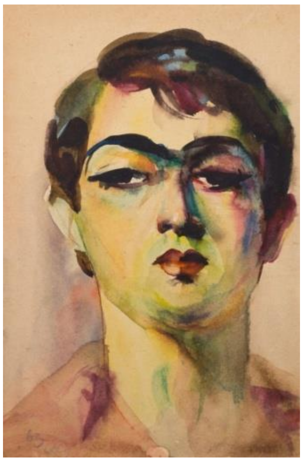

Fig.2 Albert Sokhikyan, Self-portrait, 1963

Fig.3 Albert Sokhikyan, Self-portrait, 1963

Each of them is a necessary addition to the image, it is in its well-thought, precise place and without the presence of each of them, the portret will not be completed. Along with such artistic problems, young Sokhikyan also sets himself other tasks; he tries to delve as far as possible into the emotional, mental, psychological issues of the sole and main "hero" of his sel-portraits. It can be said that the artist over the years has developed a certain pictographic scheme of his image, and often it is only with their help that one can guess — indeed, we see a portrait of a master in front of us, or not.

In his student years (1965-1971) and the subsequent decade (early 1980s), the process of self-creation of a young artist continues with a new force. During this period, he is either faithful to the traditions of classic art, and tries to accurately study what he saw and reproduce it in realistic manner, or deviates from the passive, described approaches. On the one hand, the artist does not idealize his persona, and each time it manifests itself more realistically (Fig. 4), on the other hand, the author endows his characters with new qualities, puts them into another reality, gradually ceases to feel himself as a "model", as a result of which he creates another commentary on his image (Fig. 5, 7).

As for the inner emotional world, in first case Sokhikyan is rather restrained, balanced, deprived of sensual flashes, a little tense, which speaks of the artist's responsible, serious attitude towards his work, about his readiness to pose himself (fig. 1, 2, 4). Another option for creating Sokhikyan`s own image is a completely new approach. Nevertheless, in what he saw, he highlights the approach- of identifying the key aspect and presenting it in a new form. The artist introduces individual plastic solutions into the image, enhances the impression of facial expressions, and intentionally alters one or another part of the external description (fig. 5, 7, 10, 12, 16, 17, 20, 21). Of course, the above-mentioned two options for presenting an external description were constantly addressed by representatives of world art. In brief, we turn to several of them, exclusively to those in whose creative heritage most of all are self-portraits.

Fig. 4 Albert Sokhikyan, Self-portrait, 1965

Fig. 5 Albert Sokhikyan, Self-portrait, 1968

Within the framework of this genre, when studying, it is impossible not to turn to the two of the most important painters of self-portraits - the famous representative of the golden age of Dutch painting Rembrandt Harmenszoon van Rijn (Fig. 6) and the greatest German Reneissance artist Albert Durer (Fig.7).

Fig. 6 . Rembrandt van Rijn, Self-portrait as the Apostle Paul, 1661

Fig. 7. Albrecht Durer, Self-portrait, 1500

In a study devoted to Rembrandt, Elizabeth Elias Kaufman states: *"Few other artists have painted as many self-portraits (around 100) as Rembrandt did. None of the others has been able to use this form of expression as skillfully. Rembrandt`s self-portraits are almost a diary''*[1]. These works also show the peculiarities of his artistic talent: *striving for the significance of the image, using light and shade as a factor building space and creating values of internal order* [2]. Like the great master, Sokhikyan does not consider it obligatory to depict the environment. Moreover, in his works (especially in the early stages of creativity), he is either absent or presented to the maximum as an essay, to help himself, as a model. Speaking about Durer, we can expecially mention one of his self-portraits, where we see the compositional similarity to images of Christ (Fig. 7), but even here Durer`s belief is in the identity of the individual.

In the self-portrait genre, one can imagine - in what psychological state the given personality is. In one self-portrait, Sokhikyan represents himself as a serious, stern man, with pretentious manners, in the other he seems ready to fight, with bold facial expressions, and in the third, with obvious dramatic accents. Sometimes softening the warped forms, the colors of drama and, the author conveys rationality and even poetics to the image. We see refracted plastics, deformed facial features of many famous artists' self-portraits.

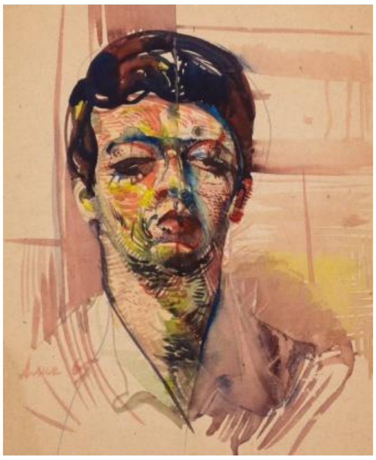

Fig. 8. Albert Sokhikyan, Self-portrait, late 1960s

Fig. 9. Martiros Saryan, Self-portrait, 1909

In the self-portrait of the author at the end of 1960 (Fig. 8), we see an image with small strokes. This is also found in one of the self-portraits of Saryan, created in 1909 (Fig. 9). But, unlike Sokhikyan, the background of Saryan`s work was also processed in the same manner, which emphasizes its importance (we note that Eduard Isabekyan is also known for his portraits in Armenian art).

A blank image of the sockets, we see in the works of the italian famous artist Amadeo Modigliani (Fig. 10). On the one hand, it is a way to divert the attention of the observer from the eyes in order to prove that the mirror of the soul are not only the eyes. On the other hand, they are sometimes blue in color (Fig. 11), which also symbolizes the heavenly boundlessness.

Fig. 10. Amadeo Modigliani, Self-Portrait, 1919

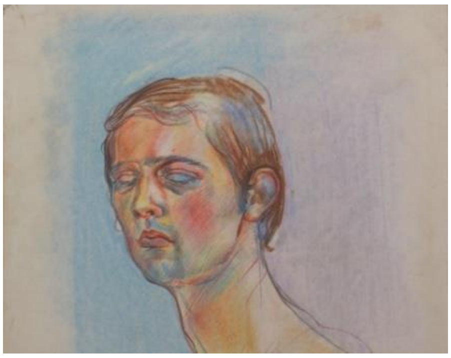

Fig. 11. Albert Sokhikyan, Self-portrait, 1970-1980s

Fig. 12. Salvador Dali, Self-Portrait with Raphael Neck, 1921

We see the intentional lengthening of the neck, underlining the proud, majestic and eccentric appearance of character not only in Sokhikyan’s self-portraits (Fig. 4, 5, 11, 13), but also in many surrealistic self-portraits created by Salvador Dali (Fig. 12) and Frida Kahlo (Fig.14).

In Albert Sokhikyan`s art are gradually revealed and formed philosophical and aesthetic views, directing his creative path from realistic “language thinking” to symbolic, even surrealistic ideology. In the years of 1980-1990 the art of the master in all genres is inclined exclusively to compositional thinking, is full of allegories, acquire a more philosophical overview. He enriches his portraits with elements inherent in other genres, compares different periods of time, culture, as a result, turns them into thematic compositional images, peculiar "riddles" (Fig. 13, 18, 22, 23), for decoding of which requires a whole arsenal of aesthetic and mental knowledge. It seems that Sokhikyan tends to surrealists` concepts about art, its philosophy and principles. Nothing, in their opinion, *could be more futile and unnecessary than an art exsclusively concerned with the rendering of some aspects of natural fact—effects of light, of* *space, of mass or solidity. This seems to them to be a purely mechanical or muscular preoccupation, and the result entirely without artistic interest* [3]. Posing to himself, Dali comes to the utmost freedom, sincerity, self-manifestation, as a result, approaching even narcissism. While drawing, he takes different gestures and monitors every change in facial expression. *"In my heart, I realized that I was playing the role of a genius. Ah, Salvador Dali! Now you know, you just have to pretend to be a genius to become one!"*[4].

Fig, 13. Albert Sokhikyan, Self-Portrait, 1982

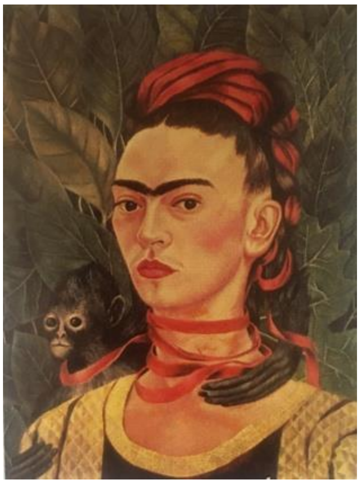

Fig. 14. Frida Kahlo, Self-Portrait with monkey, 1940

Mexican artist Frida Kahlo`s self-portraits have autobiographical character, which is a key element in her art, which seem to accurately highlight every situation in her life. Very often she presents her image figuratively, forked, thematically in a given situation, in the subject environment, among animals or people. It should be noted that in her these works are clearly expressed elements of naive painting, symbolism. *Looking at her face in the mirror, she perceived herself as depictor, not as object depicted. She thus became both active artist and passive model, dispassionate investigator of what it feels like to be a woman and passionate respository of feminine emotions* [5]. If in case of Kahlo the environment has a special meaning in the image, then Sokhikyan does not pay attention to the environment at all, but in 1980-1990s he begins to pay attention to subject attributes, as well as Kahlo. It is interesting to note that in any of the Sokhikyan`s works we do not meet even the slightest smile, but there is always the image of cigarette, moreover, this is the main leitmotif of his self-portraits (Fig. 13, 17, 18). We see the image of pipes in several self-portraits of Van Gogh and Dali (Fig. 15, 16).

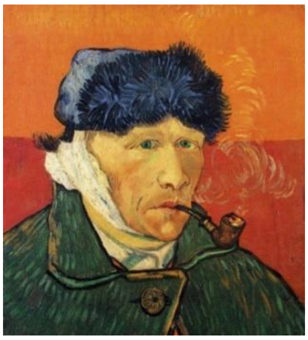

Fig. 15. Vincent van Gogh, Self-Portrait with Bandaged ear and pipe, 1889

Fig. 16. Salvador Dali, Self-Portrait, 1921

Fig. 17. Albert Sokhikyan, Self-Portrait, late 2000s

Fig. 18. Albert Sokhikyan, Self-Portrait, 1990-2000s

In the context of portrait searches of the image are also peculiar numerous cubistic, surrealistic, post-impressionistic different allegorical images, created by Pablo Picasso during his whole long creative activity (Fig. 19). An Austrian expressionist painter Egon Schiele whose huge number of self-portrets are noted for their intensity and sexuality observes himself too closely. So, in this case again we are dealing with narcissism, as well as in Dali`s works. But speaking about Schiele, we can affirm, that "*the mirror is a distorting one now, the mirror image an alter ego, an alien self*" [6]. It`s very interesting, that we see identification with the Schiele`s personage (Fig. 20) in one of the Sokhikyan`s self-portrait (Fig. 21). It`s meening that he was interested in contemrorary art movements too.

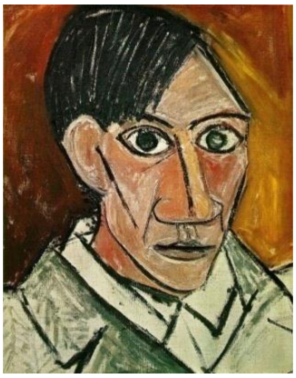

Fig. 19. Pablo Picasso, Self-Portrait, 1907

Fig. 20. Egon Schiele, Self-Portrait, 1912

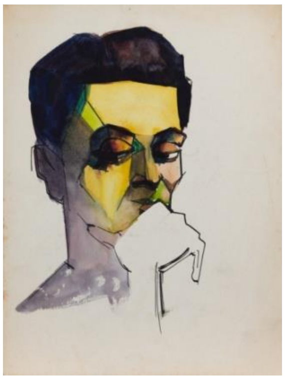

Fig. 21. Albert Sokhikyan, Self-Portrait, 1970s

In the Sokhikyan`s self-portraits relating to the years 1990-2000, sometimes we find motifs, essays from ancient Greco-Roman culture (Fig. 18). Sometimes such works are developed to the extent that they are saturated with new elements, modified, that they move to another stage, tend to more compositional thinking. This is facilitated by the introduction of a certain mood, thematic content. The master begins to devote a large place to the spiritual, divine presence, even identifying himself with the image of Christ. So, in one of these works, he is presented with a bloody prickly crown on his head (Fig. 22), in another picture, as a prophet, with a staff in his hand, on the first plane, an allegorical image of an angel and the other hand, with a gesture symbolizing St. Trinity (Fig. 23). However, it should be noted that in the first picture in the hand of the artist we see an image of a brush. So, it is a question of not identifying one's own personality with the image of Christ, but seeing him in the context of the "creator", and perceiving one's own existence as a vocation. And yet, considering all the difference in artistic points of view, we see identification with the image of Christ in Durer`s self-portrait (1500, fig. 7) and with Biblical image also in Remrandt`s "Self-portrait as the Apostle Paul" (1661, Fig. 6).

Fig. 22. Albert Sokhikyan, Self-Portrait, 1994

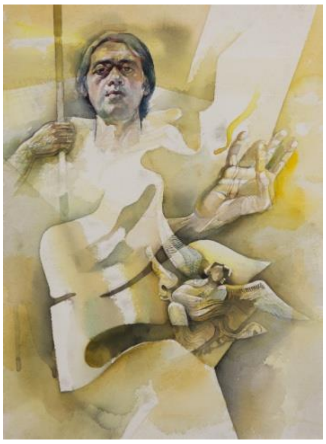

Fig. 23. Albert Sokhikyan, Self-Portrait, 1990s

So, studying, analyzing self-portraits of artist-architect Albert Sokhikyan, putting them along with the works of many world artists, comparing them, we can be sure that Sokhikyan`s images have their contribution to the development of this genre. During his youth, and then in his student years, the versatile perception of the line's plasticity, its bold, confident presentation, as well as a sense of color, interesting color matching, competent use of line and color, working with different technicians, initially established the fact that we are dealing with mature artist. For many years he studied the history of world art, mastered his centuries-old experience. It stimulated a number of changes in his work, played a big role in the crystallization of his underlining, color thinking, self-expression. However, Albert Sokhikyan showed an original art of thinking and independently created his own style, aligned his own artistic path. As a result, there was formed Sokhikyan`s clearly recognizable creative portrait, an artistic system, which is difficult to attribute to another artist. Throughout his activity the master remained as an artist, as a creative person.

3. Summary

The path traversed by Albert Sokhikyan in art is made complete by about 50 of his self-portraits. Their "protagonist" is he himself with a variety of images and comments of his physical and mental description. The desire to identify the inner being has always been a priority in his self-portraits, whether in the early creative stages or later. These works are remarkable in presenting a state of mind, a particular mood of the moment, a lively immediacy to a particular age.

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DÉCOR IN COMPOSITION OF CASCADE COMPLEX IN YEREVAN

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Keywords: Architecture, decorations, ornaments, architectural décor, obelisk, memorial pillar

Abstract. The decoration and its constructive significance in the architecture of Cascade Complex in Yerevan are discussed. The architectural-constructive analysis of the whole complex is presented, as well as each of the four platforms of the complex are described with their particular decorative and ornamental elements. The analysis of the historical and cultural importance of the elements implemented in the architecture of building has also been carried out. As the roots of the complex date back to the very beginning of 20th century, when A. Tamanyan was working on general plan of Yerevan city, firstly the history and stages of construction of the complex is presented. The complex should have had a major role in formation of urban scape: it had to connect the city center to the northern parts. Nevertheless, the idea was halted until the 1970s. Construction of the complex started when Jim Torosyan became the chief architect of Yerevan city. The architects of the complex were Aslan Mkhitaryan, Sargis Gurzadyan and Jim Torosyan. Each of them had his own role in the creation of urban monumental composition. Although the complex is eye-catching with its monumentality, it also contains impressive ornamental pieces. Each of four platforms has its own decorative elements, combination of which makes the complex complete as an essential urban loop. The key elements of medieval Armenian ornamental art such as grapes, pomegranates and wheat spikes have been used. Even though the complex has a modern architectural form, it also includes obelisks, memorial pillars and khachqars, which are Armenian memorial steles, first mentioned around the 10th century. They often bear a cross, often with rosettes, interlaces or botanical motives.

So, it can be said that the complex of Cascade is a vivid example of Armenian contemporary architecture, combined with modernized Armenian medieval elements.

1. Introduction

Cascade complex is located in the center of Yerevan. The complex is a monumental urban construction which is stretching from the statue of Alexander Tamanyan (sculptor A. Hovsepyan) to Monument's height. It includes museums, fountains, flower parterres and parks (Fig.1).

The origins of the idea of Cascade come from the times when A. Tamanyan was working on the master plan of Yerevan city. It was intended to connect the city center and the northern sections of it. Even though it was forgotten for some time, in the 1970s, J. Torosyan, who was the chief architect of the city resumed it. The project's architects were Jim Torosyan, Sargis Gurzadyan and Aslan Mkhitaryan, who continued Tamanyan's idea and created a huge complex, which subsequently became the symbol of Yerevan's modern architecture.

Fig.1. Cascade complex

2. Complex structure

As a result of the implementation of the complex, a part of A. Tamanyan's northern ridge was built and it crossed the city in the north-south direction. So, this monumental structure linked higher and lower altitude sections of Yerevan, as it was thought by Tamanyan (Fig. 2,3). Nevertheless, some changes were made in the project, especially in 1980. As a result of the innovative approach of the architects implementing the project, Cascade had four levels, each with its own observation pavement, which included open-air sections from water junctions, flower parterres, and the halls designed for galleries. Every platform had its own special decorations, the main feature of which was the modern introduction of the combination of Armenian historical decorative elements in a huge stone composition. The work was distributed in the following way: the upper complex was built by St. Gurzadyan and J. Torosyan, stairway was designed by J.Torosyan and A. Mkhitaryan, and the museum was handed over to architect D. Hudson.

Fig.2. Cascade from above

Fig.3. Four platforms of Cascade

2.1.Stalin Repression Memorial

The complex on the top part of Cascade was a memorial to 50th anniversary of Adoption of Soviet rules, which lately became Stalin Repression Memorial. S. Gurzadyan believed that architecture is a content, which should require the architectural form [1]. Based on this idea, a clear geometric complex has been implemented which has stairs on both sides (Fig.4). Nevertheless, these huge stone pillars featured elements of Armenian cross-stones (khachkars) dating back to medieval culture. They are an inseparable part of the whole architectural form and include modernized clarity of Armenian medieval elements (Fig.5).

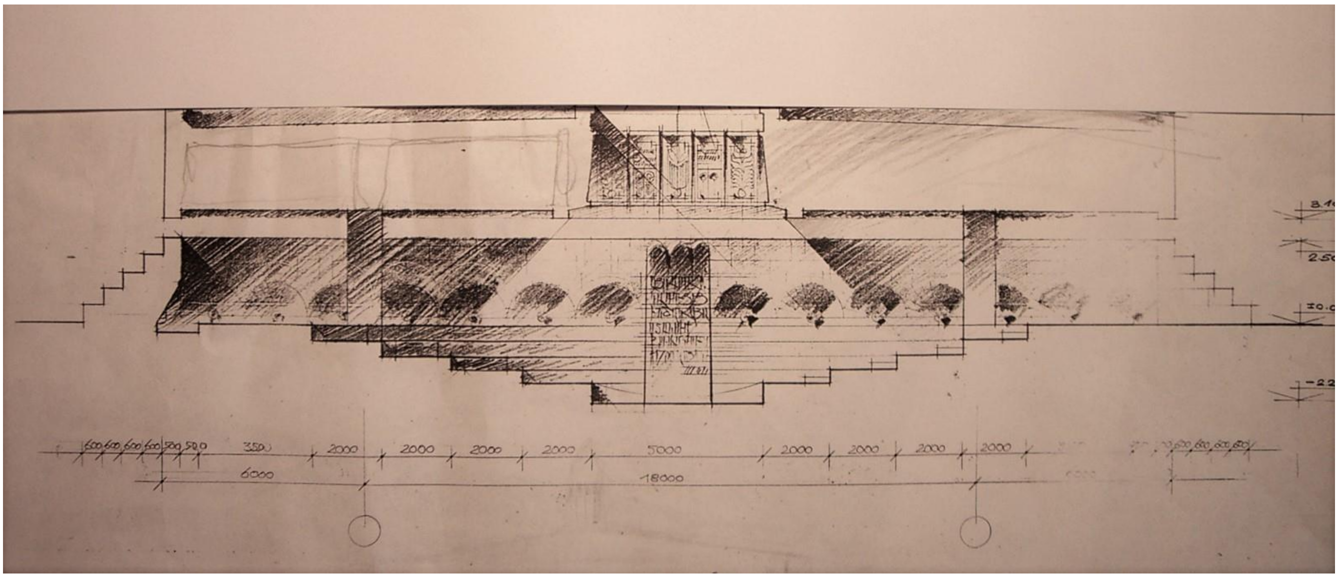

Fig.4. Stalin Repression Memorial, J. Torosyan's sketch

2.2.Museum zone

In 1980-90s the Cascade Complex was built with a quick throw. However, the collapse of the Soviet Union caused the construction process to stop. Further, in the newly independent state, several buildings, as well as the Cascade complex, were privatized by Gerald Cafesjian. This was done to make completion of construction possible. The environmental planning of the area was to be carried out on the basis of an international closed competition. Finally, the project was commissioned to the American architectural studio, represented by architect D. Hudson. The concept of the project lies in the fact that at the top of the staircase there should be a museum complex, which will be located on the common axis of the Cascade. It should also link the complexes of the city of Yerevan, Tsitsernakaberd, Mother Armenia, Youth Palace and Mount Ararat (Fig.6). A number of land and construction works were carried out, but due to financial problems, the museum segment was not over [2].

3. Four platforms

At the first glance, the cascading staircase seems to have consisted of the similar four segments, each of which has its own peculiarities that are settled through decoration. It is also worth noting the approach that is commonly used. There is a nuance between the third and fourth floors, which breaks the same repetition of the composition, at the same time expressing the professional elegance and skill of the architects. There are three cross-stones (khachkars) and a monument in the area, which at first glance looks like a monument to Gurzadyan's upper floor, but they actually are different both in their scales and geometrical forms. It is a stone pillar, in the upper part of which is a half-blooming part of the flowering form, from which the cross symbolizing Christianity appears

(Fig.7). There is an Armenian medieval round ornament at the bottom, which logically connects the top and bottom of the monument. The composition is entirely made of travertine, the main building material of the Cascade complex. Cross-stones are also made of travertine, which ensures the perception of composition as one integrity (Fig.8).

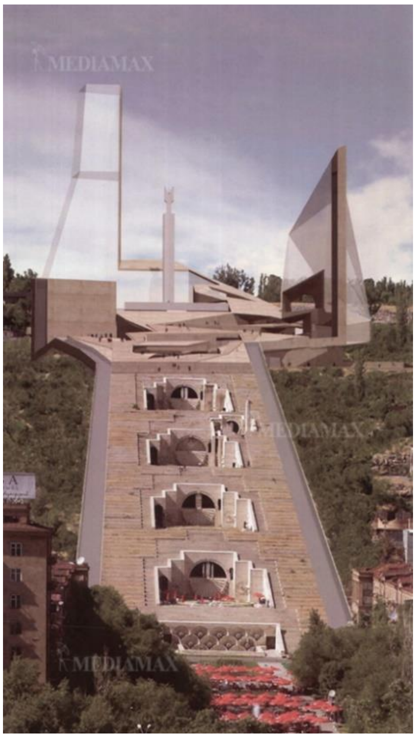

Fig.6. D. Hudson project, photo from A. Mkhitaryan's archive

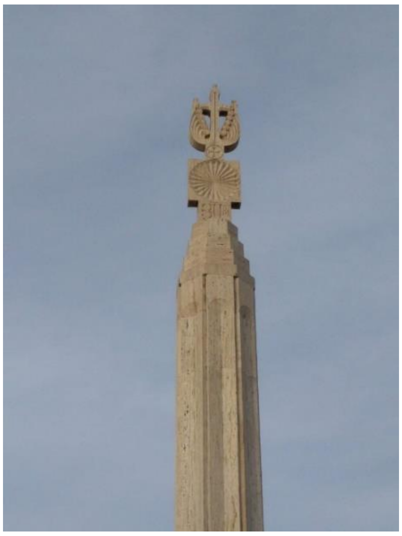

Fig. 7. Memorial

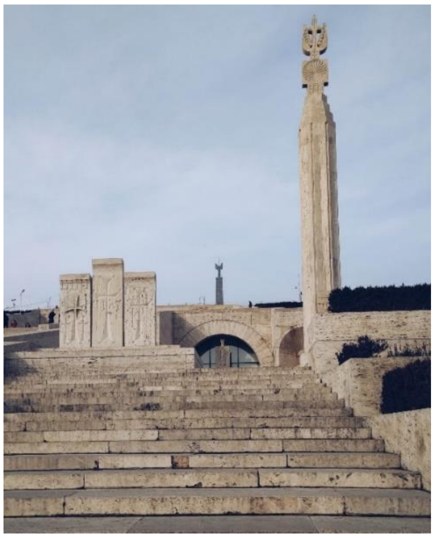

Fig. 8. Cross-stones

The water junctions in the lower section of the complex are a frontal composition, which ensures the first impression of the observer, with its simplicity and professionalism, creating the first direct connection with the complex. This frontal embodiment consists of arched stone geometric shapes. In the center of each are cylindrical fountains, which are connected to arches with slant junctions. Here is also the ′′handwriting′′ of the architects, which is conditioned by the following nuance. In the repetitive series of identical elements one is different: It has bas relief with the shape of pomegranates, which are sorted on boarder of a bow. Each of them links to the center with sliding triangular forms. (Fig.9).

3.1.First platform

In the central part of all four platforms there are squared flowerbeds, on which the water basins consisting of square identical elements are constructed. Besides conjugation, this simple layout also creates a direct link between the human and the complex - there is an inadmissible boundary, as a result of which a man appears at the focal point of the architectural composition (Fig.10).
Almost all of the platforms have circular fountains, the center of which is the source of the water. The central part of the facade also has a large circular composition. Its lower part has a watercourse of small sources, and the upper part is a window (Fig.11).

3.2.Opening ornaments

In the center of the semicircular window part, there is a stone pillar, composed of the symmetric layers of pomegranates. It is surrounded with small circular elements from top to the bottom that resemble medieval Armenian forms [3]. There are two smaller columns on both sides of the pillar, which has only ornaments of a flower elements on the top (Fig. 12). Thus, a small complex of three columns creates a logical connection between the fountains and the arc, completing it in the general compilation.

Fig. 9. Fountain complex

Fig.10. Fountain of one platform

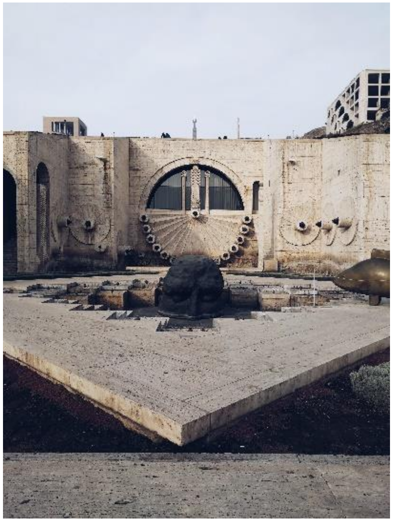

Fig.11. Frontal view of first platform

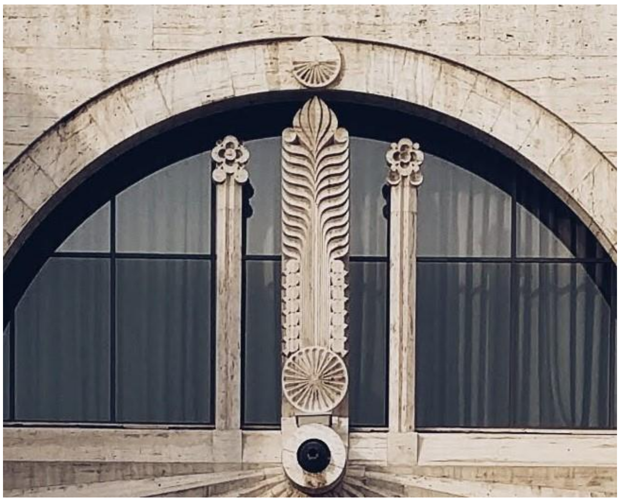

Fig.12. Decorations of first platform's opening

3.3.Obelisks

On the platform there are two more memorial pillars, one of which is a part of a wall. It is situated right on the plane of the wall and differs from others as it is entirely covered with elements that look like wheat spikes (Fig.3). The particularity of the other pillar is that it begins to be more modest; however, a bird's conture is visible on the top with up directed tail, like wheat spikes, and the legs are done in a form of pomegranate (Fig.14).

3.4.Fountain decorations

There are also several elements of decorations located in another water junction. At the top of the five cylindrical water sources there is a floral ornament, which has another two ornaments situated symmetrically on the both sides of itself in the same distance. They, along the top, follow a series of pomegranates, where each pomegranate links to the central floral ornament by the small bows. On the top of these all there is a travertine piece with a cross stone, but there is no ornament on it (Fig.15).

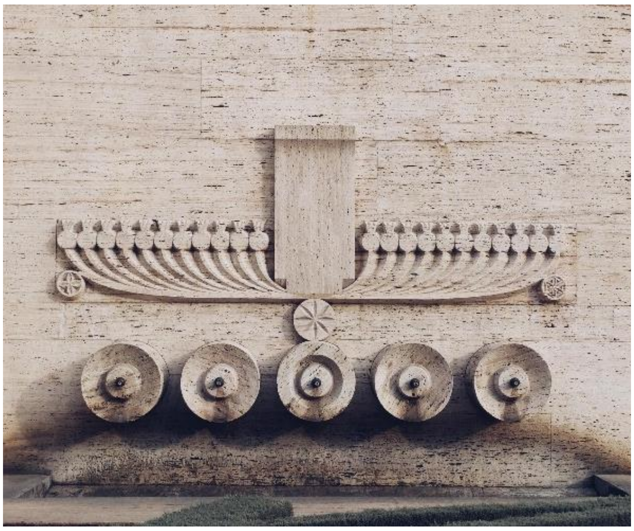

Fig.13. wheat spikes pillar *Fig.14. Bird pillar* *Fig.15. Decorations of first platform's fountain*

3.5.Second platform

The second platform differs from the first by the use variation of several elements. The façade is almost solved in the same way, except that the memorial is made of a single piece of stone. It has three identical components, one of which is hidden by two others, so that only the upper part is visible. The fronts of the front two that have a curved, spatial forms that are spread across opposite sides are repeated symmetrically after each row followed by pomegranate. There are two similar elements starting from the wheat grains. Only one of them has parallel carved leaves, which can again be regarded as a subtle nuance (Fig. 16).

3.6.Memorial pillar

In this platform, as in the same place on the first platform, there is also a memorable pillar, which, however, differs from the previous one by its compositional solution on the top. There is woman's conceptual face with a national head decoration on the left side of the pillar. At the right, the ears are repeated, as if forming the lower part of the flower, which climbs up the sprouts. Here the flower is replaced by the pomegranate as an element of Armenian medieval decoration which symbolizes Christianity [3].

3.7.Fountain decorations

The next ornament is in the upper part of small fountains. There are two birds carved on opposite directions to each other. Each of them accordingly are followed by a composition with curvy repetitive elements. This décor is visible above the birds as well. Design of water sources above the current composition are also decorated with stone-carved flowers (Fig.18).

3.8.Third platform

Third platform had less decorative facilities than previous ones. The main emphasis of this floor is the composition of frontal fountain, where the window is missing and the latter is replaced with a barrel of an eagle with wide spread wings. Eagle wings are fully decorated by early medieval Armenian ornaments, grape rhizomes, and pomegranates that seem to be bird's body structure from far (Fig.19, 20).

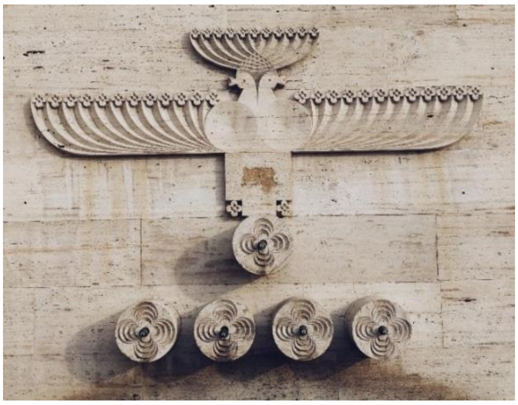

Fig.16. Decoration of second platform opening

Fig.17. Pillar with a woman's portrait

Fig.18. Decorations with birds

Fig.19. Third platform

Fig.20. Bas-relief of an eagle

3.9.Forth platform

The platform that summarizes all four floors contains the logic of the very first floor with the memorable pillar. One of the walls is interrupted by an arc-shaped opening, where the pillar is situated. It does not have any decorative element in the lower part, but the upper part consists of pomegranates that contrary to one another, which seem to be a starting point for a bunch of sprouts (Fig. 21). The decoration of main fountain is also different here: It consist of two memorable pillars with couple of pomegranate and spikes. Their arrangement is designed so professionally, that latter shapes reminds faces of a man and a woman (Fig. 22).

Thus, the Cascade complex can be perceived as an urban "jewelry" piece, which expresses the outward conjuncture of the modern architecture of Yerevan. Forms of pomegranates and grapes are used here as a decorative elements, which were wildly used in medieval Armenian architecture. In the Cascade complex, they are used in the same logic, with limited quantity and simple ornaments, but at the same time with modern skepticism. As a result, the complex is a source of inspiration for contemporary art, which allows Armenian culture to continue its identical preservation and growth in all art spheres (Fig.23).

Fig.21. Forth platform’s pillar

Fig.22. Pillars of fountain complex

Fig.23. Medal for Mother See of Holy Etchmiadzin, author M. Arshakyan

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THE MAIN PROBLEMS OF RECONSTRUCTION OF THE RESIDENTIAL QUARTERS IN THE CENTRE OF YEREVAN CITY

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Keywords: Yerevan, residential, quarter, reconstruction, city centre

Abstract. The residential quarters of Yerevan centre are the subject of this work. The problems of courtyard space in the centre have arisen since 1920s. The placement of new buildings on the perimeter and the constant postponement of inner structures implementation led to the fact, that until 1990s, a perceptible amount of old housing remained in quarters. The problem was not solved also in 1990-2010s, when under the deep socio-economic changes in the country, the courtyard space became into an object of spontaneous construction.

Research objective is the identification of the reconstruction opportunities of residential quarters of Yerevan city centre.

Used materials and methods were field observations, study of published sources, methods of theoretical research, analysis, designing, comparison, classification and generalization.

For the first time, the results of the project proposals for Yerevan central residential quarters reconstruction are subjected to comparative generalization.

The historical process of the quarters formation is generalized, the issues arisen in different periods are determined. The results of reconstruction conceptual proposals developed by the authors based on the study and analysis of the present situation in certain quarters are summarized. Socio-economic opportunities for the process implementation and the expected results are presented.

The existing problems of quarters are classified in the paper. Approaches to problem solving and positive and negative aspects of the results obtained in the proposals are presented. The results can be introduced in the reconstruction programs of the central quarters of Yerevan city.

1. Introduction

One of the important problems of the existing residential development of the Yerevan is the disorganized situation in the courtyard space. In this development, mostly formed during the past hundred years, problems have arisen over time. They have never received a system solution and it led to the formation of the present spontaneous, unsteady, unsightly and dangerous environment in the yards. On the other hand, the placement of new residential buildings in the courtyards today is primarily aimed at achieving business purposes, and not to satisfy the public interest and improve the environment. Such a situation supposes that the problem needs a global, programmatic regulation, which is the main purpose of our research [1, 2].

Since the scope of the research is very wide, it was expedient to divide it into a few directions. Based on the fact that there are several types of development organization in the residential area of Yerevan, particular directions have been chosen according to that logic [3]. In accordance with this, there are three main directions for the adjustment of the yard area: quarters with perimetral development (mainly: Centre, Arabkir, Shengavit), quarters with free development (mainly: Ajapnyak, Nor Nork, Qanaqer-Zeytun) and quarters with groupping development (mainly: Avan, Malatia-Sebastia, Erebuni, Davitashen).

The works performed so far relate to the quarters of the centre of the Yerevan city [4-6]. Despite the commonality in the principle of perimetral development there are some differences in the structure of these quarters. They are conditioned by the urban placement, by the historical value of the elements in the perimeter of the development, by the nature and the saturation of the development in the courtyard space and the existence of green area [7]. The conducted researches allowed to reveal the possibilities of reconstruction of these quarters, the generalization of the results of which this work is devoted.

2. Methodology

The work was carried out on the basis of field studies of individual sites and specific elements of the development, as well as on the study of published sources on foreign and Armenian architecture. The methods of theoretical research, analysis, design and generalization of the material were used.

3. Results

3.1. The process of the quarters formation and the problems that have arisen in different periods of time. Present-day development of the centre of Yerevan, despite significant deviations, was formed on the basis of the 1924 master plan ideas [8]. It mainly consists of quarters of perimetral development common in Soviet cities in the 1920-50s. [3, 8]. Such quarters in Yerevan were formed on the plots built up with individual houses. As a rule, the initial demolition applied to the the elements of the old development adjacent to the streets, where 4-5-storey apartment buildings were erected [1]. The demolition of houses located within the courtyards, which would allow creating comfortable yards, was constantly postponed. Inasmuch as in a limited economic conditions, the priority was rapidly provision of ever-growing demand for housing [1, 8].

In the 1960-1970s a new trend has emerged. Multi-storey buildings were placed in the intra-quarter area, in which together with new inhabitants the residents of the demolished buildings were populated [1]. However, this approach did not solve the problem of the courtyard space organization. The density of the population in the districts was increasing, and public area were further reduced. Along with that in 1970-80s the number of individual vehicles were sharply increased (during the 1965-85s the average annual growth of the individual cars number in Yerevan was 11 %) [9, 10]. It lead to the placement of numerous temporary metal garages in the yards. On the background of socio-economic radical changes in the republic in 1990s many of them turned into the reinforced concrete constructions with the right of individual property and some part of the garages became objects of public services. As a result of the above-mentioned multilateral processes, today a densely and spontaneously built-up, uncomfortable, unaesthetic and dangerous for vital activity environment requiring immediate reconstruction has formed in most of the courtyards of the centre of Yerevan.

Comprehensive surveys (study of archival and cartographic materials, observations, field studies, measurements, conversations with residents, polls) have allowed to reveal clearly expressed certain regularities in the structure of almost all residential area of the centre. Along the perimeter of the quarters there is primarily residential development, mostly dated in the 1940-80s (in some cases buildings of earlier or later periods). In the yards there is an irregular development: threadbare housing stock (individual houses), public buildings, metal or reinforced concrete garages, as well as engineering structures (transforming stations, boiler-houses). There are no recreation and entertainment area, children's and sport playgrounds, Improvement elements (sidewalks, benches, garbage cans, lighting fixtures). Often, small public service facilities were built along the perimeter of quarters, in the intermediate zones of development or on sidewalks. Almost everywhere there is a lack of parking space. United green area are often not formed in the yards. Green area are diffused and divided into the gardens near the individual houses and out of reach for the most inhabitants of the yard. In the inner space of the quarters generally there is unsystematic, random development, where elementary architectural and urban planning requirements (roads and approaches, distances between buildings, visibility, insolation, natural lighting, ventilation) are not observed. The environment is devoid of compositional and aesthetic solutions [4-6].

At the same time, despite the presence of the above-mentioned regularities, there are also some differences in the structure of the residential quarters of the centre. They are, in particular, conditioned by the presence and quantitative relation of structures of ordinary and historic-cultural value, time-worn housing stock, garages, structures implemented in violation of urban planning requirements, green area, as well as the peculiarities of their urban planning emplacement in the structure of the city centre. Based on these specifications three different quarters have been selected (fig. 1). Quarters were thoroughly investigated and a conceptual proposal of reconstruction for each of them has been designed [4-6].

3.2. Reconstruction proposals developed over the last decade. Reconstruction and renovation of the housing stock is one of the most important issues in the housing policy of each country. Reconstruction is one of the main directions in the modern world architecture. It is the main way to reform and improve the already formed urban environment [11]. Urban reconstruction is a multi-layer and complex process. This is evidenced by the already realised urban planning interferences in many cities studied (Moscow, Warsaw, Gdansk, Dresden, Berlin, Munich, Tunisia, Jerusalem, Ina-Casa, Aceh, Nias). Their experience shows that while developing projects, it is necessary not to consider the selected area as a separate operating environment, but to pay great attention to the existing urban situation, to the formed scale and architectural-artistic specific features [12-18]. Based on this approach, we have considered the reconstruction of separate quarters not only from the position of regulation of a yard, but also in terms of transformation and modernization of a specific area of the city organism.

In the project proposals, an attempt was made to solve the problems that have accumulated in the quarters and to create the favorable environment necessary for living. At the same time, special attention was paid to the economic side of the problem. As F. Steinberg notes, the reconstruction and rehabilitation of the housing is the main method of rebuilding the residential environment [16]. Each project has been developed on the principle of the formation of a certain real estate and of the ensuring through this the payback of the project. According to the Laurence J. C. Ma and Fulong Wu local governments are always interested in such development programs, which contribute to the permanent circulation of the funds [11].

Various approaches have been used to achieve the set aim. First of all, in order to obtain more regular and attractive environment, it was provided to demolish various occasional buildings along the quarters or in the internal space. Improvement works are carried out in each yard, aimed at the revival of the socially rich traditional environment of the old Yerevan's yards [19]. In some cases, construction of new residential buildings is foreseen for compensation of demolished housing as well as for the formation of area for sale. On the first floors of the proposed residential buildings, in most cases, public area are provided for servicing of the first necessity requirements of the residents, as well as for rent or sale. In some cases, yards have completely public buildings, especially given the high value they have in the real estate market. Taking into account the problem of lack of parking space in the yards and the current trend of the vehicles growth in Yerevan, it is proposed to organize underground parkings, the volume of which is calculated in accordance with the requirements of the population of the whole yard. Sometimes it is also proposed to use the attic spaces of existing buildings. It not only allows to form the additional floorspace to be sold, but also promotes reconstruction of the threadbare roofs of these buildings [4-6]. The proposals for the reconstruction of selected quarters are briefly descriped below.

Situation Plan

Layout of the project proposal

Symbol book: ● **Residential buildings** ● **Public biuldings** ● **Green area** ○ **Transport approaches**

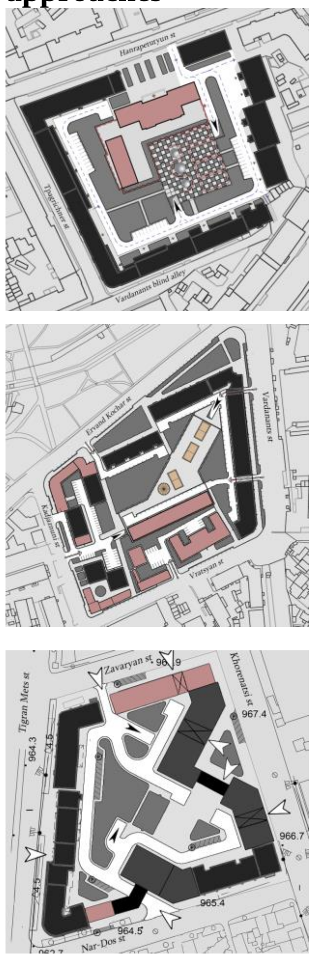

Fig. 1. Proposals for the reconstruction of selected quarters

3.2.1 Proposal for the reconstruction of the quarter between the streets Hanrapetutyan, Tpagrichneri and dead end of Vardanants street (fig. 1a). The quarter is located in the Small centre of Yerevan city. It is characterized by a small amount of buildings to be demolished (the area of demolition objects in comparison with the total area of the site - 10.8 %), and also by the presence of capital structures along the entire length of the perimeter (100 %). The project proposes to demolish individual houses, public service facilities, garages and the boiler-house located in the courtyard. On the roofs of existing 4-5-storey residential buildings, along the entire length of the streets of the Hanrapetutyan, Tpagrichneri and the dead end of Vardanants street, it is proposed to construct attics. At the expense of the formed area of attics it is planned to compensate the residential development in the yard. In the courtyard it is proposed to develop a 3-storey underground building, where in addition to parking, some service facilities will be also organized (community services and sport-recreation facilities). On the roof of the building, in the yard space playgrounds and recreation area are organized. Open-air parking lots, roads, approaches, sidewalks, green area are planned to be settled in the yard. The territory of the secondary school, located in the quarter, is also regulated and improved [4].

3.2.2 Proposal for the reconstruction of the quarter between the streets Vardanants, Y. Kochar, Kadjaznuni and Vratsyan (fig. 1b). The quarter is located on the territory adjacent to the Small centre of Yerevan city. It is characterized by a average amount of buildings to be demolished (the area of demolition objects in comparison with the total area of the site - 20.7 %), and also by the presence of capital structures along almost the entire length of the perimeter (more than 90 %). In the project is proposed to demolish individual houses, public service facilities, garages and sports hall located in the courtyard, as well as the service facilities located on the corners of the streets Kochar-Vardanants, Kochar-Kajaznuni and along the Vardanats street. In the courtyard it is proposed to build a mixed-floor residential building (5-15 floors with a variable contour), an underground 2-storey parking and also a one-storey public building (service and sport-recreation facilities), on the roof of which playgrounds will be installed. In the yard it is planned to organize open-air parking lots, regulate roads, approaches, sidewalks, increase and saturate the green area. The corner of the streets Kochar and Kajaznuni is planned to arrange with the 2-3 storey public building. The building of the special school is preserved with the possibility of functional change. In some parts of the development it is planned to erect small service buildings. On the roofs of 4 and 5-storey residential buildings along Vardanants street, on the two edges of the development, it is proposed to carry out attics [5].

3.2.3 Proposal for the reconstruction of the quarter between the streets Nar-Dos, Tigran Mets, Zavaryan and Khorenatsi (fig. 1c). The quarter is located outside the Small centre of Yerevan city (within the Big centre). It is characterized by a high amount of buildings to be demolished (the area of demolition objects in comparison with the total area of the site - 39.8 %), and also by the partial presence of capital structures along the length of the perimeter (over 47 %). In the project is proposed to save residential buildings located along the entire length of Tigran Mets street, as well as at the intersection of the streets Nar-Dos and Khorenatsi. Individual houses, public service facilities, garages located in the yard, as well as commercial premises located along the streets of Nar-Dos, Khorenatsi and Zavaryan are demolished. Along the perimeter of the yard residential (3-9 floors) and public (3-4 floors) buildings are provided. The first floors of all apartment buildings are envisaged to public premises. An underground 2-storey parking with approaches from Zavaryan and Nar-Dos Streets is designed in the inner space of the quarter. Along the street Nar-Dos two residential buildings are designed (4 and 9-storey) with access to the roof of the 4-storey building (recreation area for residents). Along the street Khorenatsi there is a 3-4-storey linear residential building with an offset in the central part. In the development of the streets Khorenatsi and Nar-Dos two covered galleries (at the level of the 2nd floor) as a recreation area for the residents are designed. In the public buildings located along the streets Zavaryan and Nar-Dos there are studio and office premises. In the courtyard regulation of the roads and parking lots, creation of sidewalks and approaches, Improvement of green area is planned [6].

4. Summarizing the results of the proposals. In the presented projects the improvement of the urban environment in the context of ameliorating the quality of life of residents is considered as the main goal. They are aimed to meet the public interest and are not intended to provide financial income. On this basis, with the help of various methods listed above, the updated development is provided in such volume that the formed funds were sufficient for the solution of all problems of the quarter. In all submitted proposals economic calculations are made in such a way that the value of the formed real estate exceeds only the costs of research, design, implementation, demolition, construction and improvement (exceed by 7-26 %). Compensation of demolished objects is provided by the constructed area. Construction costs are calculated taking into account the cost of construction works of the Committee of Urban Development of the Republic of Armenia [20]. Real estate prices are taken according to the analytical data of the Statistical Committee of the Republic of Armenia [21]. In the implementation of the project by public authorities, the possibility of excluding VAT will reduce costs by 20 % [22]. In all project proposals some positive changes of characteristic parameters were obtained. The main indicators and the results of the proposals are summarized in tables 1-2.

Table 1. Comparison of technical and economic indicators of the project proposals

<table>
<tr><th rowspan="3">№</th><th rowspan="3">Name</th><th colspan="6">Indicators by separate quarters</th></tr>
<tr><td colspan="2">Hanrapetutyan, Tpagritchneri, Vardanants dead end</td><td colspan="2">Vardanants, Y. Kochar, Kadjaznuni, Vratsyan</td><td colspan="2">Nar-Dos, Zavaryan, Tigran Mets, Khorenatsi</td></tr>
<tr><td>According to the project</td><td>Before</td><td>According to the project</td><td>Before</td><td>According to the project</td><td>Before</td></tr>
<tr><td>**1**</td><td>Total area of the site [m^2]</td><td>17200</td><td>17200</td><td>44270</td><td>44270</td><td>18000</td><td>18000</td></tr>
<tr><td>**2**</td><td>Building area [m^2]</td><td>6536</td><td>7730</td><td>17627</td><td>26000</td><td>6451</td><td>10050</td></tr>
<tr><td>**3**</td><td>Total area of residential buildings [m^2]</td><td>25183</td><td>23733</td><td>91870</td><td>78480</td><td>20486</td><td>17430</td></tr>
<tr><td>**4**</td><td>Total area of public buildings [m^2] (excluding on the ground floors of residential buildings)</td><td>1050</td><td>520</td><td>11164</td><td>9892</td><td>4413</td><td>2190</td></tr>
<tr><td>**5**</td><td>Totel area of the underground parking [m^2]</td><td>3000 (100 places)</td><td>Does not exist</td><td>14000 (470 places)</td><td>Does not exist</td><td>9764 (280 places)</td><td>Does not exist</td></tr>
<tr><td>**6**</td><td>Area of green zone [m^2]</td><td>2802</td><td>767</td><td>9479</td><td>6933</td><td>2600 (excluding the green roofs area)</td><td>2176</td></tr>
<tr><td>**7**</td><td>Building density factor [%]</td><td>38.00</td><td>44.94</td><td>39.82</td><td>58.73</td><td>35.83</td><td>55.83</td></tr>
<tr><td>**8**</td><td>Green zone factor [%]</td><td>16.29</td><td>4.46</td><td>21.41</td><td>15.66</td><td>14.44</td><td>12.08</td></tr>
<tr><td>**9**</td><td>Number of inhabitants</td><td>900</td><td>820</td><td>2940</td><td>2270</td><td>710</td><td>600</td></tr>
<tr><td>**10**</td><td>Habitation density [m^2/ha]</td><td>14641</td><td>13798</td><td>20752</td><td>17727</td><td>10820</td><td>9683</td></tr>
<tr><td>**11**</td><td>Density of the population [people/ha]</td><td>523</td><td>476</td><td>665</td><td>512</td><td>394</td><td>333</td></tr>
</table>

Table 2. Comparaison of economic performances of the projects

№	Name	Indicators by separate quarters			
		Description	Hanrapetutyan, Tpagritchneri, Vardanants dead end	Vardanants, Y. Kochar, Kadjaznuni, Vratsyan	Nar-Dos, Zavaryan, Tigran Mets, Khorenatsi
1	Design and research works [AMD]	Including all processes	0.08 bn.	0.37 bn.	0.18 bn.
2	Settlement objects (usable area) [m^2]	Residential buildings	1000	2648	4877
		Public buildings	520	3034	1752
		Garages	1200	3489	535
3	Demolition works [m^2]	Total area	3560	10171	8822
4	Construction and erection works [m^2]	Attic floor	2450	1700	Does not exist
		Residential buildings	Does not exist	15000	9153
		Public buildings	1050	4600	4413
		Underground parking	3000	14000	9764
		Improvement	7862	21921	11549
		Green zones	2802	9479	2600
5	Formed real estate (usable area, after the compensation of the settlement objects)	Residential buildings [m^2]	1450	10712	2445
		Public buildings [m^2]	530	1066	1778
		Parkings	40 places	303 places	263 places
6	Investment and results [AMD]	Cost of design and construction works	1.20 bn.	7.59 bn.	3.82 bn.
		Cost of formed real estate	1.52 bn.	8.08 bn.	4.12 bn.
7	Project duration [months]	Including all processes	20-26	24-30	24-30

5. Conclusion

1. The problems encountered in the quarters can be divided into the following groups:

- urban planning (density of the building, violations of the distances between the buildings, lack and unsatisfactory condition of sidewalks, roads, approaches and parking lots),
- structural (discrepancy with modern requirements of the structural system of the buildings, bad condition of the roofs),
- functional (absence of recreational area, green zones, play and sport grounds, summerhouses, elements of improvement),
- economic (low energy efficiency of existing structures),
- artistic (low level of buildings compositional solutions, of architectural image of the development and aesthetics of the environment).

2. The proposed project concepts are based on ensuring the payback of the project at the expense of the emerging real estate and are aimed at satisfying the public, not business interests.

3. The positive aspects of the results obtained in the project proposals are:

- reduction of the building area by 15.45-35.80 %,
- increase in parking area by 66.67-1547.05 %,
- increase in green area by 19.48-265.32 %,
- demolition of dilapidated, constructed in violation of the urban requirements buildings in the inner space, organization of well-appointed, comfortable courtyard space,
- elimination of the buildings, spontaneously arisen along the streets, improvement and regulation of street development,

- ensuring the security of life in the quarter.

The negative aspects are:

- increase in housing stock by 6.10-17.53 %,
- increase in population by 9.76-29.51 %.

4. In subsequent development proposals, taking into account the growth of funds arising from the VAT refund, in the process of reconstruction, it is also necessary to take into account the work on improving the energy efficiency of existing reinforced concrete prefabricated buiidings, improving artistic solutions, as well as strengthening the structural system of all buildings.

5. The realization of such projects can also be applied in the reconstruction of other residential quarters in the centre of Yerevan city and should be implemented on the basis of appropriate decisions and legal acts on the part of state and local authorities.

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TRANSFORMATION OF THE IMAGE OF EXISTING BUILDINGS IN THE CONDITIONS OF COMPLETE RECONSTRUCTION

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Keywords: Reconstruction, contrast, nuance, superstructure, compositional interconnection

Abstract. Current stage of urban development is characterized by increasing pace of reconstruction of developed city. Many cities experience shortage of building space, which leads to intensive use of lands in the city, since it has been proven that demolishing buildings and replacing them with new ones costs more than their reconstruction. Relevance of this study is determined by increasing need for reconstruction of existing buildings in Yerevan city, in particular, this concerns the city center, which is mostly built up with residential and public buildings from 50-60s. One of the main factors contributing to this kind of transformation is the change in socio-economic conditions since the construction of the mentioned buildings. Considering the greater development of city center, in comparison to its periphery, townspeople are trying in every way to obtain property in the center.

Some of the most common reconstruction methods are: **Superstructure** – A wide-spread method applied to both residential and public buildings. Superstructure has local character, without affecting the building as a whole. **Extension** – A method widely used for the expansion of building and the first public floors in particular, which is also more local. **Insertion** – A characteristic element that fills the gap between existing buildings, usually manifesting itself in case of a strong consolidation of urban development. **Complete** reconstruction – A not so common method of reconstruction, main features of which is integrated approach to the problem being solved.

In this paper, method of "complete reconstruction" is considered in conditions of Yerevan city.

1. Introduction

The space of the modern city appears in a complex interweaving, synthesis of various cultural, historical and socially determined elements - this is a moving multidimensional unity of time and place, place and event, event and human personality [1].

Despite the fact that the socio-economic factor is predominant, we should not forget that any change has an architectural-spatial aspect. Building and rebuilding the premises is changing the appearance of the building. Naturally, such a change is inevitable, but an approach is needed in which a change, even if it does not benefit, then at least does not damage the existing building and the architectural environment in general. Thus, any type of architectural changes applied in practice should be thoroughly considered and estimated before being brought to life that especially concerns the buildings which are thought to be primarily significant and valuable for the surrounding.

Harmony, which is so important in architecture, can be built both on the basis of "contrast", creating bright and strongly pronounced compositions, and on the "basis of nuance", creating discreet and unpretentious solutions. In any case, the integrity of the composition is fundamental, and therefore, regardless of the method chosen, the architect must maintain the integrity of the composition to the highest degree. Naturally, there is no single approach to design and the author should choose which approach is the best to apply in this case, but such concepts as form, image and proportions should be taken into account regardless of the approach. The building must meet functional criteria, but its image is equally important, only if they are harmoniously combined, it is possible to create an architectural work. The architect must have an understanding of what is being created, otherwise the result will not be achieved and the building will not fit into the architectural environment.

2. Methodology

Buildings formed in different historical epochs and under different conditions have an original and inimitable appearance, which is determined by form, plastic, structures, materials. This makes buildings from different historical times so different.

Under the conditions of reconstruction of the resulting building, the architect needs not only to try to preserve this historical building, but to adapt it to the needs of people, their way of life and the rhythm of life, but also to integrate innovative conceptual architecture into it harmoniously. Such modern conditions for the development of society adaptability is becoming one of the most important properties of progressive architecture. Architects are increasingly carrying out reconstruction of historic buildings, giving them a qualitatively new functional characteristics [2].

In the world architecture, there are frequent examples of preserving the existing part of a building unchanged, while the new part takes the form of a smooth, neutral glazed unpretentious volume, and even emphasizes the existing part without causing damage to it. This technique is interesting because a symbiosis of old and new buildings, where each building exists independently, but at the same time participates in the creation of a single composition and organization of the modern architectural environment. Unfortunately, there are also frequent cases when a part of an existing building is preserved in the facade of a new one, and the situation is aggravated by the fact that the new building basically has its own decorative elements with its own proportions, which leads to a conflict between the old and the new. A positive factor is that modern architecture has received more freedom and opportunities in a constructive way. Creative approach to the problem is being shown and more and more flexible solutions are viewed before reaching the given task and choosing the most appropriate decision. In view of this, when studying the current situation in Yerevan, the application of the following approaches to solving the above problem was revealed.

- Preservation of the existing building with its inclusion in the new
- Superstructures of one or several floors
- Complete reconstruction of the building

Preservation of the Existing Building with its Inclusion in the New

This approach is widely used in a dense urban environment and is particularly characteristic of city centers, where the price of land is prohibitively high, and is particularly relevant in cases where the site being built is already burdened with buildings that are architectural monuments. The ambiguity of this approach lies in the fact that in such cases attention is mainly paid to the building being erected, in most cases to a multi-storey building, and the existing building remains only as a tribute to the monument of the past era, without taking into account compositional features. From here comes a strong imbalance between the volumes of the new and the old building (Fig. 1).

Negative feature of this method can be considered the fact that in such cases, the dominant role goes to the new building. Often only the “historical” front wall of the old building remains, and the filling is demolished, because not always new functions fit well into the existing organism of the old building, yes and the conjugation of the old (with bearing stone walls) and the new (frame) structural systems creates difficulties. This problem is especially acute when the facade plastics of the old and new buildings come into conflict. In such cases, the historical significance of the preserved building is lost, which in itself is nonsensical, since this building was preserved in the name of its significance, historical or architectural. A good solution may be the use of modern building materials, such as glass. With this approach, although there is a strong contrast between the materials used, there is no conflict of the facade plastics, which allows the existing building not to get lost against the background of the new one.

Superstructures of One or Several Floors

This approach is also widely used in a dense urban environment, but in its main manifestations it has a small number of floors. One of the main factors limiting the number of floors is the condition of the supporting structures of an existing building, as a rule, allowing one or two (in rare cases, three and more) floors to be added. An important task with this approach is the elimination of the possible stylistic discrepancy between the old and the new parts, as there is usually a temporary and stylistic gap between the existing and the new part (Fig. 2). This approach is considered separately from the ordinary superstructure, mainly applicable to residential buildings, where the attic is converted into the mansard, since the approach under consideration transforms the building, especially if there are several floors built.

Fig.1. Preservation of the existing building with the development around it of a new building in Abovyan Street. Yerevan

Fig.2. Superstructure floors in Melik-Adamyan street. Yerevan

Complete reconstruction of buildings

In world practice there are numerous examples using this approach. One of the main features of this method is that, if it is used, the complex approach to the problem being solved prevails. Flexible tools with the ability to preserve the existing stylistic image of the building, as well as giving it a new look. This provides a wide toolkit for solving the problem. Even regardless of the specific choice of the stylistic and compositional approach, its holistic implementation is possible, which itself helps to smooth out the time difference between the old and the new.

One of the best examples of this method can be considered the reconstruction of the castle in Moritzburg, Halle (Fig. 3, 4).

The ancient castle of Moritzburg in the city of Halle is a very valuable example of Gothic military architecture, typical of Germany at the end of the 15th century. Its turbulent history has inevitably been reflected in the many alternations it has undergone over the years. But despite these, the building still keeps the original structure of its main architectural features: the surrounding wall, three of the four round towers at the corners and the central courtyard.

The reconstruction project was carried out by the Spanish company Nieto Sobehano, led by the architect Enrique Sobehano. Judging about the building from the outside, it will be perceived as a skillfully made superstructure, mostly glass, illuminated from the inside using metal sheets. So at first glance it seems that this is a purely superstructure, but, going inside, we understand that this is a complete reconstruction. In fact, the historical part of the building remained untouched, and the internal space was completely reorganized as a museum. The main principle of reconstruction is a sharp contrast between the old and new parts of the building.

The building of the Armenian General Benevolent Union (Fig.5) can be considered a good example of a “complete reconstruction” in Yerevan. It is worth making a reservation that most of the building's metamorphosis is a superstructure of the floors, one of which has changed the building itself so much that it can rightly be considered a “complete reconstruction”.

Fig. 3 Expansion of the museum Moritzburg [3]

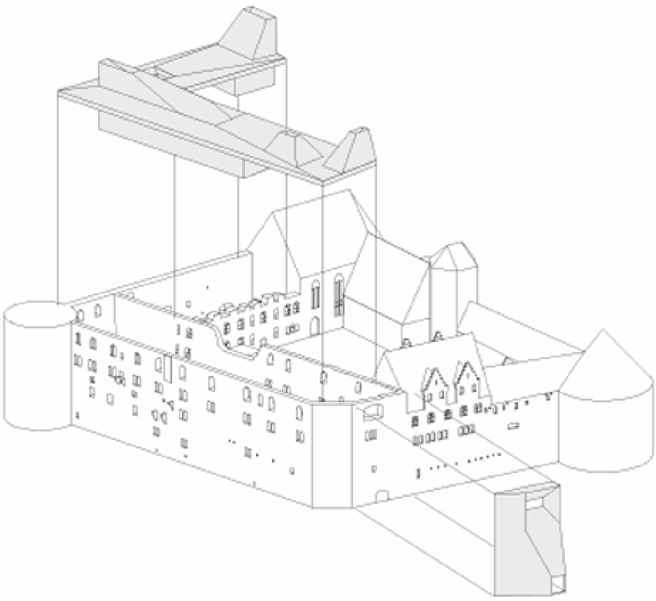

Fig.4. Expansion of the museum Moritzburg. Renovation [3]

The new AGBU office is based on the former building of the City Duma and Government, built in 1906-1907. Architect B. Megrabyan. In 1929 it was reconstructed by N. Buniatyan, who added the third floor and expanded the right wing. The building has been inhabited for decades by city self-government bodies, the Writers Union, then the Spandaryan District Council. In 2000, it was dismantled to pave Italiana Street. The stones were saved and, as it turned out, for good reason. When the question arose about the construction of the AGBU building, the head of state proposed a free area between Melik-Adamyan and Hanrapetutyan streets. And since there were already two restored “black” houses of old Yerevan (one building of the Republican Party), it was imperative to continue this concept [4].

Fig.5. The building of the Armenian General Benevolent Union on Melik-Adamyan Street. Yerevan

3. Results

The modern architect must take care of the historical buildings, building new buildings in such a way as to ensure the harmonious coexistence of the old and the new in the architectural and spatial environment of the city [4].

Considering the transformation of the appearance of buildings under complete reconstruction using the example of Yerevan, it became possible to determine three main types of transformation: preservation of the existing building with the development around it of a new building, the superstructure on one or more floors, completely transforming the building and complete reconstruction of the building.

4. Conclusion

Some strengths and weaknesses of these approaches have been listed above each of which can be applied in a separate case. However, in cases of using the method of complete reconstruction of buildings, a more holistic and flexible approach to solving the problem was clearly demonstrated. The harmonious perception of contrasting solutions was also shown, since, being different from the reconstructed building, they did not conflict with it, but served as a contrasting, but neutral compositional addition, as opposed to cases where the new facade plastics came into conflict with the old one. On the base of subject of our research we once more attract the attention to the problem of relevance of architectural additions which need extraordinary subtle approach and deep consideration and should be carefully weighed by the architect before his ideas are realized.

Acknowledgements

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ARCHITECTURAL - PLANNING FEATURES OF THE CLUSTER REUSE OF THE TERRITORIES IN SYUNIK PROVINCE AFTER MINE SITE RECLAMATION

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Keywords: Land resources, damaged landscape, mine site reclamation, new architectural environment, cluster reuse, sustainable development

Abstract Syunik province as a massive industrial hub of Armenia had lost many areas due to the collection and storage of mining and other manufacturing processes. Today a number of settlements (such as Kajaran, Artsvanik, Gomaran settlement, etc.) for the above reasons have large unused spaces in their planning structure, the reuse of which may contribute to the restoration of architectural-planning patterns of communities, the solution of environmental issues and the sustainable development of the communities.

Violation of the areas was mainly occurred due to the exploitation of minerals, as well as uncontrolled storage processes of waste. Violated lands have lost their primary value, have acquired harmful characteristics and have a negative impact on the surrounding natural environment.

The use of separate sections of the landfill as tailing dumps and other waste collection areas resulted land deformation, which contributed to the degradation of sustainable landscape and the loss of valuable attributes.

Regulation of land use issues is actual especially in the context of the modern technical progress. In order to prevent negative processes, it is necessary to carry out work on the reclamation and rehabilitation of grasslands. Works should be directed to the restoration of the land layers, as well as the subsequent inclusion into the economic activities to ensure the necessary environmental norms of the architectural space organization.

The problem is solved through reclamation of land, the purpose of which is to restore the primary importance of land use in any area of community use.

In terms of the shortage of land resources in the region to prevent new, valuable land involvement in the urban planning process of settlements, as well as the review of the possibility of including potential territories into the planning process, will make it possible to re-use and rehabilitate the lands left out of economic turnover, as well as to form a compact layout structure of the residential areas with the use of new reserves in the adjacent sections of the existed layout structure.

The spatial distribution of such lands in the region makes it possible to introduce a cluster planning model. The cluster development of the reclaimed lands (as a new useful land resources) will contribute to the creation and balanced development of inter-community connections.

Reclamation involves the restoration and maintenance of the land resource balance, which will contribute to the areas:

- recovery of the damaged soil layers
- improvement of the lands environmental status
- restoration of disturbed landscape
- formation of new architectural image of territories.

1. Introduction

From the point of view of sustainability of the environment from the three key components - economical, social and environmental in the concept of the sustainable development, the decisive role belongs to the ecological component.

From the environmental aspects, sustainable development should ensure the biological and physical integrity of natural systems. The vitality of the ecosystem is the most important, which depends on the global sustainability of the entire biosphere, in which the human anatomical environment (urban, rural) is included. At the same time, focus should be on maintaining the capabilities of self-reparation and dynamic adaptation of systems, rather than maintaining them in absolute stability. Degradation of natural resources, environmental pollution and loss of biological diversity reduce the ability of the ecosystem to self-rehabilitate [1].

From this perspective, in spatial urban planning land resources are particularly vulnerable from the natural reserves. The approach to integrated, systematic urban development restructuring for undermined and demolished land resources which has been damaged for a number of natural and anthropogenic reasons, has only been developed over the past few decades.

In international practice the mechanism of reclamation has already been actively applied to partially or entirely violated lands, combined with the introduction of modern technologies (Germany has the largest experience in this area where the systematic reconstruction has been carried out for more than 30 years and damaged lands have been restored for agricultural purposes, forest and water zones, also for other purposes). Reclamation recovery is a multidisciplinary process, by combining environmental protection, economic rehabilitation, and regional planning. The formation of new dimensional images of the reclaimed areas also makes it possible to get a new architectural recognition, with high environmental features, and in microclimatic mild conditions (Fig. 1).

Reclamation is carried out sequentially, with subsequent stages: technical, biological and constructional.

Observing the possibility of the further reclamation of the the territories, the construction reclamation, which is the construction of buildings and other objects in those areas after the previous reclamation phases, is particulary important. In this context, the proposed architectural and landscape organizing methods aim to create comfortable living conditions that must provide a complete aesthetic perception [2,3,4].

Fig.1. Inter Continental Shanghai Wonderland

a) quarry: before the reclamation

b) hotel building: after the reclamation

2. Main concept

The problem of effective use of the land fund in the conditions of limited land resources availability in RA is a key issue in the environmental, ecological, volatile planning issues of the country. In the case of scarce land resources, the most important is to investigate their damage, deterioration of qualitative characteristics, and the introduction of solutions for their prevention and recovery.

In all the regions of Armenia, in separate communities where partially operating or closed mining industries are existing, damaged areas have been occurred and the possible re-utilization of which will contribute to the increase of the country's available land resources after reclamation.

For the positive progress, for the effective, systematic and sustainable development of the territories expected from reclamation, a systematic operation of the territories is proposed by localizing the cluster model.

For the localization and launching of such a model it is necessary to:

- evaluate land degradation levels
- ensure full reclamation at all levels of soil layers
- explore localized prospective function in recycling areas
- develop land-based projects for possible renewal of land for active use of territories (Fig. 2).

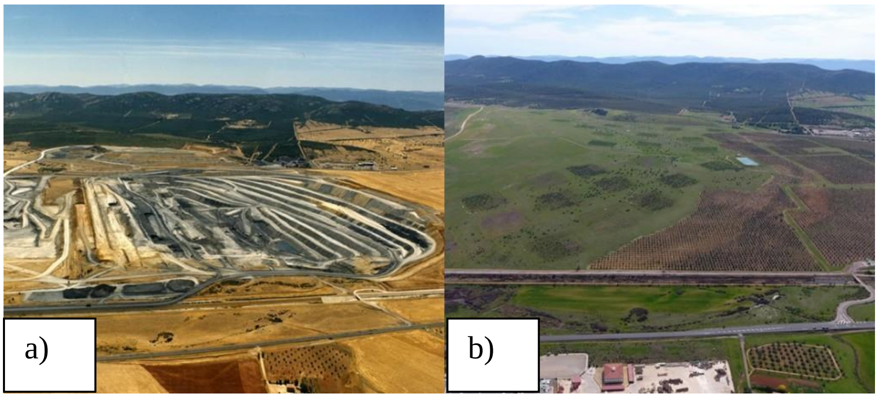

Fig.2. Mine site reclamation a) before, b) after

Larger land areas (environmental, agricultural, etc.) in Syunik province suffered losses due to pollution caused by active mining activities in the communities (Kajaran city, Artsvanik, Sevakar and other settlements).

Such damages have currently resulted a number of environmental issues in the region:

- low level of ecology
- over -exploitation of natural resources
- continuous environmental degradation, pollution.

Scrapings of mines, sedimentation basins, soil layers and other mining complexes can be considered as an object of primary reclamation:

- lands damaged as a result of construction works;
- heavy waste polygonal areas;
- damaged areas caused by liquid contamination

In Syunik, the area has been violated primarily due to the exploitation of minerals and uncontrolled storage of minerals. As a result, the affected lands have lost their primary value and now have a negative impact on the natural environment (Fig. 3) [5].

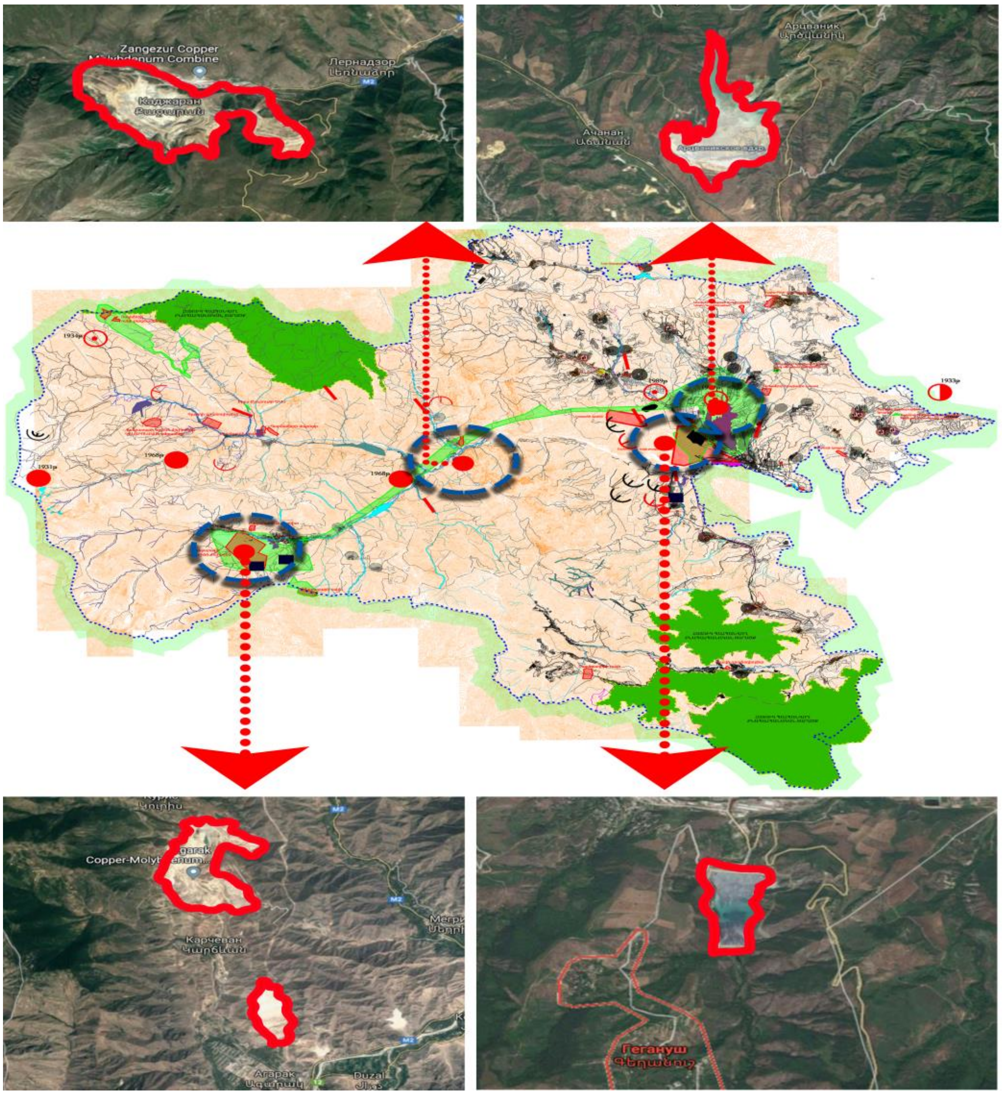

Fig.3. Distribution of tailing dumps in Syunik province, RA
(Armenia has 19 tailing dumps, out of which 9 are located in Syunik Region.
Their designed capacities are 3, 3.2 and 310 million cubic meters)

The cluster re-utilization of renewed lands will contribute to the systematic, balanced use of the territories as a result it will create new urban environments. With the help of new technologies and the cluster-based model architectural-oriented organization, the opportunity to save space and form new characters will be created. In addition, mutually beneficial, coordinated cooperation can contribute to their faster progress.

Selection of the land reclamation target and the expediency of their subsequent exploitation shall be taken into account by the following factors:

1. climatic conditions of the region or the selected areas (climate, soil, geological, hydrogeological conditions, vegetation, surveying systems or landscape complexes);
2. agro-chemical and agrophysical properties of rocks and their mixtures in hydraulic cavities, tailings,
3. socio-economic and sanitary conditions in the affected areas,

4. the period of existence of land reclamation and the possible risks of recurrence,
5. production technology of mining and reclamation rehabilitation works,
6. environmental requirements,
7. further development plans of the mining industry,
8. assessment of previously demilitarized lands (an assessment of anthropogenic landscapes and degrees of self-development resulting from the process of mine recycling).

Taking into consideration the existing and prospective regional development potential, the possible re-use of the region's reclaimed areas is as follows:

- formation of agricultural or agricultural production units;
- development of multi-functional public zones
- forming a complete touristic complex or service junction;
- formation of alternative energy, solar panels deployment stations
- increasing forest resources

The main scientific findings are as follows:

Cluster reuse is possible through the assessment of operational relationships between disturbed areas and their prospective development, with reference to the resettlement plan of the RA, providing further detailing of the lower levels of hierarchical functional planning. Development of the architectural-landscape restoration concept for the former quarries and mining areas, the formation of the architectural-building structure of the planned objects will be further elaborated in the development of long-term planning of spatial planning of areas (Fig. 4).

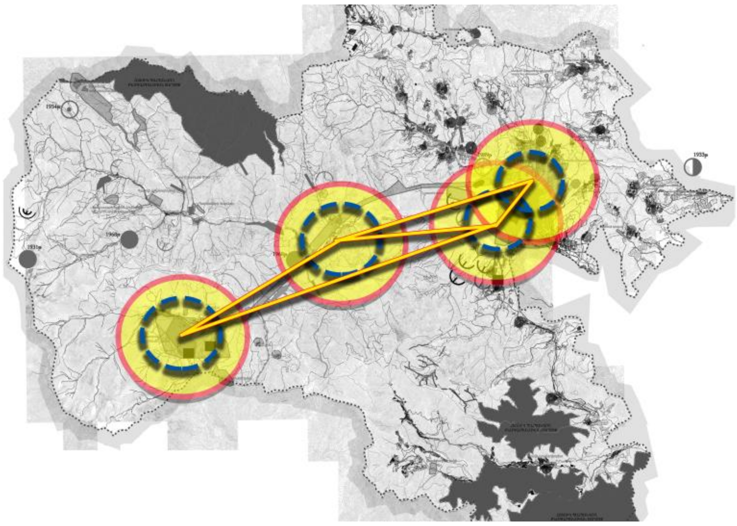

Fig.4 Cluster model localization as the possible way of develop reclaimed zones

Assessing the different degrees of land reclamation: complete or partial rehabilitation, makes it possible for future operational separation of reclaimed areas.

In case of severe damages, where there is a clear layering of the landscape, irreversible losses of soil layers, it is also possible to mitigate the violation by providing architectural solutions, envisaging the architectural solutions embodied in the relief contour. Such an approach will contribute to the mitigation of any environmental damage, but also to the organization of an environment that meets the physical characteristics of the area (geometry, volume, inclination, structure, etc.).

The potential for tourism development in Syunik province suggests that the reclaimed zones will be used to provide the necessary infrastructures as well as complete tourism complexes. In all the options discussed, rational utilization and maintenance of land is essential, which should be exercised by all stakeholders - land users, landowners, tenants etc.

3. Conclusion

Reclamation as a part of the land recovery works carried out to recover damaged areas and to safeguard the landscape is a feasible option for the restoration of the usable land balance of the Syunik province. Land reclamation will also make possible the restoration of the ruined hard-rock landscaping and their adaptation to the formation of new dimensional environments due to localization of the cluster model. Localization of the model will make it possible to have sustainable development in the region due to the unified and efficient use of unused resources (Fig. 5,6,7).

Fig. 5 Quarry zone: layering of the landscape- before the reclamation
Fig. 6 Quarry zone: envisaged of the architectural solutions embodied in the relief contour-after the reclamation

Fig.7 Proposal for reclamation of Artsvanik tailing dumps in Syunik province as an alternative energy, solar panels deployment stations

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PRIORITIES FOR THE DEVELOPMENT OF MODERN ARMENIAN ARCHITECTURE

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Keywords: Modern architecture, cultural heritage, innovation and tradition, morphogenesis

Abstract. Over the past three decades, the Armenian architecture develops under the conditions of new factors of influence that have affected the entire spectrum of architectural tasks: typological classification of buildings, functional content, technical equipment, structures and parameters of objects. In a creative context, the new time is reflected in the diversity of aesthetic concepts of the professional worldview. In the article the main aspects of the historical development of modern architecture, its innovations and traditions, new types of objects and problems of conservation cultural heritage are analyzed.

1. Introduction

In the last decade of the 20th century in modern architecture of Armenia, radical changes are taking place that affect all the spheres that characterize the profession: stylistics, the basics of morphogenesis, the specifics of creative activity. As in all times of human activity, the historical factor was the guiding force in the orientation of the development of architecture and the formation of its leading priorities. In this case, it determined the economic situation, the real possibilities of construction and the emerging new worldview. Given such criteria, the provisional periodization of the last approximately three decades is represented in two phases: the end of the 20th and the beginning of the 21st century.

The last decade of the twentieth century marked the time of dramatic changes in the political life of Armenia. In a flashback of the Armenian people, they remain as "dark", which includes the vital notion of "hungry", "cold", "bad" years, not to mention the psychophysiological desperate state of the whole people. A generalized picture of the first years of the third republic of Armenia, without going into details, can be presented to a foreigner one paragraph from a book under the same title of the historian Edik Minasyan: the general catastrophic situation in the country, when after the collapse of the Soviet state, the former republics were involved in the confrontation, and with the exception of the continued small assistance of individual countries, she was left alone with her extremely difficult concerns; complete blockade of the republic, in which Turkey actually participated from the beginning of the 1990s; the war in Nagorno-Karabakh, the fatal state of the refugees forcibly evicted to Armenia; energy crisis and inconsolable socio-economic situation [1, p. 191].

Unstable and the dire economic situation of the country, respectively, leading to a severe crisis in construction and architecture. In cold architectural studios design institutes rare architects work on unfinished projects or are in the process of visionary architecture in the hope of future prospects.

New socio-economic relations very soon impose a visible imprint on the style of work of the architect. In a specific context, one of the positive positions of the Soviet state design institutes can be considered the concept of the architectural community, where young specialists join in, for whom working in a large professional team becomes a source of professional development, such as an internship. The work of modern isolated architectural studios is based solely on individual creative priorities and the effectiveness of its activities directly depends on their professional competence, creative inclinations, as well as administrative and organizational skills of a founder of a design organization who is able to coordinate the project at all stages of development and construction.

Thus, as a result of the influence of various factors, modern Armenian architecture today has many professional opinions and creative ideas on typological, functional, and aesthetic issues. All architecture cannot be considered by the category proposed by Jeremy Melvin as an aesthetic direction, "having common cultural context" [2, p. 7], which was typical of the Soviet architecture of socialist realism, but it is fully consistent with the trends of world architecture today. It is possible to classify styles used in Armenia as "movement defined by architects", however, in the narrow sense of the framework of individual creative studios. Summarizing this aspect of Armenian architecture, in general, we can state the presence of international architectural styles and national traditional forms, expressed by their philosophical and spiritual or unpretentious mechanical reproduction. This means that each architectural studio and each author have a wide choice for creative searches, allowing them to work in any style they like, demonstrating their own artistic style, which is often recognizable in street buildings.

Important and expedient innovations that have a positive impact on the development of Armenian architecture have become the participation of foreign architects in the design and construction in the cities of Armenia; international competitions held in the republic for the design of specific structures; exhibition-contests "Design and Construction of the Year", organized by the Ministry of Urban Development and the Institute-Museum of Architecture; the possibility of private participation in the Venice Biennale and other professional events abroad.

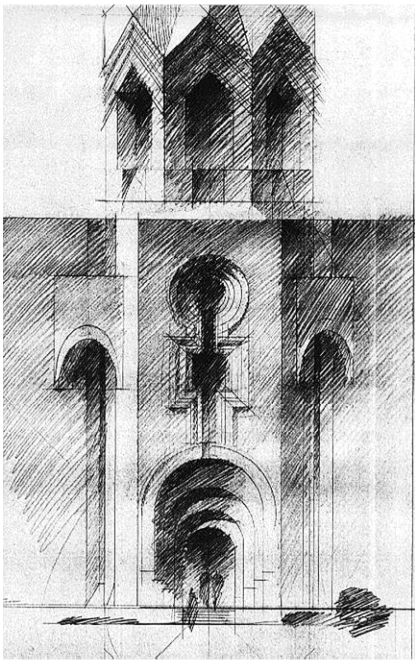
2. Methodology

The research methodology consists in the architectural analysis of buildings constructed in the last approximately three decades and is based on a field study of the objects, study of project materials and systematization of the data obtained. The dating and authorship of the buildings are specified in the process of direct contacts with the existing architectural studios, the official documents and projects they have.

3. Results

Considering the list of buildings built in the first decade of independence of Armenia, two leading areas of the original architectural activity can be identified. The first is the revival of church construction, which can also be considered a symbol of the birth of new Armenia, for it was during this period that the architectural type of churches developed, the design of which was practically inaccessible during the Soviet period. The presence of a double reminiscence is evident in church construction.

From a town-planning position, historical memory leads to the recent past, when confessional structures were built in every urban area and village of the Yerevan Governorate, the construction of which is today carried out on the personal initiative of the population and financial support from philanthropists. By the first half of the 2000s. Surb Harutyun (Holy Resurrection) in Spitak, Vazgenian Sevan School, and churches in different districts of Yerevan were built: Surb Mariam Astvatsatsatsin (Saint Mary) and Surb Errordutyun (Holy Trinity) in Malatia-Sebastia, Surb Sargis in Nor Nork, Surb Khach (Holy Cross) in Shengavit. To commemorate the 1700th anniversary of the proclamation of Christianity as the state religion in Ring Boulevard, Surb Grigor Lusavorich (Saint Gregory the Illuminator) Cathedral is being built in the centre (Fig. 1, 2).



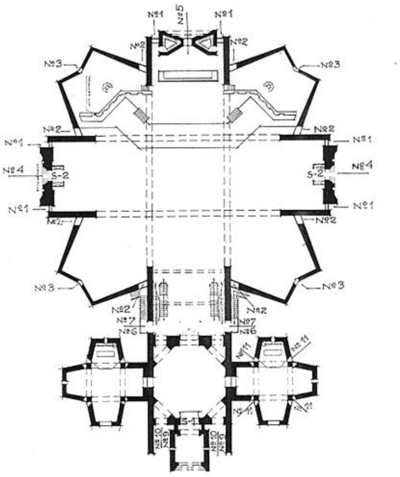


Fig. 1, Fig. 2. Surb Grigor Lusavorich Cathedral in Yerevan, 2001, architect Stepan Kyurkchyan. Sketches for the project
Stepan Kyurkchyan`s archive

In the same year, the Pantheon of the victims of the Karabakh war was created on Yerablur, where the church of the Srbots Vartanan martyrs was erected, made in the shape of a chapel.
In architectural interpretations, the gaze is turned to the times of the creative heyday of monumental architecture. The academician of architecture Varazdat Harutyunyan, who characterizes the church of architect Baghdasar Arzumanyan, eloquently testifies to this: "The designed churches originate from

- the compositions of medieval Armenian churches, but they do not repeat them and differ significantly from the originals, they seem to be planning and space-spatial innovations, magnificent and, of course,
- related to the traditions of our national architecture" [3]. These words can be attributed to all church construction in Armenia at the end of the 20th and beginning of the 21st centuries, in the architectural solutions of which the traditional structure, morphogenesis principles of construction a plan and volume, architectural elements and decorative motifs of the Armenian Apostolic Church are preserved. The main differences consist solely in the professional understanding of the true essence of the formation of the form defined by the confessional dogma. It is rare to see the use of traditional attributes in the concept of an allusion.

In the 1990s, several projects of reconstruction of historic buildings related to their re-adaptation, expansion, and modernization were realized, variously solved, but which could be a specific guideline on the method of reconstruction with adaptive reuse. In all the examples mentioned, the idea is based on a concrete cultural heritage architecture. In the Yerevan practice, modifications usually have the form of superstructures, repeating the scale, proportions, division, often the material of authentic construction, as in the example of the former P. Soghomonyan`s apartment house in Arami street. In trade objects, courtyards of the old houses are often converted into closed atriums, retaining the original configuration and traditional functional purpose of communication with the surrounding spaces. Such a motive was applied in "Sil Plaza" in the reconstruction of single-storey S. Melik-Ogandzhanyan`s shops at the corner of Abovyan and Arami streets, and for the architectural solution of the second floor, the project and old photos of H. Zakharyan and N. Harutyunyan`s apartment house were used. The technique of reconstruction of the apartment house in Nalbandyan Street, adapted to a bank, where the additional volumes were carried out in images corresponding to the new time, tactfully subordinate to the historical building and revealing its aesthetic appearance, was completely different [4, p. 597, Fig. 3]. The full restoration of the Blue Mosque was the result of the joint work of Armenian and Iranian specialists based on a thorough study of archival, literary and old photographic sources.

Fig. 3. Reconstruction of the apartment house in Nalbandyan Street in Yerevan, 1996-2002, architects Levon Vardanyan, Isaak Nersisyan Photo Khachatur Israelyan

Fig. 4. Reconstruction of Center for creative technologies in Gyumri, under construction, architect Bernard Khoury Information on https://www.bernardkhoury.com/project.php?id=303

Subsequent adaptations of cultural heritage objects, primarily in Yerevan, are unequivocally addressed to the mechanical reproduction of the idea of Facadism, in its less attractive form. A certain justification here is the lack of sufficient funds for the implementation of full-scale restoration work, though in reality this is not about conservation the architectural monument, but about the program of construction of a high-rise building in its place. The essence of the Yerevan method is that the historic building demolishes with the exception of the street facade, which is dismantled and subsequently assembled without any principal precepts – in its place or on the other. The fates of Governor's house and G. Gabrielyan apartment house are the examples of officials and architects neglect of public opinion aimed at preserving the cultural heritage and own respecting the historical heritage of the city. The first, important monument of history as a government building in the Yerevan Governorate, the first Republic of Armenia and the Soviet Socialist Republic, was in good condition, but as a result of the reconstruction, the structure and, accordingly, authentic interiors were completely lost. The second one was "forgotten" to be added to the state list of monuments of history and culture of Yerevan, and later, under the influence of numerous meetings of residents were officially approved as an object of cultural heritage, and in the end a high-rise building was built in its place. In the architecture of both new buildings there is not even a hint at the attitude to the attached facade of the architectural monument.

Indeed, from the point of view of the architectural qualities of the new buildings and their combination with the old facade, total Facadism found its most unjustified expression in an aggressive approach to the problems of preserving the aesthetics of the architectural heritage. In comparing the restored wall and the new volume, a theoretical version of contrast could be introduced, but in reality in the existing architectural image of the new building the idea of the compositional relationship between the two components rarely shines through.

One example of an original solution, in which the rational meaning of Facadism is obvious, is the building of a Center for creative technologies in Gyumri (Fig. 4). Firstly, only the facades of the old city theater are really preserved here. And secondly, in the architectural solution, the overall piety attitude to the cultural heritage is evidently: the picturesque walls of the neoclassical architecture of the building, decorated with plastic perspective arches, columns, pilasters and subject bas-reliefs on the themes of art, the theater continued upwards with clear geometric shapes made of glass, color fragments and laconic horizontal and vertical lines.

Fig. 5, Fig. 6. Architectural model of the "Old Yerevan" project, under construction, architects Levon Vardanyan, Misak Mkhitaryan, Lilit Vardanyan
View perimeter building and the interior space of the complex with an atrium
Photo Lilit Vardanyan

At last, a large-scale program of renovation of one historical quarter of Yerevan has begun recently on the section of the Main Avenue, where residential buildings of the second half of the 19th and early 20th centuries have been preserved (Fig. 5, 6). The objectives of the project called “Old Yerevan”, which locals have long been waiting for, constitute the conservation of the architectural heritage, the revalorization of the historical aesthetic environment, the restoration and reconstruction of existing buildings, the renewal and recreation of lost monuments, including those dismantled in the 2000s and 2010s., their adaptation to social functioning. The method is based on bibliographic, graphic archival materials and documents, measurements, field research and in its main direction there is an identification of authenticity, reversion to old forms in new fragments, the use of modern technologies.

The architectural and construction life of the republic in all other areas is significantly revitalized at the beginning of the 21st century under the sign of commercial and economic tasks, why rapid construction activities are concentrated primarily in the capital with the most profitable lots of land in its historical center. As a result of such a state program, Yerevan once again loses its cultural heritage and entire fragments of buildings of 19th and early 20th century, which cede own territory to new complexes that embody modern architecture. Historically, in a relatively short period of time, typologically different buildings are being designed and built, which unites multifunctionality, which is due to modern social requirements and wide technical capabilities. Functional and constructive innovations, in turn, have an impact on the development of new creative ideas, both in utilitarian and compositional stylistic decisions.

In the most common housing construction, a new type of apartment building, compared with the Soviet period, is characterized by a definitive improvement in living conditions, including the possibility of developing convenient layouts, large areas of rooms, the use of modern engineering equipment. Rich villas are being built, including in the central areas of cities, which are the most diverse in their architectural quality, more appropriate, with rare exceptions, to the owner's anti-aesthetic claims, rather than professional logic and artistry.

The most popular, both from a social and a commercial position, is expensive innovative multifunctional, multi-storey, complexes with a developed infrastructure. They are built according to an identical functional scheme of three-tier vertical zoning: parking spaces and technical rooms are arranged in underground floors, public and administrative functions like shopping and office spaces are planned to be placed on the first overground floors, apartments and penthouses are located in the upper floors. From the beginning of the 21st century the epoch of construction of high-rise structures begins with the use of monolithic reinforced concrete with seismic resistance designed for 9 balls.

Fig. 7. "House of Cinema", 2006-2008, architects Gagik Hovhannisyan, Levon Mrrikyan (Photo Gagik Hovhannisyan)

Fig. 8. "Moskovyan Plaza" house, 2016, architects Levon Vardanyan, Lilit Vardanyan (Photo Berta Martirosyan)

The internal functional separation is reflected in the architectural morphogenesis and artistic composition of the building by its multi-volume and structural dissection, which, with a rational according to the function and form aesthetically expressive. From this point of view, the 23-storeyed "House of Cinema" fits into the situational environment correctly, which is facilitated by its position in the free space, in air and green environment, creating an intermediate space between the building`s convincing vertical and the nearby relatively low-rise buildings (Fig. 7). In the general list of multifunctional complexes, a special place is occupied by the architectural version of the "Moskovyan Plaza" house on Moskovyan Street. His first facade with a height of cornices, materials, proportions, scale, interpretation of decorative forms of national architecture is organically included in the existing buildings of the 1950s. The authors used a gradual increase in the height of dynamic volumes in the direction of the inner space of the quarter and a large open atrium that separates the first and last blocks, due to which the highest part is seen in a perspective distance (Fig. 8).

However, many contrived, mechanically selected forms that do not correspond to the constructive structure, and this significantly distorts the general image of the buildings and the modern appearance. Placed side by side on the principle of perimeter building, each with its own demonstrative volumetric-spatial domination and not having pronounced ensemble interdependence, they are radically different from the concept of classical Tamanyan`s architecture, when even at different times the constructed buildings rallied in an artistically united ensemble of streets.

Multifunctional shopping and entertainment centers have become an integral part of the modern life of the city. Since the practice of modernization and adaptation of non-functioning industrial objects, if any, was not well known in Armenia, "Yerevan Mall" and "RIO Mall", recently opened in Yerevan, are interesting from this point of view. The complexes were created through the reconstruction and adaptation of abandoned Soviet industrial buildings – the factory of automobile details and the unfinished at one time furniture factory. Organized according to the rules of international standards with functional structures and technological solutions, bright and spacious interiors and their entire architectural image tells about the trends of modern architecture.

Fig. 9. Yerevan City Hall, 2004, architects Jim Torosyan, Romeo Martirosyan
Information on https://www.wikidata.org/wiki/Q8052572

Fig. 10. State Administrative complex in Shahumyan Square in Yerevan, 2015, architect Narek Sargsyan
(Photo Narek Sargsyan architectural studio)

A worthy architectural image was found in the complex of the Ministry of Defense, which textually expresses its function: strict placement of buildings, laconic forms of volumes, discreet use of color marking.

One of the exceptional achievements of the Yerevan architecture is the new complex of the airport: in the architectural solution, the functional-constructive forms flowing into one another fascinate with their plasticity, flexibility, modern general forms. The free interior space in which the entire metal structure is open, the huge glass surfaces animated with color fragments – everything is filled with air, expresses a humane attitude to people and is capable of creating a lightness and holiday mood for those traveling on an air trip.

As a statement of fact, it can be said that the concept of national traditions is gradually being lost. Modern architects, first of all, young studios, rarely turn to the past. In a very generalized sense, their architectural decisions are dominated by the desire for the functional content of the external image, for expressive and laconic geometric forms, animated by color fragments. Nevertheless, the architectural tradition of Armenia is preserved. In the new building of the Matenadaran and in the Komitas Museum there is a frankly respectful attitude to the historical buildings existing in the territory: in the first case, it is expressed in a harmonious rehash of the architectural forms of the Matenadaran of the 1950s, in the second – in a contrasting combination of the old and the new, and at the same time in the winning identification of the volume of the Soviet cinema. In the architectural idea of the "Moscow House", in carefully traced proportions of all the elements, national, classical and modern components are combined. The composition of the atrium, arched motifs, tower-like verticals in the composition is characterized by the completely different architectural interpretation and emotional perception of the Yerevan City Hall (Fig. 9) and the State Administrative complex in Shahumyan Square (Fig. 10).

4. Conclusion

Over the past three decades, Armenian architecture has been developing under the conditions of new influencing factors determined by the historical, political, social, and economic radical transformations emerging in the 1990s, which affected all spheres of architectural activity and the specifics of the architect`s work. In a creative context, the new time is reflected in the diversity of typological, functional, aesthetic concepts of the professional worldview. The typological classification of buildings has become more complicated and extended, their technical equipment has improved, the volume of premises has gone beyond the limits of the formerly standards, modern designs and technologies have become available. The architecture has been enriched with new objects that meet international architectural and functional parameters.

Analyzing the local aspects of the historical development of modern architecture, despite the obvious failures related primarily to the short-sighted state policy in the field of preserving the cultural heritage and unique image of Yerevan, we can state the actual situation: the architecture of the Republic of Armenia, having undergone a difficult path of formation started in the unfavorable political and economic conditions, today has a direction towards undoubted achievements. This means that the Armenian community of architects has a high level of professional skill – the promising potential that can create a sustainable, favorable architectural urban environment for the benefit of society.

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ON SOME ARCHITECTURAL ISSUES BASED ON COROPLASTIC ART OF ANCIENT ARMENIA

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Keywords: Coroplastic art, horseshoe arch, column, base, capital, conch

Abstract. During excavations of the ancient capital of Armenia, Artashat, numerous terracotta statuettes dating from the 1st and 2nd centuries A.D were discovered. The statuettes that depict the goddesses Anaïd and Astghik stand out among many figurines found in ancient Artashat. The study of architectural details depicted in the composition of these statuettes gives an opportunity to shed light on some architectural issues of the interiors of the temple structures of that time. So the statuettes of the goddess Anahit and Astghik framed by columns with an arched vault. These columns are represented by a type of Doric order, and a vault of a horseshoe-shaped arch. The columns limit the space in the form of a shallow niche, in the center of which the sculpture of goddess is placed.

The general analysis of the finds, the quality of the pottery clay for their manufacture, and the study of the method of making the sculptures do not raise doubts about their local production.

A study of the decoration of niches by two columns and a horseshoe arch, resembling an abside, shows that it is pictured very reasonably and realistic with specific details and reproduces the well-known architectural forms already existing in a given territory at that time.

The above makes it possible to assume that structural elements of stone architecture such as vaults with horseshoe-shaped arch, conchs were already known in ancient Armenia in the 1st and 2nd centuries AD; later, in the Middle Ages, these elements were widely used, being the main forms of religious architecture.

1. Introduction

One of the oldest types of figurative plastic art of ancient Armenia is coroplastic art – a creation of small terracotta female sculptures. Antiquity was marked by the rise of the plastic arts. On the territory of modern Armenia, more than 80 terracotta figurines and their fragments were found during the excavations of ancient monuments in Vagharshapat, Garni, Armavir, Hohmik and especially in the citadel, as well as the necropolis of Artashat. Terracotta figurines in Armenia were made starting from the 5th-4th centuries B.C., but their widespread use refers to the late Hellenistic time, to the 1-2th century A.D. However, the terracotta statuettes of the late Hellenistic time are very different from the previous ones in their artistic values and production method [1].

Statues of revered deities were placed in the temples throughout the ancient world. These statues were installed in cella niches on the opposite side of the door. Niches located in the arched vaults are found in ancient monuments of Asia Minor and in Rome [2]. In the interiors of temples, niches (small apses), where the statues of the deity were placed, were differently designed. There were niches of a rectangular configuration, which were crowned with a double-slope pediment, arched niches that leaned on column there also were statues of large magnitudes, which stood up to their full height at the back cella walls [3-5].

The existence of statues of revered idols in the temples of ancient Armenia is reported by Armenian chroniclers of the 5th century A.D., M. Khorenatsi [6], Agafangel [7], Hovhan Mamikonyan [8]. They also report on the destruction of all pagan religious buildings with the proclamation of Christianity as the state religion in Armenia at the beginning of IV century A.D.

The only exception was the cathedral church of the Garni fortress, which, after the adoption of Christianity, served secular purposes.

The Garni temple, as well as its interior, was restored (1969-1974) by A. Sainyan [9] on the basis of the remaining architectural details. The niche, where the statue of the worshiped deity stood, was located, as well as throughout the ancient world, on the wall opposite to the door. The niche was placed on a high three-stage podium, had a rectangular shape with dimensions of 2.15 x 1.80 m crowned with a double-slope pediment. The depth of the niche was 1.43 m. Whether there existed any niches of temples in Armenia of another configuration is not yet known. Archaeological excavations of ancient monuments in the territory of ancient Armenia have not yet revealed another surviving temple building. However, terracotta figurines were found in large numbers during the excavations of the ancient capital of Armenia, the city of Artashat.

In the present paper, decoration in volumetric and spatial composition of different terracotta figurines of the goddesses Anahit and Astghik found in Artashat is considered from the point of view of studying their architectural details.

2. Local production of terracotta figurines

Terracotta figurines both domestic and religious nature were found at different times and in different parts of the city Artashat. All found figurines are dated from the I-II-centuries A.D. Among them, eight terracotta figurines depicted the goddesses Anahit and Astghik attracted our attention. They are the local sample of the Hellenistic coroplastic art – the art of making female terracotta figurines. We studied composition and iconography, as well as the stylistic features of these statuettes and substantiated their affiliation with the honorable pagan goddesses of the Armenian pantheon: the goddess of fertility, Anahit (Greek Artemida), and the goddess of love, Astghik (Greek Aphrodite) [10, 11].

The goddesses are depicted in arched vaults, probably, in the niches of the temple. On both sides, this arched vault is supported by columns standing on a pedestal.

The columns depicted on the statues represent a kind of Doric order, and the arched vault is a horseshoe-shaped arc. The space between the pylons is represented by a shallow spherical niche where the figure of the goddess is placed. The main dimensions of the statuettes: width 9.20 -13.00 cm., Height 15.10 -18.70 cm.

The found statues of goddesses are mostly preserved fragmentary. Of these, four statuettes belong to the goddess Anahit. One figurine is almost solid (Fig. 1).

Two figurines have preserved fragments of the upper part of the arched vault (Fig. 2, 3), and a small fragment of the fourth figurine depicts a capital and part of a column (Fig. 4).

Two statuettes depicting the goddess Astghik were also found, which were preserved in large fragments (Fig.5, 6). The surviving fragments of these figurines make it possible to recreate their compositional integrity.

The study of these figurines showed that they most certainly are products of local manufacturing. The figurines are made of local reddish, well-levigated clay without impurities and with good firing. These statuettes were mold-made and then fired in a kiln. Only on the front side, there were images made with moderate relief and limited from the back side by the image of the arch. The back side of the statuettes is semicircular. The lower inside of the figurines up to the middle of the height is hollow. After molding, the figurines were refined by the glass, as evidenced by the good transfer of images.

Fig.1. Goddess Anahit (figurine 1). Restoration

Fig.2. Goddess Anahit (figurine 2).

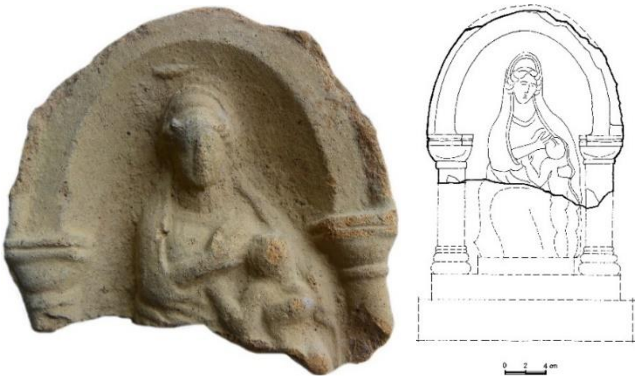

Fig. 3. Goddess Anahit (figurine 3). Restoration

Fig. 4. Goddess Anahit (figurine 4). Restoration

Fig. 5. Goddess Astghik (figurine 1).

Fig. 6. Goddess Astghik (figurine 2). Restoration

As a result, we have good patterns of Hellenistic plastic art. Stylistic features and the external decoration of the depicted goddesses, as well as their clothes, also testify to the local origin of these figurines. Opinion about the local origin of the depicted shallow vaulted niches in the composition of the figurines is also confirmed when studying them from an architectural point of view. Considering separately the architectural elements of the vaulted niche, it can be verified that each individual architectural detail is strictly argued and presented with specific detailing, reproducing the known niche forms that already existed in a given period in a given territory.

2.1 Multi-step pedestal. The multi-stage pedestal was an essential element in the architecture of ancient religious buildings. Being the foundation of bearing walls, it had not only constructive significance, but it also carried an ideological purpose. The pedestal with its shape and size emphasizes the importance of the structure, as well as the greatness of this structure (temple Garni). Only one of the discovered and considered figurines preserved part of the pedestal. This pedestal is represented by three steps, of which the bottom two are associated with a niche and serve as the base of the column. They reproduce stone steps. The third step is the lower part of the throne. The front processing of the step resembles that of wood.

The concept of a pedestal does not lose its meaning in medieval architecture. The antique multi-step pedestal in the Middle Ages is transformed into the altar-shaped elevation of the apse of the Christian church. The pedestal is represented in medieval architecture as a part of memorials and khachkars (Odzun, Ahudi, Hovhanavank) as well as stylabetes of religious buildings (temples) – Ereruyk, Echmiadzin, Hripsime, Tanaat, etc. At the same time, in the early Middle Ages, the stepped pedestals of structures are more pronounced and large in their absolute dimensions. In the late Middle Ages, pedestals become more modest in size, and sometimes they are not used at all. From the above, it is obvious that the pedestal as an architectural element traditionally moved from the ancient period to the early medieval time.

2.2 Column bases. Study of the orders depicted on the figurines from the bases of the columns. On the figurines in question, the column bases of two types are considered. The first type of bases has one torus and plinth. The bases of the columns of such profiling were found in the territory of ancient Armenia during the excavations. This type of bases – toroidal bases – were very widespread throughout the territory of ancient Armenia, beginning from the II century B.C. (Armavir, Artashat, Vagharshapat, Dvin, Spitak, Mohrablur, Okhmik, Beniamin, etc) [12]. The origin of the toroidal bases that form the basis of the Eastern order is clearly Asian. The toroidal bases found in Armenia, as well as the bases on the considering figurines, differ somewhat from the bases of the Eastern order in their proportions and elegance of forms. The study showed that the formation of toroidal bases on the territory of ancient Armenia took place on the basis of traditional local forms. In Armenia, toroidal bases continue to meet in the era of the early Middle Ages. They have already acquired new proportions and have been reworked, having received a new decoration. Such bases were found in Dvin, Zvartnots, Yegvard [13,14].

The second type of bases are bases forming a pair consisting of two tori directly placed on each other with a gap whose foundation is a rectangular plinth. Such bases dating from the II-I centuries B.C. were discovered during the excavations of Dvin [12]. These bases differ from the ancient similar bases of Asia Minor in their proportions and form. They are carved from local stones and, undoubtedly, are of local origin.

2.3 Fusts. The fusts of the niche columns are circular in cross-section**.** The surface of the columns is smooth. Such fusts were discovered during excavations in ancient Artashat, Dvin, Ararat, Garni, etc. [12]. Only one figurine has a fust of column processed by cannelures. The treatment of the fust is not typical; it differs from the classical fluted fusts by the distances between the cannelures which are incomparably wider on the local Artashat fusts of the columns. The fusts depicted on the figurines do not narrow upwards, that is, they do not have entasis.

2.4 Capitals. All the capitals depicted on the statuettes are close in their construction to the capitals of the Doric order. The capital of the fust with flutes (concave grooves) is of the same type. With their proportions, as well as their shape, the varieties of Doric capitals depicted on the figurines resemble the capitals found in the fortress of Garni, dated to 2nd century A.D [12].

Thus, it is possible to note the existence of a variety of local Doric order on the territory of ancient Armenia. This order became the prototype of the order in early medieval Christian architecture (Yereruyk, Dvin).

2.5 Arched niches. The arch depicted on the niches of the statuettes has a shape close to a horseshoe, with a pattern of a curve constructed by two centers. In shape, the arch is a rowlock one, i.e. it is a two-center arch going inside the wall with two ledges of decreasing radii (Fig. 2, 3). The outline of the arched niches have a semi-cylindrical shape, arches terminate in a well-carved conch. The back walls of the examined niches of the figurines look outwardly curved, and from the inside, they represent the horseshoe-shaped or semicircular shape of the structure, that is, the niche was concave (exedra). The conch was used to overlap the semi-cylindrical parts of the structures or semi-domes. In the temples of the Hellenistic world, statues of gods were often placed in the conch.

The use of vaulted ceilings in the construction of ancient Armenia can be judged only by the example of the reconstruction of the vault of Garni temple, the justification of which was given in the work by the author of the reconstruction A. Sahinian [9]. The conch overlap of the closed half-dome covered the exedra of the ancient Garnian bath [9].

Thus, it was possible to present a complete picture of the spatial-volumetric composition of this niche.

3. Conclusions

Based on the found artifacts, we can conclude that the statues belonging to revered deities were placed in the cult corners of the houses of citizens for worship, recreating in miniature, as we see it, a real temple niche. The time of their appearance, which was previously associated with the penetration of Christianity in Armenia, can be attributed to the pre-Christian time to the 1-2nd century A.D.

Using the examples of found figurines furnished with architectural details of the order, we can say that already in the ancient period, an order characteristic for this territory was formed in Armenia, which served as a prototype for the architecture of the early Middle Ages.

The niches and vaults of the studied statues confirm the existence of both conch and vaulted ceilings in the architecture of ancient Armenia.

The volumetric solution of the vaulted niche in its significance and design penetrated the Armenian medieval religious and memorial construction, where it was used as the main forming element in the construction of altar apses, cruciform altars and as an element of possible artistic expression.

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THE PROMENADE IN CONTEMPORARY ARCHITECTURE OF YEREVAN

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Keywords: Promenade, master plan, main avenue, green belt, Cascade, eco corridor, green architecture, park, museum, harmony, datum, hierarchy, planning axis

Abstract. The city and architecture are inseparable. Promenades are conjugations which relate the city to architecture as a featuring element of urban scale. Actually there is no any definition that describes the image of the city except promenade. This is the case of every city and this is the case of Yerevan also. That so peculiarities of Yerevan's architecture today at first derive from its urban layout included in the conceptual master plan created by Alexander Tamanyan in 1924, where design of the promenades have main indication.

1.Introduction

However promenades possess certain physical, cultural, historical or humanistic characteristics special for every city. They include the resources provided by nature, light, water, vegetation.., as well as understanding of the changing rhythms of life in the world [1]. Promenades are various as various are the culture of every country, city and urban area they do belong, such as: down-town, mall, seafront walks, remodeling of old texture areas etc. A quite enough 20 examples are studied by F.A. Cerver in his book dedicated to Architectural promenades [2]. There are so many others studied as the impetus of contemporary life on the world. The main problem of the presented article is the study Yerevan capital promenades developed beginning from 1924 Master plan and until today, as well as the systematization of them.

2.Analysis

The planning composition of Yerevan bases on three main ideas, they are: 1. derivation of existing urban solution from historical tradition, 2. creation of an enfilade layout consisted of successive streets and squares, 3. implementation the concept of garden city planning context. However main city planning problem was the pass from medieval centralized structure of the ancient texture into directly connected system of streets which relate the center by the perimeter of the "old Yerevan". This was in behalf of two parallel curvilinear highways encircling the old city and locating between them a park zone which further, according to Master plan of the year 1936, converted into Green-Belt of the enlarged city. This was a very inventive decision of planning which lay the ground for the future sprawl around the old texture shaping an amphitheatric layout. Hereby the enfilade system and the garden city concept implemented as a combination of promenades combining the Main-Square to the Green-Belt. As it could be observed on Master plans of Yerevan from 1911 and 1920 the mentioned streets held by the traces of existing roads of the old city. The wider of the streets called Main-Avenue extending from south-east to north-west direction, but the North-Avenue connected the city Railway station at the south to the city park of "Monument" towards the north. That so below studied promenades of Yerevan are the particular ensembles regulated as its planning means of harmony (for more details see Fig.1).

Fig 1. Map of Yerevan old Texture and the location of Promenades.1- Hrazdan Valley, 2-Cascade ensemble, 3-Green Belt, 4-Republic Square 5-North Avenue, 6-Main Avenue, 7-S.Shahumyan Square and the 2750 Anniversary park, 8- Al. Miasnikyan Squar and 2800 anniversary park, 9- New Municipality Square.

2.1 The Green-Belt of Yerevan.

The Green-Belt of Yerevan is a combination of advanced city planning ideas of its creation Time, i.e. the end of XIX c. and the first decades of XX c... Such were the garden city concept of Ebenezer Howard [3], the rebuilding of Paris by Georges-Eugene Haussmann [4] and "Ringstrasse" of Vienna [5], as well as organic town planning theories of Eliel Saarinen [6] etc.. The Green-Belt of Yerevan planned such that to relate the core of the city into the natural valley of Hrazdan by the mean of an eco-corridor at the area of "Victory-Bridge". The site once was the entrance of the city, neighboring the historical castle which is the Wine cellar complex of today.

The Green-Belt of Yerevan is a curvilinear succession of several parks located at the crossings of radial streets which continuously arranged till the crossing St Sargis church-prelacy at the rocky corner of Hrazdan valley. Within the defined path of parks are located many renown public buildings, such as: Cinema Russia or "Ayrarat" of today, Cathedral St Gregory the illuminator, Dynamo stadium, many resting infrastructures, as well as , such called the " education zone of Yerevan consisted of linear arrangement of several universities. Within this context are also the House of Cameral music, the Matenadaran museum-institute of ancient manuscripts and the square of Arts in front of State Opera House etc... The described is a notable planning instance of modern promenade. The most attractive fact is too: that the Green-Belt of Yerevan organically continued into the core of the city by other pedestrian promenades too, such as: the Main-Avenue, the North-Avenue, the promenade extending from Alexander Miasnikyan square into the Republic square. There is another promenades stretching from the square of France into the heights of Victory Park etc.

2.2 The Republic Square

The Republic square is the composition center of Yerevan combining all above mentioned promenades. Despite of many attempts to change the composition of the square from last decades, fortunately it remained unalloyed, only an ideological slight alteration held. Removed the Statue of Lenin from the ensemble. Any case the square remains as governmental administrative center of Yerevan being in complimentary relation with "third" and "fourth" governmental buildings located not far. Actually "first" and "second" governmental buildings are basic components on both sides of the main axis of the square's ensemble.

2.3 The Main and North Avenues.

Are on the east-west axis of Yerevan. If the composition of the Green-Belt is a green area associated with monumental buildings and complexes, the promenades of Main-Avenue and North-Avenue are street architecture instances associated by open spaces between linear rows of buildings on both sides.

The concept of Main-Avenue is very artistic and has its parallels in less or more renowned cities of the world [7]. As the other promenades of Yerevan, the Main-Avenue's construction activities held within 1960-1970ies of Armenian Architecture. The design of the avenue carried out by renowned scientist and practitioner of architecture Armen Zarian. The concept was a successive line of fountains at the midst green environment. The ends of the boulevard were the monumental statue of Vardan Mamikonyan from the east, as well as the multistory central post office from the west. Beneath the post office a tunnel leads the way to kid's railway station at the Hrazdan valley. In behalf of the Main-Avenue a very becoming environment was created, but the economic crisis of the "Dark years" of post-soviet times caused the gradual damage of the infrastructures. As it was usual for the mentioned years, not far from V.Mamikonyan statue created a trading lane called "Vernisage" which exists until today. Anyway, the crisis did not disturb to carry out a planned activity of building construction. In the period of two decades constructed a notable city ensemble of multistory public and residential buildings on the both sides of a long alee. The development of the Main-Avenue held in a reasoned way of harmony consisted of old and new buildings. Since the

Avenue extended on a long area, there were 7 intersecting streets alongside the ensemble. However on the crossing of every intermediate street were different buildings from various periods of Modern Armenian architecture. The new constructions accomplished the void places between them. Till now the construction activities of the Main-Avenue are in process, such as “Old Erevan” project by Levon Vardanyan, a mall located within the subway passing under the Mashtots-avenue by Sirekan Ohanyan etc... Recently designed many open and covered cafe-s on the western side of the avenue by Arbak Vardanyan, very becoming landscaping done along the street with so many attractive small forms and environment design elements. That so formed a very interesting promenade at the down town area of Yerevan.

In the same concept of Main-Avenue developed the promenade of North-Avenue. Hereby the difference is in behalf of subterranean street designed as Tashir-Mall. The North-Avenue typologically built up of mixed functions. The street width is apparently narrower than the Main-Avenue. The composition of the layout is a regular arrangement of 7-12 story buildings perpendicularly located by their main facades towards the pedestrian street. Here, recently undertook another public place called "Europe's Square". The Avenue extends between the theatric square of State Opera House and the Republic Square. The entrances to the subterranean mall are arranged in metrical sequence, in behalf of semicircular glass-vaults located within the central axis of the avenue. The image and the atmosphere of the North Avenue is in romanticism style of medieval Armenian architecture motivations.

2.4 The Cascade complex.

The Cascade complex is one of largest ensembles of Yerevan. It is on the extension of the North-Avenue and through the France square stretches towards the “Monument” hill direction. The cascade complex is a sustainable city planning concept implemented by Alexander Tamanyan in 1924 master plan. However the concept is baroque and Neoclassical in sense. Indeed the complex parallels the idea of Spanish stairs in Rome, Frascatti’s cascades at Villa Aldobrandini, Peter Hoff of Domenico Trezzini etc... Beside this the Cascade is a notable example of a promenade connecting the center of Yerevan to “Victory” park hillside by the mean of covered escalators. The name cascade is because of the artificial waterfalls located on five levels of the complex. The reason of green spaces and water surfaces aims to exalt the continental climate of Yerevan.

As much the concept of Cascade derives from 1924 Master plan, however the creation of the ensemble is from last 50 years only. The design works on the complex begun at the studio “Yerevan-Project- 3” in 1971. The construction of the complex held from 1980 into 1991. Because of the circumstances the last decade of the 20th century was not prosperous period for Cascade construction activities too. Later the complex privatized by Gerald Cafesjian foundation. The complex converted from a usual promenade into an open air museum and covered exhibition center. That was upon a declared competition from the beginning of the year 2000 which held among three invited international design companies: Bernard Schumi architects, Coop-Himmelbleau Architectural studio and MVRDV Co. from Netherlands. All three designs were replacing a perpendicular axis on the forth level of the complex which stated the idea of creation covered museum area in addition to the existing stair complex.

In origin the Cascade complex is a linear composition including four consisting zones. The start and the end of the Cascade conceived as green exhibition of modern sculptures. All around are green spaces of flowered palettes. The main complex consisted of 565 stairs (Architects Jim Torosyan and Aslan Mkhitarian) consists of five levels, each an open courtyard looking towards the city. The Artistic solution of each courtyard centered by artificial waterfall at the back. From both sides of the stair complex are auxiliary rooms and halls. Very creative is the left side line which consisted of series escalators intermediated by museum halls. The escalators are leading to the five courtyard levels too, as well as to the memorial on the top (coauthor Sargis Gurzadyan). The site is the place from where the soviet revolution started in Armenia. On the site exists an obelisk which is at the center of rectangular memorial by forty fountains on perimeter, as well as a garret window decorated by modern khachkars. As general the memorial dedicated to the remembrance of imprisoned victims of 1937 which commemorated by a high stele bearing an Urartian emblem above. The pass from the museum zone into the memorial is in behalf series of stairs forming a bridge over a high way passing by. The museums are not constructed yet, on situ is disorder situation by the foundations laid almost before 25 years. Very impressive are the sculptures and so many decorations of stone along by the mentioned courtyards and the stair complex. Possible to say that they are best examples of Armenian contemporary stone art.

2.5 From the point of discussed Promenades attractive is the direction beginning from the Wine-Cellars into the New Municipality square, 2800 anniversary park, the square of 4th governmental building and then to 2750 anniversary park on the south of the Republican square.

2.5.1. The "New Municipality" or "Miasnikyan" square.

There are 3 successive squares at the entrance of Yerevan from the side of Zwartnots Airport. The placement is historical area, where were located once the ancient castle and an old bridge giving entrance to the city.

The Municipality square is triangle in plan. The apex is towards the bridge and its base associated by Grigor Lusavorich Avenue passing by the square at the east. At the center of the base located the Statue of Alexander Miasnikyan (sculptor Ara Shiraz, architect Jim Torosyan), beyond is 2800 anniversary city-park attraction as a component of green architecture of the area. Main axis of the square is from the apex into the monument. On northern side successively are located the Metropole hotel, Viva-Cell telephone communication center, another hotel, the city museum of Yerevan which is adjacent to the New Municipality. On the other side of the triangle are "Ararat Trust's" wine cellars, "Moscow" business center, the "Gladzor" university, and the "Ameria" bank offices. The establishing building of the square is the Ararat trust complex built in 1937 (architect Raphael Israelyan and Gevorg Kochar). The other buildings are added in post –soviet period by different architects. The square is a regeneration by its full meaning, all the buildings distinguish by their national romanticism style constructed within the pass of 20-21 cc.. Actually among the new buildings, the main is in behalf of the New Municipality (architect Jim Torosyan). The replacement of the municipality is in tangent symmetry of the Ararat trust complex. Both of the buildings are associated by towers and horizontal volumes stretching from east to west.

The municipality is a linear composition consisted of three parts: the city museum, the administrative department and the archives. The lobby is at the juxtaposition of the administrative and archival departments, here are located the vertical communications of the complex. The administrative part is the main space solved as a nave by a long garret window on the roof. On northern and southern sides of the nave are different offices and meeting rooms of various capacity.

The nave is 5 story high having arched galleries alongside. At the west end of the nave is a stained glass composition covers whole height of the nave. From here to west is the museum demonstrating the history of Yerevan on deferent floors. The archival department is a courtyard supplied by skylight from the roof too. On the east side of the courtyard is an original tower looking to the city scattered around.

The municipality created in historical sense which is expressed by the mean of reliefs and inscriptions replaced all around the interior elevations and the exterior facades looking to the south and east. The municipality as whole reminds a long train truncated by a row of alcoves each dedicated to one of the twelve historical capitals of Armenia. The last station is at the tower recalling the site of current capital: Yerevan. Really the created atmosphere is a revitalization of "Old Yerevan". Actually the history conveyed as symbolic indication very similar to the concept of "Rational South Architecture" renown from 1960s of Modern World architecture [8].

2.5.2. 2800 anniversary promenade of Yerevan [9].

This park is one of most recent activities of 2019 held in Yerevan. The location is on the continuation of New Municipality square, beyond the Alexander Miasnikyan's monument, towards the Stepan Shahumyan square.

The promenade is on the west end of "English park" inherited from XIX c. In 1980 a reconstruction of the park carried out by architect Harry Rashidyan. But because of crisis from 1990ies the park remained out of care. According to a resolution from 2017, decided to rebuild the park as a beneficiary sponsorship by the owners of "Grant Candy" factories foundation. The author of the project is Michael Vardanyan.

The promenade is almost 150 m long and 50 m wide. The general area covered is 7500 m^2. The main axis of the park is in east-west direction including 10 pools and water ways having 2800 spurts. The technical rooms are beneath the garden including reservoirs, pumps and piping system. The environment designed by 76 granite benches and other elements, as well as 126 lighting fixtures. Special attention specified to the environment small forms and sculptures. The pavement decorated by motivations of Armenian historical carpets collected of granite tiles. Main building material used is granite. The dendrology and the palettes of the flowers studied in seasonal approach. There included 70 kinds of 339 trees. All the ornamentations are of floral motivations borrowed from different buildings designed by renowned masters of Armenian architecture from soviet times.

2.5.3 The regeneration of Stepan Shahumyan or 4th Government complex square and development of the surrounding area into financial zone of Yerevan.

Although the project is a decade later than the municipality square, but it belongs to the same concept of regenerations carried out at the center of Yerevan. The square established in 1929, at the place of Russian Nikolaevsky cathedral. The design was in behalf of renowned Soviet architect Ivan Joltovski and the sculptor Sergey Mercurov [10]. Later the ensemble continued by Nicolai Buniatyan: the first chief architect of Yerevan at the years 1924-1938. N. Buniatyan constructed here, on both sides of Shahumyan's monument the "Agriculture bank" and "Hotel Sevan". Beside the mentioned and around the square existed other XIX c. buildings too. How much it is possible to call the development of Shahumyan square a regeneration, it is not sure. But it is fact that the square and its surrounding area was an active zone of reconstructions and promenade indication landscaping in last decades. The core of the square preserved as it was. At the beginning the XIX c. public building in the place of Congress hotel adapted into 4 star hotel (architect Garnik Stepanyan, 2008). Then held the construction of Govermental-4 complex in place of Sevan hotel existed once (architect Narek Sargsyan, 2015). The last addition is in behalf of modernization held at the place of “Agriculture bank” and the “Commercial bank” which are regenerated into Ameria bank’s “Kamar” headquarters and a modern Food court beside (architects Rouben and Michael Hasratyans built in 2018). Both of the buildings: the governmental - 4 and America bank arranged symmetrically on both sides of Shahumyan’s monument. The central elements of two complexes are triumphal arches holding the ensemble in balance. The architectural style prevailing at the area is in rational sense.

“Kamar” business center includes the former Yerevanian branch of Tiflis Commercial bank (architect Michael Ohanjanyan, built in 1910), as well as the above mentioned “Agriculture bank”. The complex developed in green architecture concept and consists of 9 story high offices, 2 story parking area and 9 elevators [11]. Very becoming is the lobby. The complex as whole is an elaborate composition harmonizing the modern context with a part of the old building at the base of its left corner.

The “Governmental - 4” administrative complex conceived as a square on the side of existing Shahumyan square. The first floor almost is free and associated by the lobbies of the 5 ministries included in the complex. The main among the ministries is the Foreign affairs at the right side of the main entrance. The ministries of Transportation and IT (Information Technologies) accomplish the façade of the complex looking towards the square. At the center of the area around a semicircular courtyard are arranged the ministries of Culture, Education and Science, as well as the former ministry of Armenian minorities in different countries. From both sides of the courtyard are the ramps leading to subterranean parking area. After the courtyard is a street like space and beyond of it located the Ministry of Justice. That so the harmony is a transparent organization of the space, where the composition center of the regeneration is in behalf of the semicircular courtyard. The hierarchy created by the triumphal arch-vault, from where the main axis of the space passes through the triumphal arch, then the courtyard and the entrance of Ministry of Justice.

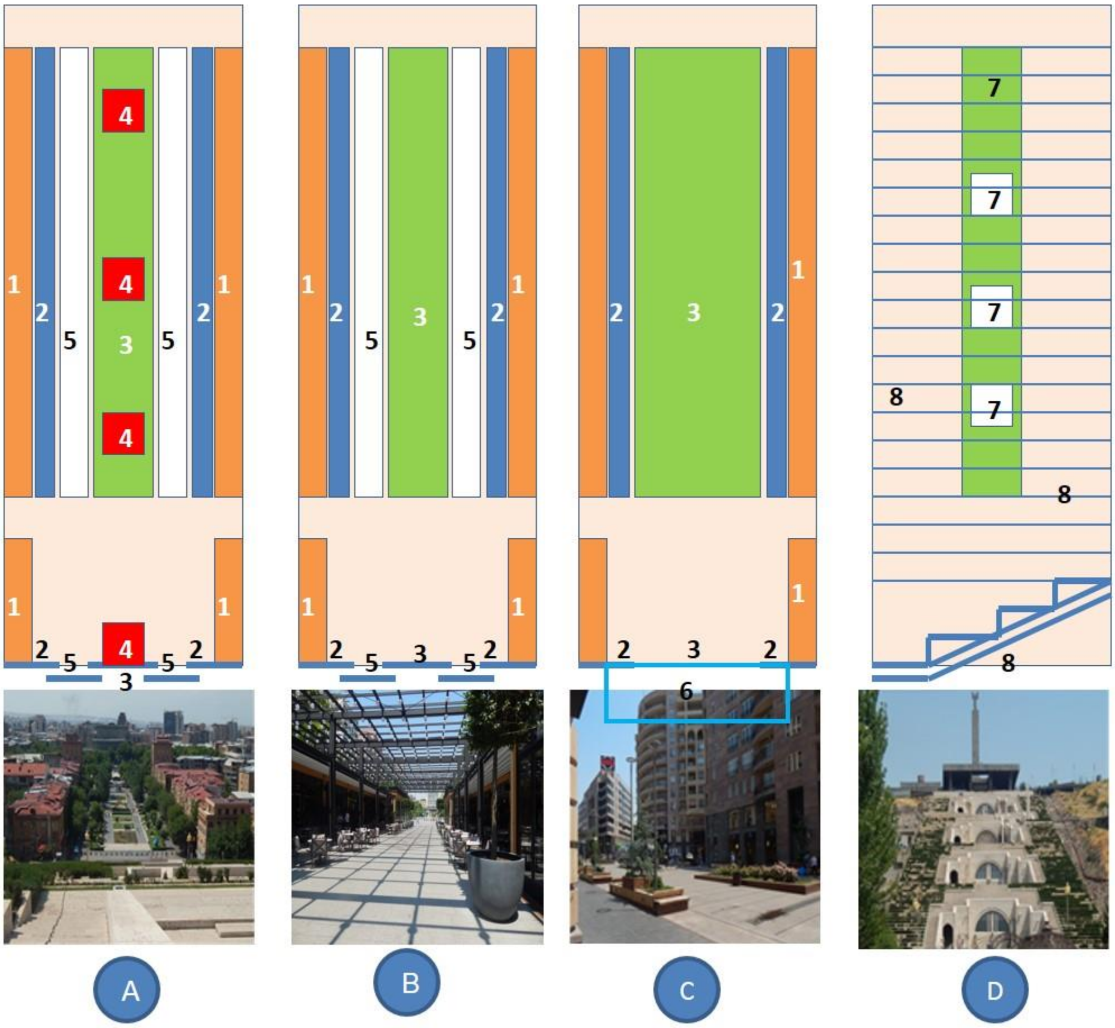

Fig.2. Types of Yerevan Promenades (plan schemes): A -green Belt type, B-Main Avenue type C- North Avenue type , D- Cascade type
Legend: 1-side buildings, 2-side walks, 3-Green walkway, 4-Public buildings, 5-Driveway , 6-Subway, 7-Cascades , 8 Ramp way or stairs

3. **Conclusion**

The promenades of Yerevan have the following planning and architectural peculiarities:

1. They are in role of basic planning concepts implemented yet in the first Master plan of Yerevan from 1924 and continuously are in developing process until today.
2. They conceived as eco-corridors passing throughout the city and critically developed within the all milestones of urban renew undertakings.
3. In theoretic sense the promenades of Yerevan are in two kinds and 4 types (Fig.2) :
   a. Enfilade green system holding the main public buildings within the central axis.
   b. Main Street or Avenue layout holding the green as datum at the center.
4. Promenades of Yerevan conceived as pedestrian walks associated by water surfaces, minor architectural forms, design infrastructures and dendrology palettes.
5. The Promenades are the main concept of Yerevan’s master plan, they are the planning hierarchy and main architectural elements of harmony of the city to day.

6. Due to mention that the “Radial Park” have serious monument protection problems in behalf of newly added infrastructures which are even warning its existence. It’s due to mention too, that the Cascade complex should be accomplished as soon as possible. However the complex has whole city architectural indication, the abandoned part apparently affecting on the image of the capital as whole.

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DEVELOPMENT PROSPECTS OF SOCIAL COMMUNICATION AREAS

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Keywords: Social communication area, urban environment, parks, yard spaces, social activity

Abstract. In the article as a prototype of SCA`s are viewed squares, with their preliminary exploitation versions and their further evolution: social communication areas (SCA), transport infrastructure and trade. The concept of SCA is decomposed. Their importance in the cities is based. The current types of SCA-s are categorized, which are squares, yard spaces and trade. Their problems are being exposed, which is mainly in the merger of CSA-s and transport infrastructures in one common area. This also leads to a number of problems: urban development, ecological, social and economic [1, 2]. Prior to the development of solutions, it is necessary to explore and identify the social life of the site, for which the method of revealing the most active social zones has been developed.

1. Introduction

To understand the origin of social life, we`ll start from the earliest times of world history. A bonfire can be observed as the first public space, which originated in ancient times and was a tribal gathering: here, for the first time ever, people geographically unification is fastened for joint actions. In different periods of history, these areas have been subjected to appropriate metamorphoses: becoming policies, then agoras, forums, later followed the squares. The three main preliminary versions of squares exploitation were movement, communication and trade. The squares were of different significance: commercial, for parades, religious, in front of stations, memorial, educational, theatral, in front of sports buildings [3]. Previously, people were moving mainly on foot and these three urban functions were balanced, but after the automobile invention the situation is gradually changing. Until the 20th century, squares still continued their main function, but after the automobile boom many of the squares were transformed into transport junctions, some of them remained abandoned and turned into an unfavorable urban environment. And trade completely moved into separate buildings: shopping malls. So, we can say that prototypes of SCAs were squares. Their initial exploitation options were social communication area (SCA) and transport infrastructure, excluding trade which does not orrelated with squares today (refer with: Fig. 1).

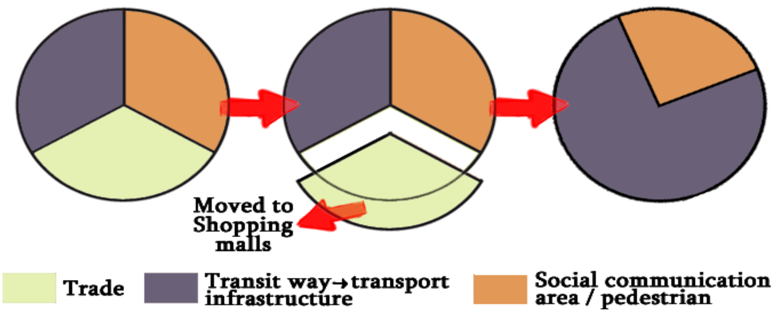

Fig 1. The evolution of preliminary exploitation versions of squares

We need to analyze first the notion ‘‘social communication area’’ (SCA), which implies the overall available space and is designed for population long stay: for communication with familiar or unfamiliar residents [4]. These include squares, parks and residential yard spaces. SCA-s are important elements in the city plan, as they create a unique character of the city: contributing to a clear perception of the sort and the main features. They reflect the development and culture level and are a quality indicator of social life [5]. The problem of design and placement on the city plan is very acute, as in many countries, as well as in Armenia. Today SCA-s and transport infrastructure have been merged into one common space, resulting in a number of problems. First we need to consider the current types of SCA-s, as a result of which we will be able to identify their specific problems by the example of Yerevan.

2. Classification of SCA-s

From the study and analysis of city master plans of different periods we can identify types of SCA-s and their characteristics today their main problem is the merger of transport and pedestrians.

Squares. Despite the diversity of classification of squares, today their main problem is the merger of transport and pedestrians [6]. Most of the squares have become a transport junction, in Yerevan approximately 70% has lost their original significance. A pedestrian is lost in such spaces, while the risk factor rises. Whereas, in many countries pedestrian improvement projects have already been implemented. Like in 2010, the crossroads of London's Oxford-Circus Street (United Kingdom) have been transformed. Transformed (43.000 pedestrian and 2000 vehicles every hour) [7]. In the scope of research works was calculated the number of elements in the square: 85 elements, 199 road fencings. Congestion occurs in places where the space for movement is significantly narrowed because of the retail points, stairs to the entrance to the underground, different indication parts. While calculating the pedestrian quantity: 13 people/1minute/ 1m sidewalk width x 3.5m sidewalk width = 46 pedestrian/minute (for each sidewalk), which is 3-4 times more than the comfortable human capacity index. Within this framework some of the elements during the traffic green go to the underground and the pedestrian movement is no longer defined only on the pedestrian zebras, but it is irregular: in all angular directions. This is a successful example of pedestrian improvement in recent years in London, which today is also a tourist destination [8]. The busiest pedestrian crossroad in the world Shibuya (Tokyo) have also been transformed with the same method (2500 pedestrian can cross once, 500.000 pedestrian during a day): by changing the pedestrian movement using their angular crossing method [9].

Yard spaces. Mostly dominated by garages and new buildings. There are no playgrounds and green zones. The activities of children in the yard spaces are virtually indifferent, whereas the majority of local activism is theirs. Even in yard spaces pedestrian and transport routes are not separated, so the coefficient of security is very low.

Parks. The majority are unclear or abandoned: full with various food points. The green zones of Yerevan's preliminary master plan: parks are mostly built with various kiosks and buildings and have lost their significance.

3. Method for revealing social active zones

We can identify two types of human mobility: active - running, biking or skateboarding, fast walking and passive - perform actions without significant movement. Throughout history until the 20th century many forms of social activity were implemented on the basis of necessity. For many, the street was a place of work and to earn money. Later transportation of goods and hard work took on different types of transport, and the urban space gradually acquires the function of recreation and entertainment that continues up to now (refer with: Fig. 2).

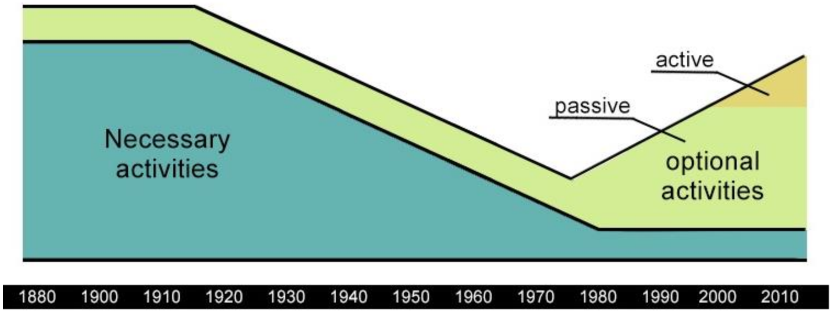

Fig.2. Social activities development in the urban environment from 1880 to the present day

Thus, for today's urban planning, one should take into consideration, that people prefer a passive social life, which is a type of recreation.

In the world, a number of methods are used to detect active zones in the cities, but they require a lot of resources: investments, time, workgroup, equipment, paper permits.

In scope of this article to find out the active zones of the city we have developed a faster and minimally costly method, the logic of which is identification of the location of the subscribers through telephone calls. In process of this work using the above-mentioned method, we took from the mobile operator the location of the unit's users in the unit period (percentage) and discovered that during weekends and days off the city center is most active zone (static), especially the gardens and places where the transportation movement is most restricted, such as the North Avenue, the Cascade and the Liberty Square. And the squares for pedestrians mostly serve as a transit route. Thus, one should pay close attention to the city centers, as it is the main contact point and the social activity center of the population.

According to the UN annual report, in 2007, half of the world's population lived in cities (Fig. 3): by 2050 the index will reach 70% [10].

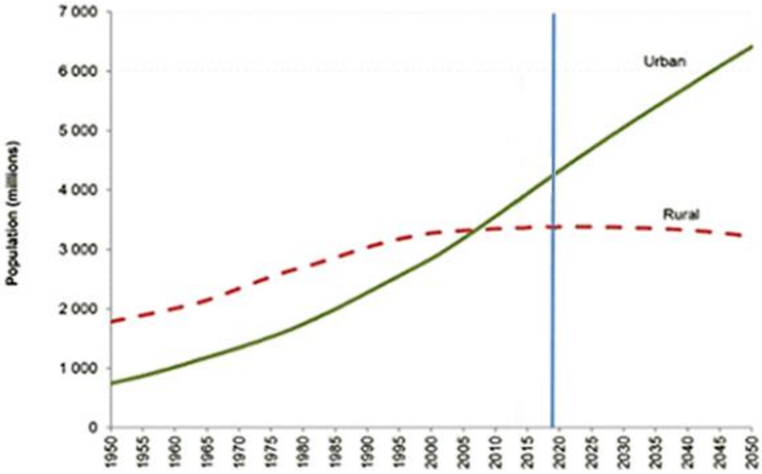

Fig.3. Urban and rural population ratio across the globe

Of the 2.9 million inhabitants in Armenia, 1.076 million live in Yerevan (according to 2017 data), which accounts for almost one-third of the Armenian population [11]. According to fig. 2, the demand for organized SCA-s is growing accordingly. Therefore, it is necessary to revive the existing ones.

4. Ways to activate SCA-s

Before developing SCA projects, it is necessary to identify ways to activate them. To activate the environment, it is necessary to promote the development of social life in the city. The first of the 12 standards of quality life developed by Yan Gale is the protection of the population from transport [8]. And as already mentioned today, SATs and transport infrastructure have been merged in one space, therefore, the primary task is to distinguish these two components.

Below we present the methods of activating existing SCA-s:

4.1. Separate as far as possible pedestrian and transport roads in the squares.

a) Eliminate the traffic movement in that particular area.

When it is possible to completely clear the area from the transport, the most optimal method of separating the two components is to turn this trafficable street into a pedestrian, as a result of which the entire territory to be monitored will be freed from the transport infrastructure and will turn into SCA. An example of this can be seen New Road in Brighton (Great Britain), which in 2006 became a pedestrian, after of transformation the number of people in the street increases by 60%, and the types of inpatient activity are increasing by 600% [8]. Here is another example: a busy street like a Times Square in New York (USA) in 2009 it becomes a pedestrian. After improvement, the number of accidents decreases by 40%, vehicle collision, 20%, criminal activity by 20%, air pollution by 60% [12].

b) Create a two-level transport junction.

When viewed area is an important transport junction, but at the same time it is necessary to handle a large flow of pedestrians, then it is necessary transfer transport infrastructure to the underground directions. For example, the Orient Square in Madrid (Spain) located in the historic center of the city, where the two main buildings of the capital are located: the Royal Palace and the Royal Theater, in 1996, during reconstruction it is built a huge parking lot underneath, which operates today as a public transit point for transport, where the central bus stops are located, and the entire space in front of the palace serves as a SCA: speaking in the form of a park and a pedestrian square, preserving the historical significance and appearance [13].

c) Use the relief features when designing the square.

When viewing area has some relief, then we need to use the relief options when designing. Let`s discuss the Cascade amfilada pedestrian square in Yerevan, but it is crossed by Isahakyan Street. According to the preliminary plan Isahakyan Street should be completed until the Cascade. Instead it`s parallel Koryun street must pass through the cascade: slitting the local relief [14]. As a result, only a pedestrian movement would be in Cascade and the social activity and safety index will steeply rise: based on existing statistics.

4.2. Restore green spaces. Today, in Yerevan, except for some renovated parks, in the rest parks 20-40% area of their spaces are occupied by different food points. The following process is proposed for garden rehabilitation:

- increase the land tax to the extent necessary, as a result of which the food points will be exhausted. For example: by analyzing the number of visitors of ‘‘Yerevan's 2800-year park’’ located between Yerevan and Beirut streets, which was renovated and reopened on May 11, we can mention that the index has grown by almost 70%. The park is designed for comfortable and aesthetic entertainment among the residents, including children.

4.3. Improve yard spaces, trying to get rid of not suitable buildings for the site. Instead of garages can be organized underground parking lots, thus liberating 50-80% of space. On released area design green zones and playgrounds, supplied with benches and lamps.
In the center of Yerevan you can see such examples: in the area located in the middle of Isahakyan, Mashtots, Tamanyan and Pushkin streets, was constructed underground parking lot for the residents, in the yard was built a football field and playgrounds, the space is greenish, intended for entertainment of residents. Here, social activity is incomparably higher.
Resulting mentioned above ideas and methods I would like to add the results of a series of research studies conducted by two architectural schools in Melbourne in 1978: people's activity on three types of streets: transport street with sidewalks, pedestrian- with limited transport (only tram) and a pedestrian street. It turned out that only the pedestrian streets give greater freedom to residents of any age, therefore, have the highest social activity rate. Streets with transport infrastructure are crowded and noisy, the pedestrian has to be very careful about security. In the streets with limited vehicle types the people`s behavior is more similar to traffic streets than pedestrians. Even a limited transportation movement, in surprise, severely narrows the possibilities of social activity of citizens.
Within the framework of the study, sensations of pedestrian safety on different streets have also been studied by paying great attention to children. It has been revealed that even on the sidewalk, almost 85% of parents accompany the children with their hands (under the age of 6 years), while only on pedestrian streets they are allowed to move freely (fig.3) [8].

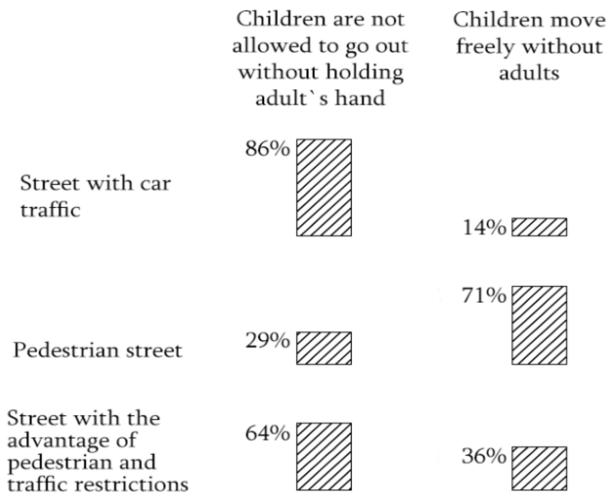

Fig.3. Monitoring of children under age of 6 years.

From the above scheme it is clear that the higher the safety index is, the higher the activity of children (about 86%), who are a part of the community. Increasing the activity of the children increases their parent’s activity, therefore, the social activity of the area.

5. Results

The results of the study revealed the types of SCA-s and their characteristics by the example of Yerevan. These are squares, yard spaces and parks. Their brief description was given: by revealing problems. In general, there was observed indifference to the mentioned areas: they developed in a spontaneous way. There wasn`t noticed a further development and design concept, boundaries that should be guided.

As a result, the city, especially the center, lost its unique character, becoming a chaotic movement environment for the residents. In addition to the above mentioned problems, there is also a lack of free movement of children in existing SCA-s, which also leads to the reduction of social activity. For the solution of these problems by using the method of telephone calls developed by us have been discovered the most active social zones and it turned out that they are mostly located in the center of Yerevan: with minimal traffic flows and were exist green zones and playgrounds.

6. Conclusion

As a result of our research, we can conclude, that the life of the population is punctuated in cities, is centralized in the SCA-s. Therefore, it is necessary to activate existing SCA-s. In the article was developed the methods of their reanimation, based on our research, including world experience.

The study of social life requires equally as well as information of human behavior in urban environments, as well as buildings and transport infrastructure. The primary goal is to restore the importance of social life during urban design.

The problem of activation of SCA-s is very actual for Armenia, especially for Yerevan, as 1/3 of Armenia's population lives here, unfortunately, research and design work on the above mentioned issue is unsatisfactory.

Today, in a number of countries, pedestrian movement and social active zones are in the study point. Numerous architects and sociologists thoroughly study the efficient transformation of SCA-s. L.Lofland, D.Jacobs, K.Lynch and J. Gehl are considering SCA-s as an inseparable part of urban life, where people`s life is passing [15].

According to G.Rashidian's every architectural work must reflect not the former era, but the new times, its spirit and aspirations. We need to find the unique character of each city, stronger than the one that came from the previous centuries [16]. This problem requires the most global research and urbanization approaches.

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OUTDOOR ARCHITECTURE FOR PEOPLE WITH ALZHEIMER: SENSORY STIMULUS AND NAVIGATION

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Keywords: Impaired cognition, natural mapping, sensory garden architecture

Abstract: This study has revisited a crucial aspect of architecture, which is how space is perceived, and is motivated by a consideration of how outdoor spaces need to be designed for people with dementia. The question of how the outdoor environments can support the sense of safety and well-being, which contribute to the sensory stimulation, socialization, and the better quality of life for residents in memory-care settings has been examined in this study by investigating the previous research, the best case-study practices in the field, and conceptualizing a proposal for the AFA, Centro Adolfo Suáre in Fuengirola, Spain. This research has approached the designed physical outdoor spaces that promote safety, stimulate senses, and direct cognition as a means to assist the people with Alzheimer who are cognitively impaired and have lost their ability to make and use a cognitive map. Likewise, this essay has highlighted the principles of natural mapping in a sensory garden and their applications in way finding and orientation through sensory awareness of touch, sights, sounds, smells, and tastes for demented people. This study has argued that evidence-informed design informs the design and turns as an effective tool in approaching such a challenge. As the result, a sensory garden as a component of a memory-care setting has been proposed and conceptualized, which benefits from application of natural materials and elements such as bamboo, water, flowers, and plants in order to not only trigger the senses of demented people but also to offer the possibilities of navigation and way-finding.

1. Introduction

Dementia can be considered as a chance to reconsider the architectural approach to outdoor spaces as an important component of therapeutic programs. An important component of memory-care settings with beneficial effects on quality of life and well-being of Alzheimer affected people is the contact with nature. It has been argued that people with dementia are strongly affected by the design of the environment because they are not usually able to change it themselves [1]. This study revisits an indispensable aspect of architecture; how space is perceived, and is motivated by a consideration of how outside environments need to be designed for people with dementia. As Alzheimer progresses, those who are affected by it feel progressively lost. The question of how gardens and the outdoor spaces can support a sense of safety and well-being, which contribute to the sensory stimulation, socialization, and a better quality of life for residents with dementia in care settings is examined in this essay. Garden spaces designed to engage the senses and provide better orientation and security for people with dementia are the case studies of this study. In this manner, the intention of this study is to take the topic of outdoor environment for people with Alzheimer as a starting point for a broader innovative regeneration of the outdoor built environment that can benefit everyone in an Alzheimer care-center environment. Outdoor spaces that engage senses, which provide the sense of security and clear orientation are useful not only for the people with dementia, but also for the personnel and visiting relatives in Alzheimer care centers.

2.State of the Art in Garden Design for People with Dementia

Outdoor Space Design for People with Dementia. Providing care for people with dementia is going to be a major challenge for the societies getting old in coming years. Alzheimer disease is characterized by the loss of nerve cells in the brain, which are associated with memory, learning, and judgment. Outdoor environments in memory care centers can offer both people with dementia and staff, healthy exposure chances to fresh air, sunlight, socialization opportunities, and gardening activities. Decreased agitation and aggressive behavior, improved sleep patterns, bettered hormone balance, and vitamin D production are among the benefits for people with Alzheimer who have the opportunity to spend time outdoors [2, 3, 4, 5]. However, people with Alzheimer confront cognitive problems such as finding the way and place identification both inside and outside the buildings. Therefore, design of gardens for this group needs specific effort and design research knowledge [6]. Despite the fact that there still exists no cure for Alzheimer disease, there have been efforts in nonpharmacological interventions such as specific care settings with focus on security, stimulation, and companionship [2]. A secure garden attached to a memory care residence can enable residents to go outdoors, specifically when residents can use it freely and safely. Respectively, the question of Why don’t people go outside? was first addressed by Bite and Lovering (1985), who challenged the issues of outdoor spaces and the factors that influence their use in care centers by patients [7]. They identified that the use of the outdoor space depends on comfortable seating, protection, and staff-initiated use [Ibid]. Though the research that addresses outdoor space design for elderly people has been available [8], findings addressing the specific needs of the elderly affected by Alzheimer have been limited [6].

Kevin Lynch, in Images of the City (1960), argues how people figure out their way through both familiar and unfamiliar environments by identifying known landmarks and recognizing pathways, places, and their boundaries [9, 10]. He identifies five elements as paths, edges, districts, nodes, and landmarks, which people use for orientation that can also be applied to garden spaces [6]. Yet, for people with Alzheimer, remembering places and connections between them is quite difficult. These five categories of Lynch are useful, when applied in garden design because they help the users of the garden to organize a mental *cognitive map*. The *cognitive map* as a mental picture of the environment, which assists individuals to make their way from one place to another is applied by most of people [10]. But, people with dementia have been increasingly lost their ability to make and use a *cognitive map*. Therefore, a designed physical outdoor space that promotes safety and directs cognition, even when the Alzheimer affected person is not aware, is a beneficial remedy. Further, *natural mapping* is another term applied to way finding and orientation through sensory awareness of sights, sounds, and smells, which can assist individuals understand where they are [11]. *Natural mapping* principles and follow-up research have been applied in the design of garden spaces for people with Alzheimer by the landscape architect Martha Tyson [12, 13].

The argumentation of the sensory awareness attached to smells and care for familiar plants can be extended to the research that has been conducted in Finland. A research study has been conducted at ten facilities with people with Alzheimer in Finland, where the researcher concluded that plants and gardening activities contributed to social well-being of residents [14]. Notably, familiar plants helped to awaken the memories of people with dementia; caring for plants in the garden assisted residents to keep their functional abilities. Moreover, plants helped people with Alzheimer to orient in space, triggered their senses, and generated positive emotions. Besides, plant caring and watering activities developed a good topic for conversation between staff and residents [Ibid].

As it is important to make the physical world of the outdoor environment as rich and stimulating as possible for people with dementia, the exposure to the fresh air and sunlight adds much more value to a garden as a component of a memory-care setting. The exposure to sunlight facilitates the production of vitamin D that results in better bone strength and muscle performance, resulting in fewer falls [15]. Accordingly, Mooney and Nicell (1992) carried out research on falls and violent incidents in five nursing homes for people with dementia [5]. They concluded that the rate of violent incidents and falls rather declined in facilities with gardens compared to those facilities without gardens [2]. Likewise, results of a study in Canada has shown that staff were using the outdoor environment in order to facilitate calming situation and to assist in managing behavioral problems and agitation [16].

On the other hand, there have been studies, which concluded that involving the staff and convincing them regarding the significance of access to garden, have been more demanding, compared to the actual design of the outdoor itself [17]. This issue emphasizes the importance of designing outdoor environments, which promote safety and accessibility in a way that allow residents to maintain independence and self-esteem. However, even the most mindful design of outdoor space for people with Alzheimer would not guarantee that the residents would use it [2]. That is because people affected by dementia usually have problems planning and accomplishing even simple tasks such as deciding to go outdoors and finding the door.

Methodology: Case study Method. The question of how the design of the garden and its space can contribute to better quality of life for the people, who have lost their sense of orientation and memory, is pursued through showcasing case-studies and their elements in this study. Case-studies are used to investigate how the outdoor space design can form a framework within which not only the well-designed gardens and surroundings help the well-being of people with dementia, but also interrelationships and social life can be facilitated for this target group. In this manner, this study investigates the design guidelines of gardens for people with Alzheimer. However, it needs to be emphasized that even the most efficient suggestions for the design of outdoor space for the Alzheimer’s facilities cannot ensure the engagement of the people with dementia.

Discussion through case-studies. Supportive outdoor environments, which are associated with positive health outcomes for people with dementia, can be conceptualized as accompanying gardens of care-memory settings. An outdoor environment that provides aesthetic pleasure and possibilities for engaging in meaningful activities and opportunities for socializing can benefit people with Alzheimer, greatly. As an evidence, in a research study in Sweden, it has been concluded that Sinnenas Trädgård (the Garden of the Senses) in Stockholm has been a preferred place among the elderly with dementia [14]. Like every garden, gardens for memory-care settings should stimulate senses in a way that residents can experience themselves as a part of nature. This argumentation goes on with discussions on design guidelines for gardens intended for people with Alzheimer. However, it is not intended as a literature review, rather as an overview and discussion of the theory and practice on the physical design of outdoor settings in healthcare and memory-care settings.

Visual Access to the Garden. Among the first set of recommendations regarding the garden design for a nursing facility, were those written by the German horticultural theorist, Christian Cay Lorenz at the end of the eighteenth century:

“The garden should be directly connected to the hospital…A view from the window into blooming and happy scenes will invigorate the patient…encourages patients to walk….The plantings should wind along dry paths, which offer benches….The spaces between could have beautiful lawns and colorful flower beds….A hospital garden should have everything to enjoy nature and to promote a healthy life” [18].

Actually, Christian Cay Lorenz developed the idea that when external spaces such as the garden are treated as an extension to an internal space, they are better used. While physical access to the garden is important, visual access can reinforce the connections of the residents of the health-care centers to nature. Plants, guided pats and safety, proper seating, and gleaming colors of flowers are principal features of a supportive outdoor environment, which enhance health and well-being of the residents. Accordingly, environmental psychologist Roger Ulrich in the late 1970s started to research the emotional and physiological effects of environmental aesthetics on hospital patients [2]. The research by Ulrich known as “evidence-informed design” or “evidence-based design (EBD)” has established the visual benefits of trees, garden, and other natural settings in healthcare facilities [Ibid, pp. 14-16]. The study by Ulrich clearly demonstrated the improvements in health for residents of healthcare centers, when exposed visually even to one tree.

Correspondingly, the visual access and contact from the staff area is crucial; TV monitors, alarms, and visual safety features can ensure that residents are permitted to go to the garden, at the same time that autonomy is enhanced. Likewise, best practice case-studies have indicated that people with Alzheimer feel more comfortable, where the whole layout of the garden is visible and “there are no disorienting hidden areas where they may lose sight of the route back to the building” [Ibid, Fig. 1].

Fig. 1. The Garden must be visible from a well-used interior space. View to garden space from a day room at the AFA, Centro Adolfo Suárez, Fuengirola, Spain (Photo: Maryam Khatibi)

Physical Access to the Garden. The outdoor space such as a garden is designed in order to encourage the movement and activity that result in good health for people with dementia. However, as dementia progresses, people with Alzheimer become less capable of initiating simple behaviors even walking through a door [10]. Therefore it is required to provide a single entry door to the garden, which is designed as a landmark, maybe by aid of colors or a distinctive symbol [2]. In this manner, people with Alzheimer can see it easily from the garden and understand where they need to return to in order to get back indoors. Moreover, the door needs to be unlocked as often as possible in order to provide physical access to the outdoor environment. Interestingly, a research study revealed that agitation was greatly reduced among people with dementia in the unlocked door condition [19]. People with Alzheimer simply knowing that they could go out were calmer. Further, behaviors such as verbal abuse and talking to oneself declined to a great degree when the door to the outside was unlocked. Besides, a door with an easily usable handle and barrier free entry that might not impede wheelchair access is recommended.

Pathways. The layout and pathways in the garden for people with impaired cognition need to be easily understood in order to minimize confusion to encourage its use [10]. The goal in addressing the issue of pathways in a garden of a memory-care center is to provide the "secure freedom" or "opportunities for the person to wander within an environment that has controlled perimeters and limits access to potentially hazardous situations" [20, p. 243]. This issue is crucial, because there are several underlying motivations that make people with dementia to wander away. They include previous fixed habits such as going home or leaving for work, sensory stimulation lack, and maybe continuation of a long-held habit of taking walks [2]. However, people with dementia lack the *cognitive map* of a space and cannot remember the pathways from past experiences clearly. Therefore, a pathway that simply loops around a garden in a circular or figure-eight, with no dead ends, which begins and ends at the same door minimizes spatial confusion. It is argued that garden circulation design has a major impact on people with limited cognition competencies. The circulation routes need to be simple, but they must not be monotonous, since cognitively impaired people get disoriented in uniform routes. To face this challenge, interesting elements along the pathway such as garden ornaments, landmarks, water fountains, a gazebo, and so on can facilitate navigation and use of the outdoor space for demented people. Besides, pathways need to be equipped with handrails and proper flooring materials in order to assist the safe navigation of the users.

Sensory Stimulation and Engagement. Sensory experiences play a crucial role for people with dementia [21]. When cognitive and memory related abilities of people declines, what remains are direct sensations. When we design for people with dementia, we need to consider what is fundamental in experiencing space. Robust cueing that engage senses of touch, smell, hearing, sight, and tasting are beneficial memory awakening devices. "Learning, remembering, feeling […] are three aspects [that] make a successful space" [Ibid, p. 20]. Today, we know that the senses of touch, taste, and hearing develop earlier than other senses, while our senses of sight and smell develop slowly after birth. Our senses are responsible for some of the most powerful memories of our early childhood, which has helped us to learn the space. Likewise, the whole collection of particular sensory impressions are required in order to feel a specific space. For example, in a garden, the pleasant smell of flowers, the soothing sound of water, a relaxed place to sit and to watch and feel the aesthetics of nature can evoke our feelings and memory of the space. Correspondingly, Peter Zumthor describes his childhood memories of space, stimulated by senses:

"Some of the other images have to do with my childhood. Sometimes I can feel a particular door handle in my hand, a piece of metal shaped like the back of a spoon. I used to take hold of it when I went into my aunt's garden. The door handle still seems to me like a special sign of entry into a world of different moods and smells. I remember the sound of the gravel under my feet, the soft gleam of the waxed oak staircase, I can hear the heavy front door closing behind me as I walk along the dark corridor and enter the kitchen, the only really brightly lit room in the house" [22, p.7].

Sensory gardens and horticultural activities are applied as non-pharmacological interventions in dementia-care settings much more recently [23]. Although the benefits of sensory garden and related interventions are not certain, they might improve the quality of life of residents of memory-care centers. Likewise, Garten der Sinne (Garden of Senses) is a garden designed for people with dementia in AWO Seniorenzentrum, Weilerswist, Germany. Garten der Sinne is designed to provide sensory experiences by several components such as a gathering space with a landmark to assist navigation, texture handrails that trigger the sense of touch, and a sound generator installation in order to stimulate the sense of hearing.

Balerna Diurnal Therapeutic Centre in southern Switzerland also benefits from a sensory garden as a component to its memory-care setting. As some of strongest memories of human beings are tied to the olfactory section of the brain, which is responsible for scent and smelling, the newly designed sensory garden in Balerna applies fourteen wooden tables alongside its ramp, which compose a hanging garden of aromatic herbs such as mint, rosemary, lavender, thyme, and sage [23]. While the edge of the tables can be used as handrails, the tables allow the demented people even with wheelchair to come closer at the same time that their senses of touch and smell are stimulated. Moreover, at the lower level of the garden flowerbeds full of flowers in different colors, which bloom at different times of the year are designed and planted in order to satisfy the visual aesthetics and stimulation. It should be noted that the plants in the garden need to be not sharp, toxic, and prickly, as people with dementia might tend to taste them. Furthermore, water producing a soothing sound effect is a pleasant presence. Garden users in memory-care settings may drink and touch the water in the specifically designed fountain. Sensory features related to smelling, seeing, and hearing nature are linked to recalling positive memories, which are provoked by presence in purposely designed garden spaces for not only demented people but also for all garden users.

The experience of the sensory garden at Balerna Diurnal Therapeutic Center has been also backed by research. An experimental study was conducted over six months between March and August 2016 in order to determine the impact of garden and its features on demented people. After three months of experimenting the garden, the caregivers at Balerna center were given questionnaires, at the same time that the people with dementia were asked short informal questions [23]. The study revealed that almost all studied demented people felt better using the garden, enjoying the scents and fresh air. Some garden users with dementia reported that they have enjoyed using the ramps as it was the way back home. While studied people with dementia drank from the water fountain, no urinary incontinence as the result of flowing water was observed. Further, no falls were reported in the garden and ramps, and there was a reduced need for sleep medications among garden users. Moreover, interviews highlighted that families and caregivers have experienced less stress when their loved ones were wandering in the sensory garden of Balerna care setting. Consequently, such an *evidence-informed* design and post-occupancy research inform the design and turn as an effective tool in convincing decision makers in designing a sensory garden as a component to the memory-care setting.

Seating, Enclosure and Lighting. Seating needs to be provided at frequent intervals along the pathways, as demented people want to rest briefly and then pace again [2, Fig. 2]. Different types of seating such as fixed and movable seats with the choice of sun and shade are recommended for memory-care garden settings. Furthermore, the garden needs to be usable at nights by applying lighting that does not create dark pools of shadow, which is near the seating locations. As the garden must not being shaded for the much of its parts at times of the day (normally morning), the view out from the garden needs to be also considered. Accordingly, an article on best practices recommends an open fence when the garden overlooks a natural scenic area, but a solid fence when it overlooks an active roadway or a parking lot [24, Fig. 3].

Fig 2. Seating at Evangelisches Alters-und Pflegeheim (Evangelical senior residence) in Chur, Switzerland, (Photo: Maryam Khatibi)

Fig. 3. Enclosure and handrails at Evangelisches Alters-und Pflegeheim in Chur, Switzerland: edges of buildings enclose the garden (Photo: Maryam Khatibi)

3. A proposal for a Sensory Garden for Demented People

Bamboo Sensory Garden. The AFA, Centro Adolfo Suáre in Fuengirola, Spain has a garden that its users, who are the people with Alzheimer, their visiting relatives, and the caregivers are prevented to benefit this abandoned outdoor space because of the several barriers such as the improper safety and access to the garden. As investigated through this study, there are several factors and guidelines that determine the success of a sensory garden, which is intended to trigger the senses of the people with cognitive disturbances. The proposal conceptualizes a bamboo theme garden; bamboo is applied in the design of several elements of the garden in order to stimulate the senses of the garden users. Bamboo is a fast growing plant with sustainable and environmental benefits. The application of bamboo in the handrails designed for the garden of this memory-care setting causes the stimulation of the sense of touch in order to trigger memory. As people with dementia walk along the circular route through the garden, their sense of touch is stimulated by touching bamboo-textured handrails.

Moreover, bamboo has a pleasant smell that triggers the sense of smelling. The proposal conceptualizes a water fountain constructed with bamboo material as a *focal point* in this sensory garden. The soothing effect of the water on bamboo can stimulate both senses of hearing and smelling. Hearing stimulation can be reinforced by applying bamboo wind chimes as a sound generator installation, which can be sounded by wind or by garden users. Bamboo is also practical for the concept of enclosure in the garden; a semi-open bamboo fence can enclose this sensory garden as it overlooks a mix of a natural scenic area, street, and buildings. As bamboo stimulates the senses of touch, hearing, smelling, it adds to visual aesthetics of the space and can be applied for enclosing the garden area (Fig. 4).

Fig. 4. The circular movement concept is assisted by applying bamboo in handrails to stimulate the sense of touch in order to trigger memory for demented people (Maryam Khatibi)

4. Conclusion.

The sensory characters of the garden, which stimulate five senses of touch, hearing, taste, seeing, and smelling need to get coupled with principles that relieve demented people from having to organize a mental *cognitive map*. The proposal of the sensory garden is conceptualized through several architectural strategies in order to stimulate senses and cognition of demented people. This sensory bamboo garden is composed of two different areas with different functions and appearances: The natural steep ground of the garden, which is proposed for the beds of flowers (Fig. 5, No. 4) and the circular pathways that contain other features of the garden (Fig. 5, No. 3). The principles regarding the orientation elements of Kevin Lynch are applied to the proposal as: the *landmarks* employed as reference points; *nodes* applied as spots in a garden that are foci to and from that demented people travel; *districts* referred to the sections of a garden that are noticeable as having unique identifying characters; *edges* considered as boundaries between two areas; and *paths* as passages that people pace along [6].

The bamboo entry/exit door (Fig. 5, No.1), water fountain (Fig. 5, No. 8), and wind chimes installation (Fig. 5, No. 9) are proposed as *landmarks* and *reference points* of the garden. The single entry/exit door applies bamboo as a distinctive symbol in order to aid the people with Alzheimer in recognizing the doorway. As the movement concept in a simple circular route through the garden is assisted by the bamboo handrails (Fig. 5, No. 2), the different color and texture of the smooth low glare path (Fig. 5, No. 3) create *edges* and guide the visual navigation in the garden. The presence of water is particularly helpful for people experiencing dementia. The simple spouts of water through the bamboo water fountain introduce a dynamic quality to the sensory garden. Two raised garden beds with possibilities of planting herbs and vegetables are intended as *nodes* and *focal points* that provide the space for shared and meaningful activities (Fig. 5, No. 10). These wheelchair-accessible raised plant beds provide the opportunities for not only planting activities but also for touching and tasting herbs.

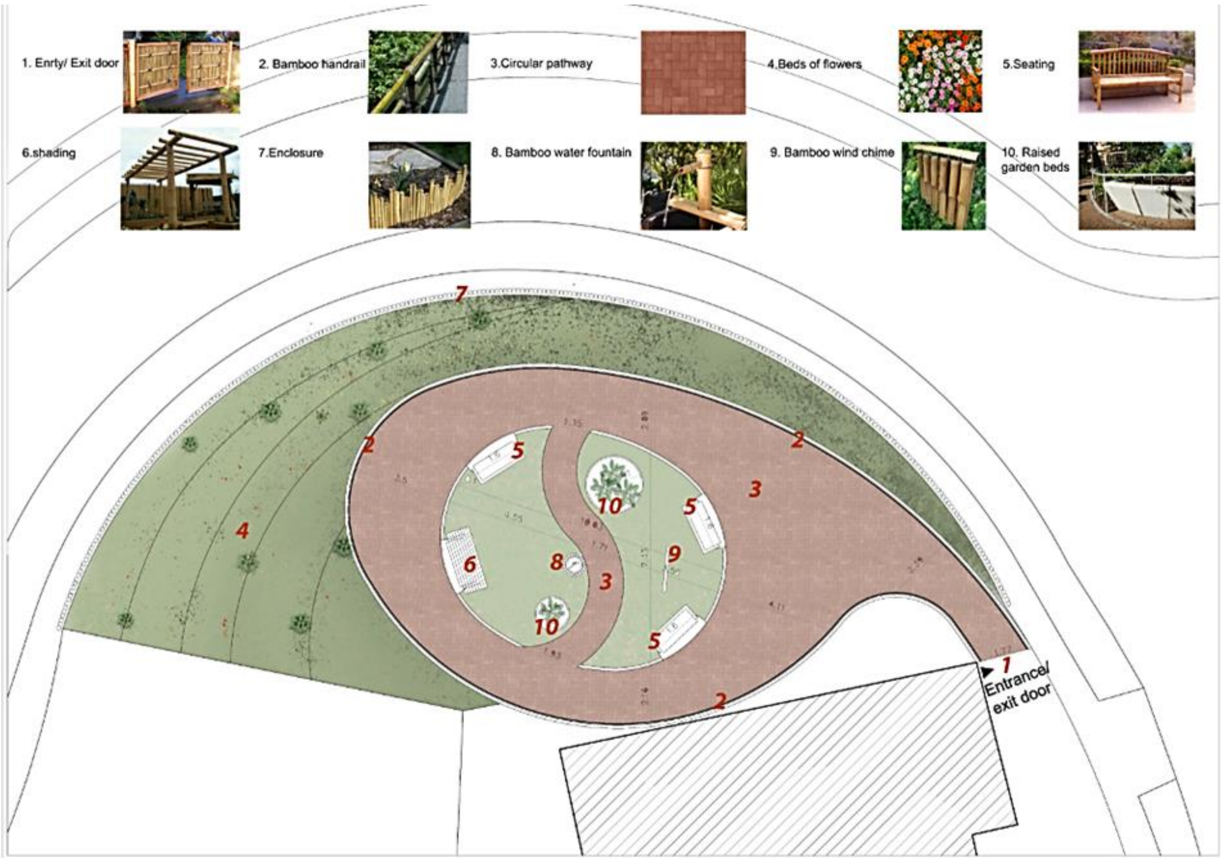

Fig 5. The proposal of a bamboo sensory garden for people with Alzheimer, the AFA, Centro Adolfo Suáre in Fuengirola, Spain, scale 1:100 (Maryam Khatibi)

Seating is intended with frequent resting bamboo benches with the choice of sun and shade (Fig. 6, 7). Seating is proposed not only as resting points, but as the opportunities to enjoy the colors and smell of the flower beds, which helps to evoke positive and reassuring memories for people with Alzheimer. The features and concept of the bamboo sensory garden are expected to provide the *natural mapping* opportunities through the design of the outdoor space. Although the components of this conceptualized bamboo sensory garden such as the variety of plants and flowers, the water feature, the enclosure and access, curvilinear pathways of tinted material with benches, and sensory stimuli need to be planed extremely carefully, even the most thoughtful design of an outdoor space for people with Alzheimer cannot guarantee their beneficial access. Such a nonpharmacological intervention in care settings for dementia needs to be coupled with the *evidence-informed* post occupancy evaluations in order to come over the existing limitations and challenges of organization of the space for people with Alzheimer. This proposed concept informed by the previous research and practice aims at contributing to the advancement of practice and knowledge in outdoor space design for demented people. The proposed guidelines and concept of this study for the bamboo sensory garden can be used by architects and designers as a tool to approach the challenge of outdoor design for cognitively impaired people with spatial confusion.

 

Figs. 6 and 7. Seating and wheelchair-accessible raised plant beds with access and safety consideration for demented people (Maryam Khatibi)

The findings of this study can be greatly improved by expanding the research with residents and garden users of the intended memory-care setting in Fuengirola, Spain. The additional information on how the residents want to experience the outdoor environment and how their everyday life in a memory-care center equipped with a future-built garden would be, can strengthen the theoretical components of this study.

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PROBLEMS OF ARCHITECTURAL HERITAGE PRESERVATION IN MODERN CONSTRUCTION OF YEREVAN

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Keyword: Architectural heritage, preservation, construction, development, urban space, tradition, monument

Abstract. Yerevan is a city with centuries-old history, where architecture is a reflection of socio-cultural peculiarities, world outlook and perceptions of different time periods. The city has gone through different stages of history and has been influenced by various socio-economic social structures, has become a space, environment, which combines and binds physical and non-physical environments.

In modern Yerevan there are the results of the outlook and artistic thinking of previous generations, embodied primarily in architectural monuments. It is these monuments that give the city a characteristic image and make it special. The issue of their protection is modern and urgent, especially in the post-Soviet period, when the social-economic crisis, construction works were carried out in Yerevan according to some investments, which were the reasons for destruction of valuable buildings.

Large-scale construction has damaged Yerevan squares too. In the vicinity of some squares there are many high-rise buildings. Undertakings, underground parkings, and numerous service facilities that do not correspond to the architectural environment. As a result of this, the territorial integrity of the squares is undermined and the use of the public space of the city has become less effective. Impeccable construction was carried out in the vicinity of St. Astvatsatsin church. Successful examples of environmental development have also been recorded (protection and reorganization of the environment by introducing small architectural forms and sculptures with new meanings).

City is a living, active, breathing organism which undoubtedly must be evolved and changed in accordance with the requirements of the times. The most important issue is to create a harmonious space and regulation of urban development situation around the monuments.

1. Introduction

The rapid transformations taking place in the development of urban space, the lack of logical connection between past and present in the organization of space and the conservation of historical and cultural heritage suggests that modern urbanism development provokes serious socio-cultural movement for the protection of individual objects consequences (civil movements on protection of the summer hall of “Moscow” cinema , Mashtots park, buildings around the medieval church on the corner of Abovyan street and Sayat-Nova, etc.). For the Armenians, the formation of urban culture is particularly important, as Armenia is a country of rich architectural heritage and traditions. Moreover, architecture is the hallmark of Armenians identity. Today, urban culture is being created according to the characteristics of modern society, to which the urban environment is not always harmonious.

The process of modern urban development in Yerevan is very often occurred mechanically copying international experience through artificial localization.

Modern urban development processeses are taking place in Armenia in the struggle and conflict between the old and the new. At 70s Japanese architect Tange called to “destroy” and to “overcome” the tradition, but not in order to exclude from contemporary architecture, but in order to get to its essence, to grasp and understand the mechanism of its formation, to develop a structure, but in the new content and in a new form. According to Tange the tradition fully understood, decoded and creatively processed, becomes in the hands of the architect's creative categories. “To turn the tradition into something creative, it must be negated and destroyed in a certain sense” [1].

Unfortunately it is perceived and implemented in simplified and literally way, leading to irreversible losses. Modern urban development must adjust the old traditions and create new ones. The debate on culture has always been existed between globalists and regionalist in nearly all countries. They were particularly vivid in the 20s of the 20th century. Now we are faced with this problem again. Tradition is not an unambiguous concept, not as a separate transfer form or details of “yesterday” to “today”. Innovation is not only overcoming the traditions, but also in the selection and the adjustment of traditions. Finally, innovation assumes the creation of traditions. The philosophical unity of traditionalists and innovators should be the basis of national architecture [2].

Unfortunately nowadays the concept of the image of the city is disappearing. The urban environment has an active effect on the psychological and emotional perception of the person. Drastic environmental changes cause negative changes in the psychological state of the people. As a result, our house is alienated. We do not even have time to integrate into the newly created spatial environment, because it all happens spontaneously, in the absence of the space-time communication. In modern cities, we can see the results of the artistic worldview thinking of previous generations, which are reflected primarily in architectural monuments. These monuments give the image of the city and make them special [3]. A lot of churches were destroyed during the Soviet period. In the post-Soviet period in severe socio-economic conditions for the benefit of investors in Yerevan were carried out building, during which the valuable buildings were destroyed (City Hall on Shahumyan square, hotel "Shirak" 19-20's building ages on the streets of the Republic, Aram, Pavstos Buzand, Teryan), instead of which were constructed tasteless and non-valuable buildings [4] (Fig. 1).

Fig. 1. Part of Buzand street

Large-scale construction caused damages also to the squares of Yerevan. Around some squares (such as the square of the Republic, Liberty, Shahumyan, Aznavour) were constructed and are still being constructed high-rise buildings, overpasses (Barekamutyun-Friendship), underground parking (square of Freedom). There are a lot of objects of services around the territories which don't correspond to the architectural environment (the square of Freedom). In particular, the area of the Opera and Ballet Theater, considered to be as a recreation area, turns into the territory of political actions (Fig. 2).

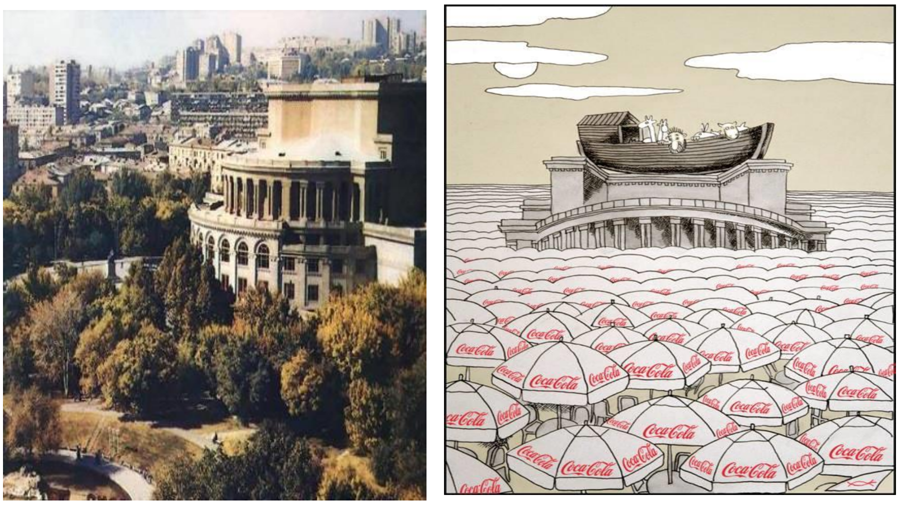

Fig. 2. Opera square: Yesterday and Today

This trend can be seen in a number of other public areas (Baghramyan Avenue, adjacent to the Matenadaran Mashtots Avenue area, etc.). As a result of all these the spatial integrity of the area are being distorted, and not least, the usage of public areas is becoming impossible. In this regard, the dismantling of monuments (Republic Square) is also important (Fig. 3).

Fig. 3. Republic square in space and time

After the dismantling of the monument of Lenin from the Republic Square, the predestal was also dismantled also predestal, which put in place a metal billboard, and after the demolition of the shield, the place is empty [5]. Yerevan Shahumyan monument work Merkurov is ranked in the list of communist monuments that must be fought (obviously due to the nationality of the hero). The monument still stands in the square named after him, as his bust in front of the school. Impeccable construction was carried out in the vicinity of St. Astvatsatsin church.

The city street has also changed its functions in Yerevan, which is seen primarily as a trading environment, and the closer to the center, so these places are more profitable. The best example of this is the Northern Avenue (Fig. 4).

Fig. 4. Northern Avenue

Historic district of Yerevan to Dzoragyugh in the 80s began to reconstruct in view of integration into the environment of new buildings. However, it remained unfinished. Nowadays, at this place in competition with each other are being rised restaurant complexes, which are incompatible with the historic environment and have completely different function.

Preservation of monuments and historical and architectural environment, of course, assumes no suspension of development of the city. City is a living, active, breathing organism which undoubtedly must be evolved and changed in accordance with the requirements of the times. The most important issue is to create a harmonious space and regulation of urban development situation around the monuments.

In the world architecture there are such examples, i.e. a small church in the front of high-rise building on New Arbat in Moscow, the glass pyramid entrance to the Louvre. Italian cities in their historicity live with modern spirit. In Florence, along with the historical architectural complexes of Renaissance and Gothic style modern buildings are made in a smooth and unobtrusive way in order to preserve the historical and architectural integrity of the space.

In Yerevan, there are also cultural values of a thousand years ago, around which there is a new construction. To organize such an environment dominant role can have the fortresses of Erebuni, Teishebaini, Shengavit, the early Christian church Awana. It is preferable to reconstruct and re-use some parts of the region Kond [6].

There are examples in the world architecture where monuments are preserved, sometimes partially being included in the construction of the new building. This experience is best demonstrated by the Italians. In Tbilisi historical buildings are also almost completely preserved. This approach however often has extreme manifestations. In some historical areas the population have a lot of operational problems, which were formed as a result of the indispensable preservation of the old heritage. In Yerevan, facades of some old buildings have been preserved in the new buildings (Fig. 5).

Fig. 5. The reuse of old building in Abovyan street

2. Conclusion

Today, Yerevan is actively being reconstructed with strong new relationships which were established in the post-Soviet Armenia. It will certainly fail the city to international standards, absorbing all the special characteristic of the eclectic architecture of the 21st century, whereas once it was warm and pink city. Our capital also experienced woes of transition period. Many monuments were dismantled, the gap between the old and new buildings is obvious. In order to remedy the situation some efforts and attempts should be planned and realized. The city is being reconstructed guided by the slogan “sustainable and harmonious development of the city over the city”.

Acknowledgements

This work has been carried out in the frame of “Creating the ways for sustainable urban, architectural and construction complexes development in RA and elaboration of directions with use of permanent monitoring systems” programme, financed by State Committee of Science of Republic of Armenia.

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REMARKABLE PUBLIC BUILDINGS OF THE SOVIET ARCHITECTURE: THE PROSPECTIVE OF PRESERVATION AND SUSTAINABLE DEVELOPMENT BY ADAPTIVE REUSE

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Keywords: Architecture, sustainability, adaptive reuse, conservation

Abstract: Carrying out the restoration of the buildings for continued use is more and more important today. It is urgent to find the right approximation with respect to the historical structures of which contemporary requirements and conditions are not performed for their previous use. Adaptive reuse can revive abandoned buildings and preserve cultural values by serving the basic concepts of sustainability. This method of preservation is an important approach today. It is an advanced step in the contemporary practice of architectural conservation, which is creating strong relations between urban regeneration and sustainable development.
This study detects a knowledge gap of the absence of consistent benchmarks regarding the future adaptive reuse of abandoned buildings. The case study is the Soviet era public architecture of Armenia. The topic investigates the considering design principles of public structures built in this period, and the lack of consensus on how to maximize the potential of adaptive reuse in Armenia. The main purpose of the research is to offer the work model and to make arrangements for increasing focus on the regeneration of Soviet period buildings as an alternative to demolition.

1. Introduction

The 1920s of the former century added a new page in the history of Armenian architecture. At the beginning of endorsement of the Soviet system, there was a strong need in qualified specialists parallel with the growth in mass construction. Renowned architects A. Tamanyan, N. Buniatyan, D. Chisliev, N. Baev, A. Zakievand many others were invited to Yerevan from Moscow. These reached specialists in the head of the academician of architecture Alexander Tamanyan and Professor Nikoghos Buniatyan started erecting esthetically and constructively high-quality architecture abundant of Armenian traditions and experience from abroad. The architects studied the roots of Armenian architecture and enriched their works with splendid national elements (Fig.1) [1].

This approach was not acceptable by the younger generation of architects. Although they considered it to be important to study and preserve the historical and national heritage, they found it nonsensical to use or reproduce those forms. These younger specialists started searching for new forms and a number of modern constructions totally different from one another and from those previously built were created. The founders of these innovative principles were G. Kochar, M. Mazmanyan, K. Halabyan, H. Margaryan and many others (Fig.2).

In 1945-1955 the Armenian cultural figures including architects who outlived World War II reflected the whole spirit of victory in their works. They recognized the national values in a new way and depictured them in their projects. The traditional forms were evaluated and used both in constructive and architectural forms. It was expressed in constructions, stonework, arches, cornices and in other architectural elements. Armenian stone in different color combinations was used in interior and exterior joining the two dimensions at its best. New Armenian architectural traditions were formulated that had no connections to the achievements of others. The national elements were considered more important than modern ones. At these time period architects like G. Aghababyan, L. Babayan, Z. Bakhshinyan, G. Isabekyan, G. Musheghyan, E. Tigranyan, R. Israelyan, and many others promoted their activity [2].

In the 1950s the towns were resurrected: the building gathered full speed, architecture and construction entered a new qualified phase. The first project institute of *"Armgosproekt"* (State Head Project Institute) was formulated. As a result of mass buildings: kindergartens, schools, hospitals, medical and scientific institutions, recreational and cultural centers and more were built. The project works were coordinated by separate studios working within the institute, which were managed by the best specialists of the time – S. Gurzadyan, K. Hakobyan, G. Musheghyan, E. Tosunyan, Z. Bakhshinyan, M. Mikaelyan, Yu. Nalbandyan, Sh. Sahakyan, Harutyunyan, A. Mirijanyan, S. Kalashyan, S. Safaryan, S. Khachikyan, L. Cherkezyan, H. Poghosyan, A. Tarkhanyan, L. Babayan, L. Khachatryan. The works of the studios were distinguished by high-quality project features. Before the collapse of the Soviet system many building, as well as serial and unique constructions of public significance were built that represent the elevated cultural and architectural level (Fig. 3) [3].

Fig. 1. N. Buniatyan, Building of Agricultural Bank, Yerevn (built in 1927) [4]

Fig. 2. G. Kochar, Writers House, Sevan (built in 1935) [5]

Fig. 3. H. Poghosyan, A. Tarkhanyan, S. Khachikyan, Cinema ''Russia'', Yerevan (built in 1974) [6]

2. Soviet-Era Public Heritage Out of State Care: Sustainable Development Issues and Regulations in Adaptive Reuse Principles

Recent decades were times of mass reconstruction, especially vulnerable were Soviet and pre-Soviet buildings. A number of historical structures, artistically original and of high architectural and cultural value, were demolished. Many of these buildings were dismantled and replaced by new ones, some facades of unique constructions appeared on plain and unsightly ferroconcrete giants. Among these buildings were Sevan hotel by N. Buniatyan, built in 1930-1939, Language Institute of Hrachya Acharyan by A. Ter-Avetikyan, built in 1938, 2nd building of Yerevan State Circus by A. Asatryan and A. Sahinyan, 1939, Sasuntsi Davit Cinema by A. Ter-Avetikyan, 1960, Youth Palace by the project of H. Poghosyan, A. Tarkhanyan, S. Khachikyan, built in 1970 and many other significant buildings. [Fig.4] Today our task is to prevent this sort of activity. It is vitally important to increase the role of historical buildings and the potential of their reuse by introducing the necessary arrangements in the field.

Currently, more than 100 public architectural monuments of Soviet-era are included in the list of Immovable historical and cultural monuments of RA – approximately 50 in Yerevan, and about the same number in regions (Marzes). If we consider Aragatsotn Marz, we'll see that only a few public buildings of that era are involved in the list of Immovable historical and cultural monuments, whereas, more than 20 prominent buildings which are not included in the list were revealed by personal research. The number of such buildings reaches 80 in Yerevan [7,8] (Fig. 5,6,7).

The legislation of the Republic of Armenia, including international laws, charters, conventions fixed by the Constitution of RA envisages several articles on construction usage. However, the current state of the Soviet buildings in Yerevan and different regions of RA, the existing town-planning issues at the historical circle and the depreciated state of separate exploited or non-exploited monuments, it is worth mentioning that the process is not properly regulated. It should be taken into account that these buildings constitute an important part of Armenian architectural culture and already formulated urban historical land-shaft. We need to comprehend their value and in what value system they are recognized.

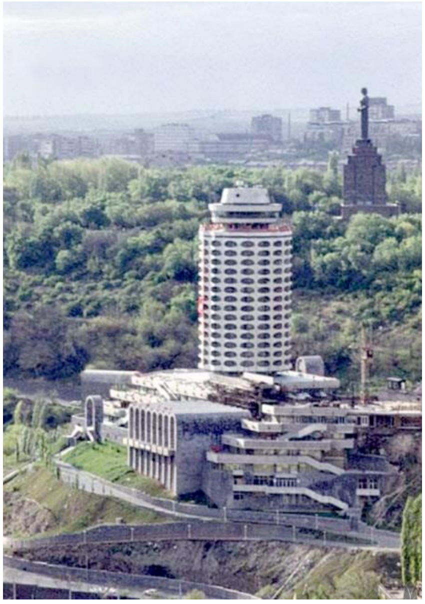

Fig. 4 H. Poghosyan, A. Tarkhanyan, S. Khachikyan, Youth House, Yereva, 1970s [6]

In accordance with the Law of RA on immovable historical and cultural monuments and protection and use of historical environment: "immovable historical and cultural monuments (further - monuments) are the constructions listed on the state accounting having historical, scientific, aesthetic or other cultural value, their ensembles and complexes with occupied by them or historically related territory." [6] An important issue arises on the above-mentioned features: are “historical”, “scientific” or “aesthetic” values sufficient condition to describe a monument? “Other cultural value” describing the building may involve or may skip many other significances. The procedure of inclusion of monuments in the state lists, as well as arrangements of their use and development of the working regulations, are directly connected to the value system formulated on the specific construction. According to the Article 38 of Chapter 8 of the law: “The use of the monument on economic or other purposes is licensed conditioned, if the mentioned use is relevant to the character of the monument, does not cause harm to the monument’s safety, does not depreciate or distort its historical, scientific or aesthetic value”[9].

Fig. 5. G. Tamanyan, ˝Oshakan Palace of Culture˝, Oshakan (built in 1950s)

Fig. 6. H. Arakelyan, ˝Hrazdan Bus Station˝, Hrazdan (built in 1971)

Fig. 7. S.Gurzadyan, M. Aleksanyan, ˝Garoon Cinema˝, Vagharshapat (built in 1978)

How to realize, which are “other cultural value” characterizing the structure? The first serious assessment to the historic building was given by Alois Riegl in the end of 19th century: He promoted the following values for the building: historical value, age value, past or present value: which were frequently identified, relative, aesthetic value, use value, newness value: responded new changes, idealized interventions of old buildings, commemorative value, which was treated the memories, incidents, historical episodes of building. By reconciling age and use values, Riegl writing: *"Where a monument has ceased to have use-value, the consideration of age-value has begun to prevail in its preservation. The situation is more complicated where the use-value comes into play; most would prefer to regard a building in use as something sturdy rather than as something ages and decaying"* [10].

In 1999 The Australia ICOMOS charter for places of cultural significance (The Burra Charter) defines cultural value by the following way: *″Cultural significance means aesthetic, historic, scientific, social or spiritual value for past, present or future generations. Cultural significance is embodied in the place itself, its fabric, setting, use, associations, meanings, records, related places and related objects. Places may have a range of values for different individuals or groups.″*[11]: In order to evaluate the constructions built in the Soviet era, we must distinguish the characteristic features according to their specifications. By leaving defined use, age, historical, place, aesthetic, scientific, social and spiritual value, add: old or previous use value: related to separate significant elements, told about previous use and historical occasions. National Value: evaluated the traditional construction techniques, architectural forms, the national traditional significance. Valuation by the author: focusing on the professional activities, achievements, and recognition of the architect. Also highlighted the values or benefits, which should evaluate the structure or its urban environment in the result of adaptive reuse: That is a public cultural communications value, value of cultural identification, the value of the healthy urban environment, and the benefits of raising the tourist interest.

Another definition from "Burra" Charter about building use: *″Compatible use* means a *use* which respects the *cultural significance* of a *place*. Such a use involves no, or minimal, impact on cultural significance.″ The same charter in "Conservation and management" section come on to historical place and historical values, it's role, the importance of historical place. It define: ″Places of cultural significance should be conserved", "*The* aim of conservation is to retain the cultural significance of a place", ″Conservation *is an integral part of good management of* places of cultural significance.″,″Places of cultural significance should be safeguarded and not put at risk or left in a vulnerable state″[11].

By the speaking of the new function of the old building, is important to recognize, that new intervention and changes are inevitable: Any change should be made with exceptional wariness without causing any damage to the structure, construction, architecture and other artistic significance of the building. *″Change may be necessary to retain cultural significance, but is undesirable where it reduces cultural significance. The amount of change to a place should be guided by the cultural significance of the place and its appropriate interpretation.″* Often the new function causes the greatest damage to the interior of the building: We have a multitude of regrettable examples in our cities today. Often, even in the case of conservation of external shapes, the interior spaces are thoroughly demolished and reconstructed. Both architectural forms, constructions, and constructional materials usually are not preserved (Fig.8) In the 15th paragraph of the charter is important points about permitted interventions: ″If a place includes fabric, uses, associations or meanings of different periods, or different aspects of cultural significance, emphasizing or interpreting one period or aspect at the expense of another can only be justified when what is left out, removed or diminished is of slight cultural significance and that which is emphasized or interpreted is of much greater cultural significance.″[11].

Regarding the issue of sustainable development, is replacement the historic structure with contemporary one is an acceptable means in the 21st century, On the way to development? Today we have a request to organize a healthy public environment, saturated with history and culture by creating

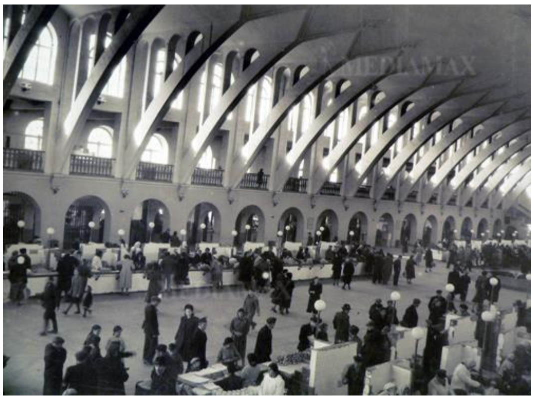

Fig. 8. G. Aghababyan, ˝Yerevan Closed Market˝ (built in 1952, reused in 2012) [13]

high-quality urban fabrics. It is important for both the cultural, social and economic development of the local population and for being more presentable for the foreigners. *''Historic urban areas are among the most abundant and diverse manifestations of our common cultural heritage, shaped by generations and constituting a key testimony to humankind's endeavors and aspirations through space and time'', ''... the principle of sustainable development provides for the preservation of existing resources, the active protection of urban heritage and its sustainable management is a condition sine qua non of development''* [12].

By considering various definitions and advice on the protection and use of the historical monument and their places, and by evaluating in new above-mentioned values scale, we are defining the several important rules for organization the work functions.

- *The place and environment of the reused historical building, as important as the building and must be preserved and used.*
- *Any intervention of the new use of the structure should be carry out by respecting the structure and its place value.*
- *No intervention in the process of adaptation reuse should reduce the significance of the building and it's cultural and historical place.*
- *If the newly done interventions, during the adaptive reuse work process, may modify or damage an important significance of the historical building, damaged or distorted the urban landscape, such intervention is unacceptable.*
- *If the new interventions, during the adaptive reuse work process, is not stemming from the requirement to improve the cultural significance or formulating more value, such intervention is unacceptable.*

3. Conclusions

As a summary should be noted, that today, the city and the urban environment, the street and the square as a public and community spaces are valuable absolutely with the structures, which are organizing it. They are responsible for all aesthetic and artistic feelings. The city is the result of a complex matrix of historical and contemporary buildings. It grows and stratified by the buildings which are edifying the city history, which are freezing the time. And today we should regret, that often, we are not taking into account already existing urban reality and we are building modern structures on the basis of the destruction of old. We are creating a new urban places, according to the separate organization or economic interests.

If we want to have a healthy and sustainable developing environment, we should be obliged to realize, that by endless destructing, reformatting and imitating the past, we can not ever talk about sustainable developing reality in our cities. Every healthy environment needs the historical buildings.

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REBIRTH OF NATIVE DESIGN IN THE EARLY PERIOD OF INDEPENDENCE OF REPUBLIC OF ARMENIA

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Keywords: Native design, design activity, market economy, Armenia

Abstract. The design activity, as a driving force of the market economy, has been considered. The key stages of the native design rebirth in the early period of the republic independence have been analyzed. The causes of occurrence of the mentioned stages and the ways of their development have been introduced in detail.

1. Introduction

The independence process of the country has set forward a number of important issues related to the stages of the historical development of design, its national peculiarities and the strategic tasks of organization, management and development of the design service in the republic.

The historical sources of design in Armenia are connected with the development of science and engineering, various branches of industry, as well as the continuous development of the consumer market and demand [1]. Many issues of the modern creative activity are rooted far back in ancient times. Studying the conditions of occurrence of those issues, their changes in different periods of time, the means, the ways of solving the problems, etc, that is knowing the history of the limits of the design activity, one will have an opportunity to expand the range of issues set to modern design and solve perspective problems.

The ways to solve numerous problems of the creative activity in the sphere of design go back to the ancient times of the history of national arts. In Armenia, the process of creating prerequisites for the design activity is based, on the one hand, on the object environment of national world advanced art and culture, the urban environment, and on the other hand – the development of science and industry.

From the 1980s of the 20th century, in the Armenian design appeared a number of new trends which became quite relevant for the whole country in that complicated period of time, which by the intensity of events, was perhaps comparable only with the 1920s of the 20th century[2].

Let us try to discuss some of the essential peculiarities of the phenomenon of the *new Armenian design* and outline the perspectives of its development in the 21st century.

2. Methodology

The first thing that had taken place in the Armenian society was the complete loss of interest in the fate of the design by the State as a consequence of the economic and political changes which had essentially affected the evolution of the native design. The formation of the Union of Armenian Designers of Soviet Armenia was the last official step to support the new creative activity.

As a result of the “reform”, many designers lost their jobs and had to quickly re-qualify as designers of graphs and urban environment. The sphere of advertisement expanded rapidly. In the late 1990s, about 500 advertising agencies were operating in Yerevan. The situation was almost the same in the areas of architecture and construction. Previously incredible financial means were invested in the architecture of expensive apartments and high-rating offices. Thousands of interior designers, architects, and decorators acquired rich experience in the nonstandard creative work. The bases of the speciality wavered towards the servicing technologies. However, certain future trends were visible behind that process. In the first place, the intensive development of the interior business raised the interest in the design and production of nonstandard devices, furniture, and light fittings.

The period of isolation had a harmful impact on the Armenian design, first of all – the moral state of designers, and this found its reflection in the theory of the native design.

The Gorbachev "perestroika" gave birth to medium and small-sized businesses, created large native organizations which could spend considerable sums of money on design. The volume of orders in the sphere of advertisements, as well as architectural design and decoration of residential and public interiors sharply increased. In these very spheres the revival of the native design started. Now, it was theory that hung behind the practice.

Step by step, post-Soviet Armenian design started to actively be incorporated in the world creative activities. Its achievements also became recognized abroad. Many of the Armenian specialists became demanded in the West. Some left for foreign countries to carry out their professional activities, and others went abroad to specialize and deliver lectures. It led to a feeling of a conviction in one's own unique style in design.

The second sphere that recovered the design activity was the urban environment. This was evidenced by the fact that the State began to coordinate the sphere of design in the country and this is proved by the fact that the post of the chief designers with corresponding subdivisions was established. A massive struggle started against the destruction of the urban landscape, obsolescence, inconvenience, and dullness.

The third wave was directly connected with the advertising activity, including printing, external advertising, and to a lesser extent – TV advertisements. The commercial agencies in regions employed hundreds of designers who mastered the computer technologies rapidly and made a considerable progress in the sphere of technical performance coming to some extent closer to the international level.

The fourth wave was the intensive development of cottage construction, the appearance of unique architectural objects (banks, offices of large organizations, hotels, supermarkets) in the capital and regional centers.

Eventually, the fifth component was the design education. The preparation of specialized designers in four-five years was a success. These designers, having the required qualification and a strong creative will, were quickly involved in the army of practical partners and stimulated the creation of healthy competitiveness within the market of design services.

The generation shift in practical design took place in the 1990s. The specialists, whose professional skill had begun to be formed still in 1980s became very active. A more interesting situation arose in the graphical design, where a few dozens of people made a rapid progress becoming leading specialists. A similar process was also going on in the sphere of architectural design.

3. Results

The new, marketing stage of the economic development of Armenia opened new areas for entrepreneurial opportunities in the sphere of the creative design. The advertising business is directly related to design, and the great resource of designers involved in it is conditioned by that fact [3]. In the 1990s, hundreds of specialists from the Armenian Diaspora came to live in Republic of Armenia promoting the development of the advertising sphere.

The marketing mechanism brought forth the competitiveness – a phenomenon which did not exist in Armenia before that [4].

The study of the modern practice of the Armenian design can create a feeling of its spontaneity and chaotic state.

Actually, the frame of the old "building" of the state design had practically been ruined in only a few years, while the new marketing skeleton was just being formed. Now it is difficult to predict how long its construction will take. Much will depend on the political and economic situation in the country.

4. Conclusion

The place of design and its role in the state structure is enormous as a lever for the development of the economy. The issue of management of design in the republic, in the period of modern reforms should be worked out. It is connected with the advance of the market economy, privatization, and the free development of the creative activity. Under the conditions of the market economy, a special attention is paid to the relation between the designer and the consumer, thus promoting the design activities and emphasizing the ways of its creative quests.

The task of the present-day generation of the Armenian designers is not to lose the skills which they have acquired in the previous period, to retain and enrich the peculiar school of national design, and aspire to further the native design in the world.

Acknowledgements

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PORTALS AND WINDOW APERTURES OF THE MONASTERY COMPLEX OF GOSHAVANK

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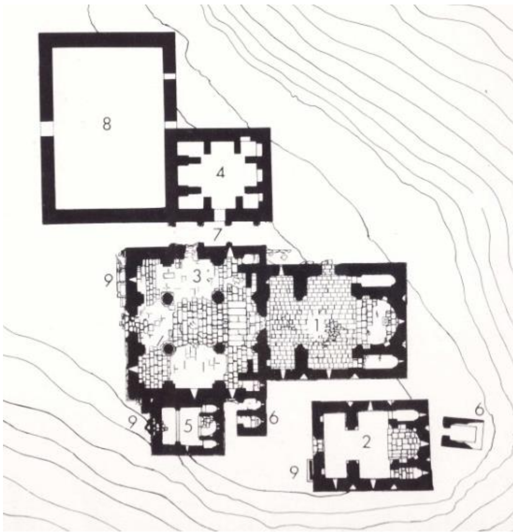
Keywords: Art decoration, portal, tympanum, window arched profile, ornament

Abstract. The external artistic decoration (portals, niches, arches, capitals, ornamental decoration) of one of the monasteries of medieval Armenian architecture, Goshavank are studied. The buildings of the monastery complex have planning, structural and compositional features of the 12th and 13th centuries meantime they are distinguished by original decoration. The article attempts to identify the compositional features of the artistic decoration of the monastic complex, the origins of formation, as well as their influence on the means of artistic expression of various monuments of Armenian architecture.

1.Introduction

Goshavank is one of the most valuable monuments of the Armenian medieval architecture of the Zakaryans period (12-14 centuries). The construction of the monastery complex began in 1188 till the first half of the 13th century by the initiative of Mkhitar Gosh on the site of Getik Monastery, destroyed by the earthquake (1186). Giragos Gandzakeci notes that first a church was built "... and a beautiful church was built of wood and was consecrated for the sake of Gregory the Illuminator ", later in 1191 construction of the St. Astvacacain main church followed [1]. Later the narthex, St Gregory and St. Gregory the Illuminator churches, Bookstore-Bell Tower, St. Hripsime and St. Arakelots chapels and the chapel-auditorium were built (Fig. 1).



Regular numbers
St. Astvatsatsin church, 1191-1196
St. Grigor church, 1208-1241
The narthex, 1197-1203
Book depository -Bell Tower, 1241-1291
St. G. Lusavorich church, 1237-41
St. Hripsime and St Arakeloc chapels, 13th century
Hall-gallery, 13th century
Chapel-auditorium 1241
Khachkars

Fig.1. Goshavank master plan

From the historical sources on the construction of the monastic complex, we have come to the names of three masters, architect Mkhitar (Mkhitar Hyusn), his pupil Hovhannes and the unique sculptor Poghos. Especially the artistic decoration of the complex shows the boundless imagination and great skills of the masters of stonemason. The main emphasis in the design of each structure is on the portals and window apertures, which are typical for the 12th-13th centuries, and are characterized by a unique artistic decoration.

2. Methodology

The main church of the monastic complex St. Astvacacin has two portals to the western and northern facades, which have the same composition: the twin pilasters are crowned with a two-dimensional archs. The second, St. Grigor church and the book depository-bell tower of the monastic complex have similar composition.

The western portal of the St. Astvacacin has a pretty graceful decoration, the right and left sides of the portals are decorated with ornaments of different vegetarian and geometric shapes, and the semi-arch is decorated with geometric elegant ornaments with circle and diamond-shaped combinations.

The northern portal is simpler by its design, only the capitals that have a simple ornamented chain composition. This ornament could be found also in St. Grigor Church's western portal of the twin pillasters, and at the top of the arch. The tympanum of the latter is decorated with an inscription (Fig. 2).

Western portal of St. Astvatsatsin | *Eastern portal of St. Astvatsatsin* | *Western portal of St. Astvatsatsin* | *Portal of Bell-Tower*

Fig. 2. Portals with circular archways

The similarities of the portal composition are found in the Kecharis St. Grigor the Illuminator (1013) and St. Nshan (11th-12th centuries), Hovhanavank St. Karapet (1216-1221), Haghpat Church of St. Grigor and other churches (Fig. 2). This is evidenced by the fact that this type of portal carries a typical stamp of that period.

Window apertures across the entire perimeter of St. Astvatsatsin and St. Grigor churches' are also made of structural ornaments This ornament with different solutions can also be found in many other structures of the 12th century (Makaravank, Kecharis, Haghpat, Hovhanavank and others).

From the western side of St. Astvatsatsin church is enclosed narthex. The ornament of narthex portal is made of a two-colour, black and red tuff (Fig. 3). The tympanum is designed with lithographic inscriptions. Creation of decorative tympanum from stones of different shapes and colors has been used in ancient Armenian architecture since the end of the 12th and early 13th centuries [2]. There are many examples of the latter: Makaravank, Nor Varagavank, Teghenyac Monastery, Saghmosavank and others.

The portal crowned with arch is involved in a rectangular circle made of chained ornament. The similar composition was later used in the narthex of Kecharis (12th century), Makaravank (1205), Geghard monastery (1215-1225), Haghpat St. Astvatsatsin (13th century) and other churches (fig. 3). This makes it possible to suppose that such an invention of the Goshavank narthex was a prototype for some structures of later centuries.

The portal thanks to its composition and stone polychromy (polygamy), it stands out from the plane of the wall, becoming a dominant, emphasizing the structure's composition center.

Goshavank Narthex 1197-1203 | *Kecharis Narthex end of the 12th century* | *Makaravank Main church 1205* | *Geghard Monastery Katoghike 1215-1225* | *Haghpat Monastery St. Astvatsatsin 13th century*

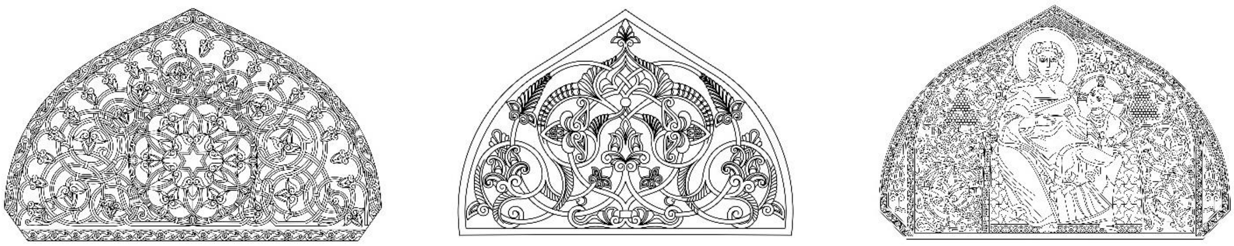
Fig. 3. Samples of portals included in a rectangular frame

Ornamental art has reached its highest perfection at Grigor Lusavorich church’s artistic decoration. Every detail of this small, ornate church is made with great care and skill. All facades, exquisite arcades, window frames, capitals, ornamentation, and miniature ornamentation in the angular triangular stones of the western and eastern facades have been elaborated in detail. A masterpiece of ornamental art is the portal. It has a composition typical to 13th century; the rectangular opening of the portal is decorated with a square-shaped, two-layer carved crown, which is included in a richly colored rectangular frame. The latter is designed with lacy complicated ornaments. This type of portal is mostly encountered in many monuments of that era (Geghard Monastery, Tegher Monastery, Sanahin Monastery, Nor Varagavank, etc.) (Fig. 4).

Geghard Monastery Narthex 1215-1225 | *Tegher Monastery Narthex 1221-1232* | *Sanahin Bell-Tower 13th century,1st half* | *Nor Varagavanq Narthex 13th century* | *Gosh. St. G. Lusavorich 1237-41*

Fig. 4. Arrow-shaped portals with archway

Particularly luxurious is sculpted the tympanum of the portal, which became an important artistic expression in the 12th -14th centuries. In the tympanums of that period, we find both vegetarian and geometric (Goshavank, Ayrivank, etc.) and depicting ornaments (Hovhanavank, Noravank, Areni Church, Spitakavor Monastery, etc.) (fig. 5).

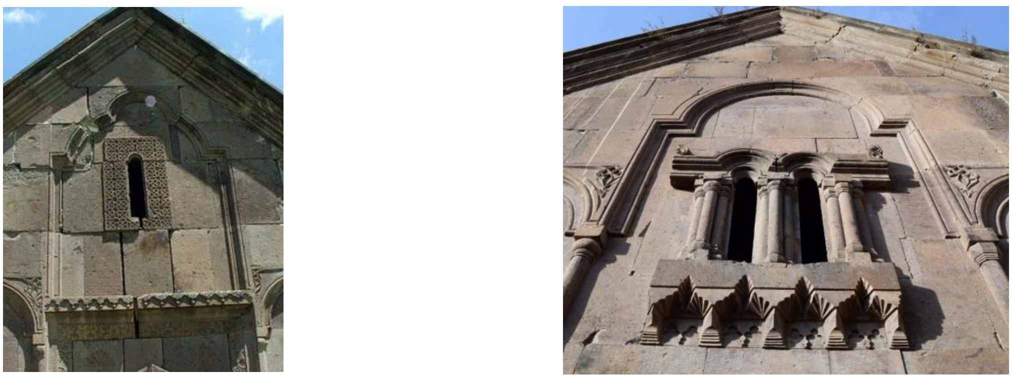


Goshavank *Ayrivank* *Areni church*

Fig. 5. Examples of Sculptured Ornaments of Tympanums (by S. Azatyan)

The slabs and anchors of the capitals are ornamented as well. The rectangular frame surrounding the portal archway was elegantly designed and its upper edge is decorated with a row of pomegranate fruits that date back to the early Middle Ages (7th century: Zvartnots, Katoghike church of Talin, Garnahovit, Sisavan and other churches). The geometric ornamental patterns on the two sides of the portal have a delicate, elegant and highly complex design of the six crosses created from the cross-section of two equilateral triangles, the originals of which are also reached in the early Middle Ages (7^{th} century) and are widely spread especially in the 12^{th} century, particularly in khachkar art [3]. In all ornaments, the master has used gentle-shaped vegetarian and geometric ornamentation, as well as traces of cochineal.

On the vertical axis of the portal is a window aperture, which is surrounded by a whole circle in a rectangular sculpted circle and emphasizes the composite center. It is fitted with a triple crown, rotating around the whole frame of the structure, in an arcade. On the vertical axis of the eastern front, in a common archway, there are double arched window apertures whose beveled columns rest on a stalactite-treated cornice.



Western Facade *Eastern Facade*

Fig. 6. Facades of St. Grigor Lusavorich

Similar solutions to the window apertures can also be considered a peculiarity that characterizes the given era.

3. Conclusion

Goshavank Monastery with its decoration of portals and window apertures is a clear testament to the stylistic features of Armenian medieval architecture (12^{th} -14^{th} centuries). In the exterior, the main emphasis is on the portals. Here we find the following types of inputs, typical for 12-13 centuries: Here are the following types of portals typical of 12^{th} -13^{th} centuries:

- Pair of pilasters deepening from wall to staircase with crowns,
- Included in a rectangular circle, crowned by circular walls, which has become a prototype for other structures of later centuries.
- Included in a rectangular frame, crowned by archs;
- The processing of the tympanum with the use of double-sided stones, inscriptions or elegant, embroidery ornaments

Acknowledgements

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MORPHOLOGY AND STRUCTURE OF THE PLATONIC SOLIDS FROM A CHINESE INTERPRETATION

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Keywords: Platonic solids, structure, Lai Taiji Diagram

Abstract. In two precedent article, in Beijing in 2018 and Barcelona in 2019, the confrontation of Platonic solids with Chinese Elements allowed the hypothesis of their *correspondence*, morphological and structural. This one of Beijing proposed a spatialized *geometrical organon* - with reference to M. Serres - for architectural purposes.

This understanding *facing each other, one through the other*, continues to reveal unthought - following the methodology of F. Jullien. The research developed in this article will exploit another configuration – a new spatial organization of regular polyhedra for an unexplored vis-à-vis with a "swirling" variant of the *taijitu*, the *Lai Taiji Diagram* (來 氏 太極 圖)

The selection of a particular sequence - nested storing - of the polyhedra according to *wuxing* - makes it possible to imagine a minimal 2D geometrical representation - diagram - which clarifies the cosmogenesis related by Plato in *Timaeus*.

This minimal figure justifies the hypothesis that this morphogenesis of regular polyhedra builds / fits between two external formal boundaries, two dual tetrahedrons - the other polyhedra deploying in the space between.

This figure / diagram also reveals structural properties that make it possible to link geometric shapes to their constructive potentialities - thus reconsidering the notion of form in an open sense of the *Life of forms* in reference to Focillon and by connecting their different dimensions *structurales* and *structurelles* - difference that allows the French language according to A. Rénier's work.

Finally, this new research allows extending the work of T. Wester on the structures of polyhedral surfaces. This knowledge, which links geometry, morphology, structure and construction, opens up new perspectives for the design work and architectural education.

1. Introduction

Previous research has allowed establishing a correspondence between the 5 *Platonic solids* and the 5 *Chinese elements* - presented to the 10th ICCPAC in Beijing [1]. The challenge was the possibility of conceiving the system of regular polyhedra as a cycle of "geometric growth", not only to better understand the cosmogenesis of Plato (*Timaeus* 53c); but also to qualify these different forms: what interests the designers of space, the architects in the first place.

By integrating these elementary bricks of space into the classification of correspondences in connection with the 5 elements of the Chinese tradition, we can establish correlations as much with *structurel* properties (in the sense of civil engineering) as with *structural* [2] properties of polyhedra: colours, orientations, *materialities*... and connect with the functioning of the human body, as envisaged by Traditional Chinese Medicine - thus with effects on health and well-being. Then, this same research proposed the development of a geometric *organon* - in the sense of Serres [3] - with the objective of making an architectural project.

This article is based on this first research - and another work on a critical reading of T. Wester's research [4]; it aims to better understand a new *organon*, not discussed in the previous article, which has similarities with the Chinese *Taijitu diagram of Lai*. The challenge is to determine what implications this new *organon* has on the properties of architectural structures. A return to the central point of the argumentation of the polyhedron/elements matching and its logical development will serve as an introduction to this new research.

The method followed is the same as before: to put in vis-à-vis elements of Western culture with elements of Chinese culture, to understand from an outside point of view: "Learn the Chinese to better read Plato" [5]. To organize a vis-à-vis – a face to face - is to maintain a co-presence that necessarily creates a tension - as in an electric battery. To make work this tension is to let the *translations* appear; let happen to new meanings on both sides. This epistemological strategy makes it possible to unveil the unthought of a culture [6].

2. The notion of Chinese *center* as origin for the correspondence between Platonic body and Chinese elements

To clarify the dual quality of the *center* in Chinese culture, let us recall the starting point of this research, the figure of J. A. Lavier which explains the line of separation of the cycle of the *nycthemeron* oriented at 45 ° - which makes it possible to determine the hottest moment at 15 o'clock in the southwest and the coldest at 3 o'clock in the northeast. The next diagrams help to follow the progress of the demonstration.

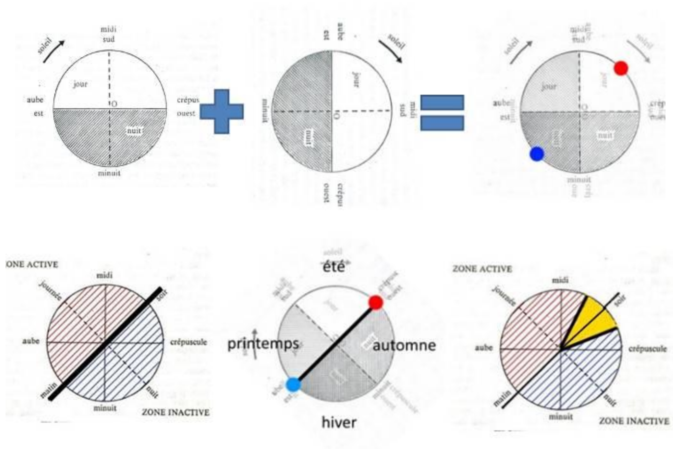

Fig. 1 The inclined line, separating the two phases [7]

Initially, it is the time lag of six hours - 90 ° between the transmitter/sky (vertical axis) and the receiver/ground (horizontal axis) on the diagram - and the superposition of their cycles that organize this *center*, identified by the inclined line, separating the two phases, yang-anabolic / yin-catabolic [8].

With this passage from the yang-ascending period to the yin-descending period, the Chinese tradition identifies and manifests the existence of an intermediate period, a middle one - the 5th element. This *center* expresses the paradoxical, double nature of the Chinese element *earth*, because it is at once a spatial center and a temporal center [9]. Besides, J A Lavier points out that the spectrographic analysis of the yellow color associated with this element has a central discontinuity, it can be concluded that there are two yellows [10].

3 Tetrahedron: *central* polyhedron

When we organize the *facing* of the 5 elements with the polyhedra, only the tetrahedron has this double potentiality, it belongs to both series at the same time: yin-logical *face* with increasing number of edges TCD (Tetrahedron, Cube, Dodecahedron) and yang-logical *vertex* whose number of edges increases IOT (Icosahedron, Octahedron, Tetrahedron) Thus the tetrahedron is transformed into itself, by duality. [11]

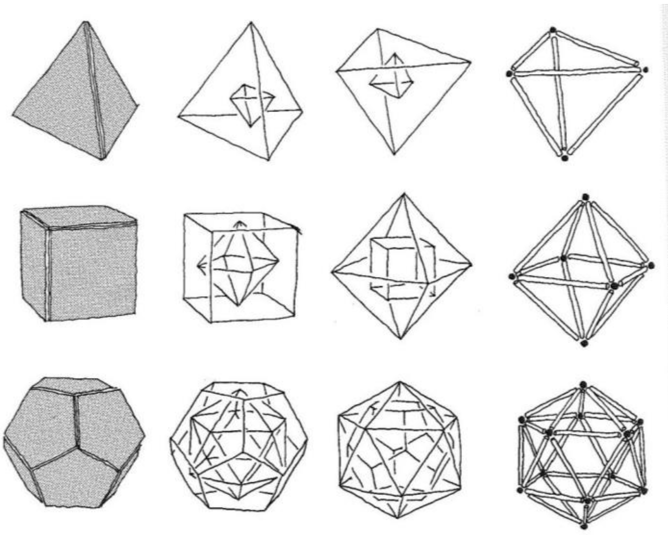

Fig. 2 Two series of polyhedra Wester's representation

From this identification of the tetrahedron as *center* - considered as an origin for the system of polyhedra - the correspondence between the 5 *solids* and the 5 *elements* then unfolds logically.

If we take into account the geometric possibility of storing the polyhedra into each other like Russian dolls or *Chinese boxes* - *Chinese boxes* are a set of boxes of graduated size, each fitting inside the next larger box - so that it takes very little space: their generation - in the sense of a growth - becomes obvious and is done by two sequences of successive nesting:

- The tetrahedron is inscribed in the cube, which is itself inscribed in the dodecahedron.

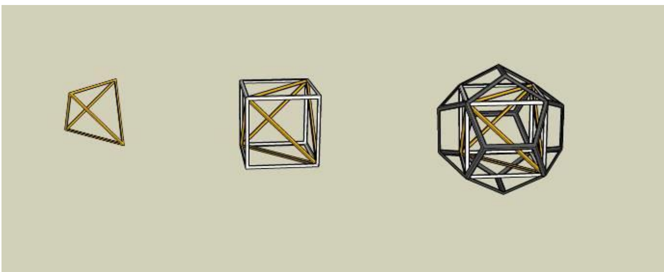

Fig. 3 Nesting of Tetrahedron, Cube and Dodecahedron

- At the level of the dodecahedron, there is duality transformation for the passage to the icosahedron - in this direction of rotation imposed by the *geometric growth*.

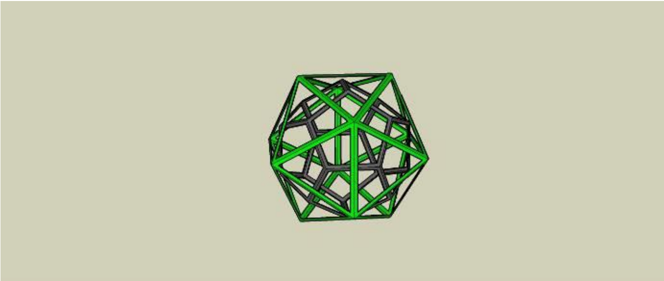

Fig. 4 Duality dodecahedron to icosahedron

- Then the icosahedron is inscribed in the octahedron, which is itself part of the tetrahedron.

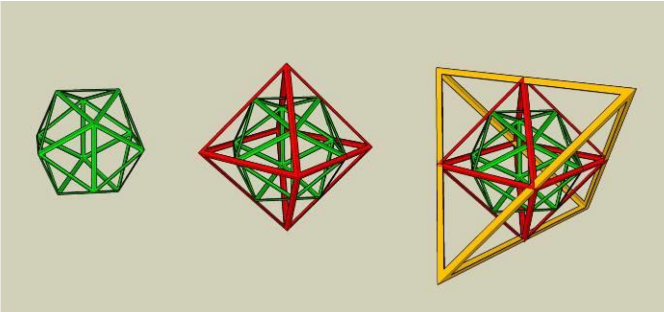

Fig. 5 Nesting Icosahedron, Octahedron and Tetrahedron

It is the spatial organization of the five polyhedra, as condensed as possible. As we associated the tetrahedron with the *earth* (yellow), the cube goes to the *metal* (white), the dodecahedron to the *water* (black or blue), the icosahedron to the *wood* (green) and the octahedron to the *fire* (red). We return to the *earth* tetrahedron (yellow).

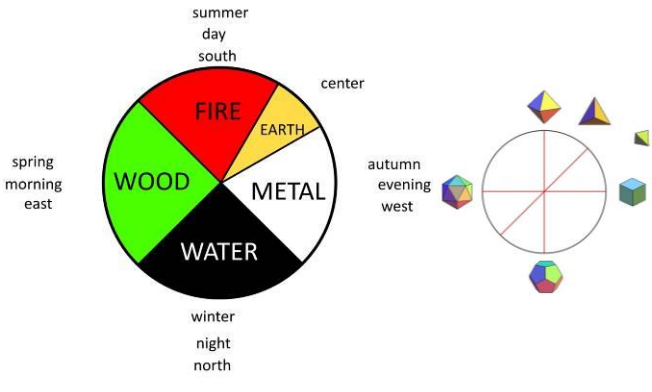

Fig. 6 Correspondence platonic polyhedra/wuxing

The coherence of this *sequence*, in correspondence with *wuxing* (五行, 5 *elements*), is also corroborated by externalist approaches [12]. So from tetrahedron-*earth* to tetrahedron-*earth*, we go from a small tetrahedron, to a larger one, dual of the first.

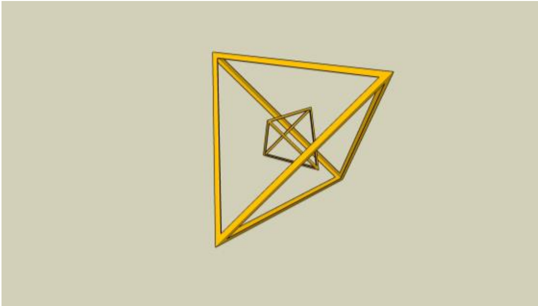

Fig. 7 From tetrahedron to tetrahedron – duality

4 Hypothesis, *model* of transformation of Platonic solids

At this stage of the reflection, there are two possible choices:

- Either this large tetrahedron continues to grow with the next cycle - and the geometric growth operates indefinitely.
- Or the large tetrahedron generates, by dual transformation, a smaller one: the same than in the beginning of the cycle.

This second hypothesis would make it possible to imagine a cycle with invariable dimensions, thus a unique *model* without particular measures. This is all the more likely that the season that corresponds to this central orientation (Southwest) is the time of the harvest. So we can think - metaphorically - that the cycle is reproduced with its seed in a new cycle ... Whatever the hypothesis considered this does not change the presentation below.

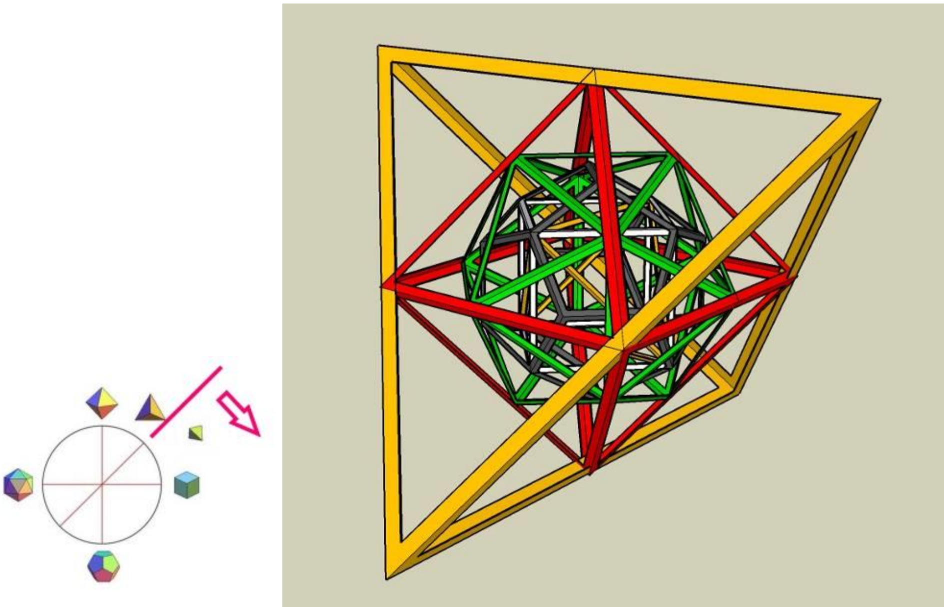

Fig. 8 Particular sequence of nesting of the 5 polyhedra

Returning to this *minimum interlock*, let's try to reveal new unthought from Chinese to Greek. This makes it possible to dispense with the usual representations that combine geometry with Greek elements and remain enclosed in a single culture – see Kepler [13], for example, who looked for nesting with intermediate spheres, but also R. Motro [14], who considers the four polyhedra inscribed in an external dodecahedron, because presumed the "form of completion" according to Plato.

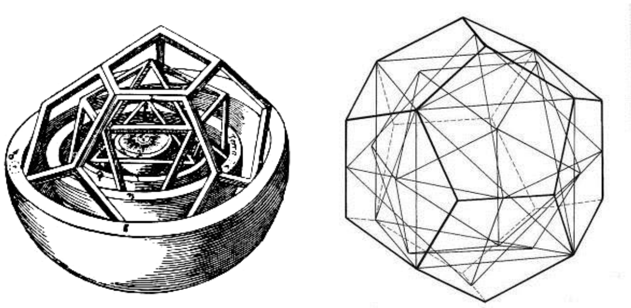

Fig. 9 Exemples of other nestings (J. Kepler, R. Motro)

5. Face to face with the Chinese diagram of *Lai Zhide*

With our hypothesis of correspondence, the large tetrahedron that generates the small dual one and the choice of this "tetrahedra tetrahedra" sequence (TCD-IOT), we have seen that it is difficult to organize differently the succession of polyhedra in space. We can imagine that this scheme of minimalist nesting forms, alone describes the cosmogenesis of Plato. There is nothing outside the great tetrahedron, nothing either inside the small one: only the four polyhedra unfold between these two limits, the two dual tetrahedra bounding this morphogenesis.

At this stage, the idea of rapprochement of this configuration with the Chinese *Taijitu Diagram of Lai* [15]- named after its creator Lai Zhide - imposes itself. Lavier comments on this diagram as follows: he "gives an account of the whole of the manifestation in relation to the Wou (emptiness), that is to say, the finite with respect to the infinite (...) [16].

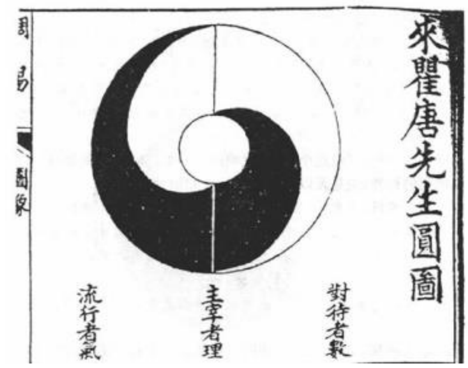

Fig. 10 Chinese Taijitu Diagram of Lai

This new correspondence will allow to "read" this Greek configuration from the Chinese cultural referential. This leads to organizing the geometric information in *diagram* too, thus to represent the polyhedral transformation sequence with an appropriate tool. This is possible with descriptive geometry and the simplest 2D projections - with 2D software: for example GeoGebra, which, in addition, allows dynamic constructions.

6. Representation of the nesting polyhedra in descriptive geometry

6.1. Beginning of the Process

To "activate" this Chinese interpretation and to simplify the representation of the nesting arrangement as much as possible, the choice of views is essential.

Each polyhedron has special orthogonal projections and rotational symmetry, as it is placed on one face, a vertex or edge [17]. We will get explicit representations of the three polyhedra - Tetrahedron, Cube, Octahedron- in Vertical Projection (VP), and Dodecahedron and Icosahedron in

Horizontal Projection (HP) by choosing to place the cube on a face in space (octahedron will be on a vertex) and other polyhedra on one edge.

For the construction method of the TCD-IOT series, the simplest to represent is first the cube, with its dual octahedron. We do not detail the geometric constructions here. But note that to design the octahedron in VP, we need to orient the cube on its diagonal in HP.

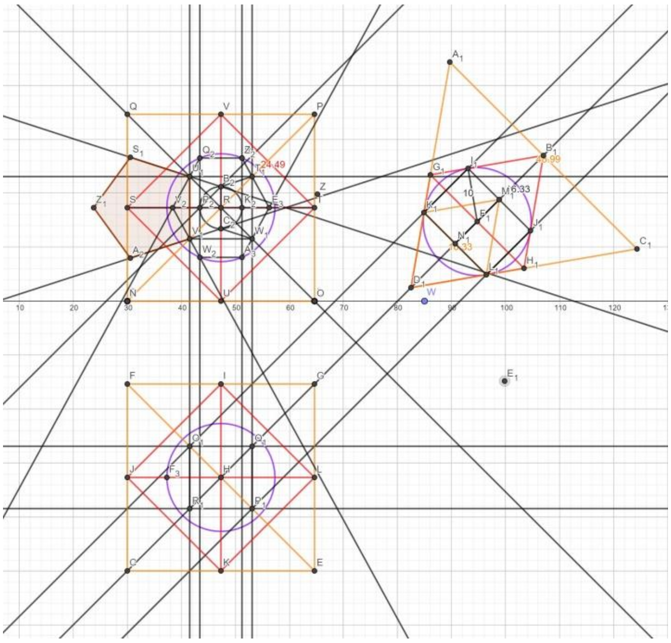

Fig. 11 First design test of nesting

6.2. Three comments

* We finally represent, on the same drawing, the 6 regular polyhedra - with the possibility to use their corresponding Chinese color. We could even keep only the vertical view (below), which clearly shows the two nested tetrahedron and the four intermediate polyhedra - a section would express better the meaning of the Chinese diagram.

* Moreover, this simplified representation can explain an implicit choice until now: the orientation of polyhedra with respect to the horizontality of the *ground*. The cube with two horizontal faces corresponds to tetrahedron *placed* on an edge. This particular geometric configuration is consistent because the tetrahedron as a polyhedron and the edge as a polyhedral component - see below - both correspond to the Chinese *central* element. The "V" vertical projection is an east-west view, as was developed in the paper presented at the 10th ICCPAC conference.

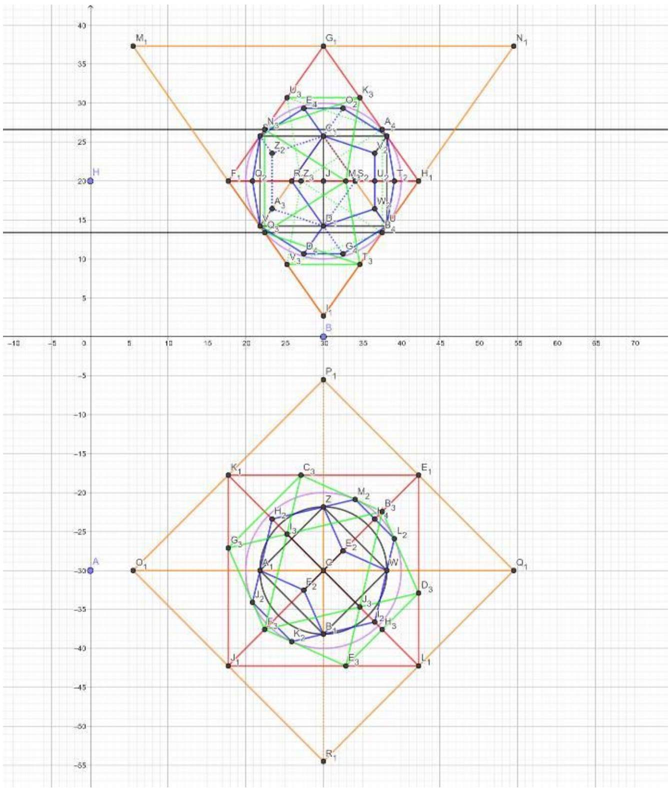

Fig. 12 Final design of the six polyhedra nesting

* Concretely, we could hardly envisage the construction of this geometric diagram without using in the different stages of drawing the geometrical properties of a particular sphere: the sphere inserted in the dual passage from the dodecahedron to the icosahedron. It is the sphere circumscribed of the dodecahedron, and also of the cube and the small tetrahedron, but at the same time it is inscribed itself in the icosahedron, the octahedron and the great tetrahedron: therefore this same sphere is common to the two series of polyhedra.

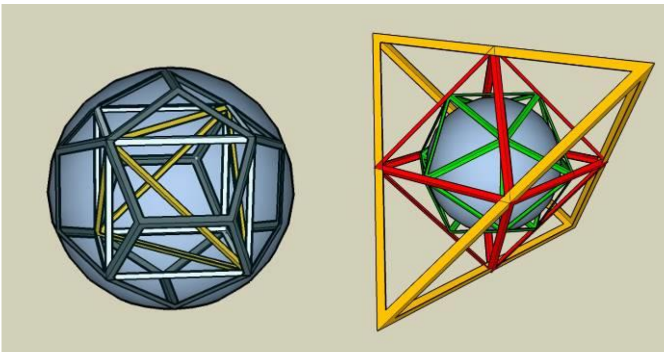

Fig. 13 Same sphere circumscribed TCD, inscribed IOT

The role of this sphere is essential not only for its geometric properties but also because, to represent it as a central landmark, helps to better "see" how polyhedra articulate with each other in space- since it becomes the support of all polyhedra, the TCD series by its vertices, the IOT by its faces.

So if we come out of a strict geometrical interpretation by making a model, this configuration already implies of itself two constructive modes. With a sphere model in rigid transparent material, the inner polyhedra can only be fixed by their vertices – rigid connections in wire model for example; the outer polyhedra can only be supported by the middle of their faces - rigid too.

Structurally, how to characterize these two constructive modalities? This question makes it possible to link with an article on a critical reading of the works of Ture Wester based on the concept of *mechanical duality* [18]. The aim of this article is to define the 3 possible structural modes to stabilize a polyhedral surface - always using Chinese thought as "external lever".

7. Three Structural Modes of Polyhedral Surfaces: Critical Reading of Wester's Research

This article proposed for the 60th anniversary of the IASS - International Association for Shell and Spatial Structures – [19] is based on the polyhedron/*wuxing* correspondence and on the fact that at the scale of a polyhedron, the geometric elements - which allow stiffness - can only be *vertices*, *faces* or *edges*. *Vertex* and *face* being in a duality relation, the *edge* plays the central role of Chinese "earth": it is therefore "double", as the tetrahedron.

These remarks make it possible to consider polyhedra not only as purely geometrical beings, but as real structural morphologies. Let's summarize here the conclusions of this research because it will enable us to connect the *diagram* with structural properties.

Based on analogue models and the Chinese interpretation of *wuxing*, it is shown that there are only three theoretical types of configurations to ensure the stability - bracing system - of any regular polyhedron and polyhedral surfaces in general. Each of these three types uses only one constituent, *plate*, *pod* or *truss member*.

7.1. Plate

For the geometrical *faces* correspond the building mode by assembling the *plate* - wall bracing in engineering - which resist in their plan. The hinges which allow assembly, receive longitudinal shear stresses. A building set *Zaks* allows modelling this structural type.

Fig. 14 Logic of plates with the building toy Zaks

7.2. Pod

At kind of *multipod* element - assembled without intermediate *edge* - corresponds the geometrical *vertex*: these multipods -which can be *tripods*, *tetrapods* and *pentapods* - are inspired by the concrete structures of the artificial dikes [20].

Fig. 15 Tetrapods of Gorky East Gorwater Breakwater

This case corresponds to gantries in engineering, it works with rigid connections. The lower part of door hinge – "gond" in french - allows assembly: it works here in radial shear. *K'nex* is a construction toy that allows making this type of model.

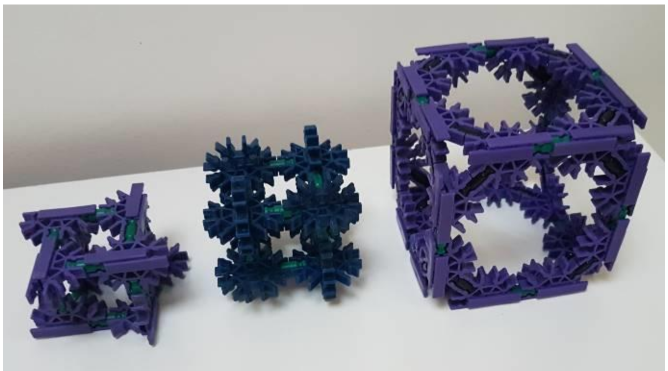

Fig. 16 Logic of pods with the building toy K'nex

7.3. Truss member

The geometric *edges* correspond to a construction mode by assembling "*truss member"*, whose structural behavior is double - traction and/or compression - and therefore more complex. The research shows how it is possible to structure each of the polyhedra from an interaction between two types of elements (members), *compression strut* that serve to keep the faces apart and *tension rods* that join the vertices – *two-force member* mixes the two functions in the same time but it's a particular case. In this structural mode, the end of the *tension rods* serves to support the ends of the *compression strut* (as with *K'nex* model). This archetypal mode corresponds to the different families of *truss* in engineering – including *tensegrity truss. Geomag* building sets allow illustrating this structural mode – but *K'nex* too with rubber bands.

These results - as Wester had already thought about - make it possible to establish continuity between geometry and structures.

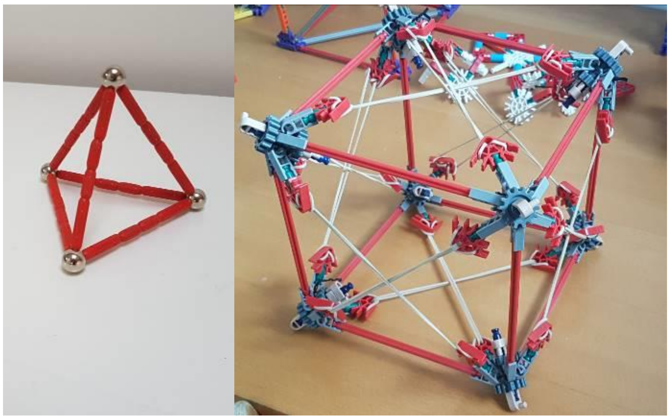

Fig. 17 Logic of truss members with Geomag and K'nex

8. From a geometric Platonic model to a mechanical Platonic model

Introducing this continuity geometry/structure in our thinking makes it possible to complete and better understand the properties of the nesting polyhedra. During the transformation of the large tetrahedron towards the small (that we can imagine without the others), there is a change in size and orientation in space, but also a dual geometrical transformation: the *vertices* of one turn into *faces* of the other and vice versa.

But, with the previous project of model, we have seen that:

- The large tetrahedron is necessarily made of *plates* - it could be called *tetrahedron-plate* - the reverse being not possible.
- It will therefore generate the small tetrahedron - which becomes the *tetrahedron-pod*: the *pods* - rigid angles - of the small tetrahedron being fixed inside the *plates* of the big one.

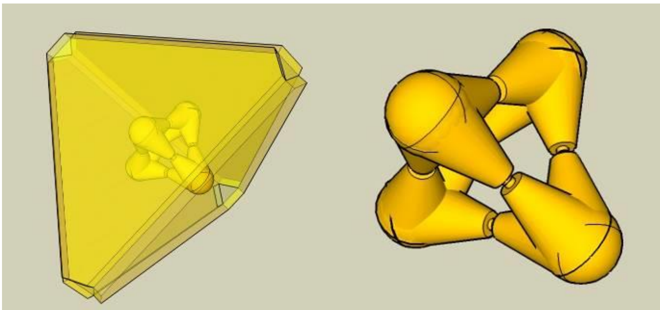

Fig. 18 Tetrahedron-plate and dual tetrahedron-pod

- Similarly, in the northeastern passage, the *Dodecahedron - pod* is transformed into *icosahedron-plate*.
- in addition to that we must imagine that the 3 polyhedra of the TCD series "have in common" portions of *pods*, as the series IOT "share" *plate* portions.

Finally, to link geometry and mode of construction allowed beginning to change a purely geometrical Platonic model by a *platonic mechanical model* and this model shows an interesting result. Whereas up to now, the *yin* TCD series was considered as the *face* logic series (see Wester figure 3); and the other series IOT *yang*, with logic of *vertices*: the above analyses show exactly the opposite.

The model shows that the *yin* TCD series (Tetrahedron, Cube, Dodecahedra) is the *pod series* (i.e. rigid connections) and the *yang* IOT (Icosahedron, Octahedron, and Tetrahedron) is the *plate series*. It would be another step to develop: identify in the same way the role and the theoretical place of the *truss member* corresponding to the *edge* in the nesting diagram...

9. Conclusion: Chinese thought to better understand the structural morphology

Finally, this simple nesting diagram opens the way to more concrete thinking: it provides a theoretical framework for practical applications. For example, this research consolidates some intuitions of Wester, the logic of wall bracing with *plates*, thus associated with *yang* - which is counterintuitive because a *plate* seems heavier - are a way of building that could be described as economic and more integrated [21].

This is all the more coherent as the wood material corresponds to the *yang* series - Chinese *wood* element, and maybe the glass, which could correspond to the *fire* of *wuxing*. Wester has developed many possibilities for faceted surfaces with constructive *plate* logic with wooden construction [22].

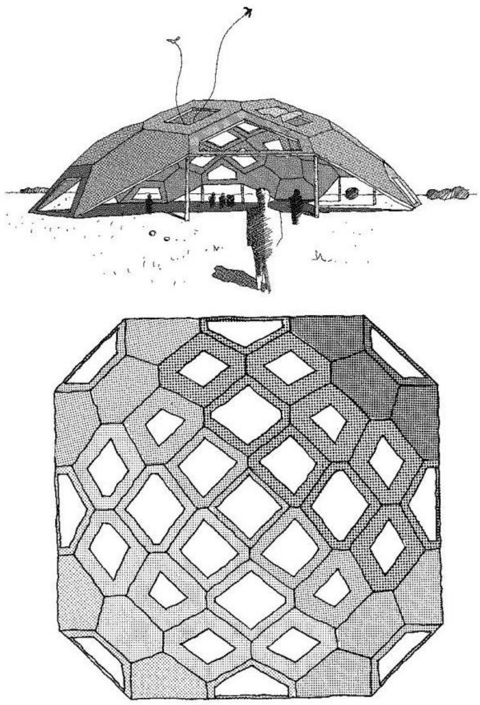

Fig. 18 Wester's architectural project

Conversely, the *pode* mode which uses rigid connections - without intermediate edges to avoid bending stresses - is a heavy and rather massive constructive solution, which is little used; but it remains consistent with the use of *metal*, the material associated with the *yin* series.

Finally, the correspondence with the Chinese diagram makes it possible to link the *structural* - morphology, associated meanings... - and the *structurel* - mechanical, construction, materials... - to extend our understanding of *polyhedral forms*. In particular, it justifies the fact that truss structures are a central and at the same time an elemental solution: from the point of view of the Chinese *central element*, they are the basis of structures...

The conclusions of this theoretical presentation are numerous. New questions appear, future areas of research in geometry and structures: concerning the central sphere, the modes of transformations of the *faces* and the *vertices*, the place of the mode truss in the diagram… - bringing at the same time more explicit arguments in favor of Plato's cosmogenesis.

This research is a type of approach that reverses the direction of observation to return upstream to a more synthetic understanding - such as Joel de Rosnay in *The Macroscope* [23] - and tries to better understand the genesis and processes of transformation systems. After all, the approach followed shows that a multidisciplinary, even transdisciplinary, research can renew approaches, enhance the research and thus provide reliance operators to fight the compartmentalisation of knowledge [24].

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"CULTURE SHOCK" IN COMMUNITY BUILDING: A CASE STUDY OF BOX HILL CHINESE COMMUNITY IN MELBOURNE

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Keyword: Community building, culture shock, structured

Abstract. When it comes to community building, "culture shock" is a common issue. As one of the world's largest overseas Chinese communities, Box Hill in Melbourne, Australia, the phenomenon of "culture shock" is more prominent. Via the investigation on the community, when Chinese are faced with problems arising from the integration of multiple cultures, although they expect to get some help from the social environment, the reality is that most people can only deal with problems at the individual level. "Culture shock" is beyond human perspective challenge. The social environment take any position. Therefore, starting from the three aspects of enhancing individual cross-cultural communication awareness and ability, developing community organizations, and appealing to government participation, the use of structured coping strategies would help alleviate this phenomenon.

1. Introduction

When economic globalization, international migration has expanded the living space of human beings, promoted the integration of different ethnic groups and the spread of human civilization, and intercultural communication has therefore become an important part of people′s lives in immigrant communities. However, "culture shock" as an inevitable result of intercultural communication has caused serious obstacles to the integration of immigrants with foreign backgrounds into the new environment. In this regard, this article takes the Chinese community of Box Hill, Melbourne, Australia as an example to explain the phenomenon of "culture shock", deeply explores the root causes of "culture shock", and propose structured strategies for "culture shock" in community building.

2. The concept and performance process of "Culture Shock"

2.1.The concept of "Culture Shock"

Box Hill is located in Melbourne, Australia. As the largest overseas Chinese community in the world, a large number of Chinese people are in contact with Australian natives, which inevitably lead to different lifestyles, values and cultural cogitation. Many contradictions and conflicts have led to the phenomenon of "culture shock". The concept of "culture shock" was first proposed by the famous American cultural anthropologist Kalvero Oberg in 1960. It refers to the various psychological phenomena that appear after a person first enters a different environment. Physiological incompatibility is a kind of deep anxiety disorder that is psychologically unfamiliar to the social symbols of the other party because of the loss of the familiar social communication signals or symbols. It is a pathological reaction with its unique characteristics and healing methods (Oberg, 1960). The definition of the concept of "culture shock", other researchers in the academic field also have their own views. Among them, Bruce La Brack's evaluation of Furnham and Bochner's Cultural Shock: Psychological Response to Unfamiliar Environment pointed out that Culture Shock is considered to be a unique disease (Brack, 2002). But Levine and Adelman believe that "culture shock can help explain the feeling of confusion and overwhelming feelings" (Levine, 1982). It can be seen that the phenomenon of "culture shock" occurs in intercultural communication activities. It is an uncomfortable reaction of the subject and object of communication in the face of unfamiliar cultural symbols, psychological, physiological and social interactions.

2.2.The performance process of “Culture Shock”

“Honeymoon Stage”: Chinese who first arrived in Box Hill have a strong sense of curiosity and freshness about the surrounding environment, culture and foods: bustling clean streets, unique style buildings, artists camping places... all kinds of distribution with exotic things, they can share the joy of being an Australian. The “tourist” status at this stage makes life full of passion.

“Shock Stage”: After a period of time, the Chinese people′ s freshness gradually disappeared. They were faced with the fluster of unfamiliar culture,the loss of familiarity with the living environment, the chaos of cultural collisions and the anxiety of not finding the direction of life. Due to the differences in cultural background, values, thinking patterns and customs, people are more lonely and helpless, making it difficult to communicate effectively with local residents. At this time, “culture shock” has emerged, it is both the result of cultural conflicts and a dynamic process in which individuals adapt to the new environment.

“Restoration and Adjustment Stage”: After the last stage, the Chinese who immigrated to

Australia began to gradually become familiar with the environment, and found a way to live in a new environment through themselves. They can understand and make rational judgments about the behaviors of people around them, participate in social communication with a more positive attitude, and be able to cope with problems and find solutions in a flexible way.

“Recovery Stage”: During this period, the Chinese living in Box Hill can naturally analyze problems from the perspective of the local people, integrating the Australian culture with the Chinese culture. The self-intercultural communication awareness and ability have been improved, and the ability to adapt to the environment has also grown significantly.

3. The root causes of "Culture Shock"

The phenomenon of culture shock exists in all aspects of intercultural communication between Chinese and Australian. Its main roots come from the differences of cultures in different regions, mainly in four aspects: living customs, values, thinking patterns and cultural background.

The differences living customs between Chinese and Australian： In terms of daily communication, China has a history of 5,000 years of civilization. It is known as the "state of etiquette". The Chinese are also known for their politeness and courtesy. The interaction between people is based on "harmony". But the Australian natives, who are deeply influenced by western culture, are more concerned about the” personal space”. They are surprised and do not understand the many behaviors of Chinese living in the same community, such as: casually revealing their personal information；When the banks line up, the Chinese like to be very close；often ask about the age of others. In terms of cultural context, there are obvious differences between Chinese and Australian language expressions. For example, in China,” Dragon” represents auspiciousness, solemnity and glory. The Chinese have always been called” the descendants of the dragon”. But in Australia, where English is the first language, ”dragon” is a symbol of ferocity, evil and greed.

The differences values between Chinese and Australian: Values are a concentrated expression of national cultural connotation, different values make people have different views on the value and meaning of human existence, and form different value standards for measuring′ truth, goodness, beauty′ (胡凌霞,2006). For example, China is influenced by Marxism and believes that human nature is the sum of all social relations, emphasizing the interdependence between people, and ethically focusing more on utilitarianism. However, in Australia, which believes in Christianity and Catholicism, it advocates ”individualism” and believes that everyone has the right to control their own destiny, focusing on the individual's own freedom, equality and human rights. “Every man for himself, and God for us all”

The differences thinking patterns between Chinese and Australian ： Influenced by the dialectic of Marxism, Chinese people are accustomed to adopt a dialectical and unified mode of thinking. They must see the mutual distinction of things and the interrelated aspects of things. Therefore, in interpersonal communication, Chinese people often show "moderate". The attitude of "modesty" is neither radical nor too conservative. However, influenced by western traditional philosophical thoughts, Australians advocate the opposition between matter and spirit, society and nature, essence and phenomenon. The pattern of thinking has a distinctive feature of rationality, analysis, and perfection (王育林, 2004). Therefore, in daily communication, the Chinese often give people an ambiguous and unpredictable impression. For example, Australians are used to responding directly to ”thank you” when accepting praise from others, but implicit Chinese usually choose to laugh at themselves to express their own humor and humility.

The differences cultural background between Chinese and Australian：China is influenced by traditional culture and emphasizes to act according to the rules. In all aspects of life, there are corresponding behavioral rules. It is precisely this rigorous attitude towards life that allows people in China to be governed in an orderly and disorderly manner. However, Australians like to pursue a free and unrestrained life style. Therefore, in a completely opposite cultural context, it is inevitable that Chinese and Australian will collide in the process of getting along. For example, in leisure time, especially on weekends, Australians like to have friends to drink at the bar, enjoy music, or go to the park for barbecue. However, Chinese who focus on family relationship training are more willing to spend time with their families.

4. The countermeasures to alleviate culture shock

In the research of Chinese community of Box Hill, it was found that community immigrants mainly relied on conversations with family members or friends around them to alleviate the phenomenon of “culture shock”. However, this way of relying on the comfort of relatives and friends and neglecting their own and environmental forces often results in negative results. Therefore, in order to enable the Chinese who are new to the community to successfully cross the “culture shock” period and feel the warmth of the surrounding environment. The author believes that a structured strategy should be adopted, that is, from the micro level of the Chinese to Australia, the meso level of the immigrant community and the macro level of the Australian government, to systematically treat the phenomenon of ”culture shock”.

4.1.The micro level of the Chinese to Australia

First, individuals should correctly view the phenomenon of "culture shock". "Culture shock" is the inevitable result of the subject and object in intercultural communication. As long as the individual enters a new culture from the familiar environment, no matter how well he prepared before, culture shock will happen to him, and have negative impact on their mood. However, culture shock is not unhelpful. It can enable communicators to understand each other's culture more deeply in a contradictory cultural context, and to enable individuals to think more peacefully from the perspective of each other. The cognitive level can rationally understand the differences between different cultures and learn more communication skills at the behavioral level. At the same time, individuals should adopt a positive attitude when facing challenges, and avoid irrational thoughts such as ”ethnographic centralism” and ”cultural stereotypes”.

Second, individuals should enhance their awareness of intercultural communication. “Intercultural Communication Awareness” is a theory proposed by Western scholar Hanvey, referring to the capacity of understanding and accepting cultural differences (Hanvey, 1979). It emphasizes that individuals should be good at discovering differences between different cultures, making rational judgments, and proactively solving problems. Hanvey's theory of cross-cultural awareness can be divided into four levels. At the first level, through the travel or textbooks to understand the visible features of the superficial cultures, the feelings are strange and exotic. The second level, due to cultural conflicts, sees some important but subtle aspects of the foreign culture that are different from the national culture. The reaction at this time is emotional depression and abnormal behavior. At the third level, understanding through the rational analysis of important and subtle characteristics in foreign cultures is acceptable at the level of cognition. At the fourth level, through the experience of living in a foreign culture for a long time, learned to look at everything from the perspective of the local people (胡文仲, 1999). Enhancing cross-cultural awareness is a key step in alleviating the phenomenon of culture shock. Chinese people can learn about Australia's relevant knowledge in advance, and use case analysis, role-playing and scenario simulation to conduct cross-cultural awareness training.

Finally, individuals should enhance their intercultural communication skills. When the Chinese have a certain cross-cultural awareness, they should also externalize their consciousness into concrete actions. The "intercultural communication ability" refers to the ability of individuals to adapt to different cultural backgrounds and to communicate with others. The stability of self-communication ability can not only effectively reduce the impact of culture shock, but also enhance the self-efficacy of Chinese in the face of similar cultural differences. In this regard, by exerting subjective initiative and learning intercultural communication theories such as Adaptation Theory and Conflict Theory, the Chinese can grasp the ability to identify different cultures, communication and empathy. Quickly adapt to a new cultural environment to achieve self-growth and transcendence.

4.2.The meso level of the immigrant community

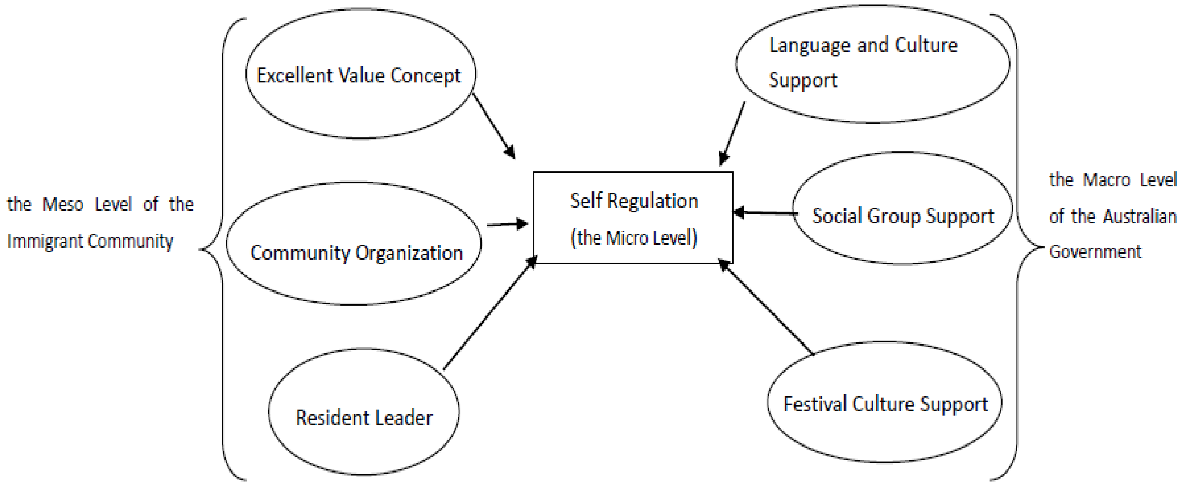
Maslow's motivation theory points out that human needs depend not only on their own actions, but also on environmental factors. The environment is an important factor affecting human behavior. An individual can become a healthy person and the environment must provide some necessary conditions. Although healthy people and moral people can appear in a flawed culture or in an unethical society, these exceptions do not justify unreasonable and unethical society. A healthy and moral person who grow up in a defective or unethical society is not the contribution of this society, but because of the human nature's ability to transcend the environment. If the social system is suitable for people and meets people's needs, it will enable most of the society to grow into healthy people, moral people and self-fulfilling people (李杨, 2008). Therefore, for the ”new neighbors” who are to the community, Australian locals should also give care and support.

In addition, it is important to promote good values. Australia's religious beliefs are dominated by Christianity and Catholicism. Influenced by the concept of fraternity and love, it continues to develop mainstream values like TLC (Tender Loving Care) and Ready to Help Others. Therefore, religious culture has gradually evolved into a spiritual civilization of "I am for everyone, everyone is for me." It is this kind of culture and civilization that enables Chinese who are new to Australia to feel the care and warmth from the community, and to ease their tension and powerlessness caused by culture shocks.

Finally, the community should also develop community organizations and promote resident leaders. As the largest overseas Chinese community, Box Hill can effectively manage and actively develop the community from top to bottom by developing self-organization and resident leaders. Community organizations are created to meet the needs of the community. Different community organizations will also exhibit different functions in the process of achieving community work goals. For Chinese who enter the community, community organizations can show three functions: First, provide services. Serving residents is the basic function of most community organizations. After understanding the needs of Chinese people, community organizations integrate relevant resources to make up for the lack of government services. Second, organize activities. Resident leaders guide the old residents to introduce the basic situation of the community to the newcomers by organizing community activities, and tell them about some life issues, such as: what are the community's service facilities；how to take the transportation；The bank's business process；Guide them familiar with the surrounding environment；Third is to enhance community cohesion. Community organizations should provide support to Chinese who have just stepped into a foreign land from both material and psychological aspects, so that their sense of community identity and cohesion can be improved.

4.3.The macro level of the Australian government

Australia is a multicultural immigrant country and is regarded as a ”national platter” by sociologists. In addition to Asian Australians, the main ethnic groups include British Australians and Australian Aborigines. In order to enable different national cultures to coexist and inherit, the Australian government encourages Australians of different races or ethnicities, including Chinese, to use their native language at home or in public. Chinese people living in Box Hill have Chinese employees to serve, whether they are eating, seeing a doctor or going shopping. Therefore, even Chinese-speaking residents can still live conveniently in the community. In terms of social groups, the Australian federal government provides various services. Assistance and allowances to reward people, groups and organizations that develop multiculturalism. Box Hill has the reputation of ”small Hong Kong” in Australia. The houses and shops built in the streets and lanes according to Chinese preferences make their lives more comfortable and convenient. In terms of festival culture, the Australian government supports different ethnic groups to carry out their own festivals. Every time the Chinese New Year is coming, Australian government officials will go to Box Hill to experience the atmosphere of traditional Chinese festivals with Chinese. The Australian government's system implementation and behavioral participation are stronger protections for the Chinese in addition to their own initiative adjustment and community support in the face of “culture shock”.



5. Conclusion

In summary, although the ”culture shock” in the immigrant community is due to the inevitable result of different living customs, values, thinking patterns and cultural backgrounds, the active avoidance of the ”culture shock” phenomenon will promote Individuals accepting new cultures and also can promote the development of human civilization. Therefore, in the face of "culture shock", not only the individual is responsible for self-regulation, but the environment should also assume corresponding responsibilities. At the micro level, individuals should correctly view the phenomenon of ”culture shock” and avoid discussing and attacking foreign cultures due to cultural stereotypes and ethnocentricism, and adopt a positive attitude to deal with problems. Through cross-cultural awareness training to enhance their ability to recognize and understand cultural differences, comprehend the charm brought by different cultures, from the three aspects of emotions, cognition and behavior, enhance environmental adaptability, and consolidate cross-cultural communicative ability； at the meso level, residents and self-organization in the immigrant community should also provide assistance to residents who have just entered the community under the guidance of excellent values, and promote the formation of a sense of belonging in the immigrant community； at the macro level, the government should protect the multiculturalism in the community through institutional implementation and personal involvement.

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INSTITUTIONAL ISSUES OF THE PRESERVATION OF THE IDENTITY OF THE URBAN HERITAGE IN THE PROCESS OF SUSTAINABLE DEVELOPMENT OF THE ENVIRONMENT (7, MAKICH, GORIS)

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Keywords: Historical-cultural heritage, adaptive reuse, institutional basis, sustainable development.

Abstract. The problem of preserving the historical urban landscapes, as well as heritage buildings become urgent, as once being lost can't be restored and a small part of history will be lost forever. The existing legislation seems to be a strong tool for this process regulation, nevertheless heritage is degrading. Thus, a local board with independent multidisciplinary specialists in each self-governing body of the communities is needed for control, regulation and safeguarding of the heritage. Sustainability is a basic challenge in the future development of cities is a tool reasoned by the increasing pollution, rapid urbanization and aimed at regulation of all components in balance. The historic cities as well as urban landscape urban is affecting greatly from above mentioned processes. It becomes obvious, that the sustainable way of the development of historic cities concern with a holistic approach to integrating all components of sustainable development with the historic heritage safeguarding, conservation or adaptation and providing balance between architectural and urban values protection and living cities development. Thus, the research is aimed at outlining the institutional tools for the possible adaptation of urban conservation and heritage preservation with sustainable development.

1. Introduction

The role of historical-cultural heritage in the process of preserving and strengthening the local identity is crucial in the sustainable development of settlements. Nevertheless, settlements are living organisms and are subject to continuous development. Development strategies, however, often contradict the identity of the heritage identity. In this process, valuable heritage sites that lose their identity in the development process require further tangible funding and efforts to regain their historical value and economic potential.

All urban planning strategies, policies and projects of all hierarchical levels have component dedicated to historical heritage protection. This measure is to protect the architectural cultural heritage from urban development impacts in case of unregulated urban sprawl. This is confirmed by RA legislation. Nevertheless, the mail role of the board is to control, regulate and manage the real implementation process. This will help to protect and safeguard cultural heritage during settlements development processes thus keeping the local identity of the settlements and having direct impact in making them more sustainable. Usually the sustainability is being studied in the point of view of economy benefits, so there is lack of a holistic approach, focusing on other benefits of cultural heritage, that can transform cultural values into economic ones. The most obvious examples are adaptive reuses of various heritage objects into tourism sector assets- visitor's centers, hotels, restaurants. All this is economic benefit for the local community from cultural heritage. The sustainability of built environment-urban historical landscapes, is seen in its great potential for saving energy and materials [1,2].

2. Main concept

First references about Goris old settlement to it go back to the 13th century. The old settlement was founded on the left bank of Vararakn River, in a picturesque area surrounded with hills, rocks, caves and ravines, on the crossroads of trading routs, joining Armenia to Persia by the Nakhichevan-Agulis-Partav well-known SALT trade route to the Caspian Sea, with a junction to the Silk Road (Fig.1).

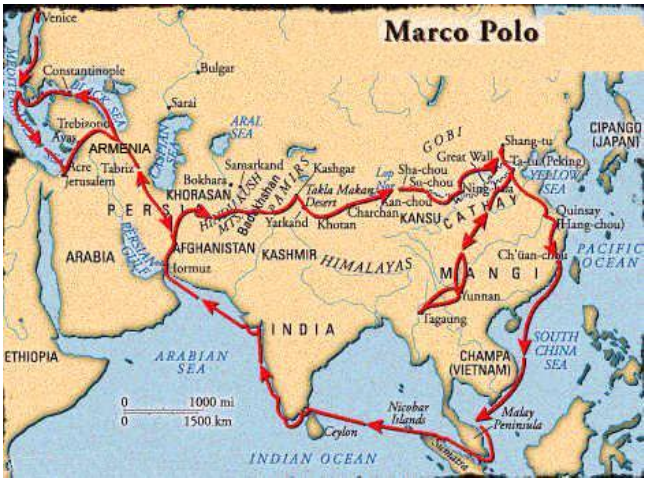

Fig.1. Silk and spice road

Thus, in the case of Goris, an ancient historical city, the importance of cultural heritage-based urbanization strategies and the role of the institutional issues in the safeguarding process of the cultural heritage within the development of different hierarchical strategies, become urgent.

Over time, the heritage has become a vital value for the society, being a link between past and present, and is identified in the collective memory of society as a way of communicating with their ancestors. Whereas very often the interventions provided by the strategies are practically incompatible with the established traditional values, undermining the city's identity and endangering the link between the generations. Sometimes there are controversies between the developed multi-level documentation, and even if there is the absence of them, there are no clear and definite tools, documentation provisions, for complete protection of urban identity. Sometimes because of lack of information, sometimes qualifications, and sometimes lack of financial means.

Because of lack of institutional regulations today, many valuable natural and artificial structures, commercial buildings and valuable houses are being demolished and destroyed, and most of the existing monuments today are ignored and are not used by their complete potential. Their aesthetic, cognitive, historical and architectural merits remain unknown.

The need for having institutional basis aims not only to discover and evaluate cultural monuments created during the centuries but also for providing regulations for their protection and adaptive reuse processes implementation with safe approach to the cultural system of the city to outline the process of normal development of the city, preventing gradual loses its originality. Thus, the main issues for the institutional regulation board within the tasks of development of the historical-cultural identity protection in Goris are:

- Fixation all spatial and image changes during the development different stages of the city, and the remarkable urban development qualities acquired in the typical stages and to clarification of the reasons for disqualification.
- Identification all the historical-architectural-valued buildings and point out the possibilities of their adaptive reuse for contemporary needs.
- Classification of urban structures and separate parts of the urban area according to their location importance and of the preservation of the historical image, evaluating them according to the architectural and artistic values.
- Supervision of definition of the system of the city's conservation zones and the urban development measures determined therein.

Residential neighborhoods were constructed with 1-2 story private houses. At the same time, the balconies stretching through the houses have been directed toward the gardens, and their narrow fronts have been directed toward the street that often have decorated small balconies. Residential districts, depending on the size, usually have been divided between 6 or 12 households. The sidewalks of the streets are paved and planted. Irrigation water streams were carried out on the slopes of the sidewalks.

Until the beginning of the 20th century, some of the most prominent buildings in Nor Goris were Armenian and Russian churches, school, printing house, shops, hotel, lemonade factory, bath, and private houses of famous Gorisian people: Mirumians, Yolyans and Badyrians.

One of the most striking examples of lack of institutional frame, responsible for heritage safeguarding process control, is the former bath house and gymnasium building at 7 Makich Street, the only preserved three-story building representing a historical value and a significant identity for the city. The former bath house is registered in the State monuments list. The inclusion of the structure into the list of historic and cultural monuments did not encourage the restoration and reuse of the latter. In none of the hierarchical ring, the issue of salvation of the structure through any means (recovery, reuse, or temporary conservation) is not put in place (Fig.2) [3].

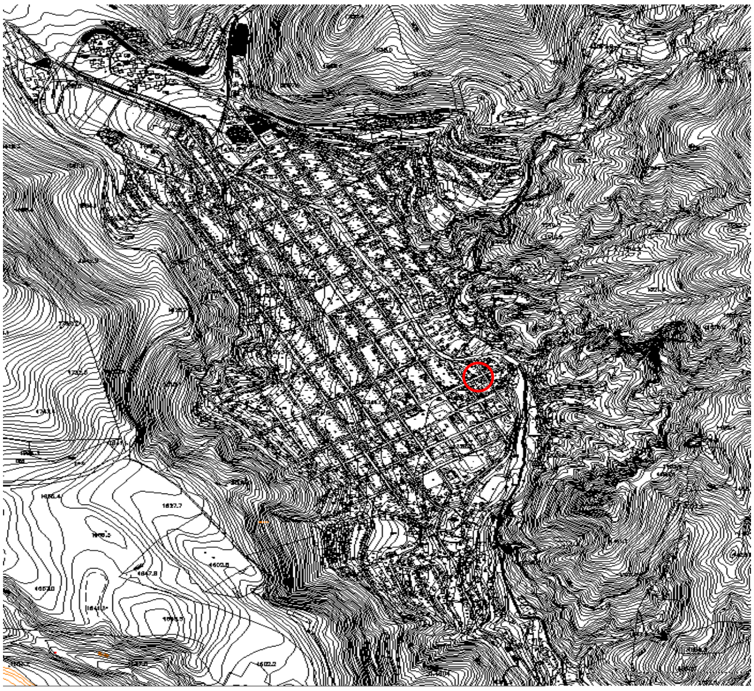

Fig. 2. The building in city rectangular structure location

The building has suffered a major fire. There were two- bath and gymnasium functions in the structure different stories. Damage of the building in the result of fire has caused the latter to be extremely vulnerable, and the decay is continual because some structural elements are missing (the roof completely). The architecture of the building differs greatly from the vast majority of the residential development of the center, as by its three story structure, also by external appearance and material. The difference in development-the main part of the city is developed with two-storied historic buildings and this one is the only three-story building in that segment. The difference in appearance in couple with the material is the combination of basalt and sandstone, using Goris's special arcades. Currently, the impact of continuous wind and precipitation is gradually declining, with a high degree of accidental breakdown. Meanwhile, the issue of the rehabilitation of the structure for its safeguarding has been proposed within the framework of the master plan and various programs (Fig.3).

Fig.3. Former Bath building of 19-th century

To save a valuable part of the history of the city and to benefit local people, combining the state, co-financing and private investments, observing all possible options, even though stage-by-stage projects for adaptive re-use of the structure have been proposed. Various options, such as a guesthouse, conference hall, creative technology center, craft training center were the main proposals. The role of the program implementation as a measure for solving the sustainable development of the historical center by increasing the value and attractiveness of the entire neighborhood by activating the life of this segment and creating a better and safer urban environment, also was emphasized. Nevertheless, the safeguarding of the historical building didn't become urgent continuing the decay of the structure thus also the identity.

Fig.4. Heritage council board structure

As a possible solution to the problem can be formation of a regulating board in the structure of the local self-government body with the involvement of various independent specialists, such as architects, urbanists, archeologists, ecologists, economists, etc. with decision-making capacity. They should involve as much as possible also the locals, living around the sites by creating awareness, educating and encouraging them to take ownership of the sites and protect from causing additional damage to the documentary form protected buildings by taking away high valued fragments, also attracting investments for the program implementation (Fig.4) [4].

Acknowledgements

This work has been carried out in the frame of "Creating the ways for sustainable urban, architectural and construction complexes development in RA and elaboration of directions with use of permanent monitoring systems" programme, financed by State Committee of Science of Republic of Armenia

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KNOWLEDGE STRATEGIES APPLIED TO CULTURAL HERITAGE BUILDINGS: THE ARCHITECTURAL SURVEY FOR THE RESTORATION AND THE ENHANCEMENT OF KATOGHIKE TSIRANAVOR CHURCH OF AVAN IN YEREVAN, ARMENIA

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Keywords: Architectural survey and 3D model, restoration, enhancement of cultural heritage buildings, Armenian religious architecture, Katoghike Tsiranavor church of Avan.

Abstract. The paper is proposed to present the first case study from Yerevan VH about a knowledge strategy applied to KatoghikeTsiranavor church of Avan in Yerevan, Armenia. The research has been conducted using a different approach from the past: many researches and theoretical works on this monument have been based on partial excavations, original studies and measurements on the site but until now there has not been used the opportunities of study that are giving the digital technologies we can apply nowadays. The YerevanVH project was configured meaning the survey as a tool for knowledge and reconstruction of the original arrangement of the contexts, with data acquisition aimed at the metric, morphological and themed restitution for the documentation of the investigated objects.

1. Introduction

Here we address the case study about the KatoghikeTsiranavor church of Avan in Yerevan, Armenia within the Project Yerevan Virtual Heritage - Yerevan VH, by a joint Italian and Armenian research group from the University of Florence- Department of Architecture and National University of Architecture and Construction of Armenia, Department of Theory of Architecture, restoration and reconstruction of historical architectural heritage, fine arts and history.

The project "Yerevan Virtual Heritage – Yerevan VH" is a first implementation of the partnership between the University of Florence-Department of Architecture/DiDA and the National University of Architecture and Construction of Armenia("Yerevan Virtual Heritage – Yerevan VH" was funded by: University of Florence ("Contributions for the promotion of the international activities of the University of Florence 2016/ Action 2: Implementation of cultural and scientific collaboration agreements with foreign universities), National University of Architecture and Construction of Armenia).

Fig.1.Geographical framework of Armenia

Fig.2. Avan church in Yerevan context

The case study was set in its scientific guidelines working on distance and finished for the acquisition of data and the presentation of the project to the public during the mission carried out in June 2017 in Yerevan, Armenia.

Fig.3. Historical picture of the building

The project "Yerevan Virtual Heritage – Yerevan VH/ Katoghike Tsiranavor Church of Avan" is divided into two strands of complementary training and applied research activities, which began in 2017 and is still ongoing.

The program included a series of lessons accompanied by a seminar application of acquisition and representations of data in the workshop "The enhancement of the Armenian architectural historical heritage: surveys and representation methodologies of the Avan church in Yerevan" (developed by the group of joint work composed of 2 teachers, 5 tutors and 9 students; as part of this activity, together with the UNIFI professor were three undergraduates and a PhD student of the University of Florence).

Fig.4. Current picture

2. Goals of the study and approach of the study

According to the official guidelines of the city of Yerevan in the field of tourism, the main objective of public policy is to create a system that meets the needs of tourists and increases the contribution of tourism to national income.

Fig.5. Main facade

The proposal of the enhancement of the church set up in the research is conceived in the direction of this line of the Municipality of Yerevan with the aim of realizing a path of digital documentation that allows to make well known the church:

1) realizing a path of digital documentation that allows to make known the monument;
2) inserting the Avan Church into the informative network already existing on the most important monuments of Yerevan;
3) promoting the activation of new initiatives to carry out the restoration of the building.

Fig.6. View from above of the church

Fig.7. Zenithal view of the building

Fig.8. Internal view of the church

The project Yerevan VH has been conceived integrating representation and surveying as an instrument of knowledge of the architecture, with data acquisition aimed at the metric, morphological and thematic representation for the documentation of the monuments; these first scientific architectural surveys of the Avan Church were carried out using direct and fast field survey and drone techniques.

Fig.9. West facade

The study is focusing on to better understand how to use the first documentation ever realized with modern technologies about the church for addressing enhancement efforts on this Armenian historical architectural heritage. The purpose of the study is to create a digital database on the Avan church with digital technologies. Using these data, will be done preparation of precise three-dimensional model of the structure and drawings from different layers, necessary sections, facades, details.

Fig.10. South facade

3. Background context

In the northeastern suburbs of Yerevan, Avan district, surrounded by dwelling houses, although without the dome does, stand the temple of Avan, which is one of the most valuable and unique monuments of the early Middle Ages.

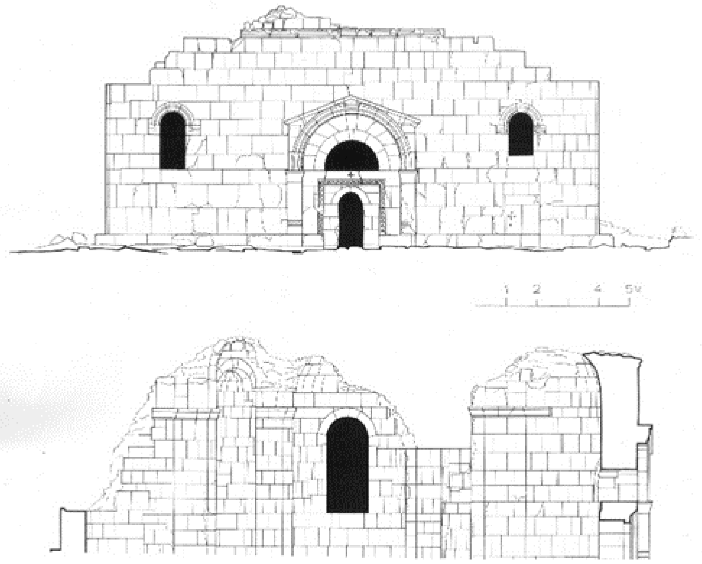

Fig.11. Historical drawings of the church

In these types of churches, Avan is one of the most ancient church (end of the 6th century: built from the antikatolikos Hovhannes of Bagaran in the period 590-602) which we have reached.

An archaic elements and solutions in it are characteristic of the Armenian IV-V centuries' monuments (Yereruik, Tekor, Qasakh). Avan is the earliest example of the transmission combination of vaultsand sails. It is also the only one structure in which the corner rooms have circular base and are ended with dome. And finally, the temple of Avan is one of the few mentioned monuments in early Armenian historiography.

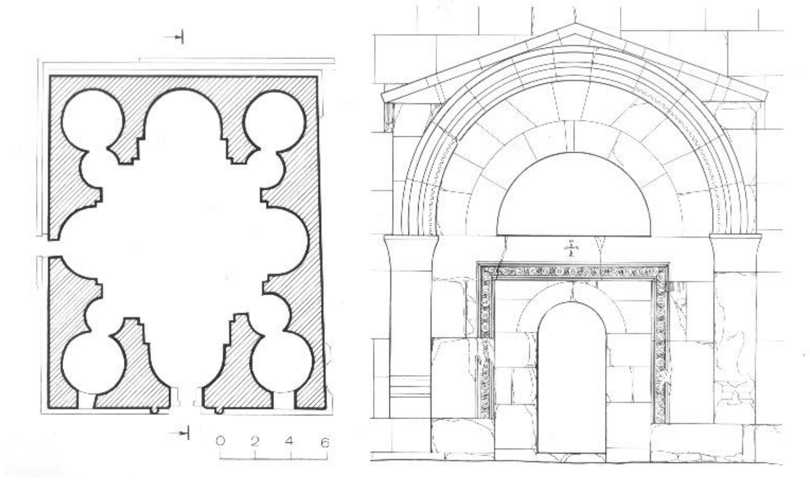

Fig.12. Plan and the gate of the church: historical drawings

Katoghike Church was constructed upon what was the site of previous structures and numerous ornamented stones found during excavations -mostly on the western side of the building- confirm this notion. The remains of the structure sit on a two-stepped platform, while the church's vaults, domes, and roof are missing as well as portions of the upper walls. The plan of the building lets us to hypothesis that church once had five domes: a single larger dome in the centre and four smaller over each corner of the church, above the circular corner chambers; if correct Avan would be one of the first such examples of a church with five cupolas. Many inscriptions can be found on the facades and on both side of the entry lintel, as well as many khachkar (cross stone) put on outside area of the church, south side. An ornamented casing, three-quartered pillars, topped with capitals and lunettes surround the arched doorway on the western wall; at the north wall is another doorway, maybe constructed at a later time to lead to the palace of the Catholicos.

Fig.13. Picture of the gate

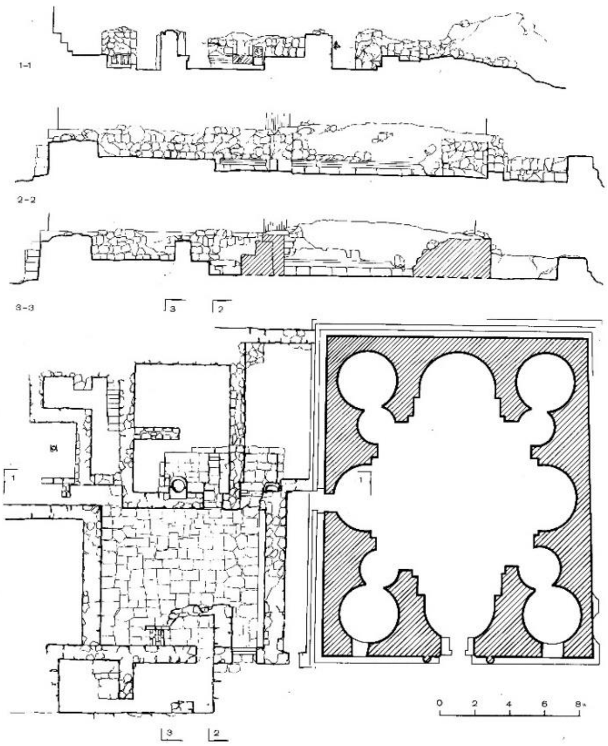

Fig.14. Drawings from historical archives

The church of KatoghikeTsiranavor church of Avan has remained half destroyed due the strong seism occurred in 1649 but is well present in the daily life of the district inhabitants and is the whiteness how the memory of the places can realize a full functional resilience despite the building cannot be used in its original destination.

The temple has been touched upon by almost all researchers of Armenian architecture (T. Toramanyan [1],Y. Strzhigovsky [2], N. Tokarski [3], G. Chubinashvilly [4], and others).

There are deferent theoretical restoration projects of Avan. The first one is belonging to R. Aghababyan (1947). The project is based on the view that in history of Armenian architecture, Avan is representing a preparation of the cross-form compositions, before the Hripsime period, the structure is a unique synthesis of local and antique forms [5, 6]. The second restoration project is belonging to T. Marutyan (1976). There is benchmark the opinion that the temple had five domes in outside. In base of this Avan had been planned with five domes in outside [7]. The third suggestion belong to V. Grigoryan (1983) who claimed that Avan had a perfect central-dome composition, in its and commonly all domed structures that had been foundation created. And if it relates to basilic churches, then only archaic details, which are evidence the earlier built of temple.
The Church was in a ruined state until 1941 partial reconstruction, and further works had been done in 1968.

4. Results and conclusions of the study

The project is still ongoing: the surveys have been processed in digital 2D drawings and a first 3D model has been performed and has been provided as a basis for the subsequent processing phases; the next step is a proposal for material and immaterial restoration. After the mission in Armenia was defended the I level Thesis “The field survey for the enhancement of the Katoghike Tsiranavor Church of Avan in Yerevan, Armenia”(Thesis from: student Federica Kolman (UniversitàdegliStudi di Firenze, Dipartimento di Architettura- DiDA); thesis coordinators: prof. Paola Puma (UniversitàdegliStudi di Firenze, Dipartimento di Architettura- DiDA) and prof. Emma Harutyunyan (National University of Architecture And Construction of Armenia, Department of Theory of Architecture, restoration and reconstruction of historical architectural heritage, fine arts and history).The first publishing results include the presentation of the research in two conferences held in 2018[1].

Fig.15. Structure from motion survey: screen shoot from 3D model

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PUBLIC AND SACRAL BUILDINGS DESIGNED BY EDWARD USAKIEWICZ IN CZESTOCHOWA

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Keywords: Edward Usakiewicz, public buildings, sacral buildings, architecture of Czestochowa

Abstract. Public and sacral buildings designed by architect Edward Usakiewicz in Czestochowa during the pre-war and post-war period are presented at the paper. Usakiewicz lived and worked in Częstochowa throughout the 1930s, 1940s and 1950s. There are still plenty of public utility buildings and a sacral building of his design in Częstochowa. All of the objects were designed in the Modernist style, were highly contemporary and very comfortable for their time. Most of them have fully performed their functions with no need of modernization until the present day.

1. Introduction

Edward Usakiewicz was born on 28 January 1905 inMława. He attended the 1st Henryk Sienkiewicz State High School in Czestochowa. Subsequently, he studied at the Faculty of Architecture of the Warsaw University of Technology, completing his study in 1930. As early as 1925, still being a student, he took up employment at the architectural design office of Prof. Marian Lalewicz. At that time, he would participate in design of such objects as the Naval Hospital in Gdynia, a complex of Navy buildings in Gdynia, the State Agricultural Bank central building at Nowogrodzka Street in Warsaw, and the Polish State Railways direction building at Targowa Street in Warsaw, as well as in reconstruction of Warsaw's Staszic Palace. His cooperation with Prof.Lalewicz lasted until March 1932. In February 1933, he assumed the duties of the County Architect in Czestochowa where he would live and work until 1954.In the pre-war period, E. Usakiewicz designed such buildings in Czestochowa as the County Office at Sobieskiego Street, three elementaryschools at Chłopickiego, Sabinowska and Szczytowa Streets, as well as a housing estate for workers at Srebrna Street. After the war, he faced a challenge of particular importance and difficulty – in view of his quite marginal prior experience in the area of sacral architecture – namely, the design of the Church of Divine Providence in Czestochowa, known as "Na Kamieniu" ("On the Rock"). Other post-war designs in Czestochowa include: a complex of residential houses for the employees of the Czestochowa Steelworks, workshops of the Industrial Junior High School of the Częstochowa Steelworks at Reja Street, an elementary school at Narutowicza Street, a charity and social home at Barbary Street, the Financial Administration building and a residential building for its employees at Sobieskiego Street. Usakiewicz also created the designs of conversion of the National Bank of Poland building at Al. NajświętszejMariiPanny and the State Department Store building at Śląska Street. He cooperated on the general spatial development plan of the city of Czestochowa. In 1954, E. Usakiewicz was transferred to Warsaw and his activities thereafter were connected with the capital. [1]

2. Public utility buildings

Among the designer's numerous projects carried out in Czestochowa, schools occupy a special place. Four of them have survived until the present day and are still performing their functions well; they include pre-war buildings at Szczytowa, Chłopickiego (currently Sikorskiego), and Sabinowska Streets, as well as the school at Narutowicza Street (currently, Krakowska street), designed immediately after the war.

An example of such project may be the ElementarySchoolNo. 1 at Chłopickiego Street. It was commissioned in 1938. This was a very modern building at the time, with its wide corridors and bright, sunny classrooms. It had central heating and well-equipped bathrooms. The surroundings of the school were also taken care of, where young linden trees, which grow there until today, were planted. During World War 2, the Germans arranged a field hospital at the school building, which resulted in severedevastation thereof. After the war, the building was renovated with considerable efforts, to serve in such condition for more than 60 years, housing an elementary school as well as a high school. Today, the building is the seat of Elementary School No. 38 and has been comprehensively refurbished recently.

Fig. 1 School at Sikorskiego Street – a view to the main entrance (author's photo)

Usakiewicz made the structure's geometry attractive through mutual shifting of cuboids with diverse dimensions and proportions. This is a single building without dilatation, and yet it seems to be a complex of structures, which is additionally stressed by the use of a varied number of storeys as well as different window rhythms and dimensions. Over the main entrance, the architect placed a circular bull's-eye window typical of Modernism. A prominently juttingcornice is a hallmark of Usakiewicz's style, enriching the building's elaborate yet stern geometry. In combination with a very carefully considered functional layout of the interior, this makes the school an example of a very well-conceived school building.

In the pre-war period, Edward Usakiewicz designed the County Office building at Sobieskiego Street in Czestochowa. This was a double-wing building with a three-storey entrancesection. Typically for the author, it was designed as a set of simple geometric solids, mutually shifted and juxtaposed so that this quite a large structure could nevertheless make an impression of lightness. Retraction of the taller entrance section brought an effect of optical lowering and diversification of the façade. A balcony, unusual for a public utility building, simultaneously served as a canopy over the building's entrance.

Fig.2. County Office in Czestochowa before the expansion(from the collections of the Czestochowa Historical Documentation Center)

Fig.4. Public administration building, currently the County Office at Sobieskiego Street in Częstochowa, current condition (author's photo)

Today, the converted and surmounted building has lost its lightness. Elevation of the wings by two storeys and the entrance part by one equalized the whole building in terms of height, making it massive. The colour scheme changed too, traditional grey plaster being replaced by pastel colours, which was presumably supposed to compensate for adverse visual effects of the building's enlargement. The superstructure of the County Office surely was functionally justified, yet its architectural effects leave much to be desired, as can clearly be seen on photographs.

Other post-war designs by Edward Usakiewicz, implemented in Czestochowa, included the Financial Administration building and a residential building for its employees, located at Sobieskiego Street. Today, this structure houses the County Office. As in all other post-war designs by this architect, it can be seen that the concept was adapted to the post-war realities. The body is simplified and although it still consists of adjacent cuboids, their mutual shift is slight and they have equal height. There are no vertical or horizontal façade divisions, windows on upper storeys are smaller. Only a trace of Usakiewicz's pre-war style can be seen here.

Fig.4. Public administration building, currently the County Office at Sobieskiego Street in Częstochowa, current condition(author's photo)

The charityhome at Barbary Street was designed in the 1950s as directly adjacent to an existing house. Despite its very simple form, this four-storey building with a basement stands out among the surrounding urban buildings. It has excellent proportions, and an interesting detail of a window juttingout thefaceof the side façade. Currently,the building houses a retreat centre and is functionally connected with the adjacent house. The colour scheme has been changed over the recent years.

Fig.5. Charity and social home, currently a retreat home at Barbary Street in Częstochowa, current condition *(author's photo)*

3. "On the Rock" church

The design of the „On the Rock" church at Warszawska Street was an enormous challenge to Edward Usakiewicz. Efforts to build this church started immediately after the war, and the design was finally created in 1948. The construction permit was obtained in the same year, and the consecration of the finished and equipped building took place as soon as 1950.

The Church of Divine Providence in Czestochowa may stylistically be classified as an example of the Constructivist trend. The architect employed a symmetrical polygonlayout and a two-storey interior configuration.

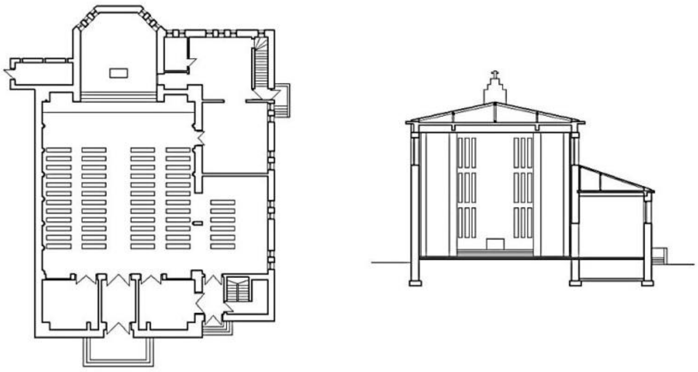

Fig.6. Church of Divine Providence in Częstochowa, horizontal projection and section
(author's drawings)

The church is a double-nave structure with a taller main nave as well as a lower and smaller aisle on the west side. The main entrance is situated on the northern side, so the traditional east-west axial orientation of a church was abandoned. A chancel with a hexagonal layout is elevated by five steps above the main nave level. The aisle houses a chapel and a winter chapel. The sacristy, constituting an extension of the aisle, may be accessed through an entrance from the winter chapel or through an external entrance. The basement part under the chancel houses acatechetical classroom, currently disused, whereas a boiler roomwith a fuel depot is situated beneath the sacristy and the winter chapel.

Fig.7. Church of Divine Providence in Częstochowa, view from the north-west
(author's photo)

Fig.8. Church of Divine Providence in Częstochowa, view to the chancel from the main entrance
(author's photo)

The structure was designed and built in a traditional technology. It has external walls made of full ceramic brick, a reinforced concrete ceiling, a main external stairway of reinforced-concrete slabs, as well as a reinforced-concrete double-flight, quarter-turn internal stairway to the choir. The church roof has a wooden, purlin-and-rafter structure. A steel turret is located atop the roof.

The Church of Divine Providence in Częstochowa stood out among other sacral buildings erected in the Częstochowa Diocese in the same period. The prevailing style at the time was Syncretism, typically represented by another church in the city – the Church of Exaltationof the Holy Cross, erected as a neo-Renaissance building. It was only in 1957 that another Constructivist sacral building was designed in Częstochowa (the Church of St. Therese of the Child Jesus at Gościnna Street). The "On the Rock" Church was very modern for its time. With excellent functional solutions and a body interesting in spite of its simplicity, the church has been perfectly performing its function until the present day [2- 4].

4. Conclusion

Over more than twenty years of his residence in Czestochowa, Edward Usakiewicz, as a part of his professional work at the City Office, both before and after the war, employed by the construction administration bodies, was involved in matters of architecture and urban planningof our city. It should be assumed he had a large influence on many decisions shaping the imageof Czestochowa, even though it is difficult to unambiguously point out his personal achievements in this regard. What he did unquestionably leave in this city were the implementations of his designs of buildings of various purpose. These included public utility buildings (among them several schools), industrial structures, residential buildings and a sacralbuilding. Buildings of his design can be found in most districts of Czestochowa. Almost every local citizen has used a building designed by Usakiewicz at least once, yet very few are aware of this fact. This architect of great merits to Czestochowa is not widely known; when gathering materials for this paper, the author had the opportunity to find out that users of the buildings did not know who had designed them.

All the projects under consideration were designed in the Modernist style, with distinct personal features of the author's style. They are characterized by a very thorough balance between simplicity, typical of Modernism, and the use of diversified geometry as well as thoroughly considereddetails. Several decades have passed since their construction, yet all buildings have performed their function invariably, with virtually no significant modernizations, which proves the timeless character of Usakiewicz's designs.

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SOME OF THE PROBLEMS OF PRESERVATION OF MONUMENTS IN THE CURRENT LEGISLATION OF THE REPUBLIC OF ARMENIA

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Keywords: Historical settlement, archeological site, monument, law

Abstract. Based on this provision we are going to study the law of the Republic of Armenia “On the Preservation and Use of Immovable Historical and Cultural Monuments and Historical Environment” adopted by the National Assembly of the Republic of Armenia on the 11th of November 1998. Let's try to present some of the issues that are beyond the scope of the law. In particular the present law lacks the definitions, such as "monument". The propositions the draft law on making amendments and supplements to the RA Law "On the Preservation and Use of Immovable Monuments of History and Culture and Historical Environment" would specifically regulate gaps in the field of archeology, as well as supplement the RA Criminal and Civil Code.

1.Introduction

The Republic of Armenia presents itself to the international community with its rich material and intangible cultural heritage. The most important and distinctive group of material heritage are monuments, which can be of nature, historical-cultural or historical-architectural or archeological, etc.

The basic law of the Republic of Armenia - the Constitution states that “The Armenian language and cultural heritage are under the care and protection of the state"[1]. Based on this provision we are going to study the law of the Republic of Armenia “On the Preservation and Use of Immovable Historical and Cultural Monuments and Historical Environment” adopted by the National Assembly of the Republic of Armenia on the 11th of November 1998. Let's try to present some of the issues that are beyond the scope of the law.

2. Proposals

In this law, "immovable monuments of history and culture (hereinafter referred to as monuments) are structures of historical, scientific, artistic or other cultural value, with their co-structures and complexes ..." [2]. This article lacks the definition of a "monument" as it is mentioned only as an "immovable monument of history and culture" giving arise to some questions. Why only historic and cultural, why immovable, and how should the movable ones be described? Another contradiction: according to the law, a monument is really a monument if "taken from the state register", and if we haven't found it yet, isn't the monument an object of material existence? The Republic of Armenia has acceded a number of international conventions regulating the protection of cultural heritage, which may enable to clarify certain concepts. Thus, the conventions on the protection of the world cultural and natural heritage (The Convention entered into force for the Republic of Armenia on December 5, 1993.) and on the protection of the European architectural heritage (The Convention entered into force for the Republic of Armenia on June 1, 2009). set out the concept of a "monument" that can be used in our legislation as well. I am presenting to you for discussion my version of the concept of a "monument" based on the criteria for inclusion in the World Heritage List of nature and cultural heritage (The Convention entered into force for the Republic of Armenia on June 1, 2009).

Thus, we present our version of the concept of "monument", which is based on the criteria of inclusion of nature and cultural heritage in the World Heritage List. "Monument is an object", which represents human creativity, mind, a specimen of traditional construction art, evidences the tangible interplay of architectural or technology, monumental art, urban development or landscapes in a given time and space, etc. It covers a significant part of human history, directly or objectively related to events or existing traditions, beliefs, artistic or literary works, and is important to national cultural heritage.

Another approach is also possible: archaeological layers of historical, archaeological, architectural, monumental art, scientific, artistic or other cultural value, cathedral stations, cave-dwellings, structures, their complexes and complexes, occupied and historically connected with their state-owned and monument status elements and fragments of archaeological, artistic, lithographic, ethnographic nature, historical-cultural reserves, historical landscapes and landmarks, historical settlements and historic cores, regardless of the level of conservation. Following this notion, it may be prescribed by law that monuments are subject to state registration.

The next issue is the classification of monuments according to value criteria. The law classifies monuments to two types: i. e. of republic and local importance, but in reality the monuments have three types: of world heritage or universal, republic and local importance. And this is an omission in the law. Monuments of universal significance are among the most high-priced, exceptional monuments of the people's history, of their material and spiritual culture, whose historical, artistic, intellectual, and spiritual virtues represent an international interest, and comply with the criteria set by international norms.

The purpose of the law is to establish the legal bases for the conservation and use of monuments, to regulate the relationships that arise during that activity, and also number of issues related to archaeological excavations that are not regulated by this law. These issues should either be addressed in the newly edited law of the Republic of Armenia on the preservation and use of immovable monuments of history and culture or should be regulated by the newly adopted law on the discovery, preservation and use of archaeological monuments.

The importance of archaeological monuments and excavation issues are set out in the European Convention for the Protection of Archaeological Heritage, signed on January 16, 1992 in Valetta (revised). This Convention was signed by the Republic of Armenia on May 26, 2000. The National Assembly of the Republic of Armenia ratified it on May 26, 2004 (Signed by the Speaker of the National Assembly of the Republic of Armenia on November 9, 2004 N N-149-3), and before ratifying it the Constitutional Court of the Republic of Armenia adopted that the obligations contained in the European Convention (revised) comply with the Constitution of the Republic of Armenia [1]. According to the Convention, the Republic of Armenia assumes the following obligations:

- to create a legal system for the preservation of archaeological heritage. This obligation includes the maintenance of the archaeological heritage inventory and the classification of monuments or

[1] The decision of the Constitutional Court of the Republic of Armenia on 24 September 2004 on the question of compliance with the Constitution of the Republic of Armenia in the European Convention on the Protection of the Archaeological Heritage (Revised) signed at Valencia on 16 January 1992

protected areas, the establishment of archaeological reserves, the provision of the obligation for the competent authorities and finding archaeological heritage elements;

- to take the steps provided for in Article 3 of the Convention [3] [2] to safeguard the archaeological heritage and to ensure the scientific relevance of archaeological research;

- to implement physical protection measures for archaeological heritage,

-to take steps to ensure the full preservation of the archaeological heritage as provided for in Article 5 of the Convention; [4][3]

-to provide financial support for archaeological research, increase the material resources of preventive archeology,

- to facilitate the collection and dissemination of scientific information;

- to promote public awareness to develop a conscious attitude towards the value of archaeological heritage;

- commit to preventing the illegal circulation of elements of archaeological heritage, to take the measures provided for in Article 10 of the Convention, including to reduce as far as possible illegal excavations, as well as the uncontrolled movement of archaeological heritage items stolen during illegal and official excavations;

- Provide mutual scientific and technical support to the other Contracting Parties and facilitate the exchange of relevant specialists.

Part of the above obligations to apply for authorization and surveillance procedures for excavation and other archaeological activities [5], that is to say, issuing an open leaflet [6] is carried

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[2]In order to safeguard the scientific relevance of archaeological heritage and archaeological research, each Party undertakes:

1. Apply authorization and control procedures to excavations and other archaeological activities to:

(a) Prevent any illegal excavation or transfer of elements of archaeological heritage;

(b) ensure that archaeological excavations and research are carried out by scientific methods and provided that:

- Non-destructive research methods will be used as often as possible;

- elements of archaeological heritage will not be extracted and exhibited neither during excavations nor in the future without appropriate measures for their conservation, protection and management;

2. to ensure that excavation and other potential devastation operations are carried out only by qualified and specially authorized persons;

3. Conduct the use of metal detectors and other detecting devices or processes for archaeological research in cases provided for by national law with prior special authorization.

[3]Each Party undertakes:

1. Coordinate and coordinate appropriate archeology and construction needs, ensuring that archaeologists participate:

(a) planning policies for balanced strategies for the conservation, conservation and improvement of the site of archaeological interest;

b) the different stages of the development plans;

2. Provide regular consultation between archaeologists, architects, and site developers to enable:

(a) modification of construction projects damaging the archaeological heritage;

b) the allocation of time and sufficient resources to carry out appropriate scientific research on the site and to publish the results;

3. to ensure that archaeological sites and their surroundings are taken into account in environmental impact studies and their decisions;

4. Provide that archaeological materials are discovered on site when possible during construction work;

5. to ensure that the opening of archaeological sites for the visit, in particular in the event of large numbers of visitors, does not prejudice the scientific and archaeological character of those archaeological sites and their surroundings.

out in accordance with the law, but the following point: "b) ensuring that archaeological excavations and research are carried out by scientific methods and conditions;

- Non-destructive research methods will be used as often as possible;
- Elements of archaeological heritage will not be extracted and exhibited neither during excavations nor in the future without proper measures for their preservation, protection and management. The authority and responsibilities of the organization that is to carry out scientific excavation and conditional oversight are not legally defined so that non-destructive research methods will be used as often as possible.

"To facilitate the process of gathering and disseminating scientific information, that is, to facilitate the study of archaeological findings and the dissemination of information on them, each Party undertakes:

1. carry out or modernize the study, inventory and mapping of archaeological sites in the areas under its jurisdiction;
2. to take all practical measures to prepare a scientific summary of the publication as a result of archaeological work before the publication of all the information necessary for professional study [7]. The law does not set out the principles for the study of archaeological finds and the space for information about them, the timing of the publication of excavation results by the archaeologist has not been regulated[4], and today, for example, there are thousands of excavations found in the Museum of the History of Armenia. Findings from excavations that archaeologists have uncovered do not allow the archaeologists to research and publish scientific research on the findings, or which do not exist anymore. The museum is also unable to investigate due to a shortage of personnel, and at the same time does not provide other researchers with the view that these findings are the "copyright" of the archaeologist and cannot be granted without the archaeologist's permission.

It is necessary, by law, and not by-law, to provide access to the findings of excavations to be explored, namely the right to a timely publication, the right and timeframe, and to determine the most important responsibility of the excavation manager after laboratory investigations, investigations, and investigations. , (which is also not preserved, as evidenced by the large number of excavations at the National Institute of Archeology and Ethnography) but not later than 2 years, submit to the appropriate state museum, and to submit to the facilitator a scientific work summarizing the results of the excavation for publication within 3 years after the completion of the excavation or archaeological excavations[5]. An important issue is the definition of control and responsibility for the destruction of an archaeological site, excavations carried out by wrong methods, which our legislation has not addressed.

Thus, the Civil Code of the Republic of Armenia stipulates only the responsibility of the owner of the real estate and the taking of cultural property that is kept intact [8], while the Code of the Republic of Armenia stipulates that the violation of the rules for the preservation or use of monuments of history and culture is violated. imposes a fine on citizens at the rate of 50 to 80 minimal salaries, and on officials at two hundred and fifty hundred degrees [9]. Destruction or damage of monuments of history and culture by the Criminal Code of the Republic of Armenia is

[4]However, paragraph 49-50 of Chapter 4 of Decision N 438 of the Government of the Republic of Armenia of April 20, 2002, "On Procedure for State Registration, Preservation, Study, Repair, Restoration, and Use of Immovable Monuments of History and Culture".

[5] Ibid, paragraphs 55, 56, 58, 59

punishable by a fine up to two years in prison [10] [6]. Are these legislative solutions sufficient for the preservation of monuments, but more specific and legal remedies are needed for the preservation of archaeological sites?

The next important issue is the maintenance of the organization and the issues of control. The concept of "reserve" should be clarified in the law, as only the historical-cultural reserve is defined in the current law [11]. Modern demands for cultural preservation raise new issues, so the concept of 'reserve' has become more widespread [12]. Not only monuments but also include the restoration of intangible cultural heritage as well as the restoration of the environment. Certain types of museum-reserves acquire qualities that bring them closer to eco-museums and animal-museums. It is necessary to clarify the right and forms of ownership and creation or organization of the reserve-museum. It is necessary for the state, while maintaining its right to protect the monuments, to find at the same time various forms and legal grounds for the issue of the protection of the monuments to become the responsibility of every individual in the community.

3. Conclusions

A number of Conventions which the Republic of Armenia has acceded and ratified can be assisted in regulating the process of preservation, restoration and use of monuments. Including the Landscape European Convention [13], as well as the Convention on the Protection of the European Architectural Heritage and the Convention for the Protection of the World Cultural and Natural Heritage.

In order to regulate the processes of preservation, restoration and use of monuments, much work has been done in recent years to regulate the legal field related to the field, and to amend the bylaws. However, the draft law on making amendments and supplements to the RA Law "On the Preservation and Use of Immovable Monuments of History and Culture and Historical Environment" must be approved a as soon as possible, which would specifically regulate gaps in the field of archeology, as well as supplement the RA Criminal and Civil Code. The mechanism of punishment for damaging the monument will be tightened.

[6] Article 264. Destruction or damage of monuments of history and culture?

1. Destruction or destruction of state-owned historical, cultural monuments, as well as objects or documents of particular historical or cultural value:

is punishable by a fine in the amount of 200 to 400 minimal salaries, or by imprisonment for the term of up to two months, or imprisonment for the term of up to two years.

2. The same acts committed against objects or monuments of particular value:

are punished with a fine ranging from three hundred to five hundred minimal salaries, or imprisonment for the term of up to three months, or imprisonment for the term of up to 5 years.

3. The acts referred to in paragraph 1 of this Article committed negligently and causing great harm to:

are punished with a fine ranging from one hundred to two hundred fold of the minimum wage, or imprisonment for the term of up to two months, or imprisonment for the term of up to one year.

4. Actions referred to in paragraph 3 of this Article which have been committed against objects or monuments of particular value or have caused particularly serious damage:

are punished with a fine ranging from two hundred to four hundred minimal salaries, or imprisonment for the term of up to two months, or imprisonment for the term of up to two years.

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[1] The RA Constitution, article 15.

[2] RA Law "On Preservation and Use of Immovable Historical Monuments and Historical Environment", Article 1.

[3] European Conservation of Archaeological Heritage (revised) Article 3.

[4] European Conservation of Archaeological Heritage (revised) Article 5.

[5] European Conservation of Archaeological Heritage (Revised) Article 3 (1).

[6] RA Law "On Preservation and Use of Immovable Historical Monuments and Historical Environment", Article 25.

[7] RA Law "On Preservation and Use of Immovable Historical Monuments and Historical Environment", Article 7.

[8] Civil Code of the Republic of Armenia, Articles 107.1 and 284.

[9] Code of the Republic of Armenia on Administrative Offenses, Article 95.

[10] Criminal Code of the Republic of Armenia, Article 264.

[11] RA Law on Protection and Use of Immovable Historical Monuments and Historical Environment, Article 17.

[12] Rossiyskaya muzeynaya entsiklopediya. Slovar' terminov [Russian Museum Encyclopedia. Glossary of Terms], Information on http://www.museum.ru/rme/dictionary.asp?6

[13] On 18 February 2004 the National Assembly of the Republic of Armenia ratified the European Landscape Convention signed in Florence on 20 October 2000.

CREATION PRINCIPLES OF CLASSIFIER OF COMMERCIAL HOUSING DEVELOPMENT

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Keywords: Classifier, class of comfort, multi-apartment residential buildings, real estate market

Abstract. Based on the results of the international experience analysis, as well as the principles of the application of the classifiers developed by the former Soviet Union countries, was a classifier of residential buildings for Armenia have been developed, which will allow citizens to obtain information on the class of the building when buying an apartment.

In the process of creating a classifier, the RA laws on the Housing and Urban Development Laws, operational norms, technical standards and the Code for multi-apartment residential buildings design and construction have been taken into account. As a result of the creation of class of the design of multi-apartment residential buildings, three classes of apartments have been separated: the most comfortable, comfortable and less comfortable. The Classifier can be also used by real estate market analysts to determine the comfort class of residential buildings and provide buyers with precise information.

The introduction of classifier in practice will also allow to prevent the process of awarding a class to the multi-apartment residential buildings in the real estate market.

1. Introduction

Social-economic situation revealed the formation of a new type of residential houses, and its worldwide known name is commercial housing construction. The change of the economic system directly affected the principles of commercial housing construction in the Republic of Armenia by proposing its own rules, which did not been settled yet in any way and it is evident that it needs to be shaped.

2. Methodology

Countries of the Soviet Union, such as Russia [1], Ukraine [2], Belarus [3], and Kazakhstan [4], have already developed and are in the charge of commercial housing construction in their country, which allows citizens to get the exact details of the building they purchased when buying an apartment. In the republic of the USSR, housing construction requirements were based on the same principles for all and housing was provided by a state. Now the number of such apartments has become very low and they are called social or affordable houses. As before, now the function of such residential buildings is to provide a minimum living standard. Previously, these were made with typical designs, ensuring the minimal surfaces and only a small amount of added surfaces. Today, times have changed and business analysts are researching the possibilities of purchasing power, according to investors - only after the architects and artists get the possibility of implementing the draft order. However, commercial apartment construction may not be a true imagination of the buyer without the presence of a disparate person. That is why owners of apartments bought at high enough prices often find themselves in misunderstanding because their proposed apartments do not meet the requirements that were offered before buying. This phenomenon is often noticed when the future building is advertised as a structure that meets the highest requirements, but its design solutions do not correspond to the reality because of ventilation, insulation, solar irradiance, in accordance with the vision of certain services, comfortable environment surrounding the lack of infrastructure. Believing advertising buyers pay large amounts of money, while getting a low-quality apartment. In practice, even the most dwelling residential building in Yerevan may appear in a dormitory and become victims due to the urban development policy in that area, deprived of the complete absence of sight. For this reason, the development of a classification has a number of features for Yerevan, as many times there are also cases when the planning solution of the purchased surface is not only maintained, but also distorted by its own residents, not keeping air conditioning, insolation and a number of preconditions that will ensure the proper exploitation of the apartment.

The most important thing for the designer to develop is that the buyer will have a clear idea of what kind of apartment will be purchased in the residential building and what will be his / her service charge (electricity, water, gas, heating and other services). Let's list the classification criteria by which buyers generally value the living space, the residential area, the percentage of total and residential surfaces, the adjusted zone, the vision of the insulation to the reality environment, the infrastructure and so on [5]. The classification of multi-storey residential buildings, classes division begins from the occupied building, the building's configuration, apartment planning solutions, floor height and many other factors. For example, the criterion may be the kitchen surface, if it does not exceed $9m^2$, then this is definitely the lowest grade. In middle class cases one-room apartment area reaches 34 m^2, and in case of high class the surface reaches $45m^2$, the kitchen is up to $14m^2$. In case of more than two rooms, two sanitary units will be provided. The minimal surface area of the high class apartments should be $60m^2$. For middle and high class, there should be a number of comfort conditions, such as free recreational areas and surface and underground parking spaces. Low and middle class residential multi-apartment buildings can also be built with typical designs that are now referred to as repetitive designs, but in the case of high class, the project must be built on a single individual project, even if it can claim architectural monument level with local significance. The principles of accepting a classification decision should be the indicators that design and implement the building. If some of the indicators do not meet this class, they will be descend to belong to the appropriate class. According to studies conducted by the Yerevan Supervisor for the Republic of Armenia, three classes should be defined: low, medium and high. The consumer classification method of the proposed determines the criteria for evaluating multi-apartment buildings in Yerevan. The proposed classification can be used in the determination of the relevant class by the analysts of the local real estate market. This classification method can also serve as a basis for future studies in the field. The design of the subcontractor is based on the existing multi-apartment buildings management law and existing norms. The basic principles laid down in the proposed method are as follows.

The Global Comparison Principle, based on the generalization and analysis of the regional classification, taking into account the existing normative acts in urban development.

The subcontractor is based on the consumer preferences of buyers, taking into account the flat surfaces and comfort of the apartments, thus determining the demand and the price. The proposed classifier's principle is to describe the quality of the project presented by the developer. The principle of application of this method is based on modeling of spatial extent it can be the whole territory of Armenia, besides those regions, which may have some changes. The purpose of the regulatory application is not only to limit the quality and types of multi-apartment buildings, but also increase profitability, control and management of projects [6].

The criteria for belonging to this class may be architectural, facade solutions, precise location of the environment, dimensional solutions, engineering equipment, car parking, security, etc.

3. Conclusion

The designer's idea will not affect the price scale but, in the case of its application, it can prevent the sale of flats without providing proofs by simply giving the building the "elite" name or reducing the prices by submitting unsuitable flats.

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CITY SKYLINE: VERTICAL PICTURE OF YEREVAN ARCHITECTURE

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Keywords: Silhouette, city verticals, development

Abstract. While creating unique appearance of the city silhouette, the vertical developments of the skyline dominating the urban landscape are considered to be of exceptional importance. They turn into symbols of the city due to their singularity. Since they can be easily recognized in the city silhouette, these verticals become characteristic feature of the city. Silhouette formation and the evolution of Yerevan city panorama within the period of its development, and the quality of eye and perspective perception in the space are the topic of this paper. Yerevan city skyline is formed as well by means of height variations - 750-1370 m above the level of the sea. Thus, the character and peculiarities of the relief of Yerevan districts are highlited. The silhouette and panorama of the capital is emphasized by means of some skyline forming buildings and structures as well as and the reasons that caused the changes in the image of the city within the last 20 years are analized. There is also an attempt to point out the problem of messy construction in order to prevent the city silhouette from further chaotic development in the environment.

1. Introduction

The main component of the composition of the city is the silhouette of its building developments. The harmony of Yerevan city silhouette is its surrounding landscape, as well as its unity with the natural environment. The unique image of Yerevan was created by the original combination of architectural and landscape environment. Today, the panorama of our capital is chaotically formed by solid multi-story massive monoliths. The inept arrangement of high-rise buildings do not fit the concept of the city and lead to changes in the vertical image of Yerevan.

Alexander Tamanyan, an outstanding Armenian architect, while developing the master plan of the city, used the peculiarity of the topographic structure of Yerevan. The relief of the districts of Yerevan is very complicated; it has a concentric arrangement around the central site with a stepwise increase from the center. Absolute heights vary from 865 to 1390 m above sea level; the city center is 994 m [1].

2. Review

In the 50s, the central part of Yerevan appeared as a city with its expressive facades of 3-5 floor residential and public buildings. Here the Opera House was intended to become one of the main components of the image of the city, creating a compositional center of the north-south axis. Being placed in one of the central squares of the city, and having an island position with height of about 42 m the Opera House became observable from various points in the surrounding environment (Fig.1).

Fig. 1. The Opera House

Natural growth of the relief to the north and east turned Yerevan into a natural amphitheater. Due to the increase of the city-population, as well as its territories, Yerevan began to merge with all the suburban towns and villages in the surrounding hills. The building activities were carried out in accordance with the features of the relief. The most important buildings and structures in Armenia have always been located in the most interesting places in the landscape. It is obvious that Yerevan dynamic silhouette is formed by the significant difference in relief variations.

Let us take a glimpse to some of silhouette forming buildings and structures.

The picturesque Cascade Complex is organically inscribed on the falling slopes of the Kanaker plateau as the completion of the main axis of the city. This multifunctional complex is in perfect harmony with the environment, at the same time connecting the center and the upper parts of the city (Fig 2). Today it is considered as one of the symbols of the city, since an amazing view of the city panorama and the Ararat valley are opened from here.

Fig. 2. The Cascade Complex

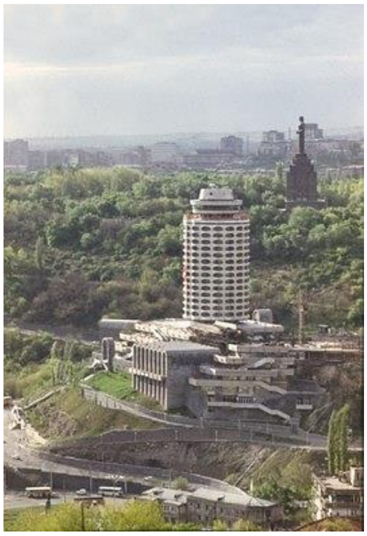

Fig. 3. Youth Palace with Victory Monument

The masterpiece of Yerevan's modernist architecture in the mid-70s, the Youth Palace was also built on the Kanaker plateau. Perhaps the most important vertical of the city was perfectly visible practically from anywhere in Yerevan. The 14-story hotel was an absolute high-rise dominant of the Armenian capital. Yet, unfortunately, the most recognizable symbol of Yerevan was demolished at the beginning of the 2000s.

Another vertical is on the edge of the Arabkir plateau, on the continuation of the main avenue of the city, the Victory Monument was erected in 1967 which, due to its convenient location and considerable height, about 50 meters, is well viewed from many sides of Yerevan, thereby enriching the silhouette of the city (Fig. 3).

Another hight to mention is the Tsitsernakaberd Hills in the north-west of Yerevan. In 1967 one of this hills was chosen for the construction of the Tsitsernakaberd Memorial Complex (Fig. 4). Here, on the top of the hill, it is in complete harmony with the environment and today with architectural and ideological point of view this monument is considered as the most successful solution. On the same hill the Sports and Concert Complex was designed, dominating the entire northwestern zone of Yerevan (Fig. 5). The complex seems to soar above the city, spreading its majestic wings, and is visible from all surrounding districts.

Further upper. In the mid-60s the territories of the Nork plateau, the northeastern part of Yerevan - was marked by the development of mass residential construction. The area here is with pronounced complicated relief, the average height of which is 1370 m above sea level.

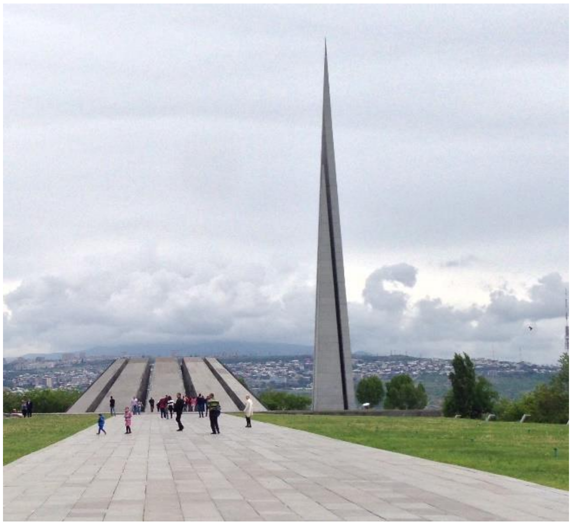

Fig.4 Tsitsernakaberd Memorial Complex

Fig. 5 Sports and Concert Complex

The construction here began with 4-5-story houses, and by the development of the construction industry, 9-16-story building enriched the silhouette of the city. In the same hight, on the edge of the Nork plateau, stands the 311.7 m TV tower of Yerevan (Fig 6). Undoubtedly, since 1977, being the tallest building in the city, it is the main vertical of the capital.

The surrounding of the Akhtanak Bridge was also successfully formed. As a result of the successful implementation of urban development ideas on two banks of the gorge of the Hrazdan River, the complex of Ararat Cognac Factory grew up with its picturesque silhouette [2] (Fig 7).

Fig 6. TV tower

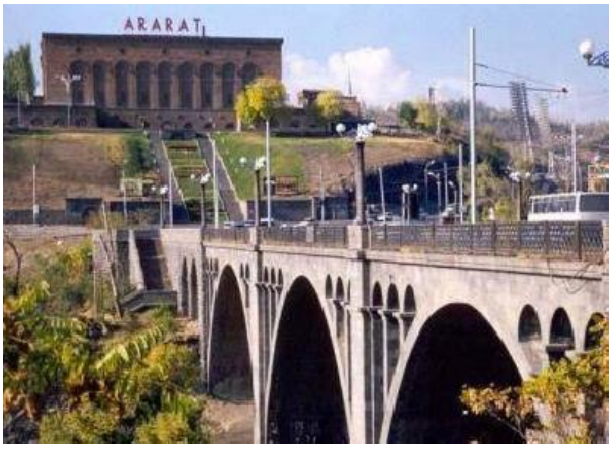

Fig 7. Ararat Cognac Factory

Mass housing construction on free areas was mainly developed in outlying territories. The central parts remained untouched but for a short period. Without any urban development projects, construction activities started in the area of the historically developed center. Along with dilapidated buildings, some of historically valuable buildings of the 18th and early 20th centuries were demolished. Certainly, there were good solutions among them, but their number was very few [3]. By the end of the 80s of the XX century, the center of Yerevan was a well-coordinated architectural ensemble, with low-rise buildings of the 30-50s, with streets of historical buildings of the late XIX - early XX centuries. Even the Soviet nine-story buildings also existed, but most of them were hidden inside the neighborhoods - in the yards. Houses with original and rather attractive architecture faced the streets [4].

The picture of Yerevan began to be distorted during the crisis period for Armenia in the 90s, when a lot of illegal construction was carried out, especially in the center of Yerevan. Many developments were erected on expensive plots of lands which didn’t meet the requirements of architecture, in particular there were a lot of add-ons [5]. Each resident started to rebuild the top floor of their building based on their own needs, tastes, financial capacities. In central Yerevan, it’s hard to find a single building that doesn’t have something on top of it [6].

In the 2000s, advanced economy enlarged the construction activities in Yerevan. The center of the capital was filled with great number of high-rise buildings. Most residential developments do not fit the general concept of the city; some old valuable buildings of Yerevan were demolished. The location of many high-rise buildings caused considerable damage to the development of streets and squares of the city, and some of them to the buildings that form its architectural image. While development of the Northern Avenue, by means of connecting the two main squares, such concepts as compatibility with the environment, harmony of the old and the new developments did not take into consideration. Northern Avenue with multi-story monster houses turned into a corridor, overhanging over the pedestrian movement, distorting the composition of the environment. They came so much close to the Republic Square and they distort not only the appearance of the square of the capital, but also they hide the perspective view to this significant creation. In the past, surrounded by 4-5 story buildings, the area was highlighted by the size of its volumes and its height, and it dominated in the environment. Today the role of the square is belittled in the new surrounding of multi-story environment; it gradually loses its importance [6].

3. **Conclusion**

The city is a complicated organism, and it cannot be once built and stay forever frozen. It must be developed in its historical structure. Studying and analyzing the current spatial crisis of the capital, which took decades, will provide, and in some cases, ensure a peaceful renewal of the city's image.

The old silhouette of Yerevan is irretrievably lost and how it will look like in future depends on us - architects. Neither political nor economic nor any other aspects should affect the individual appearance of the city.

Today, one thing is important - the further development of the image of Yerevan is to ensure the harmony of its silhouette and the surrounding landscape, its unity with its natural environment Here is what the architect seeks in his professional activities.

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ARMENIAN DIASPORA’S CHURCH ARCHITECTURE

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Keywords: Diaspora, church, chapel, architecture, compositional analysis

Abstract: The funcional and architectural peculiarities of the Armenian churches built in the Diaspora are presented. Archival and photographic materials of spiritual buildings have been collected. The funcional, constructive, structural and compositional analyzes of the Armenian churches in the Armenian Diaspora have been made. Their results were summarized in the conclusions.

1.Introduction

Currently, there are about 724 Armenian churches, chapels, and monasteries in the Armenian Diaspora and the construction of the majority of these churches took part in the 20th century. At that time the church's architecture lived in a period of searches with the latest construction materials and technologies, as a rule. However, the Armenians have sought to commemorate the traditional forms of the Armenian church building in their structures. The reason is that every newly-built church is not only the home of Faith and God for the Diaspora but also a symbol of salvation and survival of Armenian nation.

2. Analize

The inspiration for the architects were always the prototypes of medieval churches of Ani, Zvartnots, and Echmiadzin, whose solutions are in architectural compositions of most of the churches of the Diaspora (Saint Hripsime Church of Etchmiadzin and Saint Hripsime Church of Yalta; Bell tower of Haghpat and St. Sarkis of Kensington, London; Odzun Church and St. Vartan of Kislovodsk; Etchmiadzin Cathedral and Church of the Holy Archangels of Bucharest) (fig. 1). The latter, by the way, is the only Armenian Church in the world anointed in 1915. The parallels of traditional churches and churches built in the 20th century in Diaspora are so evident and abundant that they can be a subject of separate research. Indeed, constructions of the churches were not in Armenia, where the local climatic conditions and building materials, the tuff, and basalt have been influential factors for the architectural composition and image of the church. In the Diaspora, church architecture has "localized" the structures. However, there are many documented cases when the building materials of the church were from Armenia, such as in cases of many Russian churches especially for Holy Transformation Church of Moscow and Holy Resurrection Church of Rostov, also for St. Ghevond Cathedral of Burbank, California, and many other churches.

Few of the best examples of contemporary interpretation of the Armenian classical church architecture are St. Vartan Armenian Cathedral of New York by the great master R. Israelyan, Milan's Chiesa Apostolica Armena and Montevideo's Surp Nerses Shnorhali Cathedral, and Yalta's St. Hripsime Church (1909-1914) based on G. Sureniants's sketches, and designed by G. Ter-Melikyan.

Saint Hripsime Church of Yalta

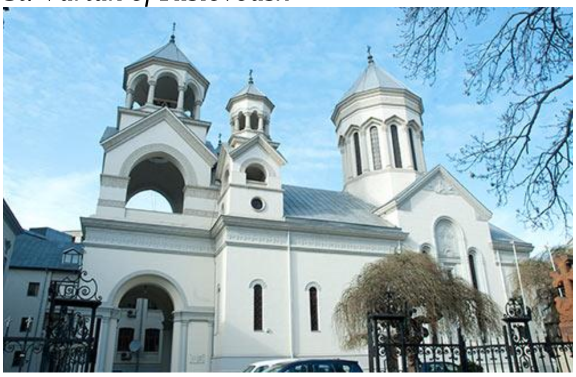
Saint Hripsime Church of Etchmiadzin

St. Sarkis of Kensington

Bell tower of Haghpat

St. Vartan of Kislovodsk

Odzun Church

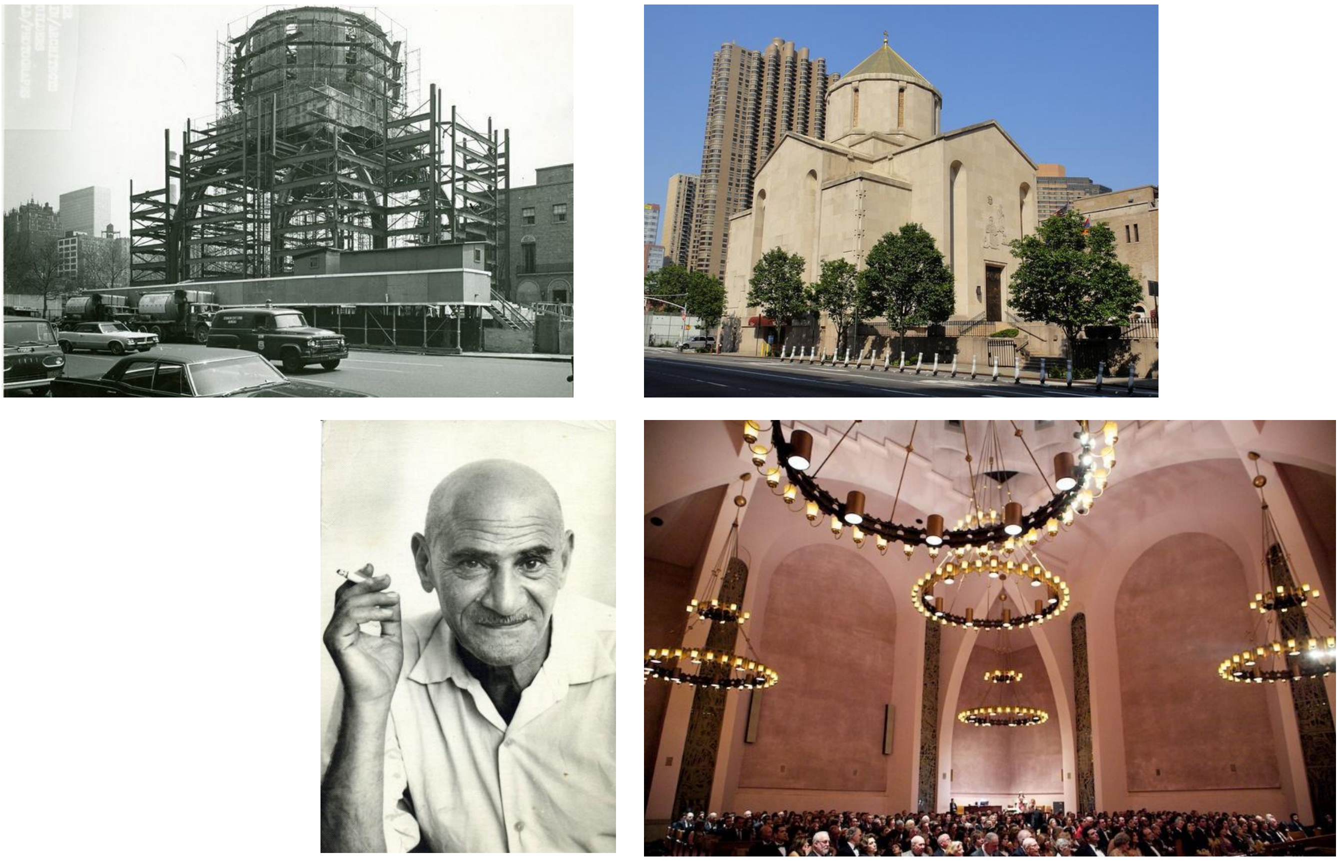


Church of the Holy Archangels of Bucharest

Etchmiadzin Cathedral

Fig. 1. Comparative analysis of Diaspora's several churches of the 20th century and their medieval prototypes

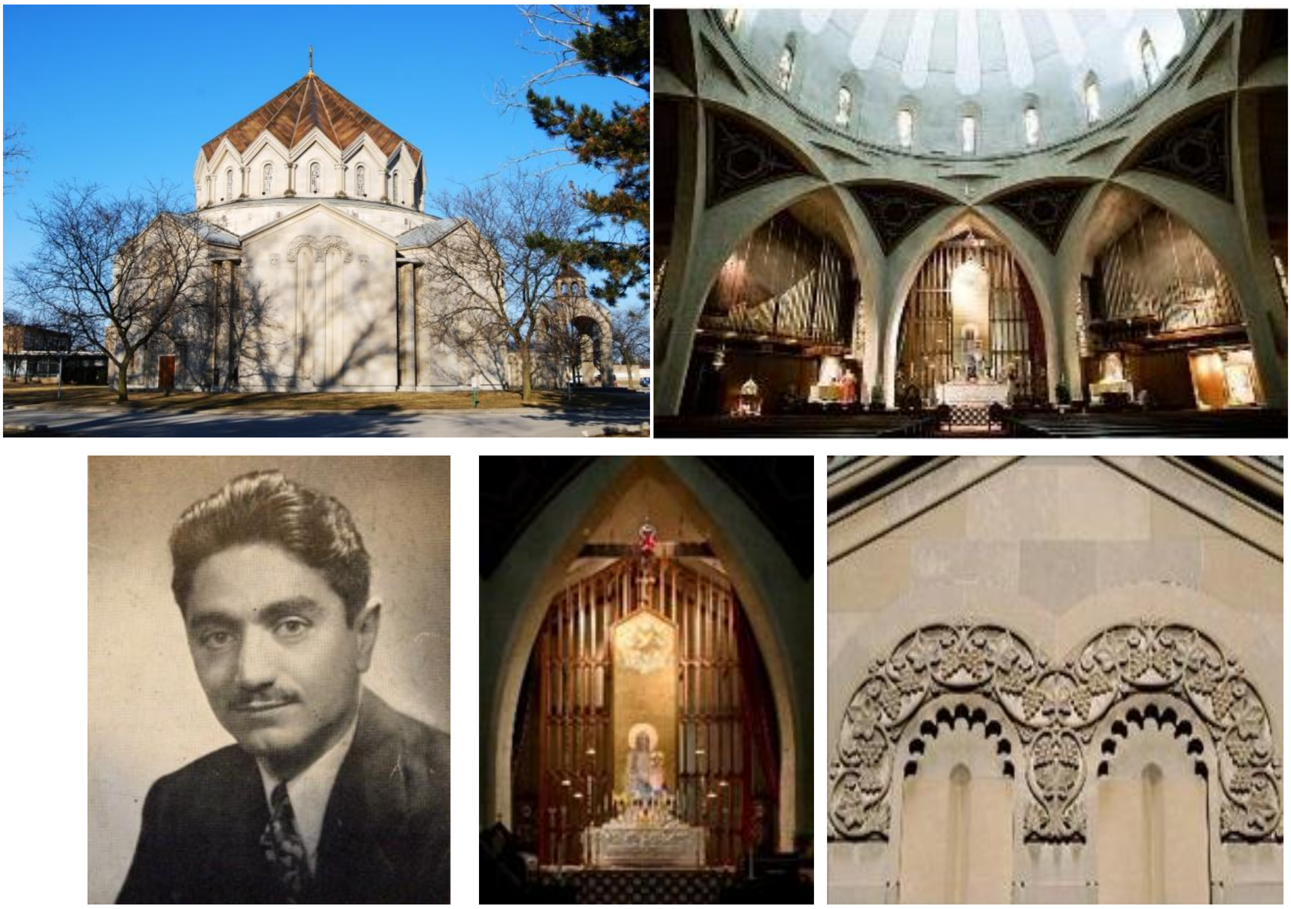
Despite traditional architectural compositions, among the Armenian churches in the Diaspora, we find quite courageous and worthwhile constructions and Tehran's St. Cross Church from concrete is an example of such structure (1987, by R. Voskanyan) [1, pp. 9-15].



Architect Rafael Israelyan

Fig. 2. The construction, general and inner views of St. Vartan Cathedral in New York (1968)

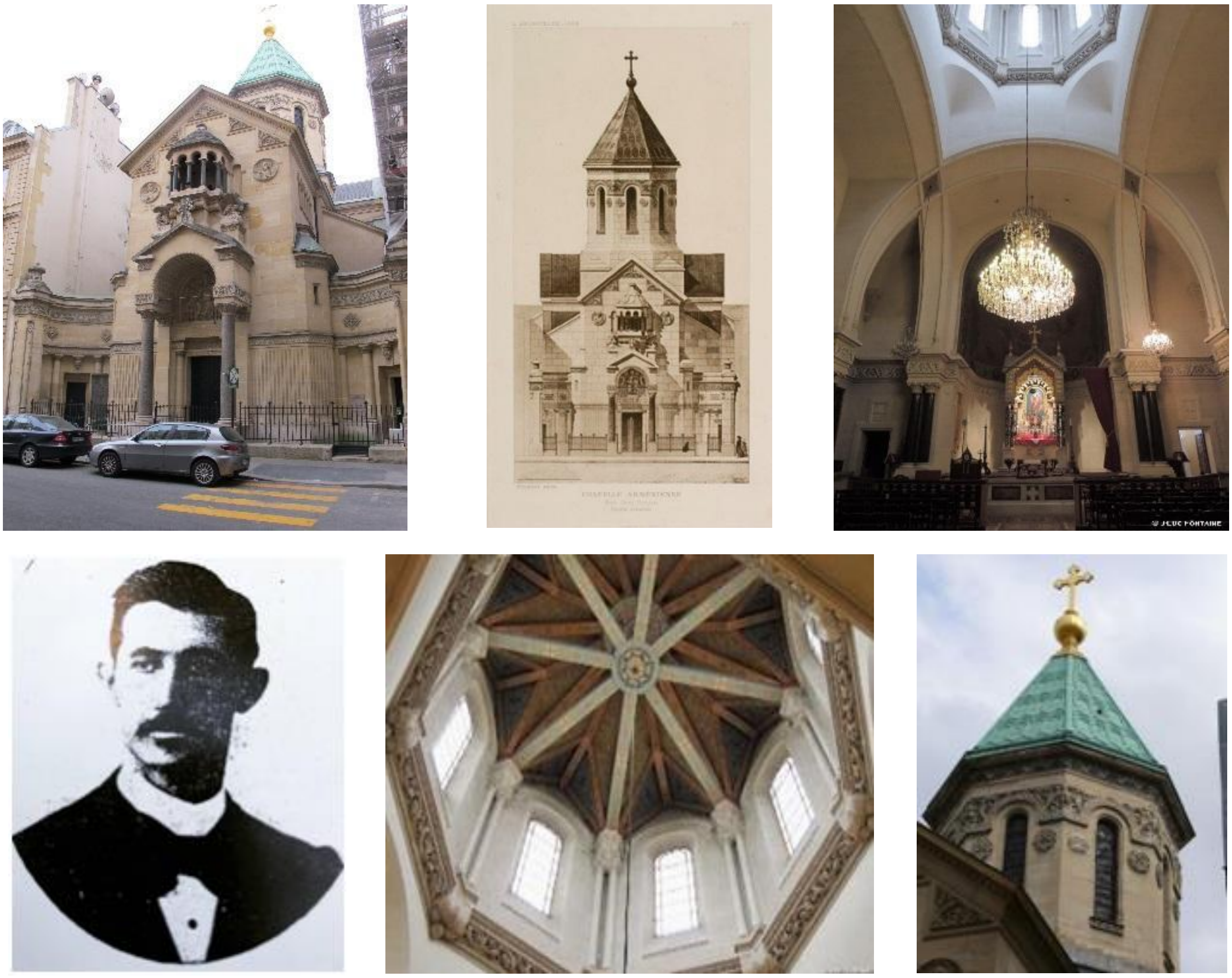
St. Vartan Armenian Cathedral, New York: Creating the design of the New York Church, Israelyan presented six versions of the project to the Catholicos and the Architectural Committee adjacent to the Armenian Apostolic Church. The construction supervision of the church was carried out by the architect Édouard Utudjian. The dimensional settlement of the Church reminds St. Hripsime church’s dimensions. The interior arrangement is with crossed arches that also emphasize the aspiration to the Armenian architectural tradition. Also, the summarization of the space with crossed arches which are characteristic of the structure of medieval Armenian hawks highly skilled R.Israelyan interpreted in the foyer of Monument's Memorial (Fig. 2).



Architect Suren Pilafian

Fig.3. Detroit's St. John Armenian Church's (1931) general and inner views, and details

The idea of intersecting arches has its unique architectural solution in **Detroit's St. John Armenian Church.** The architect is Suren Pilafian [3, p.2], [4], well-known American-Armenian modernist, who visited Armenia, got acquainted with the Armenian medieval architecture, and then just started the design work. During the project, he collaborated with E.Utudjian a famous Parisian architect of Armenian descent. With its dimensional composition St. John Armenian Church is modern, but there are feelings of Armenian breath and motives. The layout has a shape of an octagon, and each pair of sides split apart with prolonged ornaments. The designs of the surfaces of all the fragments are with traditional niches that end with thematic crowns from Armenian grape vases and leaves. Only the entrance has a circular shape surrounded with round ornaments. The dome of the church ends with sixteen sided, hand-held fan-shaped golden roof. The design of angles which connect the drum segments are with a pair of columns, and arches are open from the center of the sides. The described in real creates a unique mood and environment. Eight double-intersecting arches express the structure of the church, each of which includes two external fragments. At the crossroads of the arches, there are formations decorated with Armenian ornaments. Thereby, the dome's space is united and fascinating. The church has a covering from Indiana limestone (Fig. 3).



Architect Albert D. Guilbert

Fig. 4. The general view, facade, inner view and dome of the Cathedral of St. John the Baptist in Paris (1902)

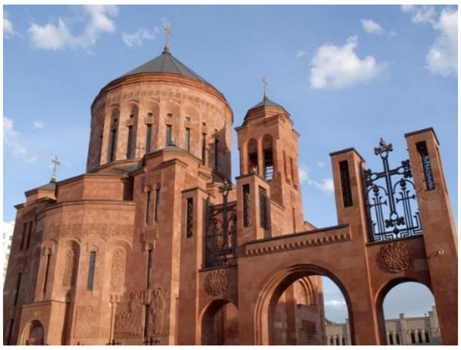
The intersecting arches theme is in the structure of the Armenian Cathedral of St. John the Baptist in Paris which construction started in 1902 by the efforts of a great Armenian philanthropist Alexander Mantashev. The design of the church belongs to French architecture Albert-Désiré Guilbert. The location of the Cathedral is at Rue Jean-Goujon street near the Champs-Élysées. The architect studied medieval Armenian churches and in his design synthesized European and Armenian styles. Albert-Désiré Guilbert expressed his studies while processing the facade and in dimensional composition. The cathedral is rich in decorations: traditional Armenian ornaments and crowns, the sculptures of apostles Jude Thaddeus and Bartholomew, and fascinating cornices. It is noteworthy that the architect used a characteristic of Armenian architecture the structure of the intersecting arches. The method enabled to create a complete, unified space. The arches lie on a pair of columns. The solution of transition from the arches to the octagonal drum is the laconic pallets. Decorated with ornaments the wooden roof has hand-held fan-shape and more European structure. The entire church is rich in frescoes which represent heroic moments of the Armenian nation. Armenian Cathedral of St. John the Baptist in Paris became the home for Armenians of Paris, a place where they gathered and organized the life of the diaspora. From here the Armenian volunteers left to the front. Here the diaspora buried Komitas Vardapet and Andranik Ozanian. The weddings and baptisms of thousands of Armenian people took place in this church.

Churches with medieval Armenian church motives	Armenized Churches	Adaptized churches

St. Vartan Cathedral of New York

St. Illuminator Armenian Cathedral in New York

Armenian Church of Saint Gregory the Illuminator of Singapore



Holy Cross Church of Moscow

St. Garabed Church in Hollywood

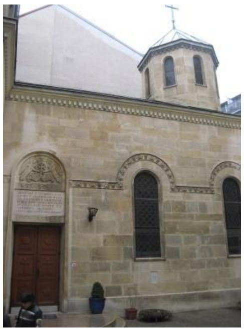
Armenia Apostolic Church of St. Mary in Melbourne

St. John the Baptist Church of Paris

St. Asdvadzadzin Church in Massachusetts

St. Vartanantz Armenian Apostolic Church in Rhode Island

St. John's Church of Detroit



St. Hripsime Church in Vienna

Armenian Churche in Bangladesh

Fig.5. The classification of churches constructed in the Diaspora

3. Conclusion

1. From a functional point of view, the Armenian Church built in the Diaspora has the following peculiarities: it carries out a primary function from the very beginning, but also church is the focal point for the community, it is the gathering place, where Armenians hold the majority of their events.
2. The architectural organization of churches also expresses the needs of the community. In the plan, they are mostly spacious halls with organized spaces. For the same reason, near to the churches, there are usually separate spacious halls for meeting events and other needs of the Diaspora (e.g., St. Gevondyan Cathedral of Los Angeles).
3. The church's compositional and ideological emphasis was on giving an Armenian characteristics to it. Three principles are the bases of the external image of the structure (In Fig.5 there is their classification).

a. St. Vartan Cathedral of New York, Cathedral of the Holy Cross Church of Moscow, Armenian Cathedral of St. John the Baptist of Paris, and St. John's Armenian Church of Detroit are the original churches whose design and construction has medieval Armenian church motives in them.
b. By Armenization of formerly differently functioned structures, churches with transformations are St. Illuminator Armenian Cathedral in New York, St. Garabed Armenian Church in Hollywood, St. Asdvadzadzin Armenian Apostolic Church in Massachusetts, St. Hripsime Armenian Apostolic Church in Vienna.
c. In some cases, there are also churches with no reference to Armenian architecture, which previously served for the religious needs of other communities. The Diaspora adapted the insides of these buildings to the Armenian Church rituals. The examples of such churches are Armenian Church of Saint Gregory the Illuminator of Singapore, Armenia Apostolic Church of St. Mary in Melbourne, St. Vartanantz Armenian Apostolic Church in Rhode Island, Vartan, and the Armenian Churches in Bangladesh.

Acknowledgements

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ON CRAFTSMANSHIP IN ANCIENT CHINA FROM MATCH BETWEEN LU BAN AND MO ZI

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Keywords: Lu Ban, Mo Zi, Chinese ancient craftsman, craftsmanship

Abstract. Craftsmanship refers to the professional ethics and spirit that craftsmen adhere to in their professional practices. Manifested as dedication to work, constantly striving for perfection, perseverance, pursuing excellence and innovation, craftsmanship is essentially a kind of spiritual culture and spiritual strength. As advocated by the Party and state leaders including General Secretary Xi Jinping and Premier Li Keqiang, craftsmanship is exerting increasing influence in China. In addition, the essence of fine traditional cultures of China is embodied in craftsmanship. Originating from the Spring and Autumn Period and Warring States Period over 2,000 years ago, it was closely related to the two world-renowned craftsmen at that time, Lu Ban and Mo Zi. The debate between Lu Ban and Mo Zi on the relation between principle and technology and between technology and application had inspired two different views of craftsmanship of later generations, and, even now, still enlightens us on the understanding of the historical connotation and contemporary values of craftsmanship.

1. Introduction

Craftsmanship, also known as "labor spirit" or "professionalism", refers to the spirit, values and professional ethics and conduct that workers and practitioners of different industries and professions adhere to in their labor practices. Manifested as the professional ethics of dedication to work, the professional ideal of striving for perfection and excellence, the working attitude of pursuing innovation and progress and values of indifference to fame and interest and willing to sacrifice, craftsmanship is essentially the respect and love to labor as well as the sense of identity, honor and mission towards work. As advocated by the Party and state leaders including General Secretary Xi Jinping and Premier Li Keqiang, craftsmanship has become a hot word known by one and all and is exerting increasing influence in China. In March 2016, Premier Li Keqiang proposed in the *Report on the Work of the Government*: "Foster a craftsmanship spirit of striving for the best, so that more types of products, products of a higher quality and brand products will be made", which advocated craftsmanship at a national level. In the *Speech at the Symposium of Intellectuals, Model Workers and Youth Representatives* in April 2016, General Secretary Xi Jinping pointed out:"Man and society were created by labor. Any occupation is glorious without superiority and inferiority.... Love the work we are doing and endeavor to perfect professional skills. In a workshop, we shall meticulously process every part and produce high-quality products to carry forward "craftsmanship".... By studying, practicing and working diligently and always striving for the best, every worker will make great achievements." [1] In October 2017, Xi Jinping proposed in the report of the 19th National Congress of the Communist Party of China: "Cultivate knowledgeable, skilled and creative workforce, develop and expand the spirit of model workers and craftsmen and create a social climate that advocates the glory of labor and dedication to work." All these talks have emphasized the value and significance of craftsmanship in economic and social development of China [2].

In addition, the essence of fine traditional cultures of China is embodied in craftsmanship.

Originating from the Spring and Autumn Period and Warring States Period over 2,000 years ago, it was closely related to the two world-renowned craftsmen at that time, Lu Ban and Mo Zi. The debate between Lu Ban and Mo Zi on the relation between principle and technology, between principle and art and between technology and application had inspired two different views of craftsmanship of later generations, and, even now, still enlightens us on the understanding of the historical connotation and contemporary values of craftsmanship.

2. Match between Lu Ban and Mo Zi and Their Different Understandings of Craftsmanship

2.1. Biography of Lu Ban and Lu Ban Culture

Lu Ban's surname was Gongshu and first name was Ban or Pan. As a descendant of the royal family in the state of Lu (current Qufu in Shandong), he was also known as Lu Ban. Lu Ban was born in 507 B.C. and died in 444 B.C. Born in a craftsman family, he had participated in many construction projects with his family from childhood and accumulated rich labor experiences. At the age of fifteen, he started studying Confucianism under Zi Xia, a student of Confucius. Later, after living in seclusion in the south of Mount Tai for thirteen years, he met an old man surnamed Bao and learned carving and other crafts from him.

Lu Ban always focused on using his hands and brain in practices and thus invented numerous engineering instruments and mechanical tools. He had constructed imperial dwellings, pavilions and terraces, produced military instruments such as the scaling ladder for attacking a city, the towing hook for water fight and the wood-horse vehicle etc., and invented various carpenter's tools such as the square, ink marker, saw, plane and chisel as well as production tools such as the mill and roller. These tools and instruments had extricated carpenters from primitive and heavy work and significantly improved their efficiency of labor.

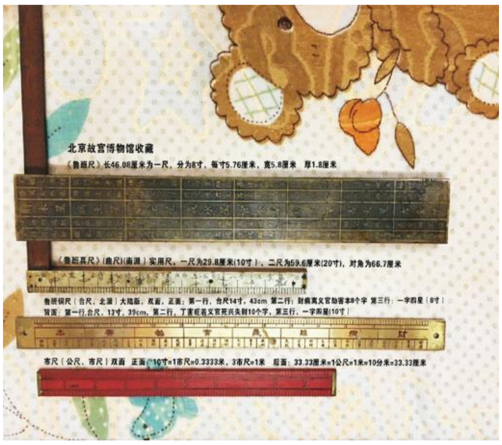

Fig. 1 The "Lu Ban Ruler" displayed in the Palace Museum in Beijing

Fig. 2 Carpenters' tools invented by Lu Ban

The "Lu Ban Lock", a kind of developmental toy similar to a magic cube, was one of Lu Ban's excellent inventions. With an appearance of a cross, it is made up of six wood strips which are inserted into each other in a three-dimensional way and are gripped through the internal mortise and tenon joint.

Fig. 3 "Lu Ban Lock" in Beijing University of Civil Engineering and Architecture

In the Sino-German Economy and Technology Forum held in October 2014, Chinese Premier Li Keqiang presented an orange-red "Lu Ban Lock" made up of 6 aluminum alloy strips to German Chancellor as a gift, and said: "To solve the 'Lu Ban Lock' is like to solve a difficult problem. I believe that China and Germany will jointly solve worldwide problems through constant innovation of Sino-German cooperation." Premier Li Keqiang chose "Lu Ban Lock" as a gift with a profound implication. As Lu Ban is honored as the earliest ancestor of Chinese carpenters, "Lu Ban Lock" represents the "craftsmanship" of China; and meanwhile, "made in Germany" has been regarded as the pacesetter of modern manufacturing worldwide, so its essence also rests in "craftsmanship". Thus, this gift implies the in-depth cooperation between China, the world largest manufacturer, and Germany, the world best manufacturer [3]. Lu Ban is honored as the "founder" by craftsmen, carpenters and engineers in later generations owing to his outstanding achievements. By the Ming and Qing Dynasties, the only book about folk architecture and construction in China at that time was titled as *Lu Ban Scripture* and widely circulated among carpenters. Lu Ban had been gradually deified with the changes of the times and become the wisdom master and the god of craftsmen respected and worshiped by later generations. His deeds and achievements had been widely known in different regions and nations of China, forming the Lu Ban culture of unique characteristics and profound influence.

2.2. Biography of Mo Zi and His Book

Mo Di, born in the state of Lu in 476 B.C. in a carpenter's family and died in 390 B.C., was the founder of Mohism and respectfully addressed as Mo Zi by later generations. According to *Huai Nan Zi Brief Introduction*, Mo Zi "studied Confucianism and accepted Confucian ideas in his early years, but he considered that the rites of the Zhou Dynasty advocated by Confucius were too complicated and cumbersome. In his opinion, the elaborate funerals had cost so much that poverty grew and long time of mourning jeopardized people's life and government affairs. Therefore, instead of applying the rites of the Zhou Dynasty, Mo Zi advocated using government decrees in the Xia Dynasty." [4] Later, Mo Zi founded Mohism, which was a famous school on a par with Confucianism at that time. After the death of Mo Zi, Mohism developed into three major factions, Xiangli, Xiangfu and Dengling. It was finally interrupted by the Han Dynasty and became a lost body of knowledge ever since then. Mo Zi's thoughts are mainly embodied in the book *Mo Zi*. As recorded in the *Descriptive Accounts of Books in Dynastic Histories of the Book of Han*, Mo Zi had 71 chapters, compared to only 53 which are still extant. The core of Mohism lay in the Ten Major

Programs including "universal love" and "non-attack". In Mo Zi's opinion, the fundamental principle of statecraft was to bring goodness and remove all evil. The great evil referred to successive wars among dukes, which caused a huge loss of people's life and property. Thus, Mo Zi advocated "non-attack". Also in his opinion, "universal love" among the people was necessary to wipe out the war or other harms. In a word, Mo Zi's basic thought of administering a country was to advocate universal love and save the world with universal love. As stated in *Consistent Mind of the Springs and Autumns Annals of Master Lv*, "Mo Zi advocated universal love", i.e. standing for "equal love for everyone". (*Mo Zi, Definition of Terms*) However, Confucianists including Mencius strongly opposed universal and equal love. Mencius had once said: "Those who carry out universal love are merely beasts." (*Mencius, Second Chapter of Duke Tengwen*)

Like Lu Ban, Mo Zi was also an excellent carpenter as well as a teacher to engineers and technicians from all sectors. He had invented many instruments for defending small and weak countries from invasion by powerful countries, including the famous crossbow car, stone-casting car and tunnel defense facilities. As recorded in *Mo Zi, Defense against High Attack*, the crossbow car was a heavy weapon of defense against the attack from a height. [5] According to the research of British scientist Joseph Needham, the crossbow car invented by Mo Zi could shoot one big arrow of 10 Chi (approximately 3.3 meters) long and 60 small arrows at a time, making it the most powerful weapon of the world at that time.[6] In addition, Mo Zi also invented another weapon of defense, the stone-casting car. "Also known as the rotatable-firing machine, the stone-casting car is actually a mechanical stone gun that throws stones to kill enemies produced by means of the lever principle." [7] *Mo Zi, Defense of the City Gate* explained the structure and functions of the stone-casting car as follows: "The stone-casting car has a pillar approximately 340 cm long and the underground part of approximately 80 cm long.... As to the base of the car with a length of approximately 600 cm, about three fourths are above the wheels and the horse face (i.e. the convex structure at both edges of the car) is placed at the one-third length of the base. The horse face is approximately 56 cm long and the base has a length of about 480 cm.... The axle bearing of the stone-casting car is made with iron, and the chariots supporting the stone-casting stone closely follow the car." [8] Finally, Mo Zi also invented various facilities of defense against tunnel sneak attack by the enemy. These weapons and facilities of military defense invented by Mo Zi "embody practical military strategies and feature profound technology connotation, and have been regarded as the golden laws for the defense of small cities. Derived from the 'Defense of Mo Di'....a famous set phrase 'Mo Shou Cheng Gui' was gradually formed, which means to be fettered by old conventions"[9].

2.3. Match between Lu Ban and Mo Zi and Their Different Understandings of Craftsmanship

Mo Zi, Gongshu recorded the story of how the two famous carpenters in the Spring and Autumn Period, Lu Ban and Mo Zi, made use of the sand table to simulate military attack and defense. This was the first match between them two. The story is as follows:

Gongshu Pan, also known as Lu Ban, produced the scaling ladder for the state of Chu as a preparation for attacking Song. Hearing this, Mo Zi set off from the state of Qi and walked for ten days and ten nights before arriving at Ying, the capital of Chu. He met Gongshu Pan there. Gongshu Pan asked: "What can I do for you?" Mo Zi said: "A man from the north is bullying me. Please kill him for me." Gongshu Pan was displeased. Mo Zi continued: "I can give you two hundred liang (approximately 10 kg) of gold as a reward." Gongshu Pan answered: "I adhere to benevolence and righteousness and will never kill a person."

Mo Zi stood up and saluted Gongshu Pan again, saying:“ I've heard that you have produced the scaling ladder as a preparation for attacking Song. What is the accusation against Song? As Chu has surplus resources of land but a small population, it is not wise to sacrifice your precious human resources for the land you have enough; it is not benevolent or righteous to attack Song that is not guilty; you are not loyal as you know this but choose not to argue with the government; you are not powerful if you fail to stop the war through great efforts; and it is unwise of you to reject to kill one person but agree to kill more people." Gongshu Pan was persuaded by him. Mo Zi asked: "Why don't you cancel the plan to attack Song?" Gongshu Pan answered: "I have already told the king of Chu about the attack." Mo Zi said: "You can recommend me to the king." Gongshu Pan agreed.

Then Mo Zi met the king of Chu and said: "Now there's a man who gives up his own gorgeous colored car to steal his neighbor's broken car, gives up his own beautiful clothes to steal his neighbor's coarse clothes and gives up his own delicious food to steal his neighbor's meager food. What do you think of this man?" The king of Chu answered: "This man has a problem of stealing." Mo Zi said: "The land of Chu covering five thousand square kilometers and Song's land covering five hundred can be compared to the colored car and broken car; Chu embraces rare and valuable animals including rhinoceroses and deer near Yunmeng Lake and also has fishes and all kinds of turtles in Yangtze River and Hanshui River, but Song has even no pheasant, hare or fox, which exactly like the comparison between delicious food and meager food; and Chu having precious timber such as the pine tree, catalpa, nanmu and camphorwood and Song having no big tree can be compared to the beautiful clothes and coarse clothes. From the three aspects, it can be seen that Chu, if attacking Song, is exactly the same as the man with a disease of stealing. According to my prediction, if you do so, you will gain nothing but only impair benevolence and righteousness." The king of Chu responded: "Notwithstanding what you said, I have to attack Song as Gongshu Pan had produced the scaling ladder for me."

Then, the king summoned Gongshu Pan to fight Mo Zi through war simulation. Mo Zi unfastened his waistband, coiled it to be a city and used small wood chips as the defense instruments. Gongshu Pan applied nine different attack instruments, while Mo Zi successfully defended the city for nine times. When the attack instruments of Gongshu Pan had been used up, Mo Zi still had more strategies for defense. Gongshu Pan said wearily: "I know a way to take you down but I won't say." The king asked why. Mo Zi said: "Gongshu Pan's way is to kill me. If I am killed, Song cannot defend against Chu army and will be soon conquered by Chu. However, I have my three hundred disciples including Qin Huali wait for Chu army on the wall of Song, holding the defense instruments I invented. Even if you kill me, you are still unable to seize Song." The king of Chu answered: "All right. I will drop the plan to attack Song."

Returning from Chu, Mo Zi passed the state of Song. It suddenly rained, so Mo Zi wanted to stay at a gate of Song's capital for shelter. However, the guardian rejected him. Therefore, "No people know who invents and uses the magic machine; but everyone knows who argues with others in the open"[10].

Fig. 4 The story of Mo Zi saving Song and the match between Lu Ban and Mo Zi recorded in Mo Zi, Gongshu

This story had also been recorded in *Growing Big with Care of the Springs and Autumns Annals of Master Lv*, "Mo Zi was skillful in attacking and defending a city and even convinced Gongshu Ban (Lu Ban), but he chose to be unknown despite his great talents in military strategies. Thus, the undefeated people always find a way to develop a weak country to be strong." [11] The match between Mo Zi and Lu Ban in the state of Chu was essentially an asymmetric warfare between one person, Mo Zi, and a super power with advanced weapons for attacking a city. This story advocates Mo Zi's humanitarian ideas and pacifist spirit of "universal love" and "non-attack", reveals his great personality and wisdom and displays the different understandings of the two great craftsmen, Lu Ban and Mo Zi, on craftsmanship and the relation between technology and application. Both of them possessed excellent skills, with one inventing the weapons of attack including the scaling ladder and wood-horse vehicle and the other producing the weapons of defense including the crossbow car and stone-casting car. Meanwhile, both were proficient in military strategies and tactics and applying military instruments to military attack or defense.

However, they two had different understandings about craftsmanship and held different attitudes towards the relation between principle and technology and between technology and application. In Lu Ban's view, the highest realm of a craftsman was to perfect the tools and instruments invented by him and fully apply these tools to people's production and life and wars, thus to improve the efficiency of labor and combat. By comparison, Mo Zi believed that a craftsman should not only be proficient in technology, but also utilize the tools and technologies in a correct manner and serve humanism, i.e. benevolence and righteousness. Mo Zi also held that the principle of administering a country should be promoting the interests of the whole world and removing the harms of the whole world. As the successive wars among dukes were considered as the major disaster of the world, he opposed the war of aggression. In Mo Zi's opinion, the root cause of wars and other social evils lay in "no love" among the people: "The duke who has love for only his own country but no love for other countries will use military force to attack other countries; and the person who has love for only himself but no love for others will exert himself to the utmost to hurt others. No love among dukes necessarily leads to war; and no love among the people necessarily cause people hurting each other. In a world without love, the strong bullies the weak, the rich humiliates the poor, the superior despises the inferior and the deceitful picks on the foolish." (*Mo Zi, Second Chapter of Universal Love*) [12] Thus, in his opinion, "universal love" among the people was necessary to wipe out the war or other harms. According to *Mo Zi, First Chapter of Universal Love*, "If all people love each other like loving themselves, there will be no unfilial behavior under heaven; if viewing the father, older brother and king as oneself, there will be no disloyalty; if treating the younger brother and subordinate as oneself, there will be no unkindness; if regarding others family as one's own, there will be no theft; if considering others body as one's own, there will be no harm to others; and if treating others country as one's own, there will be no invasion. In a word, if all the people under heaven love each other, countries will not attack, people will not steal, the relation between the monarch and his subjects and between the father and his sons will be kind, and the country will be under good governance." [13] Therefore, Mo Zi strongly opposed the powerful state of Chu invading the weak state of Song relying on the scaling ladder invented by Lu Ban. Considering the great damages to the people in Chu and Song that would be caused by the war of invasion, he would rather sacrifice his own life to stop this war. The story of the match between Lu Ban and Mo Zi fully demonstrates that Mo Zi attached great importance to "universal love" and "justice" and advocated the philosophy of serving the "justice" principle with tools and technologies.

3. Historical Connotation and Contemporary Values of Craftsmanship in Ancient China

3.1. Connotation and Culture of "Craftsman"

In classical Chinese literature, the two Chinese characters, "Gong" and "Jiang", were used separately in early times (while the two characters together mean the craftsman). "Gong" was written as "Gong" (工) in the oracle bone inscription and was written as "工" and "工" respectively in the Chinese bronze inscription and the small-seal script. As explained by Xu Shen, an ancient writing master in the Eastern Han Dynasty, in his *Origin of Chinese Characters*, "Gong means the elaborate tool, such as the tool to draw a square or a circle." The definitions of "Gong" in other dictionaries were similar. For example, the *Song Rhyming Dictionary* stated: "Gong refers to the ingenious." *Yu Pian* (another dictionary of Chinese characters) explained: "Gong means to do a work well." Thus, the original meaning of "Gong" was the implement held in people's hands, which was later extended to be the craftsman, professional musician and official or any elaborate or ingenious thing.

The character "Jiang" (匠) was written as "匠" and "匠" respectively in the Chinese bronze inscription and the small-seal script. According to the *Origin of Chinese Characters*, Xu Shen defined "Jiang" this way: "It means woodwork. Both "匚" and "斤" in this character are semantic elements. Jin (斤) refers to the implement made." "匚" was the character "Fang" (方) in early times, which indicated the square implements. *Song Rhyming Dictionary* recorded: "Jiang means the craftsman." It can be seen that the original meaning of "Jiang" was the carpenter, which was later extended to be a worker with professional skills or a person having great accomplishments in a certain area.

By combining "Gong" and "Jiang" together, it means the person skilled in certain craft. This word "Gong Jiang" (i.e. craftsman) firstly emerged in the literature of the Warring States Period, the Qin and the Han Dynasty such as *Xun Zi* and *Huai Nan Zi*. For example, as recorded in *Xun Zi, Honor or Disgrace,* "You can be either a craftsman, a farmer or a merchant." According to *Huai Nan Zi*, *Consistent Customs*, "The sage judges everything like a craftsman cuts the tenon and mortise and like a cook kills and dismembers domestic animals, which shall be intricate and appropriate without damaging the tool or arm. However, it is not the case with clumsy workers, who may have the work blocked by too big a tenon or fail to realize its function due to a small tenon.

They can hardly express their minds with their hands." [14] Thus, as a contrast to the "clumsy worker", a craftsman refers to a handicraftsman who embraces a clever mind and clever hands, great originality and superb skills, instead of the common workers of a dull head or rough technology. Rich craftsman culture is hidden in Chinese traditional culture. The *Rites of the Zhou Dynasty, Winter Official, Record on Crafts* had recorded the professional norms for workers respectively engaged in the construction of wheels, cars, potteries and cities. The story of "Pao Ding dismembering an ox skillfully" recorded in *Zhuang Zi* and the story of famous craftsman "Chui" in the *Springs and Autumns Annals of Master Lv* fully reflect the excellent skills of Chinese ancient craftsmen.

3.2. Historical Connotation of Craftsmanship

Being a concept relative to "material", "spirit" refers to "people's consciousness, thinking, general state of mind and vitality." [14] "Craftsmanship", the spirit of craftsman, indicates the ideology, psychology, mood and will of the craftsman, which refers to either the mental state of an individual craftsman or the mental outlook of craftsmen as a group.

The history of the Chinese nation embodies the wisdom and creation of numerous craftsmen. On the land of China, once the largest country of originality of the world in ancient times, a large number of excellent craftsmen had emerged, including Chui, Lu Ban, Mo Zi, Pao Ding and Zhang Heng et al., and have been admired by the posterity for their gorgeous skills. Among them, the craftsmanship of Lu Ban has driven the progress of the whole social civilization and the development of manufacturing as a model and symbol of Chinese craftsmanship and constituted a concentrated reflection of the innovative spirit of the Chinese nation.

According to some scholars, Lu Ban's craftsmanship mainly consists of five aspects. **First, the soul of craft of a great power: rigorous attitude, great concentration and pursuit of high quality.** With numerous inventions and outstanding achievements in woodworking instruments, agricultural implements, construction and military weapons, Lu Ban is regarded as the representative of skilled craftsmen. These great accomplishments demonstrate the professional spirit of Lu Ban, including the rigorous attitude, great concentration and pursuit of high quality. **Second, the ethical foundation for mass entrepreneurship and innovation.** Lu Ban always maintained an innovative mind and therefore invented the tools including Lu Ban ruler, ink marker, saw and axe, built halls, lofts, bridges and pavilions etc. and produced military weapons or instruments including the scaling ladder, towing hook and battering ram, making him the "ancestor of all works". The innovative spirit of Lu Ban provides great spiritual support to the strategy of mass entrepreneurship and innovation. **Third, the national heritage: observing rules and being diligent and progressive.** The first-class craftsman shall equip the professional quality of knowing and observing rules. Lu Ban had studied skills from his family since his childhood, acquired many innovative craft skills through the civil and structural engineering and adhered to the professional ethics of observing rules, being diligent and progressive, holding himself in awe and exercising self-discipline. **Fourth, the scientific foundation: striving for excellence and practicing self-examination.** According to *Material Origin* and *Ancient History*, Lu Ban always studied intensively and strove for excellence in each work. His inventions, being "ingenious, excellent, refined, precise, functional and innovative", reflects the scientific spirit of striving for perfection and self-examination. **Fifth, the method of teaching and learning: respecting teachers, valuing education and the unity of knowledge and action.** When studying from a teacher, Lu Ban always remembered the teacher's instructions. Later he had received and taught a great number of disciples and cultivated many great craftsmen. Constantly improving himself through practices, he also showed the spirit of the unity of knowledge and action [15].

Also according to some scholars, Lu Ban's craftsmanship mainly comprises four connotations: **First, the perseverance**. Lu Ban had devoted his whole life to constantly improving his skills and exerted a long-lasting influence on later generations with his perseverance and persistence. **Second, striving for excellence.** Lu Ban attached great importance of the quality of projects. He would repeatedly conduct calculation based on the standards and norms and pay attention to details before mounting the beam of a house, in order to assure the perfect joint between the beams without any seam. To inherit and carry forward Lu Ban's craftsmanship of striving for excellence, China Construction Industry Association has named the prize for the highest quality of construction as the "Lu Ban Prize of Architecture Engineering", shortly known as the "Lu Ban Prize". **Third, innovation.** Innovation of Lu Ban was mainly manifested as his clever and ingenious design. In *On Balance, Exaggeration of Confucianism*, scholar Wang Chong in the Eastern Han Dynasty had recorded the story of Lu Ban applying the ingenious skills of woodworking to produce the manned flight tool by imitating the fly of birds. Various tools and instruments invented by Lu Ban including Lu Ban ruler, Lu Ban lock and scaling ladder etc. also reflect his pioneering and innovative spirit. **Fourth, closely combining practices.** As a craftsman at the grass-root level, Lu Ban had closely combined the practices and life of laboring people in all his creations and inventions, which had extricated the people from strenuous labor and vigorously promoted the development of social productive forces [16].

3.3. Contemporary Values of Craftsmanship

In addition to rich historical connotation, craftsmanship in ancient China represented by Lu Ban and Mo Zi also features important contemporary values. As craftsmanship still presents important contemporary values under the background of globalization and the new era, it is of great theoretical and practical significance to inherit and carry forward craftsmanship.

Firstly, it will provide a strong spiritual motivation for the transition of China from "a big manufacturer" to "a powerful manufacturer" and the completion of the strategy "Made in China 2025" by inheriting and carrying forward craftsmanship. At present, Germany has proposed "Industry 4.0", and the United States has put forward the strategy of Industrial Internet; while China is at a critical stage for transformation and upgrading. Through the rapid development for four decades since the Reform and Opening up, China has become the largest manufacturer of the world as well as the "world factory", and products made in China can be seen at every corner of the world including automobiles, electrical appliances, clothes and toys etc. The sizes of many sectors in China are even leading the world. However, China still lacks famous brands of great influence and is only active in low-end products and downstream products of an industry, which severely hurts the image of Chinese enterprises and Chinese brands. An important factor contributing the large size but weak strength and low product quality of Chinese manufacturing lies in the shortage of highly skilled talents with "craftsmanship". In order to drive the transition of China from "a big manufacturer" to "a powerful manufacturer", the State Council had issued *Made in China 2025* in May 2015 and released the program of action for the first decade of the implementation of strategy "a powerful manufacturer". To catch up with world manufacturing powers and achieve the strategic goal of "Made in China 2025", it is necessary to advance and develop "craftsmanship" of striving for excellence and innovation, integrate this spirit in every link of production, design and operation and realize the transfer of the focus from the quantity to the quality.

Secondly, it will provide a solid theoretical foundation for the construction of professional ethics and the development of vocational education by inheriting and carrying forward craftsmanship. Despite the dramatic progress made in the construction of professional ethics in Chinese society, some problems have arisen, including the blind pursuit of economic interests and short-term benefits, wrong values of utilitarianism and money orientation dominating certain industries and the production and sale of fake products that seriously threaten people's life, health and safety such as "fake vaccines", "toxic milk" and "dyed steam buns". Craftsmanship attaches great importance to the heart of the craftsman, advocates the professional ethics of "knowing and observing rules", pays attention to the quality of products and long-term cultivation of brands and stresses on the professional spirit of striving for excellence and innovation, which provides a solid theoretical foundation for the construction of professional ethics in China and advances the healthy development of Chinese enterprises and industries.

Vocational education constitutes an important part of education in China. Since the Reform and Opening up, vocational education has supplied vigorous talent and intelligence support to economic and social development in China. With the advent of the new stage of development and the accelerated industrial upgrading and economic-structure adjustment in China, all industries are having an increasingly pressing demand on technical and skilled talents. Thus, vocational education is playing a more important role in education. For this purpose, the State Council has successively released the *Outline of the National Program for Medium-and Long-Term Educational Reform and Development (2010 - 2020)* and the *Implementation Plan for National Vocational Education Reform*, put forward the national strategy of cultivating high-quality laborers and high-end skilled talents, emphasized on "optimizing the structure of higher education and cultivating skilled craftsmen of the nation by developing higher vocational education", carried out the activities of "craftsmen on campus" and "model workers on campus" etc. and given publicity to the deeds and images of the craftsmen of the nation, skilled craftsmen and high-quality laborers, in order to spread and inherit craftsmanship. Thus, craftsmanship is the soul of vocational education as well as the essential professional qualities of high-quality laborers and high-end skilled talents. To support the construction of a power country in vocational education, it is necessary to inherit craftsmanship and integrate it in vocational education.

Thirdly, it will provide rich cultural resources for the development of the core values of Chinese socialism including "dedication" by inheriting and carrying forward craftsmanship. The core values of Chinese socialism are dominating current Chinese society. The Eighteenth National Congress of the Communist Party of China proposed to actively cultivate and implement the core values of Chinese socialism, including prosperity, democracy, civility, harmony, freedom, equality, justice, the rule of law, patriotism, dedication, integrity and friendship. Being a value for the code of professional conduct, "dedication" requires citizens being devoted to their duties, repressing the private for the public, respecting and loving their work and being willing to selflessly dedicating to their work. The Chinese nation has boasted of its traditional virtues of "respecting work and enjoying company" and "being devoted to the duties", while Chinese craftsmanship always advocates "excellence coming from diligence" and "being prudent and honest in work". Both advocate that people shall work seriously, prudently, concentratedly and unremittingly. As stated by Liang Qichao in *Respect and Love Your Work*, "All professions are sacred and respectful.... If showing little respect for your work, your are blaspheming the sacredness of your job and doing harm to yourself. Therefore, dedication is the most necessary and meanwhile the most beneficial for your life." Thus, it will provide rich cultural resources for the development of the core values of Chinese socialism by inheriting and carrying forward craftsmanship and advocating respect and love for work.

Fourthly, it will provide important enlightenment for the national strategy "mass entrepreneurship and innovation" by inheriting and carrying forward craftsmanship. Premier Li Keqiang put forward the national strategy "mass entrepreneurship and innovation" in the Summer Davos Forum in September 2014. In July 2017, the State Council issued the *Opinions on Strengthening the Implementation of Innovation-Driven Development Strategy and Further Promoting the Deep Development of Mass Entrepreneurship and Innovation*, which pointed out: "Innovation is the soul of social progress as well as an important method to advance economic and social development and improve people's livelihood. The deep development of mass entrepreneurship and innovation plays as the important carrier to implement innovation-driven development strategy." Since craftsmanship advocates technical innovation based on traditional technology and pursues excellent quality, original design and rigorous attitude in work, it can provide important experiences to "mass entrepreneurship and innovation" and enlightenments for cultivating the craftsmen of the nation, realizing exquisite craftsmanship and building China into a powerful manufacturer.

4. Conclusion

Under the background of globalization and the new era of socialism with Chinese characteristics, it meets the demands of the special age and practical demands to advocate and carry forward craftsmanship, which features important contemporary values. Thus, we shall profoundly explore the spirit of craftsmen contained in the excellent craftsman culture of the Chinese nation as the powerful spiritual motivation and cultural foundation for the transition of Chinese manufacturing, the development of vocational education, the expansion of the core values of Chinese socialism and the implementation of the national strategy "mass entrepreneurship and innovation".

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STATUS AND ROLE OF BEIJING REVOLUTIONARY MEMORIAL ARCHITECTURAL CULTURE IN THE NEW AGE

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Abstract. The rich and profound revolutionary memorial architectural culture in Beijing plays a unique and important role. Beijing is not only the place where revolutionary memorial architectural culture originated but also the center of national revolutionary memorial architectural culture in the new age. By carrying forward red architectural culture in Beijing, we can promote ideological construction of the capital, strengthen political and cultural identity in Beijing, inherit the red DNA of Beijing, cultivate the core values of Chinese socialism, foster the spirit of the three cultural belts of Beijing and advance collaborative development of Beijing, Tianjin and Hebei.

1. Introduction

Being the place where the Communist Party of China (CPC) was nurtured as well as the command center for national liberation and the political center for the construction of new China, Beijing has experienced a series of major revolutionary and historical events including the spread of Marxism, the May 4th Movement, preparations for Party building, the war of resistance against aggression, the founding of new China, initial explorations of new China and the Reform and Opening up. Thus, while the revolutionary memorial culture in other places generally focuses on only one specific revolutionary spirit, the rich and profound revolutionary memorial architectural culture in Beijing covers the complete red chain from the preparation to the founding and development of the CPC and embodies revolutionary spirits of all time, before and after the founding of the Party and during the new democratic revolution, the socialist revolution, the socialist construction and the Reform and Opening up. By carrying forward red architectural culture in Beijing in the new age, we can promote ideological construction of the capital, strengthen political and cultural identity in Beijing, inherit the revolutionary DNA of Beijing, cultivate the core values of Chinese socialism, foster the spirit of the three cultural belts of Beijing and advance collaborative development of Beijing, Tianjin and Hebei.

2. Status of Beijing Revolutionary Memorial Architectural Culture

2.1 The Birthplace of Revolutionary Memorial Architectural Culture

As an outcome of Marxist localization in China, revolutionary memorial architectural culture is a precious treasure of the CPC. Mao Zedong once stated "The October Revolution sent us Marxism-Leninism". The Red Building Sites of Peking University, an important landmark of Beijing red culture, not only functioned as the stronghold of emancipating thought in the New

Culture Movement and the source of and main position for the spread of Marxism early in China, but also witnessed the activities of the early CPC organization.

- Where the voice of revolution of China started spreading. Li Dazhao, a great revolutionary pioneer of the CPC, was the earliest to systematically introduce and promote Marxism in China, for whom the Red Building Sites of Peking University were the main position. After the victory of the October Revolution in 1917, Li Dazhao, the Director of Peking University Library at that time, had published important articles including *Comparison between French and Russian Revolution*, *Victory of the Common People*, *Victory of Bolshevism*, *The New Era* and *My Marxist View* and so on, which systematically introduced and promoted Marxist theory and Communist theory and laid the theoretical foundation for the founding of the CPC.

- Where the Chinese working class boarded the stage of history. The May 4th Movement in 1919, with the Red Building Sites of Peking University as the main position, was the first patriotic movement that completely and uncompromisingly fought against imperialism and feudalism in modern Chinese history. As a sign of the beginning of China's new democratic revolution, it witnessed that the Chinese working class boarded the stage of history for the first time, promoted Chinese people's resolution and awareness of fighting against imperialism and feudalism, advanced Chinese people's reflection on and exploration of China's transformation and cultivated the class and cadres for the founding of the CPC.

- Where the earliest group researching and spreading Marxism was established. In March 1920, under the leadership of Li Dazhao, the Research Society of Marxist Theory, the earliest group that researched and spread Marxism in China was established in the Red Building of Peking University. This Society actively popularized Marxism. Advanced intellectuals represented by Deng Zhongxia and Luo Zhanglong rushed to all places of Hebei Province to widely spread Marxism-Leninism before and after the founding of the CPC, and had played an important role in cultivating and making early Marxists in China.

- Where the first Party organization in North China was founded. In October 1920, the Beijing Communist Group, the first Party organization in north China, was founded in Li Dazhao's office in the Red Building of Peking University. The Beijing Communist Group had created workers' publications including *Worker's Voice* and *Workers Monthly* in an organizational and planned way, started workers' schools, led workers to establish labor unions, actively carried on workers' campaigns, proposed to found the Socialist Youth League and further combined Marxism and workers' movements, which practically prepared for the founding of the CPC.

In conclusion, revolutionary pioneers such as Li Dazhao, Chen Duxiu, Lu Xun and Mao Zedong had held high the torch of Marxism in the "dark China" in the Red Building Sites of Peking University, which observed how Chinese people explored the road of Communism despite all difficulties and hardships and determined the status of Beijing revolutionary memorial architectural culture as the source of national revolutionary memorial architectural culture [1].

2.2 The Center of National Red Culture

Having seen the spread of Marxism in China before and after the founding of the Party as well as a series of major revolutionary incidents of the CPC development during the new democratic revolution, socialist revolution, socialist construction and the Reform and Opening up, the rich and profound revolutionary memorial architectural culture in Beijing, with a complete structure and a continuous history, has played a significant role in the liberation and development of China. Beijing has actually become the center of revolutionary memorial architectural culture of the whole China.

- The cornerstone of the victory of new democratic revolution. As the origin of revolutionary memorial architectural culture of the whole China, Beijing revolutionary memorial architectural culture had played as the cornerstone of either the spread of Marxism or the founding of the CPC, either during the War of Resistance against Japan or in the War of Liberation. From the New Culture Movement, the May 4th Movement, the founding of the Beijing Communist Group, the Great Strike of February 7, 1923, the Anti-Japanese National Salvation Movement of December 9, 1935, the opening of the second front, revolutionary memorial architectural sites at Fragrant Hills and Tian'anmen Square [2] revolutionary memorial architectural sites, we can see how the leaders of the CPC led Beijing people to struggle for the liberation of the Chinese nation, which laid the foundation for the victory of new democratic revolution.

- The cultural center of the construction and reform of new China. After the founding of new China, capital Beijing has become the political center, cultural center and international exchange center of China. Revolutionary memorial architectural sites including Tian'anmen Square, Zhongnanhai, the Great Hall of the People, Jingxi Hotel, the Hall of Chinese People's Political Consultative Conference and Beijing Hotel have become the venue of activities of the CPC leaders and important Party figures and witnessed the great course of new China construction and the Reform and Opening up. Many important decisions and important events in Chinese history of construction and reform were made or held here. Thus, Beijing has played a core pivotal role in the development of China.

2.3 The Spirit of Beijing Advanced Culture in the New Age

Xi Jinping emphasized in the report of the 19th National Congress of CPC that "to develop socialist culture with Chinese characteristics, it requires adhering to the guidance of Marxism, sticking to the position of Chinese culture and basing on realities of contemporary China." Beijing revolutionary memorial architectural culture is not only an important part of excellent traditional culture of Beijing, but also the spiritual core and inherent DNA of Beijing that drives the development of advanced socialist culture. Perfectly combining excellent Chinese traditional culture and Marxism, it adopts the "form" of excellent Chinese traditional culture and the "soul" of Marxism and has played a leading and guiding role in ideological and cultural sector in all historical stages.

- The "soul" of advanced guiding ideology of Marxism. The generation and development of revolutionary memorial architectural culture is essentially the process of localization and popularization of Marxism in China, while the achievements of revolutionary memorial architectural culture in all historical periods were essentially the accomplishments of Marxism popularization. Beijing revolutionary memorial architectural culture has recorded the whole history of the preparation, birth and development of the CPC and also witnessed the process of localization of Marxism in China. Thus, it presents rich content including the advanced guiding ideology of Marxism, firm ideals and beliefs, lofty moral quality and indomitable revolutionary spirit and so on.

- The "form" of excellent Chinese traditional culture of Beijing. As pointed out in the report of the 19th National Congress of CPC, "since the founding of the CPC, it has always been guiding and practicing Chinese advanced culture and meanwhile inheriting and carrying forward excellent Chinese traditional culture". As a famous cultural city with a long history, Beijing features the excellent principles of "patriotism, diligence, courage, self-reliance, persistence, love for peace and unity". The CPC has led Beijing people to dialectically analyze and critically inherit excellent traditional culture in Beijing from the perspective of Marxist dialectical materialism and scientific world view, extract its essence and discard its dross, and raise it to be patriotism, spirit of utter devotion, revolutionary heroism, mankind emancipating thought and collectivism of China's revolutionary memorial architectural culture, which constitute the "form" of Beijing revolutionary memorial architectural culture.

- Theoretical quality advancing with the times. In the light of the 100-year difficult journey of revolution, construction and reform of the CPC, it is because the CPC always adheres to lofty communist ideals, sticks to the guidance of Marxism, carries forward the spirit of seeking truth from facts, combines constantly changing realities in China, develops new thoughts and theories through practices, accurately seizes and scientifically solves social contradictions in different periods and gradually forms "revolutionary memorial architectural culture" perfectly combining Marxist scientific theory and excellent traditional culture of the Chinese nation that it had survived from the severe tests of life and death, overcome difficulties and reverses in the explorations right after the founding of new China and successfully coped with dangers and challenges during the reform.

Beijing revolutionary memorial architectural culture was born and developed along with the spread, popularization and revolutionary practices of Marxism in China. Presenting rich content including the advanced guiding ideology of Marxism, firm ideals and beliefs, lofty moral quality and indomitable revolutionary spirit, it is an important theoretical outcome of localization of Marxism in China, which embodies the aim, spirit and principle of Marxism, always represents the advanced productive force and advanced culture and is regarded as the soul of advanced culture in Beijing in the new age.

3. Role of Beijing Revolutionary Memorial Architectural Culture

Being the soul of Beijing culture, Beijing revolutionary memorial architectural culture, with its clear political standpoint, lofty values, deep-seated mass foundation and resolute spirit of struggle, not only strengthens ideological construction of Beijing and promotes international and domestic political identity of Beijing, but also plays an important role in inheriting revolutionary DNA of Beijing and cultivating socialist core values.

3.1 Boost ideological construction of the capital and strengthen political and cultural identity of Beijing

As a positive affirmative political culture, Beijing revolutionary memorial architectural culture functions as an important channel to guide domestic and foreign people to understand and recognize Beijing and plays a positive role in safeguarding political legitimacy and improving political authority of the Party.

-The excellent carrier of ideological construction in the new age. The revolutionary sites, revolutionary ruins, revolutionary pioneers, revolutionary stories and revolutionary spirits in Beijing are all precious resources of great value for ideological construction of China. It is through the Peking University Red Building architectural culture sites that people remember the revolutionary pioneers' spirit of exploration and utter devotion in the spread of Marxism in China in those years; through the red architectural culture sites of the Great Strike of February 7 that people witness how the Chinese worker class fought bravely for people's happiness; through the precious cultural relics of the War of Resistance in the Museum of the War of Chinese People's Resistance Against Japanese Aggression that people see the Chinese nation's spirit of being unbending, united and brave in the struggle; and through revolutionary architectural culture sites at Fragrant Hillst hat people will not forget how Chinese people fought courageously for the liberation of the whole China under the leadership of the CPC. Thus, the precious revolutionary wealth is the best carrier of ideological construction in the new age as well as the previous resources for the CPC to win domestic and foreign people's recognition.

-The historical proof of the CPC winning the people. As the saying goes, he who gains the hearts of the people gains the world. The political legitimacy, authority and credibility of the CPC had been practically determined when the Party won people's support. Originating from all previous people's struggles under the leadership of the CPC, Beijing revolutionary memorial architectural culture is a kind of spiritual heritage that reflects people's desire for revolution victory, liberation, national unity and good life as well as a product of culture developed in the history of arduous struggles of the Chinese nation. While Beijing revolutionary memorial architectural culture is constantly enriching and growing, the CPC has won the hearts and confidences of the people.

-The excellent material to politically promote Beijing worldwide. When talking about international communications of China, General Secretary Xi Jinping proposed "to tell a good story and utter a good voice of China". By telling the touching revolutionary stories in Beijing, we can enable foreign people to know the hardships that Chinese people have overcome when pursuing freedom and prosperity in modern times, help them understand the great efforts and dedications paid by Chinese people in this process, successfully promote the image of the CPC to the world, convey the idea of co-development of China and the world and guide foreign people to correctly understand the development of Beijing and China and realize the great contributions made by the development of Beijing to the development of China and the world. If creatively remade in terms of the mode of discourse, expression and narration, the diversified facts in the history of revolutionary struggle contained in Beijing revolutionary memorial architectural culture will become excellent materials to politically promote Beijing to the world.

3.2 Inherit the red DNA of Beijing and cultivate the core values of Chinese socialism

In December 2016, Xi Jinping pointed out again in the National Conference on Ideological and

Political Work in Universities and Colleges "strengthening education on revolutionary culture and advanced socialist culture, inheriting revolutionary traditions and carrying forward the red DNA". The red culture of Beijing incarnates Beijing People's love for their motherland, fully reflects the great efforts and great sacrifices of Beijing people for national independence and prosperity under the guidance of Marxism and embodies revolutionary traditions and revolutionary spirits with Beijing characteristics. It is precious wealth for carrying forward the red DNA of Beijing and cultivating the core values of Chinese socialism.

- High-quality resources for education on the core values of Chinese socialism. Beijing is a famous cultural city with a long history as well as a city boasting of glorious revolutionary traditions. During the new democratic revolution, the CPC had led Beijing people to wage successive heroic struggles in Beijing, written a glorious history that shocked the world and left numerous revolutionary memorial architectural culture remains. These remains embody material and spiritual accomplishments of Beijing People in national independence, liberation, construction and reform under the leadership of the CPC. As the material proofs of Beijing revolutionary history and non-renewable revolutionary cultural resources, they constitute the high-quality resources for education of students on the core values of Chinese socialism.

- Great lesson for education on the core values of Chinese socialism. Derived from the arduous struggles of revolutionary pioneers to explore the path of salvaging the country and the nation, spread Marxism, prepare for the founding of the Party and carrying out new democratic revolution, socialist revolution, socialist construction and Reform and Opening up in Beijing area in the recent century, Beijing revolutionary memorial architectural culture that is distributed widely presents vivid and moving stories. When visiting and studying the rich and profound revolutionary culture, students will listen to and feel the vivid and moving revolutionary stories and be affected by revolutionary pioneers' patriotism to overcome all difficulties and hardships and dedicate themselves to save the country and the people. Thus, Beijing revolutionary memorial architectural culture provides spiritual education and morality cultivation for students and encourages young people nowadays to build their patriotism, revolutionary optimism and the spirit of arduous struggle and dedication and establish the common ideal of socialism with Chinese characteristics and the lofty communist ideal.

3.3 Shape the soul of the three cultural belts in Beijing and advance collaborative development of Beijing, Tianjin and Hebei

The rich and high-class revolutionary culture resources in Beijing, Tianjin and Hebei mainly include the revolutionary sites, war ruins, monuments to revolutionary martyrs, revolutionary remains and memorial halls left during the May 4th Movement, the spread of Marxism, the War of Resistance against Japan, the War of Liberation and the founding of new China. To fully explore the connotation of revolutionary memorial architectural culture in the three places and give full play to the integrated construction strength of Beijing, Tianjin and Hebei, it will help shape the soul of the three cultural belts in Beijing and drive the collaborative development of cultural construction in these three places.

-Shape the soul of the three cultural belts in Beijing. The "13th Five-year Plan" of Beijing expressly lists "promoting the protection and utilization of the Great Wall Cultural Belt [3, 4], the Western Hill Cultural Belt and the Grand Canal Cultural Belt" as a major task. The revolutionary memorial architectural cultures contained in "the Great Wall Cultural Belt, the Grand Canal Cultural Belt and the Western Hill Cultural Belt" [5-7] are the core of the capital culture and the great spiritual DNA generated when the Communist Party of China led the people of all ethnic groups through the revolutionary struggle and construction practices. By integrating the inheritance and utilization of the revolutionary culture in the planning, development and construction of the "three cultural belts", the revolutionary memorial architectural culture will develop the attraction of the "three cultural belts", and, conversely, the construction of the "three cultural belts" will boost the red culture undertakings, realizing the mutual promotion and joint development of the two.

-Advance collaborative development of Beijing, Tianjin and Hebei. As the "three cultural belts" stretch over Beijing, Tianjin and Hebei and the revolutionary memorial architectural cultures in the three regions are closely linked together and indispensable from each other, it is necessary to promote the development of revolutionary cultures in Beijing, Tianjin and Hebei with the three cultural belts as the bridge, adhere to the complementary advantages and mutual benefits of the three regions and expand the cooperation, collaboration and integration of the revolutionary cultures in these three regions, which will not only improve the soft power of regional revolutionary culture and promote cohesion of ideology of revolutionary culture, but also facilitate the integrated development of revolutionary culture resources and tourism in the three places and advance common prosperity of cultural construction in Beijing, Tianjin and Hebei.

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2. CONSTRUCTION (CIVIL, INDUSTRIAL, HIDRAULIC, TRANSPORT AND UNDERGROUND) CONSTRUCTION MECHANICS

PROBLEM SOLVING TECHNOLOGIES OF MATERIAL AND TECHNICAL SUPPLY IN CONSTRUCTION INDUSTRY

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Keywords: Construction, material and technical supply, logistics chain

Abstract. Specifications of material and technical supply in the construction sector, as well as substantiates the significance of material and technical support (MTS) and its investment in construction industry are presented.

A phase graph investment is proposed for MTS problem solution technologies in construction industry: The first step is the MRP-adapted technology, then - MRP II, and in the third stage - ERP, which are integrated software products and require professional reprocessing and adaptation to the requirements of construction industry.

The use of the solutions of the logistics blocks will help not only to increase competitiveness and productivity of works in construction companies, but also provide the investment of logistics technologies based on MRP, MRP II and ERP modern information systems.

1. Introduction

In the context of the market relations and development of the international integration processes, the need of effective planning of investment expenditures, the general development of the construction industry and creation of the favorable investment environment demand reforming of cost assessment system.

It is known that the construction products are characterized by the high level of materiality. Researches in the construction industry show that up to 57% of construction installation works make the cost of the used material resources, and the share of logistics' costs can reach up to 55%. The absence of material and technical support (MTS) in a control system of construction company leads to losses which, according to statistical estimates, can be accounted up to 30% of the cost of the entire work [1].

The purpose of this work is to observe features of material and technical supply in construction, to allocate the arising problems of MTS and to offer technologies for their decision.

2. Research

The MTS junction combines all types of resources of building production in construction site: materials, equipment, mechanisms, workers, finances, where the material resources are transformed into a built-in (completed object). Technical characteristics of construction products and their identifying parameters are presented in Table 1.

Thus, constructional production has a variable demand for its final product /built object /, as well as the probability of changing the conditions at various construction stages and a complex system of flow of resources, the management of which has many limitations and interrelations [2].

Due to the features of construction production, MTS problems can be divided into two large groups (Fig. 1).

- Global problems, whose solutions provided with well-grounded strategy for MTS junction (construction site) within the range of price, quality and time frames.
- Special problems that reflect the specificity of the manufacturing process.

Table 1. Features of construction production

N	**Features of construction production**	**Identifying parameters**
1	Uniqueness of the building site	Even construction of standard objects requires to take into account a large amount of local features which are caused by the choice of characteristics of each building site (the MTS junction).
2	The ability of MTS junction to change over time	The functionality, predefined parameters, also the used materials, the composition of the specialized machinery and equipment change depended on the stage of the implemented construction works.
3	High level of cooperation	A number of subcontracting companies with different qualification degrees can be employed on the same construction site, whose coordination is carried out by the general contractor. Their structure can change depending on the stage of construction works and signed contracts.
4	The need for specialized warehouses on the construction site	It is required to have warehouses ready to accept, to support and transport large amounts of construction materials and equipment.
5	The complexity of a flowing system of financial resources	It is conditioned by a large number of contracts between co-operative participants and economic entities.

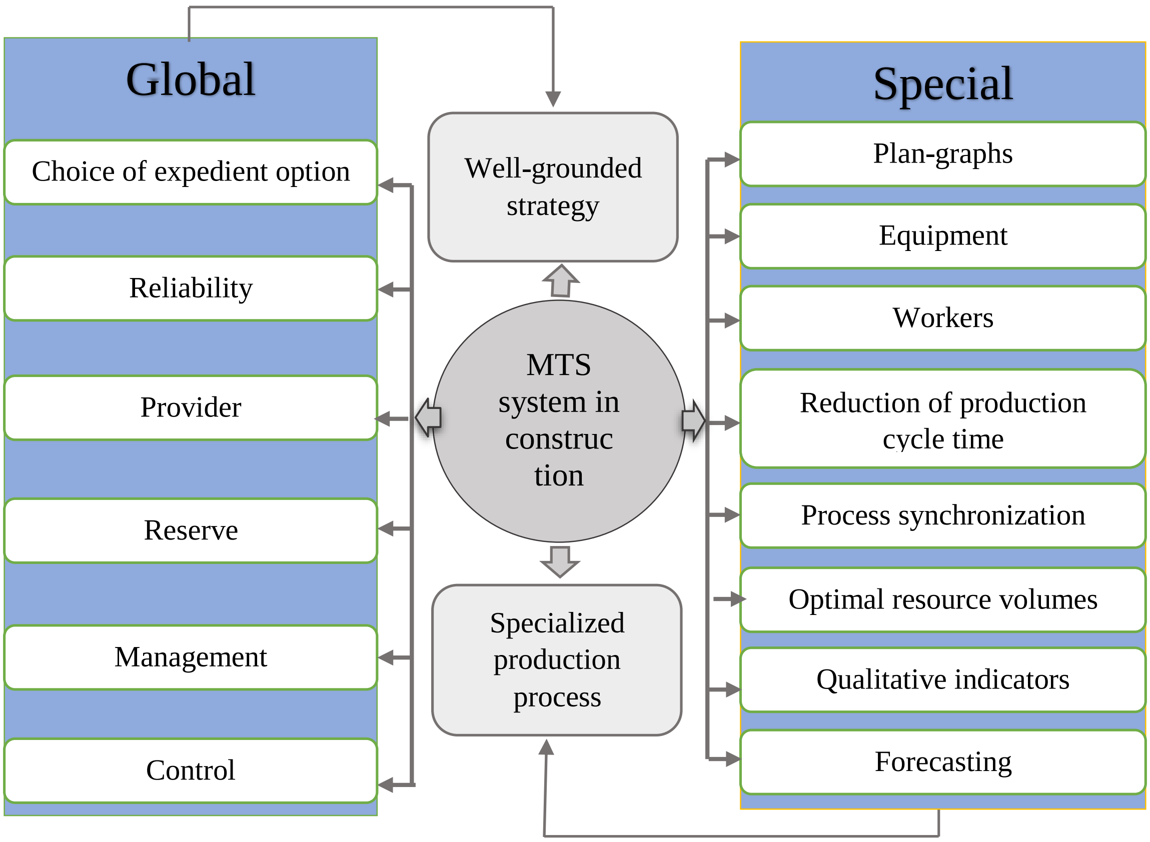

Fig. 1. MTS system in construction

3. Proposition

A phase graph of investment for MTS problems solution technologies are proposed: first the MRP-adapted technology, then - MRP II, and in the third stage - ERP, which will create the basis for the application of more advanced technologies and the operation, considering features of construction production from the perspective of MTS (Fig. 2).

Problems of MTS and observed solving technologies must often satisfy the simultaneous solution of several logistic problems. Groups of such problems are divided into logical blocks [3].

The following basic parameters are required for the operation of any logical problem block:

- coherent project;
- working documents, including the construction organization project (COP);
- work performance plan (WPP);
- preliminary financing plan.

It should be noted that these problems can be related to the entire construction process, as well as separate stages of the construction work, or separate building structure in which the project is supplemented with plan-graphs, with the information about currently available resources at the construction site at the given time [4].

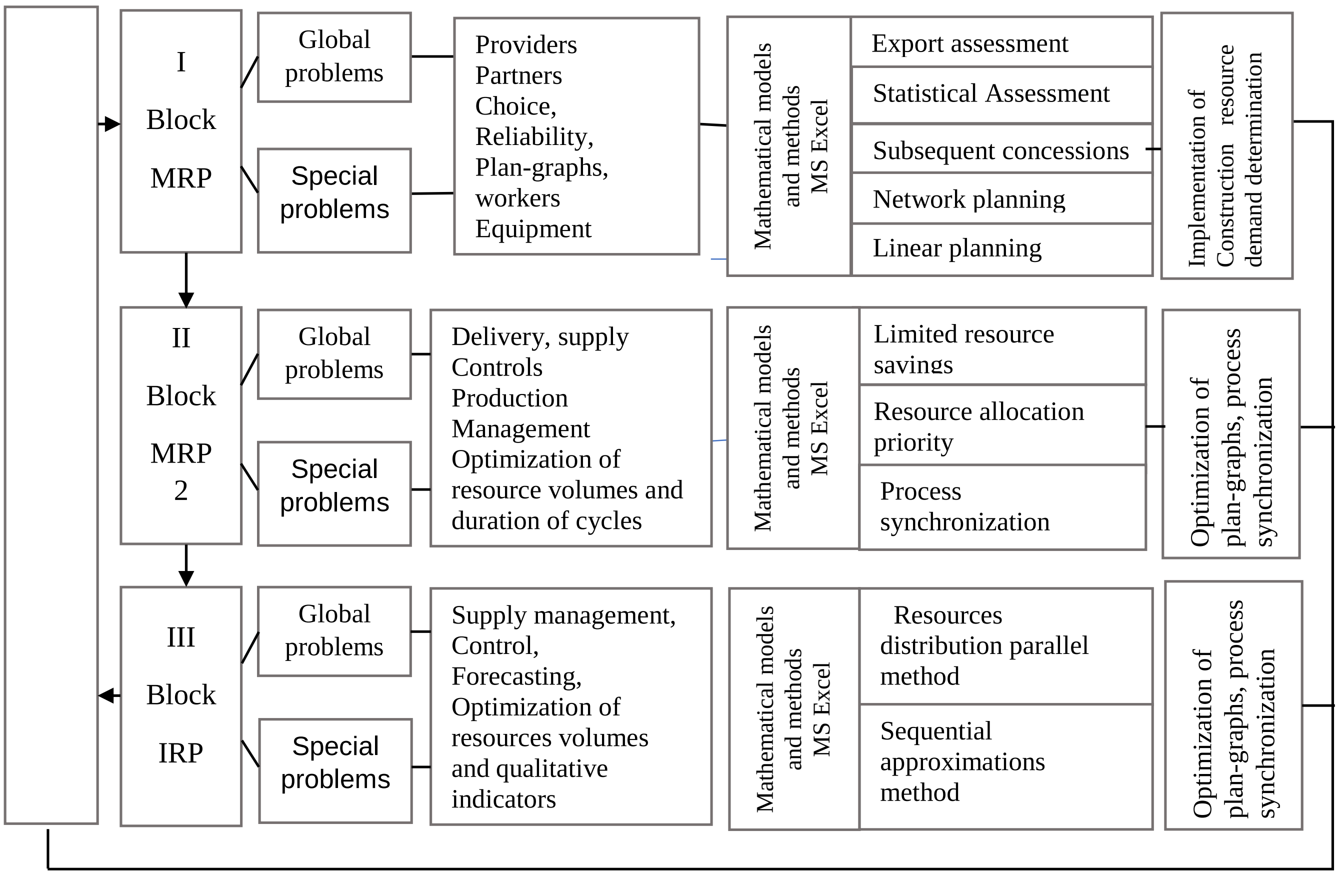

Fig. 2. Proposed logical model of MTS's problems solving technologies of construction production

Further optimization of the schedules, search of reserves, minimization of the required resources, compensation of probable characteristics of the initial phase of the construction works are carried out during the solution of the third block issues.

In the case of critical deviations from the deadlines of construction works cycle (stage), compensating solutions are recalculated using methods of “parallel distribution of resources” and “successive approaches”, as well as the MS Excel model that allows to minimize resource and time losses.

4. Conclusions

Thus, the use of the solutions of the logistics blocks in the article will help to increase competitiveness and productivity of works in construction companies, as well as will provide with investment of logistics technologies based on MRP, MRP II and ERP modern information systems.

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ELASTIC-SPIN WAVES IN MAGNETO-ORDERED TWO-LAYER STRUCTURES

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Keywords: Elastic-spin waves, bilayer structure, Love waves

Abstract. This work is devoted to the existence and propagation of transverse elastic spin waves in a two-layer structure of a ferromagnetic-dielectric, which is located in an external constant magnetic field directed parallel to the surfaces of the layers. The thickness of the layers is finite. The problem is solved using equations that take into account the interconnection between spin (magnetic) and elastic perturbations. This is the equation of the theory of elasticity of the mechanical motion of the medium and the Landau-Lifshitz equation, describing the motion of the density of the magnetic moment in a magnetically ordered medium magnetized to saturation. Established the conditions for the existence of elastic-spin waves in the structure. In conclusion, the results of the numerical experiment presented in the form of dispersion curves.

1. Introduction

Paper is devoted to the existence and propagation of the Love type Elastic-Spin Waves (ESW) in the two-layer structure of a ferromagnetic-dielectric (non-magnet). The problem is solved using equations that take into account the interconnection between spin (magnetic) and elastic perturbations [1–10]. This is the equation of mechanical motion of the medium and the Landau-Lifshitz equation, which describes the motion of the density of the magnetic moment.

2. Statement of the problem

A two-layer construction consisting of elastic ferromagnetic and dielectric (nonmagnetic) layers of finite thickness, located in an external, constant magnetic field $\vec{H}_0$, directed along the Z axis (Fig. 1), it considered to coincide with the axis of easy magnetization of a ferromagnetic [1-4].

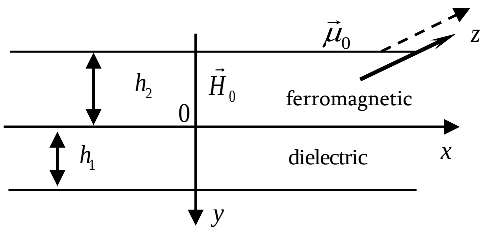


Fig. 1. Bilayer structure

We believe that the region $0 \le y \le h_1$ is nonmagnetic, and the region $-h_2 \le y \le 0$ is a ferromagnetic. Let us denote by $\vec{M}_0$ the volume saturation magnetization of the ferromagnetic, and the mass saturation magnetization we denote by $\vec{\mu}_0 = \vec{M}_0 / \rho$, ρ is the density of the ferromagnetic material. We denote by μ and ν the components of the magnetization vector $\vec{\mu}(\mu, \nu, 0)$. Next, we consider two cases of fixing the boundaries of the structure. The first case, the lower boundary of the structure $(y = h_1)$ is fixed, and the upper one is free; the second case is when both boundaries surfaces of the structure are fixed. Of the components of mechanical displacements in both media, we assume that only the Z components w_1 and w_2 are nonzero, i.e. shear waves are considered.

The equations describing dynamic processes in the structure are represented as follows:
a) non-magnetic layer:

$$\ddot{w}_1 = S_1^2 \Delta w_1, \tag{1}$$

b) magnetic layer:

$$\begin{aligned} \ddot{w}_2 &= S_2^2 \Delta w_2 + f \mu_0 (\mu_x + \nu_y), \\ \dot{\mu} &= \omega_M (\hat{b}\nu + f \mu_0 w_{2y}), \\ \dot{\nu} &= -\omega_M (\hat{b}\mu + f \mu_0 w_{2x}), \end{aligned} \tag{2}$$

S_1 and S_2 are velocities of elastic waves, f is a coefficient of magneto-elastic coupling, $\hat{b} = H_0 / M_0$ is inverse magnetic susceptibility, $\omega_M = \gamma M_0$, $\gamma = 1{,}8 \cdot 10^7 \ 1/e \cdot s$, γ - gyromagnetic ratio. Equations (2) are written without taking into account the exchange interaction, the magnetic potential, and magnetic anisotropy $(b = 0)$, which for example is true for the widely used in practice yttrium iron garnet (YIG) [2,7]. The boundary conditions of the first case are as follows:

$$\begin{aligned} &a) \, w_1 |_{y=0} = w_2 |_{y=0}, \qquad c) \, \sigma_{yz}^{(2)} |_{y=-h_2} = 0, \\ &b) \, \sigma_{yz}^{(1)} |_{y=0} = \sigma_{yz}^{(2)} |_{y=0}, \quad d) \, w_1 |_{y=h_1} = 0, \end{aligned} \tag{3}$$

$\sigma_{yz}^{(1,2)}$ are stresses in the corresponding media; they are in the form:

$$\sigma_{yz}^{(1)} = G_1 w_{1y}; \ \sigma_{yz}^{(2)} = G_2 w_{2y} + f M_0 \nu,$$

where G_1 и G_2 are the shear modules.

3. The solution of the first problem.

Solutions of (1), (2) we seek in the form: $(w_1, w_2, \mu, \nu) = (W_1, W_2, M, N) e^{(i(\omega t - px))}$, (4)

p is a component of the desired wave vector, ω is circular frequency. Substituting (4) into (1), (2), for amplitudes, we obtain the following equations:

$$\frac{d^2 W_1}{dy^2} + a^2 W_1 = 0, \ a^2 = \omega^2 / S_1^2 - p^2; \tag{5}$$

$$\frac{d^2 W_2}{dy^2} + c^2 W_2 = 0, \tag{6}$$

$$c^2 = \frac{(\Omega^2 - \hat{b}^2)(\omega^2 - p^2 S_2^2) - f^2 \mu_0^2 \hat{b} p^2}{S_2^2 (\Omega^2 - \hat{b}^2) + f^2 \mu_0^2 \hat{b}}, \tag{7}$$

where $\Omega = \omega / \omega_M$. Solutions of equations (5), (6) have the following form:

$$W_1(y) = A \sin(h_1 - y) a, \tag{8}$$

$$W_2(y) = B_1 \cos yc + B_2 \sin yc. \tag{9}$$

A, B_1, B_2 are the unknown constants. Note that when finding the solution (8), the boundary condition (3.d) was used. Further, using condition (3.c), we find the connection between the constants B_1 and B_2:

$$B_2 = \beta B_1 , \tag{10}$$

where $\beta = \dfrac{c(p^2\eta\varsigma_1 - 1 + \varsigma)tgh_2c + \xi p^2\sqrt{\eta\varsigma_1}}{\xi p^2\sqrt{\eta\varsigma_1}\, tgh_2c - c(p^2\eta\varsigma_1 - 1 + \varsigma)}$.

Hereinafter we use the designations:

$$\eta = \frac{S^2}{S_1^2}, \varsigma = \frac{f^2\mu_0^2}{\hat{b}S_2^2}, \varsigma_1 = \frac{S_1^2}{\gamma^2 H_0^2}, \vartheta = \frac{S_1^2}{S_2^2}, \vartheta\eta = \frac{S^2}{S_2^2},$$

$$\frac{\Omega^2}{\hat{b}^2} = p^2\eta\varsigma_1, a = p\sqrt{\eta - 1}, c = p\sqrt{\frac{(\vartheta\eta - 1)(1 - p^2\eta\varsigma_1) + \varsigma}{1 - p^2\eta\varsigma_1 - \varsigma}},$$

S is velocity of desired wave, ς characterizes saturation magnetization of a ferromagnetic, ς_1 characterizes the external field $\vec{H}_0$. Using boundary conditions (3.a) and (3.b) we obtain the following system to determine the constants A, B_1:

$$A \sinh_1 a = B_1,$$

$$\text{-}aAG_1 \cosh_1 a = B_1\Bigl(\frac{f^2\mu_0^2(p\Omega - \beta\hat{b}c)}{\hat{b}^2(\frac{\Omega^2}{\hat{b}^2} - 1)} - c\beta G_2\Bigr) \cdot \tag{11}$$

From this system follows the characteristic equation:

$$\operatorname{tg} h_1 a = \frac{a(p^2\eta\varsigma_1 - 1)G_1G_2^{-1}}{c\beta(p^2\eta\varsigma_1 - 1 + \varsigma) - \varsigma p^2\sqrt{\eta\varsigma_1}} \quad . \tag{12}$$

For a magnetic layer and a nonmagnetic half-space adjacent to it, the corresponding dispersion equation we obtain from (12) with $h_1 \to \infty$:

$$tgh_2 c = \frac{c(p^2\eta\varsigma_1 - 1 + \varsigma)R}{c^2(p^2\eta\varsigma_1 - 1 + \varsigma)^2 + R\varsigma p^2\sqrt{\eta\varsigma_1}} \quad , \tag{13}$$

where

$$R = \varsigma p^2\sqrt{\eta\varsigma_1} + p\sqrt{1 - \eta}(p^2\eta\varsigma_1 - 1)G_1G_2^{-1}.$$

If we neglect the magnetization, then from (13) follows the classical Love equation. Let us determine the conditions for the existence of a shear elastic-spin waves in a structure magnetic layer-nonmagnetic half-space. From (13) we conclude that the condition for the existence of a surface elastic-spin wave is the following inequality:

$$\frac{(\theta\eta - 1)(1 - p^2\eta\varsigma_1) + \varsigma}{1 - p^2\eta\varsigma_1 - \varsigma} > 0 . \tag{14}$$

We first consider the particular case where in (14) we can neglect the term $p^2\eta\varsigma_1$, so we assume that

$$p^2\eta\varsigma_1 << 1 \tag{15}$$

Condition (15) in the source variables is as follows:

$$\omega << \omega_H = \gamma H_0 . \tag{16}$$

As it is known [1-3], γH_0 is a natural frequency of spin precession (magnetization) in a constant external magnetic field. Thus, for the frequency range below the natural spin precession frequency, condition (14) takes the form:

$$\frac{\theta\eta - 1 + \varsigma}{1-\varsigma} > 0 . \tag{17}$$

It is easy to make sure that if $1-\varsigma < 0$ inequality (17) does not hold, i.e. there is no wave process, so we will assume that $1-\varsigma > 0$, then from (17) it follows: $\sqrt{1-\varsigma}S_2 < S$. Next, taking into account the attenuation condition of the waves in the substrate, we obtain the condition for the existence of the Love type elastic-spin waves in the frequency range $\omega << \omega_H$:

$$\sqrt{1-\varsigma}S_2 < S < S_1 . \tag{18}$$

It is clear from (18) that in the case when the usual conditions for the existence of Love waves for nonmagnetic media not fulfilled, for a magnetic layer with an appropriate choice of the parameters of the magnetic layer and the intensity of the external magnetic field, Love type waves can generate.

We now consider the general case (14). Condition (14) is equivalent to two systems of inequalities: $\eta < \dfrac{1-\varsigma}{p^2\varsigma_1} = \eta_0; \quad \theta p^2\varsigma_1\eta^2 - (\theta + p^2\varsigma_1)\eta + (\varsigma - 1) < 0$, (19)

$$\eta > \frac{1-\varsigma}{p^2\varsigma_1}; \ \theta p^2\varsigma_1\eta^2 - (\theta + p^2\varsigma_1)\eta + (\varsigma - 1) > 0 . \tag{20}$$

We first consider system (19) the roots of the square trinomial in the second inequality of this system are as follows:

$$\eta_{1,2} = \frac{\theta + p^2\varsigma_1 \pm \sqrt{(\theta + p^2\varsigma_1)^2 - 4\theta p^2\varsigma_1(\varsigma - 1)}}{2\theta p^2\varsigma_1} .$$

It is clear that, if $\eta_0 < \eta_2$, then the system (19) has no solutions, but if $\eta_0 > \eta_2$, then the condition of wave existence takes the form:

$$\eta_2 < \eta < \min(\eta_0; \eta_1) . \tag{21}$$

Otherwise, this condition can be written as follows:

$$S_1\sqrt{\eta_2} < S < S_1\sqrt{\min(\eta_0; \eta_1)} . \tag{22}$$

The solution of system (20) is represented as:

a) if $\eta_0 < \eta_2; \eta \in [\eta_0; \eta_2] \bigcup [\eta_1; +\infty)$, (23)

b) if $\eta_0 > \eta_2; \eta \in [\max(\eta_0; \eta_1), +\infty)$. (24)

Thus, in the structure magnetic layer - nonmagnetic substrate, when conditions (22-24) are fulfilled, then elastic-spin waves exist.

4. **The solution of the second problem**

The boundary conditions for fixed boundaries represented as follows:

$$a) w_1 |_{y=0} = w_2 |_{y=0}, \qquad c) w_2 |_{y=-h_2} = 0,$$
$$b) \sigma_{yz}^{(1)} |_{y=0} = \sigma_{yz}^{(2)} |_{y=0}, \quad d) w_2 |_{y=h_1} = 0. \tag{25}$$

We omit the detailed solution of the second problem, since it is similar to the solution of the first problem. We present only the corresponding dispersion equation, as well as the condition for the existence of the ESW. Dispersion equation represented as:

$$tgch_2 = \frac{\mathrm{c}(1-\mathrm{p}^2\eta\varsigma_1-\varsigma)\,\mathrm{tg}(\mathrm{ah}_1)}{\mathrm{a}\,G_1G_2^{-1}(\mathrm{p}^2\eta\varsigma_1-1)+\varsigma p^2\sqrt{\eta\varsigma_1}\,\mathrm{tg}(\mathrm{ah}_1)}\quad, \tag{26}$$

The condition for the existence of ESW is the condition of positivity of the radicals: $(\vartheta\eta-1)(1-\mathrm{p}^2\eta\varsigma_1)+\zeta>0,$

$1-\mathrm{p}^2\eta\varsigma_1-\zeta>0,$

$1-\eta>0.$

We present some results of a numerical study in the frequency range $\omega<\omega_H$, when the magnitude $p^2\eta\varsigma_1$ can be neglected in relation to the unit. In this case, the dispersion equation (13) takes the form: $\mathrm{tg}\, ph_2\sqrt{\frac{\theta\eta-1+\varsigma}{1-\varsigma}} = \frac{\sqrt{1-\eta}G_1G_2^{-1}}{\sqrt{1-\varsigma}\sqrt{\theta\eta-1+\varsigma}}$.

5. **Results**

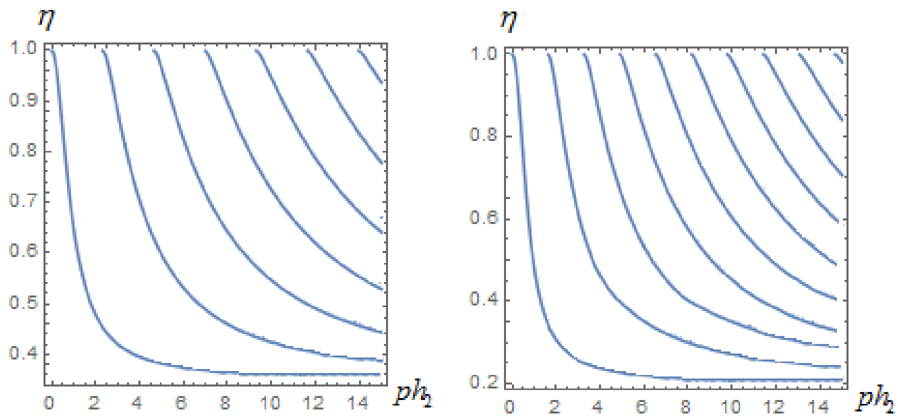
The velocity range of elastic-spin waves in bilayer construction with a magnetic layer, in contrast to a non-magnetic layer, expands and simultaneously the branches of different elastic-spin waves come together.

6. **Summary**

Replacing the ferromagnetic layer in a two-layer construction leads to a change in the dispersion equation, which allows us, by appropriate selection of the magnetic and mechanical parameters of the layer to ensure that the elastic-spin waves would have the appropriate frequency range.

Fig. 2 shows the results of a comparative numerical experiment for the structure of a layer-half space in the frequency range $\omega<<\omega_H$ for the first problem. Dispersion patterns for the magnetic layer and the nonmagnetic layer are compared, in both cases the substrate is the same.

The material for the magnetic layer is YIG: $S_2=3{,}8\cdot10^3$ m/s, $\rho_2=5{,}17\cdot10^3\,\mathrm{kg/m}^3$, $G_2=7{,}64\cdot10^{10}\,\mathrm{N/m}^2$, $\mu_0=139{,}3\cdot10^{-4}\,\mathrm{Tl}$, $H_0=870\cdot10^{-4}\,\mathrm{Tl}$, the parameters of the nonmagnetic substrate are: $S_1=5{,}03\cdot10^3$ m/s, $\rho_1=4{,}5\cdot10^3\,\mathrm{kg/m}^3$, $G_1=1{,}14\cdot10^{11}\,\mathrm{N/m}^2$ [7].



a b

Fig. 2. a- the curves for a nonmagnetic layer, b- the curves for a magnetic layer for the first problem.

Analysis of the results leads to the conclusion that, in a construction with a magnetic layer, in contrast to a non-magnetic layer, the velocity range of elastic-spin waves expands, and simultaneously the branches of different elastic-spin waves come together.

The dispersion pattern for the second task presented in the Fig. 3.

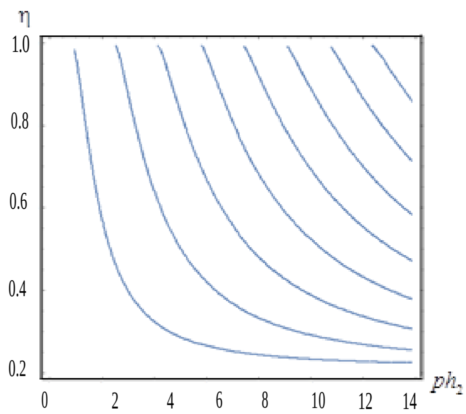


Fig. 3. Dispersion curves for the second problem

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INTERRUPTION OF CRACK AND INCLUSIONS IN ELASTIC COMPOSITION SPACE UNDER ANTI-FLAT DEFORMATION

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Abstract. The antiplane contact problem for a three-component elastic package modeled as a composite space consisting of two elastic half-spaces and a rigid elastic layer connected to them is studied. The layer is weakened by the Central tunnel crack perpendicular to the material separation lines and reinforced by symmetrically arranged elastic plates (inclusions) of finite width and small thickness relative to the crack. For secondary crack amplification, it is assumed that inclusions in the form of thin rigid plates of finite width are inserted along the contact surfaces. Using the Fourier transform, the solution of an auxiliary elastic problem (the influence function) corresponding to the contact problem was first constructed. The method of constructing solutions to the auxiliary problem allows you to directly write out the solving equations of the corresponding contact problems, when heterogeneous boundary conditions can be set on the banks of the crack. In the end, the solution of the contact problem is reduced to a system of singular integral equations with a generalized Cauchy kernel, the solution of which is constructed by the numerical – analytical method of mechanical quadratures.

1. Introduction

In composite elastic bodies, which are part of different designs, sometimes contain different stress concentrators in the form of thin elastic or rigid inclusions (fiber, plate) and cracks. Unfortunately, sometimes for some reason there is a detachment of the inclusion edges from the elastic matrix (medium) and as a result there are cracks that reduce the stiffness and strength of the structures. An in-depth study of the properties of inhomogeneous materials containing thin inclusions provides important information that allows developers to significantly improve the strength characteristics and bearing capacity of structural elements. The proposed problem here, in its formulation, refers to related problems of these types. In the formulation of antiplane deformation, the interaction of heterogeneous stress concentrators in a three-component elastic medium is studied. Given the huge number of works on this issue, we will indicate only works [1-7] with the bibliographic instructions given there.

2. Methodology

Consider a composite elastic space consisting of two identical half-spaces and rigidly connected to them by an elastic layer. In demetrova right hand coordinate system $Oxyz$ half-space is a region $\Omega_1\left(|x,z|<\infty;\ y>h\right)$, and $\Omega_2\left(|x,z|>\infty;\ y<-h\right)$ with modelyami shifts $G_1=G_2$. Layer, with shear modulus G_0 , occupies an area $\Omega_0\left(|x,z|<\infty;\ |y|<h\right)$. The layer and half-spaces are in contact with the planes and are in full contact. At the same time, the bands

$L_j\left(c_j < x < c'_j,\ |y| = h\ \right)\left(c_j < c'_j\right)\left(j = 1,2\right)$ they are connected to each other by means of rigid plates – strips of small thickness. In turn, the layer weakened central tunnel crack on the strip $L_0\left(x = 0,\ -l_1 < y < l_2,\ |z| < \infty\right)$ and on symmetrical stripes $L_0^{(1)}\left(a < |x| < b,\ y = 0,\ |z| < \infty\right)\left(0 \le a < b\right)$ supported by elastic plates (inclusions) of small thickness h_s and shear module G_s (Fig. 1).

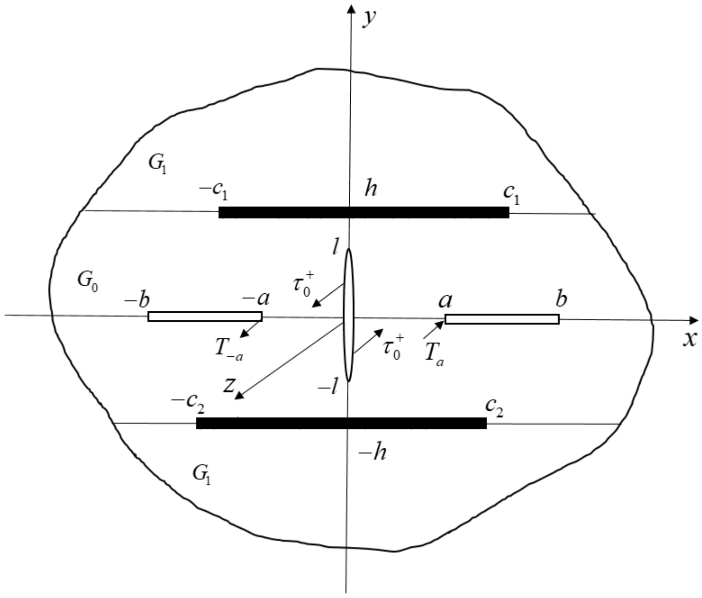

Fig.1. Compound space

The resulting elastic system is a composite space, deformed under the influence of external influence of the applied: a) on the boundary surfaces of the crack in the form of specified shear shear stresses or displacements at any possible combination thereof: b) on the surfaces of heterogeneity of materials and on the ends of elastic plates in the form of concentrated forces. It is assumed that the external influences are evenly distributed along the axis direction Oz, thereby antiplane deformation of the system.

With respect to reinforcing plates, it is assumed that $G_s > G_0$, and $h_s << b - a$. This allows reinforcing for inclusions to take known in the field of contact problems with thin-walled elements of the physical model of Melana with antiplane deformation [5,6].

Under these assumptions, it is necessary to determine the basic mechanical parameters characterizing the stress – strain state of the system, as well contact stresses and the stress intensity factor at the ends of the crack.

Under the above assumption, a uniform direction of the axis Oz it is obvious that the system will deform under the conditions of longitudinal shear with the base plane Oxy consisting of two half-planes $\omega_1\left(|x| < \infty, y > h\right)$, $\omega_2\left(|x| < \infty, y < -h\right)$ and stripes $\omega_0\left(|x| < \infty,\ |y| < h\right)$. In this case, only one component of the displacement will be different from zero $w\left(x, y\right)$ - in the direction of the axis Oz. Then the problem is mathematically formulated as boundary value problems for the harmonic operator [7]

$$\Delta w_j\left(x, y\right) = \frac{\partial^2 w_j}{\partial x^2} + \frac{\partial^2 w_j}{\partial y^2} = 0, \qquad \left(j = 1,2\right), \tag{1}$$

for half-plane ω_1 provided

$$w_1(x,h+0)=w_0(x,h-0), \qquad |x|<\infty \tag{2}$$

$$G_1\left.\frac{\partial w_1}{\partial y}\right|_{y=h+0}-G_0\left.\frac{\partial w_0}{\partial y}\right|_{y=h-0}=H_1(x)q_1(x), \qquad |x|<\infty \tag{3}$$

and for half-plane ω_2 provided

$$w_2(x,-h-0)=w_0(x,-h+0), \qquad |x|<\infty \tag{4}$$

$$G_2\left.\frac{\partial w_2}{\partial y}\right|_{y=-h-0}-G_0\left.\frac{\partial w_0}{\partial y}\right|_{y=-h+0}=H_2(x)q_2(x), \qquad |x|<\infty \tag{5}$$

where $w_j(x,y)\ (j=1,2)$ - component of the elastic movement in the areas w_j; $q_j(x)$ - the unknown jump of the tangential stresses on the edges of the hard inclusions; $G_0^{-1}H_j(x)=\vartheta(x-c_j)-\vartheta(x-c_j')$ - where $\vartheta(x)$ - the function of Heaviside.

For bands w_0 it turns out a heterogeneous problem:

$$\Delta w_0(x,y)=-G_0^{-1}\tau_s(x)H_0(x)\delta(y) \tag{6}$$

with contact conditions (2), (3), (4), (5) on the edges of the strip and on the banks of the crack:

$$\left.\frac{\partial w_0(x,y)}{\partial x}\right|_{x=\pm 0}=\frac{1}{G_0}\tau_0^{\pm}(y) \tag{7}$$

Here $H_0(x)=\left[\vartheta(x+b)-\vartheta(x+a)\right]+\left[\vartheta(x-a)-\vartheta(x-b)\right]$, $\delta(y)$ - Dirac function, $\tau_0^{\pm}(y)$ - specified shear stresses at the crack edges, a $\tau_s(x)$ - unknown jump of contact stresses arising at elastic inclusions.

It should be noted that in cases where the edges of the crack will be given displacement, instead of the condition (8) you should accept the condition

$$w_0(\pm 0,y)=w^{\pm}(y), \qquad -l<y<l \tag{7$'$}$$

And if on the banks of the crack conditions of mixed type are given, then from the condition (7) and (7$'$) we should take the corresponding two of the boundary conditions.

For conditions (2) – (5) and (6) - (7), you should attach more conditions

$$\left.\frac{\partial w_0}{\partial x}\right|_{y=0}=\frac{1}{h_s G_s}\begin{cases}\displaystyle\int_{-b}^{x}\tau_s(s)\,ds-T_{-a}, & -b_1<x<-a_1\\ \displaystyle\int_{a}^{x}\tau_s(s)\,ds-T_a, & a_2<x<b_2\end{cases} \tag{8}$$

$$w_0(x,h)=0, \quad -c_1<x<c_1 \tag{9}$$

$$w_0(x,-h)=0, \quad -c_2<x<c_2 \tag{10}$$

Obviously, (8) provides joint deformation of the band points and elastic inclusions in the framework of the Melana model, and (9) with (10) reflect the absence of movement under rigid inclusions.

Thus, the solution of the problem is reduced to boundary value problems (1) – (7) with additional conditions (7) – (10).

To solve problems (1) – (7) first, we construct the corresponding discontinuous solution [1]. Assume that the contact areas under the inclusions are specified $\tau_s(x)$ и $q_i(x)$ $(i=1,2)$, and on the crack line the jumps (breaks) of displacements and stresses are given as follows:

$$g_0(y) = w_0(+0,y) - w_0(-0,y) \tag{11}$$

$$f_0(y) = \left.\frac{\partial w_0}{\partial x}\right|_{x=+0} - \left.\frac{\partial w_0}{\partial x}\right|_{x=-0} \tag{12}$$

Now assuming given more $f_0(y)$ и $g_0(y)$, with the help of Fourier transform $w_0(x,y)$ get:

$$w_0(x,y) = \frac{1}{2\pi}\int_{-l_1}^{l_2}\left[-arctg\frac{y-\eta}{x} + R_{11}(\ )\right]g_0'(\eta)d\eta - \frac{1}{2\pi}\int_{-l_1}^{l_2}\left[\frac{1}{2}\left(\ln\frac{1}{x^2+(y-\eta)^2} + R_{22}(\ )\right)\right]f_0(\eta)d\eta +$$

$$+\frac{1}{2\pi}\left(\int_{-b}^{-a} + \int_a^b\left[\ln\frac{1}{(x-t)^2+y^2} + R_{33}(x,y,t)\right]\right)\frac{\tau(t)}{G_0}dt + +\frac{1}{2\pi}\sum_{k=1}^{2}\int_{c_{k'}}^{c_k} R_{k+3}(x,y,t)q_k(t)dt \tag{13}$$

$$R_{11}(x,y,\eta) = \frac{1-\mu_{01}}{1+\mu_{01}}\sum_{n=0}^{\infty}\gamma^{2n}\left\{A_n^{(2h)}(x,-y,-\eta) - A_n^{(2h)}(x,y,\eta) + \gamma\left[A_n^{(4h)}(x,y,-\eta) - A_n^{(4h)}(x,-y,\eta)\right]\right\}$$

$$R_{22}(x,y,\eta) = \frac{1-\mu_{01}}{1+\mu_{01}}\sum_{n=0}^{\infty}\gamma^{2n}\left\{B_n^{(2h)}(x,-y,-\eta) + B_n^{(2h)}(x,y,\eta) + \gamma\left[B_n^{(4h)}(x,y,-\eta) + B_n^{(4h)}(x,-y,\eta)\right]\right\}$$

$$R_{33}(x,y,t) = \frac{1-\mu_{01}}{1+\mu_{01}}\sum_{n=0}^{\infty}\gamma^{2n}\left\{-M_n^{(2h)}(x,-y,t) + M_n^{(2h)}(x,y,t) - \gamma\left[M_n^{(4h)}(x,y,t) + M_n^{(4h)}(x,-y,t)\right]\right\}$$

$$A_n^{(\beta)}(x,y,\eta) = arctg\left[(4nh+\beta+y+\eta)/x\right] \qquad B_n^{(\beta)}(x,y,\eta) = -\ln\left[x^2 + (4nh+\alpha+y+\eta)^2\right]$$

$$M_n^{(\beta)}(x,y,t) = B_n^{(\beta)}(x-t,y,0) \qquad \mu_{01} = G_0/G_1 \tag{14}$$

Similar expressions such as (13) obtained also for $w_1(x,y)$ and $w_2(x,y)$. They, along with (13) represent the so-called, discontinuous" solution of the contact problem. This means that for certain values of the unknown functions included there, the resulting $w_j(x,y)$, $(j=0,1,2)$ will represent the overall solution of the problem.

From the statement of the problem it is easy to notice that the representation (13) it is enough to compile the resolving equations and determine the mechanical quantities of interest to us. Using well-known formulas [8]

$$\tau_{xz}^{(0)}(x,y) = G_0\frac{\partial w_0}{\partial x}; \qquad \tau_{yz}^{(0)}(x,y) = G_0\frac{\partial w_0}{\partial y} \qquad , \tag{15}$$

you can determine the stress state in the region Ω_0 and at its edges, and thus satisfy, not yet used boundary conditions.

In the (13) and hence in (15), includes five, yet unknown functions: $\tau_s(x)$, $q_1(x)$, $q_2(x)$, $g_0'(y)$ и $f_0(y)$. Satisfying, using (13) and (15) conditions (8) – (12) in the most general case, we come to a defining system of five singular integral equations with certain additional conditions [5,8]. Here these equations are obtained for the symmetric case of the considered problem $c_1 = c_2 = c$ and at a given $f_0(y)$. Then the solution of the problem is reduced to a system of three singular integral equations with respect to $g_0'(y)$, $\tau(s)$ и $q(x)$ $(q_1 = q_2 = q_3)$, which are not given here.

The introduction of the dimensionless parameters

$$\mu_{01} = \frac{G_0}{G_1}, \quad \alpha = \frac{a}{h}, \quad \beta = \frac{b}{h}, \quad \eta = \frac{l}{h}, \quad \gamma = \frac{c}{h} \quad , \tag{16}$$

the system of integral equations is formulated on intervals (-1,1). The solution of the latter, taking into account the corresponding features at the ends of the integration line, is constructed by the numerical – analytical Gaussian method [8].

For the following special cases of the considered problem the numerical implementation is made

1. $\alpha = \beta, \quad \gamma = 0;$ - no inclusions.
2. $\alpha - \beta = 1, \quad G_s = \infty, \quad \gamma = 0;$ - there are no inclusions at the edges of the layer and along the line $\gamma = 0$ rigid inclusions of finite length are inserted.
3. $\alpha = \beta$ (or $G_s = 0$); - on the line $\gamma = 0$ the inclusion of the missing.
4. $\alpha = 0, \quad \beta = 1, \quad \gamma = 1;$ - both inclusions are supplied.

In all cases considered, it is assumed that the only external load in the form of uniformly distributed shear stresses is $\tau_{xz}^{+}(y) = \tau_{xz}^{-}(y) = \tau_0$, applied on the banks of the crack. According to the results of numerical calculations, the effect of amplifying inclusions on the intensity coefficients of the decaying stresses at the ends of the crack is studied.

Table. 1 Relationship of stress intensity factors $K_3^{(1)} / K_3^{(2)}$

η \ α	0	0.25	0.5	1
0.2	4.714	3.821	2.157	1.051
0.4	2.825	2.223	1.812	1.0
0.6	1.907	1.517	1.219	1.0
0.8	1.315	1.321	1.121	1.0

Table. 2 Relationship of stress intensity factors $K_3^{(1)} / K_3^{(3)}$

η \ γ	0	0.25	0.5	0.75	1	10
0.2	1	1.017	1.071	1.138	1.218	1.221
0.4	1	1.517	1.256	1.314	1.385	1.401
0.6	1	1.231	1.312	1.301	1.484	1.517
0.8	1	1.315	1.421	1.517	1.691	1.712

Table 3 Relationship of stress intensity factors $\alpha = 0, \quad \beta = 1, \quad \gamma = 1, \quad \mu_{01} = 1$

η	0.2	0.4	0.6	0.8
$K_3^{(0)} / K_3^{(4)}$	4.474	2.921	2.431	2.271

On the table 1 and 2 the values of the relations are given $K_3^{(1)} / K_3^{(j)}$ $(j = 2,3,4)$ by $\mu_{01} = 1$. Here $K_3^{(1)}$ stress intensity factor at the crack ends in the case of 1, and $K_3^{(j)}$ $(j = 2,3,4)$ - in case 2,3 ,4.

Calculations show that in the observed cases μ_{01} the effect of the short-sightedness coefficient is negligible: For this reason, in the table 1 and 2 reduced $\mu_{01} = 1$ according to the case: In spite of this, as is easily seen by the table 1 and 2 in a certain scenario of the crack and the investor, we have a noticeable decrease in the intensity factor:

3. Summary

Observed problem-multistage: So it is a complete study relates to the broader calculations: But what happened is enough to show that the presence of investors significantly reduces the tension around the tips of the crack: Moreover, as can be seen from the table 3, as a result of the joint interaction of investors, the change in the stress intensity coefficients near the crack tips is stabilized:

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MECHANICAL PROPERTIES OF SPHERICAL CELL POROUS ALUMINUM ALLOY-POLYURETHANE COMPOSITES AT DIFFERENT TEMPERATURES

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Keywords: Mechanical properties, porous aluminum-polyurethane composites, temperature

Abstract. In the present work, mechanical properties of spherical cell porous aluminum alloy-polyurethane composites (SCPA/PU composites) at different temperatures (-20, 25, 70, and 120°C) were experimentally investigated. The experimental results show that the force-displacement curves for the composites include the three various regions: linear-elastic regime, a long plateau region and densification stage. Moreover, the plateau force decreases with the growth of temperature, and the sample with higher density show the larger plateau force. Both energy absorption density and energy absorption efficiency also declines with the increasing of temperature.

1. Introduction

Filling polymers into open-cell porous metals (PMs) to produce porous metal-polymer composites (PMPCs) has attracted great attention in recent years because of their superior energy absorption capacity, damping ability and mechanical properties, when compared with the PMs. Generally, the PMPCs are comprised of two various mono-materials which are connected on the macroscopic level [1]. The metal materials can make up for the inferior mechanical performances of polymer materials, while the polymer materials can make up for the poor damping capacity of metal materials.

Studies on the mechanical properties of the PMPCs have been performed by some researchers. Reinfrid et al. [1] fabricated hybrid foams by introducing expandable polystyrene into open-cell steel foams, and explored their uniaxial compression as well as damping properties. Dukhan et al. [2]investigated flexural properties of an interpenetrating phase composite, which is produced by injection molding polypropylene into open-cell aluminum foam. Wang et al. [3, 4]examined the damping and uniaxial compression properties of polystyrene/CuAlMn composites obtained via sintering-dissolution and sol-gel methods. Raju et al. [5]manufactured two types of multifunctional hybrid materials made up of Fe foam-epoxy resin and Fe_2O_3 foam-epoxy resin, respectively, and studied their quasi-static and dynamic uniaxial compression properties. Moreover, in order to enhance mechanical properties of open-cell porous aluminum, several types of polymers, e.g., silicon rubber, polypropylene and polyurethane (PU), were designed to infiltrate into the porous aluminums, and the quasi-static, dynamic uniaxial and cyclic compression behaviors for the fabricated PMPCs were reported by some investigators [6-11].

However, the researches mentioned above were mainly focused on the mechanical properties of PMPCs at room temperature, and very few studies are reported on the mechanical performances of

PMPCs under different temperatures. Therefore, in the present work, the uniaxial compressive properties of one of PMPCs, named spherical cell porous aluminum alloy-polyurethane composites (SCPA-PU composites), at different temperatures were studied.

2. Experimental procedures

2.1 Testing specimens

Spherical cell porous aluminum (SCPA) specimens here were fabricated by the space-holder method [12] and provided by Qiangye Metal Foam Ltd (Beijing, China). The average cell size of SCPA is approximately 5mm, along with 4-6 openings with a size of 1-1.5mm are arranged with different orientations and situated in the cell wall of the spherical cell. The composition of the aluminum matrix was measured by Spark atomic emission spectrometer that is listed in Table 1. SCPA specimens with the dimensions of 50mm×50mm×75mm were prepared using a line cutting machine. The density values of the utilized SCPA specimens in this paper are 0.9351g/cm^3 and 1.0896 g/cm3 by weighing and measuring each individually.

Table 1 Chemical composition of the aluminum matrix (in wt %)

Si	Fe	Mg	Mn	Cd	Zn	Cr	B	V	Al
0.701	1.43	2.23	0.0106	0.0296	0.0176	0.0059	0.0068	0.006	Bal.

The polyurethane (PU) filling was typical for high-elastic polymer and supplied by Haida Rubber and Plastic Ltd., (Wuxi, China). Chemical and processing details of the PU are proprietary, but the PU can be considered as a two-component material. The mechanical properties of the PU at room temperature and glass transition temperature are summarized in Table 2.

Table 2 Mechanical properties of the PU

Type	PU
Density(g/cm^3)	1.123
Hardness(SHA)	45
Glass transition temperature, Tg(℃)	-48
Tensile strength(MPa)	3.5
Maximum elongation (%)	815
Stretching strength at 100%(MPa)	0.9
Stretching strength at 200%(MPa)	1.3
Stretching strength at 300%(MPa)	1.6

SCPA/PU composites were prepared by the pressure infiltration method [9]. A uniform pressure of around 0.5MPa was applied to press the liquid PU into the cells of the SCPA, and then was heated at 125^{o}C for four hours to cure. After carefully polishing, the cross-sectional area and the height of all the specimens are 52×52mm^2 and 75 mm, respectively, as shown in Fig.1 (a). All the samples here were wrapped up certain thickness PU on the side, while had no PU coating on the surfaces perpendicular to the loading force. The microstructure of the SCPA/PU composites samples was observed utilizing scanning electron microscope (SEM), as shown in Fig.1 (b).The

SEM samples were carefully polished using sandpaper with different grits, then coated by the High Resolution Sputtering Coating Instrument. It is seen from Fig.1 (b) that the interface between the aluminum matrix and the PU is well defined without apparent voids or cracks, indicating a good bond between the aluminum matrix phase and PU phase.

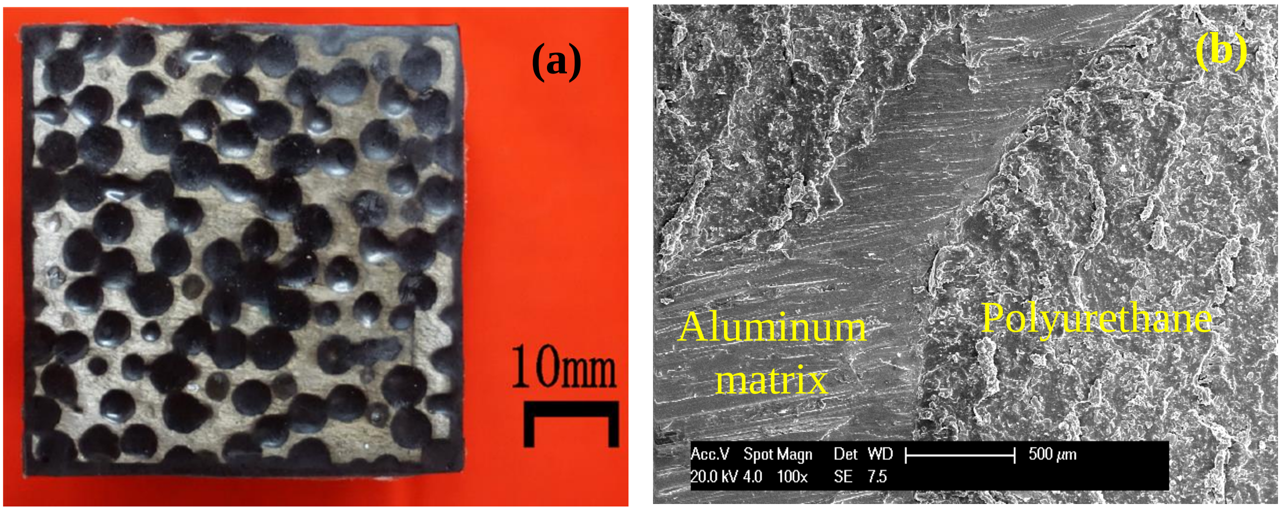

Fig.1 The fabricated specimens: (a) images of SCPA/PU composites specimens; (b) SEM micrograph of SCPA/PU composites.

2.2 Experimental test

250 KN MTS 810 hydraulic testing system with an attached ambient chamber (shown in Fig.2 (a)) was utilized to investigate the mechanical properties of the SCPA/PU composites under uniaxial compression at -20, 25, 70 and 120ºC, respectively. It is worth noting that liquid nitrogen is used as cryogenic coolant, while the high temperature is achieved by heating electric furnace. A thermocouple was located inside the ambient chamber and was placed adjacent to the specimen. The cross-head velocity was set to 5mm/min, and the loading was stopped when the specimens were compressed to $0.8*h_0$, where h_0 is the initial height of the sample, as illustrated in Fig.2 (b). Prior to test, each specimen was lubricated to reduce the friction between the loading platen and the specimens, and then was kept in the ambient chamber of the testing machine for more than 15 min.

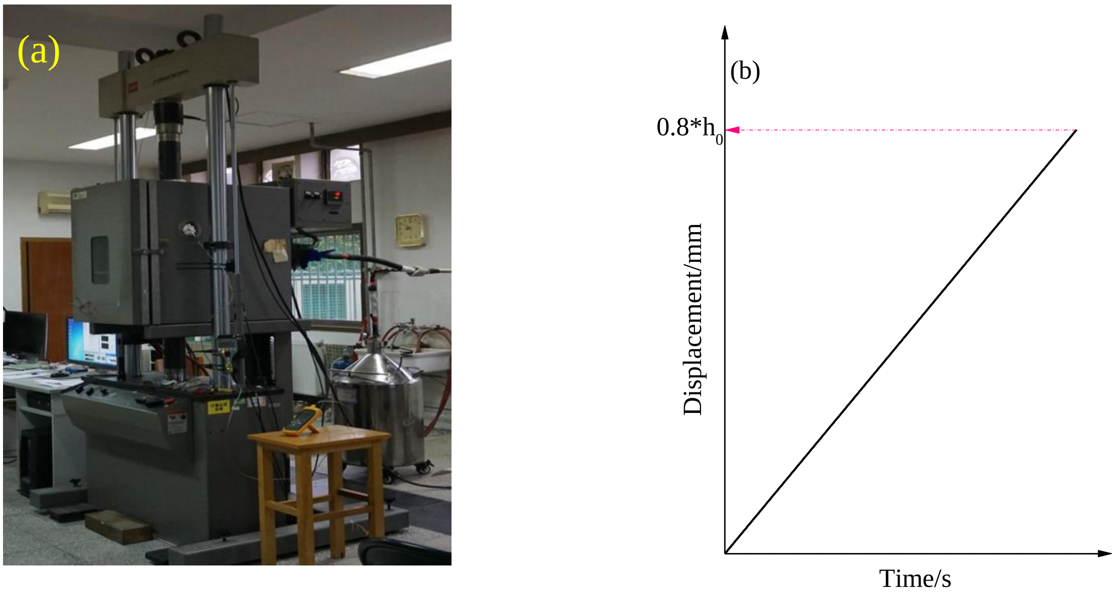

Fig.2 (a) Experimental equipment; (b) Loading protocol

3. Results and discussions

3.1 Force-displacement response

The force-displacement curves for the composites with two densities at different temperatures are shown in Fig.3. It is observed that the force-displacement curves for the composites exhibit three different regions: (1) linear elastic phase at low deformation; (2) a long plateau region where the aluminum skeletons buckled and collapsed, and (3) a densification phase resulting in a swift increase in the force. Moreover, the fluctuation of force aggravates in the plateau regime with the growth of temperature. The behavior is attributed to the flowing aspect: as the glass transition temperature for the PU is -48oC, thus, the PU is in the state of high-elasticity in this paper. As is known, the mobility of chain segment for the polymer with typical super-elasticity was increased with temperature increasing. Therefore, the extent of expansion for the PU also rises with rising temperature. The rupture of aluminum skeleton causes the declining in force, meanwhile, the expansion of PU located in the cells accelerates the break of the aluminum skeletons due to the incompressibility of volume for the PU. On the other hand, the plateau force decreases with the increase of temperature. The phenomenon is mainly related to the softening behavior of the aluminum matrix and the PU as temperature rises. This softening behavior has also been reported in the literatures. For example, Aly M S [13] investigated the uniaxial compression mechanical properties of closed-cell aluminum foams at ambient as well as elevated temperatures and reported that, the compressive strength of foams decreased with the increase in homologous temperature. Ashrafizadeh et al. [14] found that, the PU elastomer became softer and the hysteresis loop decreased with the increase of temperature.

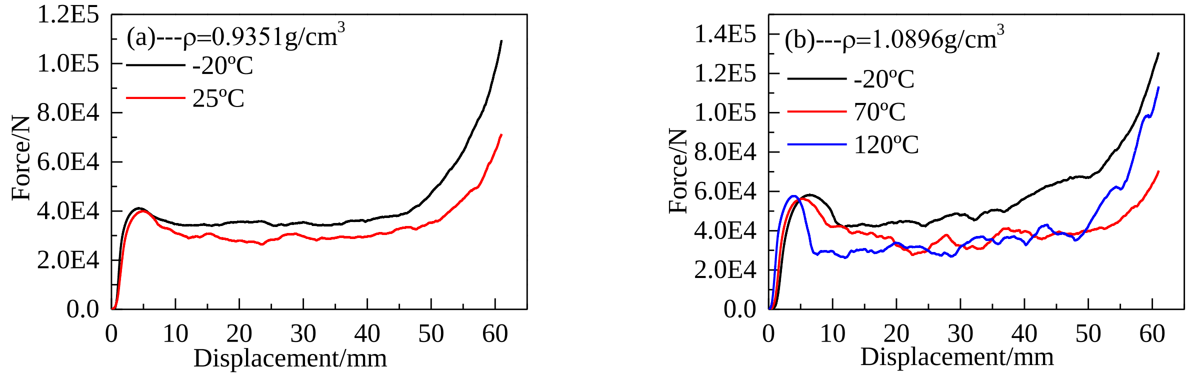

Fig.3 The force-displacement curves for SCPA/PU composites with two densities at different temperatures.

3.2 Plateau force

The plateau force for the composites, which is defined as the mean value of flow stress from yield displacement of the specimen corresponding to the start of the plateau region to 50mm displacement, is shown in Fig.4. From it, the plateau force declines with the growth of temperature irrespective of density. And the composites with higher density value exhibits larger plateau force. For example, the plateau force for the composites with density value of 1.0896g/cm^3 is 56097.5N, while the plateau force for the composites with density value of 1.0896g/cm^3 is 37223.7N, at 20°C temperature.

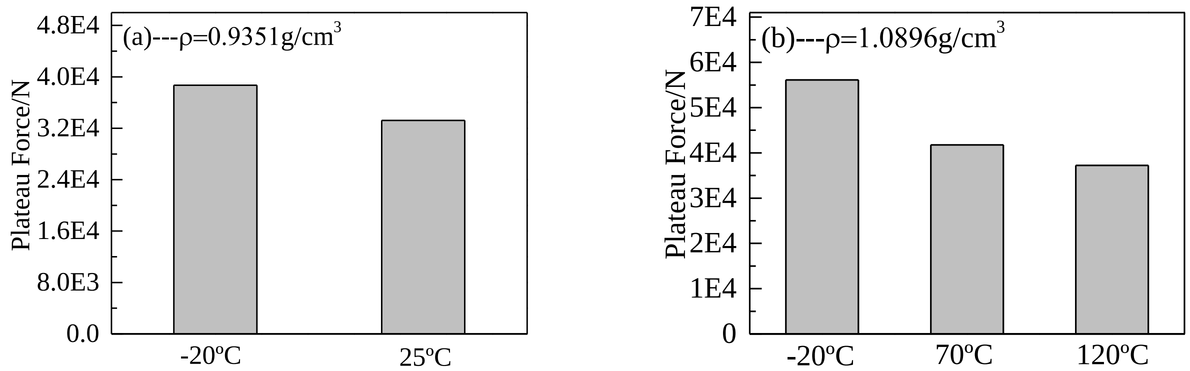

Fig.4. The plateau forces for SCPA/PU composites with two densities at different temperatures

3.3 Energy absorption

As described in Section 3.1, the composites can undergo large plastic deformation under relatively constant compressive force, which indicates that the composites can be utilized in the field of energy absorption. Two types of energy absorption parameters are frequently used to characterize the energy absorption characteristic of materials. One is energy absorption density (WV), which is defined as the energy which is required for the deformation of the material to a specific displacement, is calculated as follows [15]:

$$W_V = \int_0^D F(D)\,dD \quad . \tag{1}$$

The other metric is energy absorption efficiency, which can be evaluated as follows:

$$\eta = \frac{\int_0^D F(D)dD}{F_{max}D} \quad . \tag{2}$$

The term (Fmax D) is the ideal energy absorption, where Fmax is the maximum force and D is the specific displacement.

The energy absorption density of SCPA/PU composites with two densities after a compression displacement of 10-50mm at different temperatures is shown is Fig.5. It is observed that the energy absorption density is increased for all the samples with the increasing of applied displacement. Furthermore, the slope of the energy absorption density is obviously found to increase with the declining of temperature. And the composites with higher density value exhibit larger slope at the same temperature. For example, increasing the density value from 0.9351 up to 1.0896g/cm^3 at -20ºC, leads to increasing the slope of Wv-D curve from 178417 to 247716N.

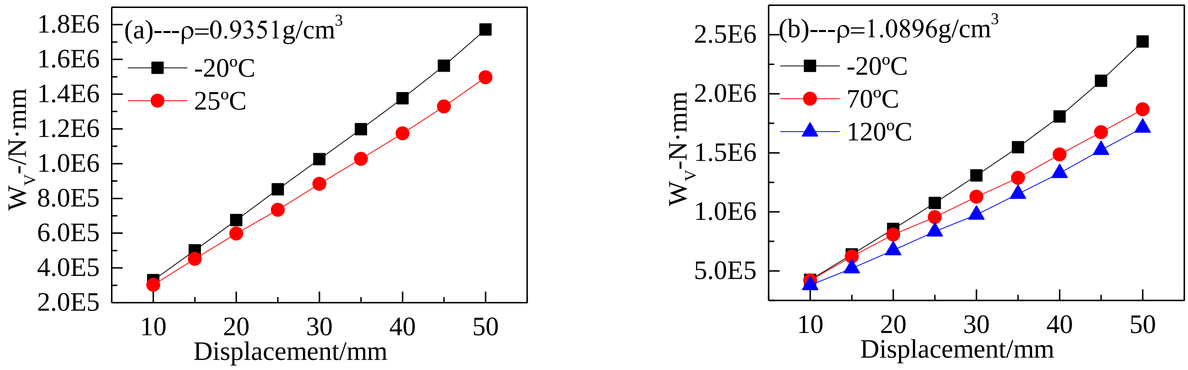

Fig.5. The energy absorption density of SCPA/PU composites with two densities after compression displacement of 10-50mm at different temperatures

Fig.6 shows the energy absorption efficiencies of the composites with two densities at different temperatures as a function of applied displacement. It can be noted that both temperature and density have a significant impact on the energy absorption efficiency. Generally, the energy absorption efficiency for the samples ascends with the decreasing of temperature, e.g., the energy absorption efficiency for the composites with density value of 1.0896g/cm^3 at -20ºC is 14.95% and 25.8% higher than that of the composites at 70 and 120ºC, respectively, at 40mm displacement. In addition, the composites with smaller density exhibit the higher the energy absorption efficiency at the same temperature. For example, at -20ºC temperature, the average value of the energy absorption efficiency in the range of 10-50mm for the sample with density value of 0.9351g/cm^3 is 0.8185, while the average value of the energy absorption efficiency in the range of 10-50mm for the sample with density value of 1.0896g/cm^3 is 0.7412. Therefore, it is important to decrease the operating temperature of SCPA/PU composites to achieve the superior energy absorption capacity.

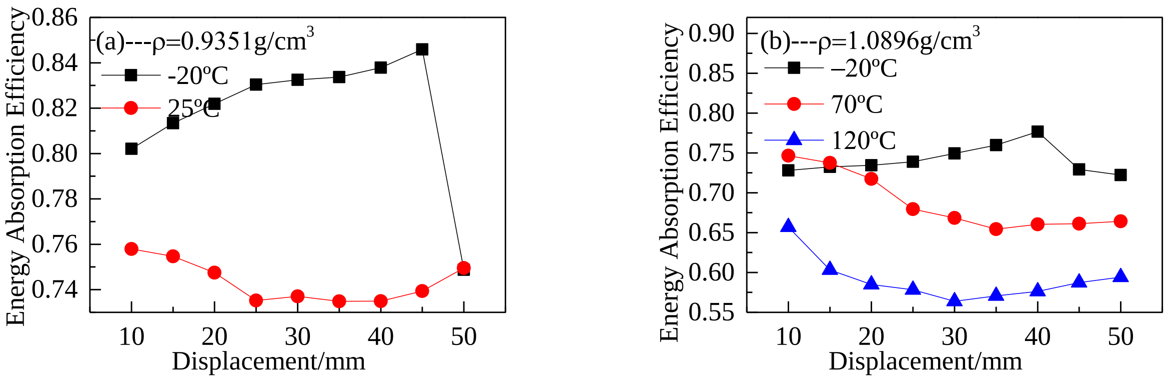

Fig.6. The energy absorption efficiencies of SCPA/PU composites with two densities after compression displacement of 10-50mm at different temperatures

4. Conclusions

The main conclusions of the present work are as follows:

1. Three different regions are observed for SCPA/PU composites under uniaxial compression: linear elastic regime at low deformation; a long plateau region where the change of force is slight with the progress of deformation; and the densification phase in which the rigidity of the composites increases rapidly.
2. The extent of the fluctuation of force in the plateau regime increases with the growth of temperature due to the ascending of the mobility of chain segment for the PU as temperature rises. Moreover, the plateau force increases with the decreasing of temperature because of the softening behavior of the aluminum matrix and the PU. And the sample with higher density exhibit larger plateau force at the same temperature.
3. Both Energy absorption density and energy absorption efficiency ascend with the declining of temperature.

Acknowledgements

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CONSTRUCTION OF MODERN HIGH-RISE BUILDINGS IN ACCORDANCE WITH CITY PLANNING RULES AND REGULATIONS

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Keywords: Seismic, unified frame, coordination council, liquefaction of foundation, prevention

Abstract. The development of high-rise buildings construction in Tbilisi from 11-storey house on Heroes Square up to 40-floor house in Tbilisi I. Chavchavadze Avenue are reviewed. It is noteworthy that in the cities where the land price is high and city infrastructure and architecture require a creation of modern vision, it is necessary to design high-rise buildings and complexes. The modern civil engineering science gives this opportunity. At present, we have created a whole pleiad of engineer-constructors who are able to successfully solve this problem. In the opinion of the authors, high-rise construction in Tbilisi and resort zones that is currently developing at such rate, are based on the modern foundations of seismic science and should also be developed in the future.
The fact that high-rise construction does not have an alternative, is the experience of many countries around the world, even in countries with high seismic activity. But it is also the activity from that population, who live in the city in a densely populated condition, and the high-rise construction limits their living conditions. but all such issues are yet resolved by the acting norms and rules of urban planning. It is only necessary to maintain and implement them.

1. Introduction

Based on the statistical data [1] Georgia always belongs to the intensive earthquake area. Due the devastating earthquakes were destroyed number of religious or civil monuments. The similar situation is in various continents worldwide. Accordingly of [2] data since 1556 up to 1990 devastating earthquake with magnitude from 6 up to 9.5 worldwide makes up to billions losses of humans lives as well as in material values.

Despite the mentioned state, the humanity, it's scientific society trends to implement tower buildings construction in same cities, same countries, where prior earthquakes cause destruction and great losses.
Since the 20-iesn of last century when the academician Kiriak Zavriev extend the resonance-oscillations theorem of Japan scientist Mononobe, the study of seismic phenomena in Georgia and seismic resistance formed the whole generation of specialists. In 1928 was created seismic resistance civil engineering construction norms and rules that makes duty for designers and civil engineers to implement antiseismic measures on level of that time scientific achievements.

2. Basic part

In the Georgia was established Railway Transport and Polytechnic Institutes, then Structural Mechanics and Seismic Resistance Institute, Building Materials and Hydraulic Engineering Facilities Research Institutes design institutes for developing of industrial and public destination objects. In 1964 was founded Tbilisi Zonal Research and design-experimental Institute. It was most significant research and design institute in whole Soviet Union. It carries out versatile zonal function in issues of architect and construction, was leading institute in seismic civil engineering field in including in Soviet Union 11 republics. It has branches in Baku, Batumi, Piatigorsk, Sochi and Sokhumi [3].

Developed in the institute scientific papers and typical and individual projects were implemented in all soviet seismic republics. In that time Tbilisi most high was so called 11 storey residence building on Heroes Square and also after the Pitsunda resort in Tbilisi were constructed several similar frame 14 storey buildings. In this conditions by our scientists and specialists was constructed 271 m dam that successfully generates the power. Urban planning in large cities has it's features – construction of multi-functional tower buildings, where are arranged in addition to residence areas also hotels, administrative, cultural, entertainment, service, medical, educational and so on organizations. Often these multi-functional tower buildings are unified in joint interconnected and functionally independent complexes [4].

But for construction of tower buildings was necessary to develop such structural systems that gives possibility to come in and out from it. The history of development of elevators starts since 236 BC, when Archimedes create first elevator. its history follows by inventions of Kulibin, In 1845 by English physician Thomson creates the first hydraulic elevator and so on. In 1861 the first electric elevator for tower building was created by American inventor Alisia Otis. But in population starts the protests against it, because was prevailing the opinion that is is unsafe. The Otis answered by experiment – hi itself comes in heavy loaded elevator and order to cut out the rope. From 12 m height the dropping down elevator was stopped by safety mechanism.

The first 15 storey building was constructed only in 1880. The building has metal frame. during that century several buildings were constructed in USA cities, but after the well-known fires it was clear that in necessary to replace the metal on other non-burning material. In 1903 in Cincinnati (USA) by architect Akfred Elcner was constructed first 15 storey by from reinforced concrete – residential building with 64 m in height. The expanses on construction were reduced in comparison with metal structures, but the main was its fire resistance.

For 20-30 storey building the consumption of metal per m^3 of building are almost two timeless in comparison with metal frame buildings [5]. But some skeptics were standing at building and waiting when it will be ruined due the own gravity weight. But despite it currently in Tbilisi and resort towns of Georgia are constructed only tower buildings. In Batumi and in general in Adjara are under construction few dozen tower bys up to 40-50 storeys.

The mass distribution of tower buildings starts due the implementation of reinforced concrete structures. In Baltimore fire were ruined all metal buildings but reinforced concrete building were survived. The tower building are in mass constructed also in our neighboring countries, Armenia, Azerbaijan. In China cites are located lot of 30-40-50 tower buildings. Due the 2011 data worldwide are more than 49 so called skyscrapers and their height exceeds 300 m [6].

In last years the tower building are constructed by developers with application of seismic insulation means. As example in study and research as well as implementation of seismic insulation systems by Armenian specialists. the activity for improve seismic insulation systems for existing buildings are still continued.

In city of Taipei (Taiwan) on inertial dampers of "Taipei 101" are arranged two pendulums on 92-thickness and 88-thickness storey's. Yet are existing many types seismic insulation and seismic damping adapted systems as well as stationary, etc, but on this issue we publish number of scientific papers. As for issue of category of tower buildings it would be mentioned that in various countries such gradation is different. Of course in the 2-3 storey settlement 10 storey building will be like skyscraper. If we make generalization and based on major cities and countries we will obtain such state:

- as tower buildings are accepted more than 75 m in height or 25-storey and more buildings;
- ultrahigh building in height from 150 up to 300 m;

– skyscrapers more than 300 m in height.

At the same time the ultimate horizontal displacement is limited. Now let's briefly review how is developed the construction of tower buildings in our capital and in general in country. In 1967-1980 by TbilZNIEP was developed and experimentally tested for residential and public buildings, as well as for industrial facilities, building unified IIS-04 series frame structures for 16-18 storey building in up to 7 magnitude seismic areas. The problem was rather complex. Makes necessary to develop up to 30 thousand schemes for analysis of various height and different spans combinations. I will mention new structural systems that were created and developed, as well as tested in experimental bases of TbilZNIEP and Moscow Central Research Institute. First of all development of frame-connected systems (stiffness diaphragms) for high seismic activity areas. This gives the possibility to construct the building with same unified load bearing structures cross-sections. Were developed and experimentally tested created by us new joint units. Due them in the Georgia was possible to construct 16-18 storey buildings up to e times less consumption in comparison with Pitsunda frame's buildings as well as with less concrete consumption. In Tbilisi and whole country now are more than 300 such constructed under our authorship buildings. This system currently is used in up to 50 storey's buildings under construction [7].

The next stage was reinforcing of central unit of frame systems "girder-column" on alternating moment that is the main reason for building's destruction. Was tested our invention on the basis of TbilZNIEP as well as on Moscow on central institute bases. This method also is widely implemented in seismic areas.

Were developed and implemented new systems for external panels connection with frame that also is implementing in frame-panel systems in all constructions.

The Jiugoslav professor Branko Jejel system for prestressing of reinforcement bar in coverings is successfully implemented in construction of 18 storey buildings. This system was implemented in non-seismic areas of Russia at large loadings as well as in other republics.

Were created and implemented 5 storey columns with spiral transversal reinforcement that makes the construction cheaper and reduce the erection period.

Currently the architects are switched on creation and development of tower buildings.

It would be mentioned that all research, experimental and design works for unified frame structures for construction in all-union scale in seismic resistant residential, publics and multi-storey industrial buildings, by order of Soviet Union Construction Minister G. Karavaev, were guided by your most humble servant. In coordinating council were included the top-level officials from all 11 seismic active republics.

Of course the creation of such up-to-date, seismic resistant, profitable systems and their implementation in all seismic areas of Soviet Union will be impossible without high level research, design and civil engineering personnel.

But this article is dedicated to problems of tower buildings construction in Georgia. This is mass protests of population against construction of such building on adjacent of them. The reason of protests mainly are flagrant violation of construction codes, such as:

Arrangement of new tower buildings in existing urban housing development does not limit the living conditions of population [8].

Would be satisfied the requirement for planting in large cities territory – up to 6 m² on per habitant. The access to this territory will be free, without any obstacle from residential areas.

3. Conclusions

In the conditions of construction of tower buildings extremely attention would be paid for streets network, capacity of roads and transport flow crossings and available car parking. Also extreme special attention will be paid for access possibility of fire vehicles to residential and public buildings, free access of fire fighters and stairs to arbitrary flats.

Also will be attended on proper density of population in territory of residential districts that is determined by population per hectare. In the seismic areas the design density of polutation will be determined accordingly of regional norms but must not exceed 300 habitant/hectare.

And finally the necessity of construction of tower buildings, its number of storey's will be determined due technical-economical, social-living, hygienic, demographic requirements, features of construction basis and engineering equipment and their capability. Such buildings will be meet aesthetic criteria would be beauty and functional. And after this we must bless the way for tower buildings construction.

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CONSTITUTIVE MODEL OF MARINE SOIL UNDER CYCLIC LOADING

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Keywords: High confining pressure; high pore water pressure; constitutive model; cyclic loading

Abstract: In this paper the effect of high confining pressure and pore water pressure on mechanical behaviour of deep-sea marine soil under cyclic loading is investigated. In the theoretical framework of the modified Cambridge model, the dilatancy equation for marine soils is proposed based on the analysis of deformation tests of soil materials under different confining pressures. The bonding stress between ocean soil particles is defined, and an elastic-plastic constitutive relationship of ocean soil under cyclic loading is established based on the damage theory of structural soil and the mapping criterion. The model can not only describe the dilatancy and shear behavior of marine soils, but also reflect the influence of damage caused by particle debonding on the constitutive relationship and the deformation characteristics of marine soils under cyclic loading. By comparing the prediction of the proposed model with those published in the literature, it is found that the agreement between them is very good, indicating the rationality of the proposed model.

1. Introduction

In recent years, with the rapid development of social economy and engineering technology, people begin to cast their eyes on the ocean. Marine engineering is closely related to marine soil mechanics. The nature of subsea soil is very different from the land. The theory and experience applicable to land engineering are often not applicable for marine engineering. In the quiet seabed, there will be the danger of water gushing and collapse in the construction process of the submarine tunnel, and the engineering accident of tunnel floating will also occur in the operation process of the tunnel. For example, the submarine tunnel in Cangfu City, Okayama Prefecture, Japan, is about 140 meters long. On February 7, 2012, a landslide occurred. The landslide site is located 30 meters deep under the sea. The submarine tunnel was completely submerged by sea water and five people were killed in the accident.

Engineering and academic circle have carried out research on Marine soil for a long time. Ye *et al*. [1] believe that Marine soil is in the environment of high pressure and low temperature for a long time and forms natural gas hydrate with the methane gas generated by the metabolism of Marine organisms. At this time, the microstructure, physical and mechanical properties of Marine soil have undergone great changes. Once disturbed, natural gas hydrate will decompose a large amount of methane gas, which will not only pollute the environment, but also release into the pores of rock strata, making the consolidation of gas-bearing soil worse and damaging the Marine foundation structure. In the long-term process of resisting evolution, Marine soil contains a large number of minerals, showing strong cementation characteristics and a strong "apparent early consolidation pressure" phenomenon [3-4]. Many scholars [5-8] divided the stress in soil into soil skeleton stress and cementation stress. The soil skeleton stress is regarded as the friction strength of soil particles and the elastic-plastic model is adopted. With the increase of soil strain, relative displacement or rotation occurs between soil particles, soil structure is gradually damaged, and the stress intensity is gradually weakened.

Verdugo and Ishihara [9] studied the relationship between tangential elastic modulus and confining pressure of sandy soil, and they believed that the greater confining pressure, the steeper the stress-strain curve, the more obvious the hardening characteristics of the stress-strain curve, the greater the peak strength, and the larger the volume shrinkage deformation. Experimental studies [10-13] show that the condition with high confining pressure and high pore water pressure not only affects the internal friction angle of the sand soil, but also affects the peak strength of the sand soil. Moreover, with the increase of confining pressure, the strain softening characteristics of the soil will gradually change into strain hardening characteristics. In the triaxial shear process, the shear stress will cause shear strain and the volumetric strain. And the volume change of soil will increase with the increase of confining pressure. The higher the confining pressure cause the stronger the occlusal action between soil particles and the higher the peak shear strength. Miyazaki *et al.*[14] found that effective confining pressure can inhibit the lateral deformation of specimens under high pore water pressure through experiment tests. The test also found that the shear behavior of sandy soil is related to the compactness and confining pressure of sandy soil material. When the confining pressure is larger relative to the compactness of sandy soil, the sand particles are rearranged in the shear process, causing the volume smaller and appearing the phenomenon of shear shrinkage. When the confining pressure is small relative to the compactness of sandy soil, with the reason of shear, the soil particles cross over and the sample volume increases, resulting in dilatancy.

In summary, the above studies describe the influence of high confining pressure, high pore water pressure and cementing stress on the mechanical properties of soil, and the research results have been well verified by experiments. However, these theories did not establish a complete constitutive model, and their research conclusions are only limited to the description of one aspect. At present, there is a lack of a systematic theory to describe the constitutive relationship of Marine soil under the influence of multiple factors. In this paper, the modified Cambridge model is taken as the theoretical framework and the structural damage theory is combined to establish an elastic-plastic model with clear physical meaning and simple parameter determination to describe the constitutive relationship of Marine soil under cyclic load.

2. Intergranular stress of soil under high water pressure

The soil particles are very hard, and the deformation of soil particles under stress is usually not considered. It is believed that the deformation mainly comes from the deformation of soil skeleton. In saturated soil, the surface of soil particles is often covered with a layer of bound water. The stress contact between soil particles through bound water contact [15-16]. When the soil skeleton is forced, the bound water at the contact point of soil particles is squeezed and deformed. Due to the presence of bound water, the contact mode of soil particles has changed from point contact to surface contact. According to Du *et al.* [17-18], when soil particles are in the form of surface contact, pore water pressure will create an unbalanced force between soil particles, as shown in Fig.1. In order to maintain the system balance, the transfer stress between soil particles will inevitably be adjusted accordingly. Based on the principle of effective stress and considered, the influence of pore water pressure on the transfer stress between soil particles, the effective stress applicable to saturated soil under the conditions of deep sea is proposed by Du *et al.* [17-18]:

$$\sigma' = \sigma - u + \alpha_c u \tag{1}$$

Particularly:

$$\alpha_c = \sum A_i / A \tag{2}$$

Where, $\sum A_i$ is the component of the sum of the contact areas of soil particles in the direction of the shear failure plane; A is the area of the shear failure surface of the soil mass; σ is the external load; u is pore water pressure; α_c is coefficient of contact area of soil particles.

Compared with the Terzaki effective stress, a modified term was added to the right side of equation (1) to express the effect of pore water pressure on the transfer stress between soil particles. When the soil is under low water pressure, the modified term is very small relative to the external load and can be ignored. At this time, the effective stress degenerates to the Terzaki effective stress. Particularly, the coefficient can be determined by the experimental method [19].

Due to the effect of sea water for the long-term, Marine soil presents a typical flocculation structure, in which small particles of flocculation accumulate into huge flocculants. Therefore, Marine soil has a greater porosity than terrestrial soil. Marine soil contains a large amount of biological skeleton, diatomaceous remains and other organic rock debris, and dissolves a large amount of gas, forming Marine soil cementing material that is very different from land soil [1]. In laboratory conditions, soil samples are prepared artificially, and the bond strength has been destroyed. In this paper, it is assumed that the bond stress of soil samples comes from pore water pressure, regardless of the influence of cementing substances.

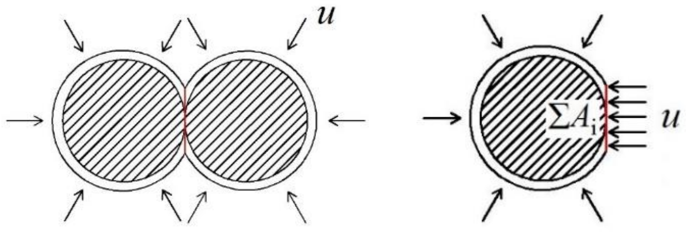


Fig.1. Effect of pore water pressure on the bonding stress of soil particles

3. The development of model

The modified cambridge model [20] has the advantages of fewer parameters and clear physical significance in describing the mechanical properties of normally consolidated saturated soils. Based on the theoretical framework of the modified cambridge model, an elastoplastic theory which takes into account the effects of high confining pressure and high pore water pressure on marine soils is established in this paper.

3.1 Yield surface equation

In this paper, the influence of the term in equation (1) on the yield surface of saturated soil is considered by introducing the bonding stress p_b.On the basis of the modified Cambridge model, the elliptic yield surface as shown in Fig.3 is established. The yield surface equation of Marine soil is as follows:

$$f = q^2 + M^2(p' - p_b)(p' - p_x) = 0 \quad , \tag{3}$$

Where, p' is the average net stress; q is deviatoric stress; p_x is the intersection point between the yield surface and the p' axis of the ellipse, which is related to the initial consolidation stress; p_b is the bonding stress between soil particles; M is the slope of the critical state line.

Experimental studies [14,21] show that the shear failure process of saturated soil is often accompanied by dilatancy under the condition of high confining pressure and high pore water pressure. However, the dilatancy will gradually disappear with the increase of confining pressure. If the confining pressure is high enough, there will be no dilatancy during the whole shear process.

The assumed stress path is shown in Fig.2.The loading process starts from the point p_{x1} and then load along the stress path to the point A. At this time, the confining pressure can well restrain the lateral deformation, and the volume compression occurs in this process. In the process of continuous loading from point A to point B,the lateral strain increases significantly, the soil sample is close to shear failure, and the soil sample shows volume expansion. The shape of yield surface is similar to that of unsaturated soil, and the bonding stress is similar to the suction of unsaturated soil, which can enhance the tensile strength of saturated soil. The larger the confining pressure, the smaller the proportion of segment to the whole stress path, which means that dilatancy is less likely to occur.

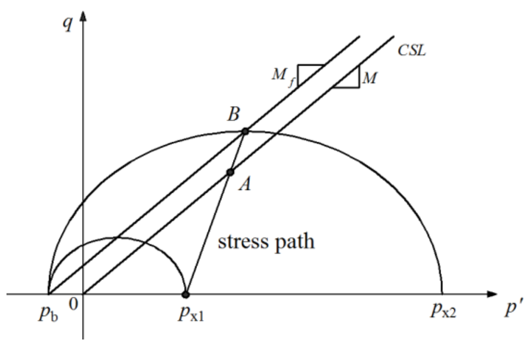


Fig.2. Yield surface and stress path of marine soil

3.2 Dilatancy equation

In order to analyze the deformation characteristics of marine soil in the process of triaxial compression, it is assumed that three different stress paths are shown in Fig.3. With the increase of load, all three stress paths reach the peak stress line (the line with slope M_{f} in the figure), and the stress ratio η is equal to the peak stress ratio M_{f} .If the confining pressure is not large enough, the soil sample will dilate, the strength will decrease, the stress level will return to the vicinity of the critical state line, and the deformation will continue to increase until the failure of the sample. If the confining pressure is high enough, the soil sample does not soften after the stress path reaches the peak stress line, and finally the soil sample is destroyed near the peak stress ratio. Fig.4 shows three soil samples with different confining pressures. It can be seen that the first group of soil samples with lower confining pressures underwent softening failure after the stress reached the peak. However, the soil samples of the second and third groups with high confining pressure did not show strain softening and finally failed near the peak stress.

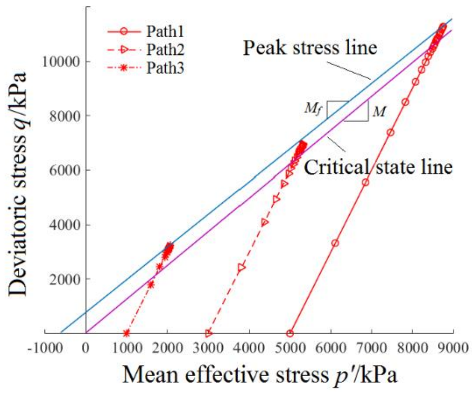


Fig.3. Peak stress and failure stress

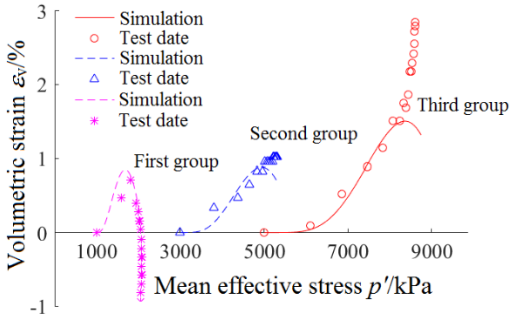


Fig.4. Deformation analysis under different stress paths

It can be seen from Fig.3 that the line connecting the peak stress point does not go beyond the origin. According to the provisions of the dilatancy equation in the modified Cambridge model, the dilatancy equation needs to meet the following two conditions [22]:

(1) when the stress ratio $\eta = 0$, the orthogonal condition requires: $\mathrm{d}\varepsilon_{\mathrm{d}}^{\mathrm{p}} = 0$, and the dilatancy equation is required:

$$d=\frac{\mathrm{d}\varepsilon_{\mathrm{v}}^{\mathrm{p}}}{\mathrm{d}\varepsilon_{\mathrm{d}}^{\mathrm{p}}}\to\infty .$$

Where, $\mathrm{d}\varepsilon_{\mathrm{v}}^{\mathrm{p}}$ is the plastic volume strain increment; $\mathrm{d}\varepsilon_{\mathrm{d}}^{\mathrm{p}}$ is the increment of plastic shear strain.

(2) when the stress ratio $\eta=M$, the failure characteristics requires: $\mathrm{d}\varepsilon_{\mathrm{d}}^{\mathrm{p}}\to\infty$,the dilatancy equation is required:

$$d=\frac{\mathrm{d}\varepsilon_{\mathrm{v}}^{\mathrm{p}}}{\mathrm{d}\varepsilon_{\mathrm{d}}^{\mathrm{p}}}=0 .$$

The concept of peak stress ratio M_{f} was not included in the modified Cambridge model.Therefore, in this paper, a peak stress ratio M_{f} is introduced into the dilatancy equation to meet the requirement when the stress ratio $\eta=M_{\mathrm{f}}$, the dilatancy equation is required $d=\mathrm{d}\varepsilon_{\mathrm{v}}^{\mathrm{p}}/\mathrm{d}\varepsilon_{\mathrm{d}}^{\mathrm{p}}=0$ .Suppose the dilatancy equation is expressed as a function as $d=d\left(1-\eta/M_{\mathrm{f}}\right)$.

The equation of dilatancy in the modified Cambridge model is derived by plastic work, and the expression of plastic work is as follows:

$$p'\mathrm{d}\varepsilon_{\mathrm{v}}^{\mathrm{p}}+q\mathrm{d}\varepsilon_{\mathrm{d}}^{\mathrm{p}}=p'\sqrt{\left(\mathrm{d}\varepsilon_{\mathrm{v}}^{\mathrm{p}}\right)^{2}+\left(M\mathrm{d}\varepsilon_{\mathrm{d}}^{\mathrm{p}}\right)^{2}} . \tag{4}$$

The dilatancy equation of the modified Cambridge model can be obtained from equation(4): $d=\frac{\mathrm{d}\varepsilon_{\mathrm{v}}^{\mathrm{p}}}{\mathrm{d}\varepsilon_{\mathrm{d}}^{\mathrm{p}}}=\frac{M^{2}p'^{2}-q^{2}}{2qp'}$ .In consideration of the influence of p_{b},replacing p' in equation(4) with $p'-p_{\mathrm{b}}$, and introduce the peak stress ratio M_{f} into the dilatancy equation to obtain the dilatancy equation under high confining pressure and high pore water pressure:

$$d=\frac{\mathrm{d}\varepsilon_{\mathrm{v}}^{\mathrm{p}}}{\mathrm{d}\varepsilon_{\mathrm{d}}^{\mathrm{p}}}=\frac{M^{2}-\eta^{2}}{2\eta}\left(1-\frac{\eta}{M_{\mathrm{f}}}\right) . \tag{5}$$

Where, stress ratio $\eta=\frac{q}{p'-p_{\mathrm{b}}}$.

Literature [23-24] think that the dilatancy equation is related to the stress ratio, and gives the expression of the dilatancy equation in the form of power function. Meanwhile, considering that the term $\left(1-\eta/M_{\mathrm{f}}\right)$ in equation (5) is a quantity less than 1, in order to compensate the value of the formula. Therefore, this paper introduces a simple power function of stress ratio based on the above dilatancy equation:

$$d=\frac{\mathrm{d}\varepsilon_{\mathrm{v}}^{\mathrm{p}}}{\mathrm{d}\varepsilon_{\mathrm{d}}^{\mathrm{p}}}=\frac{M^{2}-\eta^{2}}{2\eta}\left(1-\frac{\eta}{M_{\mathrm{f}}}\right)b\eta^{c} , \tag{6}$$

Where, b and c are fitting parameters. As can be seen from Fig.3 $M_{\mathrm{f}}\approx M$, take $M_{\mathrm{f}}=M$.

The dilatancy equation obtained by the modified Cambridge model and the dilatancy equation (6) proposed in this paper are compared with the experimental data in literature[25], as shown in Fig.5.At different initial void ratios e_0, the fitting degree of the proposed equation with the experimental data is better than that of the modified Cambridge model.

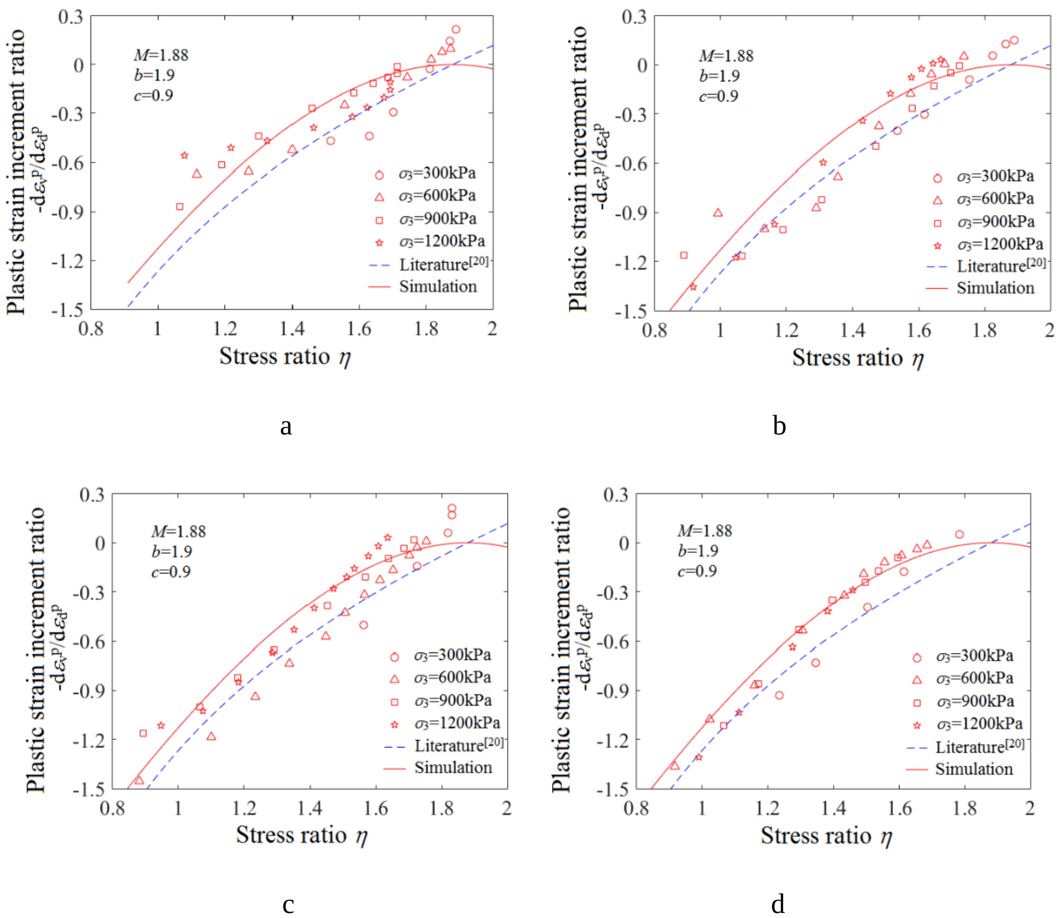


Fig.5 The relation between Stress ratio and dilatancy.

(a) $e_0 = 0.248$, ***(b)*** $e_0 = 0.252$, ***(c)*** $e_0 = 0.264$, ***(d)*** $e_0 = 0.282$

3.3 Plastic stress-strain relationship

In this paper, the flow criterion that the plastic potential function is equal to the yield function is adopted, i.e. $g = f$:

$$g = q^2 + M^2 (p' - p_b)(p' - p_x) = 0 \quad . \tag{7}$$

It is assumed that the plastic flow direction is orthogonal to the plastic potential surface:

$$dp' d\varepsilon_v^p + dq d\varepsilon_d^p = 0 \quad . \tag{8}$$

The plastic strain increment is determined by the plastic potential theory, i.e. $d\bar{\varepsilon}^p = \Lambda(\partial g / \partial \bar{\sigma})$.The plasticity factor Λ is expressed in the following form:

$$\Lambda = \frac{1}{H}\left(\frac{\partial f}{\partial p'}\mathrm{d}p' + \frac{\partial f}{\partial q}\mathrm{d}q\right) \quad , \tag{9}$$

Where， H is the plastic modulus.

The stress-strain relationship of soil can be expressed as follows:

$$\mathrm{d}\bar{\sigma}=\left[C^{\mathrm{e}}\right]\left(\mathrm{d}\bar{\varepsilon} - \mathrm{d}\bar{\varepsilon}^{\mathrm{p}}\right) \quad , \tag{10}$$

Where, $\left[C^{\mathrm{e}}\right]$ is the elastic stiffness matrix; $\mathrm{d}\bar{\varepsilon}$ is strain increment; $\mathrm{d}\bar{\sigma}$ is the stress increment.

In this paper, the maximum historical average net stress p_{x} is selected as the hardening parameter to describe the yield surface movement. Hardening parameters satisfy the following relation:

$$\mathrm{d}p_{\mathrm{x}} = \Lambda \frac{v}{\lambda - \kappa} p_{\mathrm{x}} \frac{\partial f}{\partial p'} \quad , \tag{11}$$

Where, λ is the normal consolidation line slope of saturated soil; κ is the slope of the rebound line of saturated soil; v is the specific volume, $v=1+e_0$.

According to the consistency condition:

$$\mathrm{d}f = \frac{\partial f}{\partial p'}\mathrm{d}p' + \frac{\partial f}{\partial q}\mathrm{d}p' + \frac{\partial f}{\partial p_{\mathrm{x}}}\mathrm{d}p_{\mathrm{x}} = 0 \quad . \tag{12}$$

Substituting equations(11) and (12) into equation(9), the plastic modulus H can be expressed as:

$$H = -\frac{\partial f}{\partial p'}\frac{\partial f}{\partial p_{\mathrm{x}}}\frac{v}{\lambda - \kappa} p_{\mathrm{x}} \quad . \tag{13}$$

3.4 Bonding stress damage between soil particles

Soil structure refers to the comprehensive characteristics of particles or aggregates in soil and the size, shape, arrangement, combination and connection of pores [24,26]. The bonding stress between saturated soil particles under high confining pressure and pore water pressure is also a kind of structural stress, and with the development of deformation, the bonding stress gradually weakens, but does not disappear completely. Damage theory has been widely used in the study of structural soils because of its unique advantages in describing the mechanical response of materials during deformation.

The expressions of elastic modulus and shear modulus of structured soil are given in literature [7, 27] :

$$E = E_0 \left(\frac{p'+1}{\sigma_0}\right)^n \quad , \tag{14}$$

$$G = G_0 p_{\mathrm{a}} \left(\frac{\sigma_3}{p_{\mathrm{a}}}\right)^n \quad . \tag{15}$$

Where, n is the fitting value; E_0 is the initial elastic modulus; G_0 is the initial shear modulus; p_{a} is atmospheric pressure; σ_3 is the confining pressure; σ_0 is the reference stress, take 1MPa.

The exponential expression of damage variable ω and plastic strain ε^{p} is given in literature[28] :

$$\omega = 1 - e^{-\varepsilon^{\mathrm{p}}} \quad . \tag{16}$$

Particularly,

$$\varepsilon^{\mathrm{p}} = \sqrt{B\left(\varepsilon_{\mathrm{d}}^{\mathrm{p}}\right)^2 + (1-B)\left(\varepsilon_{\mathrm{v}}^{\mathrm{p}}\right)^2} \quad , \tag{17}$$

Where: B is a dimensionless parameter, denoting the influence ratio of plastic shear strain $\varepsilon_{\mathrm{d}}^{\mathrm{p}}$ and plastic bulk strain $\varepsilon_{\mathrm{v}}^{\mathrm{p}}$ on soil structure damage.

The peak strength of soil sample depends on the connection strength and friction strength. In the process of shear, soil particles stagnated with each other, and the connection strength between particles gradually weakened with the increase of deformation. The connection strength after introducing the damage variable is expressed in the following form:

$$p_{\mathrm{b}} = (1-\omega)^{\beta} p_{\mathrm{b0}} \quad . \tag{18}$$

Where, β is the decay exponent, which affects the rate of soil structure degradation with deformation. p_{b0} is the initial connection strength; ω is the damage variable.

By combining equations (14) and (15), the elastic stress-strain relationship of soil material can be obtained:

$$\begin{Bmatrix} \mathrm{d}\varepsilon_{\mathrm{v}}^{e} \\ \mathrm{d}\varepsilon_{\mathrm{d}}^{e} \end{Bmatrix} = \begin{bmatrix} \dfrac{3(1-2\nu)}{E(p'+1)^n} & 0 \\ 0 & \dfrac{2(1+\nu)}{3Ep_{\mathrm{a}}}\left(\dfrac{p_{\mathrm{a}}}{p'}\right)^n \end{bmatrix} \begin{Bmatrix} \mathrm{d}p' \\ \mathrm{d}q \end{Bmatrix} \quad . \tag{19}$$

Substituting equations (9), (11) and (12) into equation(10), the total stress-strain relation in the following form can be obtained:

$$\begin{Bmatrix} \mathrm{d}\varepsilon_{\mathrm{v}} \\ \mathrm{d}\varepsilon_{\mathrm{d}} \end{Bmatrix} = \begin{bmatrix} D_{11} & D_{12} \\ D_{21} & D_{22} \end{bmatrix} \begin{Bmatrix} \mathrm{d}p' \\ \mathrm{d}q \end{Bmatrix} \tag{20}$$

Where, $D_{11} = \dfrac{3(1-2\nu)}{E(p'+1)^n} + \dfrac{\alpha \dfrac{\partial g}{\partial p'}}{-\dfrac{\partial f}{\partial p_{\mathrm{x}}}\dfrac{\nu}{\lambda-\kappa}p_{\mathrm{x}}}$; $D_{12} = \dfrac{\alpha \dfrac{\partial f}{\partial q}\dfrac{\partial g}{\partial p'}}{-\dfrac{\partial f}{\partial p'}\dfrac{\partial f}{\partial p_{\mathrm{x}}}\dfrac{\nu}{\lambda-\kappa}p_{\mathrm{x}}}$;

$D_{21} = \dfrac{\dfrac{\partial f}{\partial p'}\dfrac{\partial g}{\partial q}}{-\dfrac{\partial f}{\partial p'}\dfrac{\partial f}{\partial p_{\mathrm{x}}}\dfrac{\nu}{\lambda-\kappa}p_{\mathrm{x}}}$; $D_{22} = \dfrac{2(1+\nu)}{3Ep_{\mathrm{a}}}\left(\dfrac{p_{\mathrm{a}}}{p'}\right)^n + \dfrac{\dfrac{\partial f}{\partial q}\dfrac{\partial g}{\partial q}}{-\dfrac{\partial f}{\partial p'}\dfrac{\partial f}{\partial p_{\mathrm{x}}}\dfrac{\nu}{\lambda-\kappa}p_{\mathrm{x}}}$; $\alpha = \left(1-\dfrac{\eta}{M_{\mathrm{f}}}\right)b\eta^{c}$.

4. Example analysis

4.1 prediction of static triaxial test results

This section verifies the effectiveness of the model in this paper by simulating the test results of three groups of Toyoura sand soil. In this paper, the experimental data in literature [21] were compared with the calculation results of the model proposed in this paper. The test conditions are shown in table 1 below. The values p_{b0} in table 1 are obtained according to the test in literature[21], and then calculated by formula(18).It can be seen from table 1 that the higher the confining pressure, the higher the value p_{b0}.

Table 1. Test soil samples and working conditions

Group	u [MPa]	σ_3 [MPa]	p_{b0} [MPa]
First group	10	11	0.55
Second group	10	13	0.60
Third group	10	15	0.63

Table 2. Test soil sample parameters

Parameter	Value	Parameter	Value
p_a	100 kPa	B	0.4
a	0.01~0.12	β	1
λ	0.0333	κ	0.0001
ν	0.22	M	1.2
E	20000 kPa	e_0	0.67

Table 2 is the soil sample parameters, which can be obtained by triaxial test and fitting.Fig.6 shows the stress-strain curves of three groups of soil samples under different confining pressures. It can be seen that the strength of soil samples increases with the increase of confining pressures. Soil samples under high pore water pressure showed the same mechanical properties as those under low pore water pressure, and the critical strength of soil increased with the increase of confining pressure. However, under high confining pressure and high pore water pressure, the critical shear strength of soil samples is reached at very small axial strain.

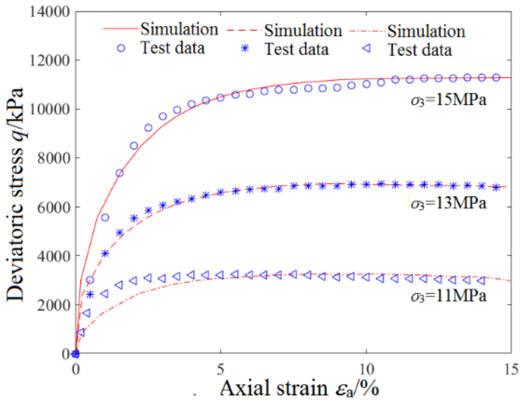


Fig.6. Stress-strain relationship of soils under high confining pressure and pore water pressure

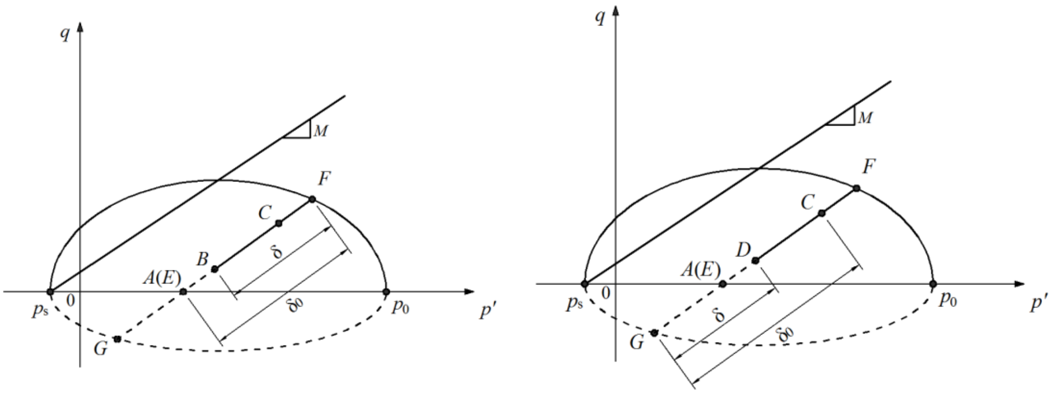
4.2 The movable center mapping criterion

In order to simulate the "hysteretic loop phenomenon" of soil under cyclic load, the movable center mapping criterion, is adopted in this paper. The elastic-plastic modulus D of the current stress point is determined by the interpolation function of the elastic-plastic modulus [29]:

$$D=\left(\frac{\delta}{\delta_0}\right)^{r_{\mathrm{L/U}}}D_{\max} \quad , \tag{21}$$

Where, $r_{\mathrm{L/U}}$ is the parameter to adjust the change rate of elastic-plastic modulus in the process of loading/unloading, which can be determined by test fitting; $D_{\max}$ is the maximum elastic-plastic modulus in the cyclic loading process; δ is the distance from the current stress B point to the boundary mapping point F; δ_0 is the distance from the mapping point F on the boundary surface to the initial stress point A,as shown in Fig.7.

Considering the particularity of soil, the reverse yield surface was subjected to appropriate shrinkage treatment in this paper, which was used to reflect that the tensile strength of soil material was much lower than its compressive strength, as shown in the dotted line in Fig.7.



a b

Fig.7 Mapping rules in boundary surface model

The loading process is shown in Fig.8. The current stress point B starts from the initial loading point A and reverses until the stress point C. During the loading process, the slope of stress-strain curve gradually small. Then the unloading starts. The point D is current stress point in the unloading process until the unloading reaches the reverse stress point E. At this time, a loading and unloading cycle ends. In Fig.8, the coordinates of the current stress point B is (p_1,q_1), the coordinates of the boundary mapping point F is(p_2,q_2), and the coordinates of the reverse boundary mapping point G is(p_3,q_3).Wherein, the loading process:

$$\begin{cases}\delta=\sqrt{(p_1-p_2)^2+(q_1-q_2)^2}\\ \delta_0=\sqrt{(p_2-p_3)^2+(q_2-q_3)^2}\end{cases} \quad . \tag{22}$$

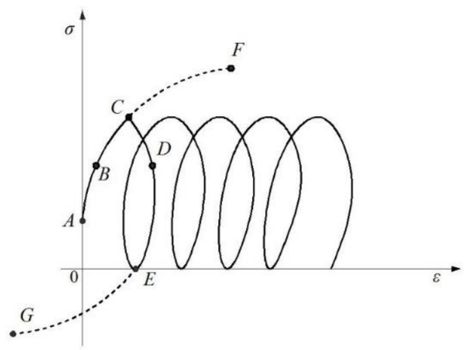


Fig.8. Stress-strain curve of loading and unloading

4.3 Prediction of cyclic triaxial test results

In order to consider the influence of changes in pore water pressure of high-water pressure on Marine soil under cyclic load process, the calculation expression of residual pore water pressure under cyclic load derived by XU *et al.*[30] was introduced:

$$u_w = f\left(H, \frac{\sigma_d}{\sigma_{c0}}, N\right) \quad , \tag{23}$$

Where, H is the stress process; σ_d is cyclic stress; σ_{c0} is the confining pressure; N is the number of cycles.

Assuming that the cyclic load always keeps the stress level unchanged and the confining pressure remains unchanged during the cyclic process, the pore water pressure expression can be simplified as a function related to shear strain, i.e $u_w = f(\varepsilon_d)$.Take a simple linear proportional function $\Delta u_w = m\Delta\varepsilon_d$, m is proportional coefficient. The experimental results in literature [31] were compared with the calculation results obtained by the above movable center mapping criterion, and the results shown in Fig.9 were obtained. The comparison results show that by selecting appropriate parameters, the movable center mapping criterion can well describe the stress-strain relationship of Marine soil with high confining pressure and high pore water pressure under cyclic load. According to the principle of effective stress, the effective stress between soil particles will gradually decrease. As the number of cycles increases, the cyclic strain will no longer develop. Therefore, the hysteresis loop obtained from each cycle will gradually overlap and finally reach a stable state.

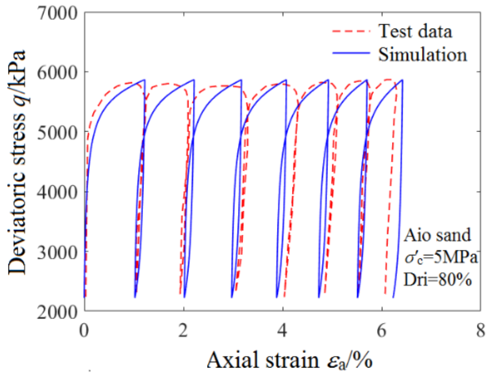


Fig.9. Comparisons between calculated and experimental values under cyclic loading

5 Summary

Based on experiments, study, this paper summarizes the stress-strain characteristics of Marine soil under high confining pressure and high pore water pressure. The effect of high confining pressure and high pore water pressure on the effective stress of Marine soil is considered in this paper. An elastoplastic model for deep-sea Marine soil is proposed, which can be summarized as follows:

(1) According to the contact mode between Marine soil particles, a new effective stress formula is introduced to consider the effect of high confining pressure and high pore water pressure on the effective stress of soil particles.

(2) Combined with the test results, the deformation characteristics of Marine soil under different confining pressures were analyzed, and the dilatancy equation of Marine soil considering the influence of peak stress ratio was proposed, and the better fitting results were obtained by comparing with the test data.

(3) The influence of high confining pressure and high pore water pressure on soil shear strength was explained from the microscopic physical mechanism. The value of the slope of the critical state line can be determined by experiments, and then the value can be determined according to the intersection point between the critical state line and the axis.

(4) Combined with radial mapping rules, considering changes in pore water pressure in the process of cyclic loading, established relationship between the pore water pressure and cyclic strain, simulated high confining pressure high hydrostatic stress strain curve of Marine soil under cyclic loading, verified the proposed constitutive model in the description of the Marine soil under cyclic loading the rationality of the mechanical properties.

The dilatancy equation proposed in this paper lacks reasonable theoretical support and is still a semi-empirical and semi-theoretical formula. At the same time, many parameters proposed in this paper are determined by fitting, and there is a lack of more scientific determination method, which needs to be further studied.

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PROBLEMS OF MODERNIZATION OF ESTIMATION NORMATIVE BASES IN CONSTRUCTION SECTOR IN REPUBLIC OF ARMENIA

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Keywords: Estimate, rationing, construction, information modeling, modernization

Abstract. Current issues in estimation norms in the construction sector of the RA, substantiates the need for modernization and interstate harmonization of the national estimation normative bases. In the context of the active implementation of the information construction modelling system (BIM) in the post-Soviet space, a model is proposed to interconnect the architectural, engineering, and estimate processes with the updated estimate and regulatory bases for the initial period of reformation of the existing estimation normative bases in the country.

1. Introduction

With the transition to a market economy in the post-Soviet space there have been fundamental changes both in the design of construction projects and technology of their implementation. In particular, the volume of panel and frame-panel construction decreased sharply. In Armenia, these types of buildings are built in single cases, and even then under new technologies, with the use of effective thermal insulation wall panels. Predominantly the technology of erection of buildings from combined constructions-monolithic reinforced concrete frame and enclosing structures from tuff stones of the proper form, light concrete blocks, hinged sandwich-panels with application of effective heat insulation (foam polystyrene and heat-insulating materials on the basis of perlite). The formwork and materials, which are not described in the current normative collections, are used.

In the Republic of Armenia, some steps are being taken to improve the production and estimate rationing: with minor additions and reductions, the old regulatory framework has been translated into Armenian and partially automated, and the prices of materials, constructions and products are constantly monitored. These activities cannot be called effective, because in the first case it is automated a cumbersome, burdened with inapplicable norms system with many corrective coefficients, in the second case - the prices are based on the data of individual manufacturers (firms) or trade organizations.

The attempts to develop aggregated prices for the types of works and objects of construction also cannot be characterized as successful, because the actual cost of similar works and objects of extremely small sample (often based on the example of one object), which does not reflect the average cost.

There is another, in our opinion, important problem: people's mindset has changed. A complex system of estimate and production rationing is available to the people of older and middle generation, who are familiar with the old system and somehow adapt to the new conditions, often make mistakes that are invisible only because the inspector does not have special knowledge.

The current system of estimate rationing in the republic leads to the fact that there is not enough theoretical knowledge obtained at the university to work as an estimator. Some experience is required: knowledge of the old system, possession of old normative literature, friendly relations for the timely exchange of new instructions. In such conditions knowledge transfer to young specialists becomes unprofitable for two reasons: lack of time and competition (today it is one of the rare cases when an elderly specialist is in demand, for example, young architects, designers, financiers with excellent knowledge of computer programs easily find a highly paid job).

2.Analytical part

Currently, the technology of information modeling of construction is being actively developed, providing wide opportunities for the interconnection of designers of different trends [1].

The approximate scheme of interrelation of age structure of a contingent of designers and estimators in the RA with the real functional possibilities in the field of estimate affairs is shown in Fig. 1.

It can be seen on the scheme that the information modeling of construction can be effectively done by the specialists from 25 to 45 years old, trained with modern computer programs like REVIT, TEKLA, ARCHICAD etc.

At the same time, it is difficult for this contingent to work with the old estimates and regulations base available to the specialists from 55 to 75 years of age.

Thus, the specialists from 45 to 55 are beyond these systems. There are two possible development scenarios here:

- in 20 years' time, the old system of estimate rationing with abundant useful information is completely lost,
- with the help of specialists of the "buffer" zone (45-55 years old), the modernization of the estimate and regulatory base and the system of estimate calculations are provided.

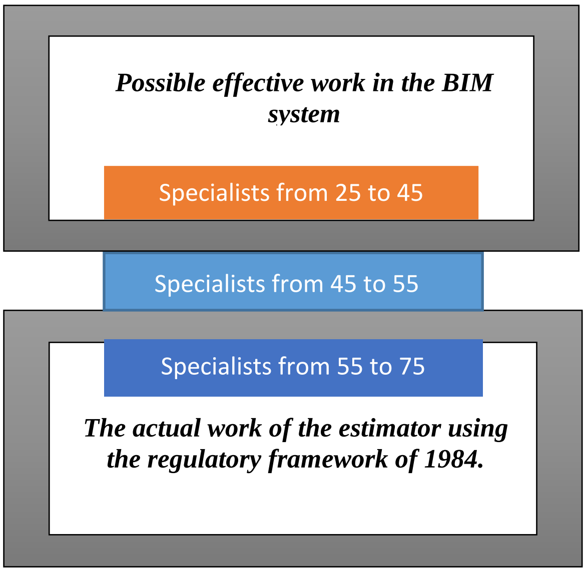

Fig.1. The scheme of interrelation of the age structure of designers and estimators with the efficiency of their functional activity

The analysis of the international experience in the field of technical regulation and standardization of construction testifies to the presence of prescriptive and parametric approaches to achieving a common goal [2,3]. The most significant problem of prescriptive regulation, which has become more acute in recent years due to the emergence of new efficient materials, technologies and increased international integration, is the chronic lagging of prescriptive norms from practice and their excessive rigidity. The development of manufacturing and estimate norms for new technologies and traditional ones, but carried out by modern technical facilities is extremely relevant. However, the process of adaptation of new norms in the old system is hampered by the complex calculations of indexing.

3. Recommendations

In our opinion, there is only one way out of this situation - the maximum simplification of the system of manufacturing and estimate rationing, the creation of an opportunity to unify the norms of traditional and new technologies, ensuring maximum "transparency" and availability of information [4]. The market itself regulates the prices of construction products, the task of estimated rationing is to provide an objective assessment of the expenditure of financial, labor, material, technical and time resources, while the average, aggregated, but timely calculation may be much more effective than a detailed, but long-term calculation.

In fact, a resource-based method of determining value is proposed as the only possible way to integrate with the norms of new technologies.

An approximate model of modernization of the budget standardization in the RA, in our opinion, can be presented in the following form (Fig. 2).

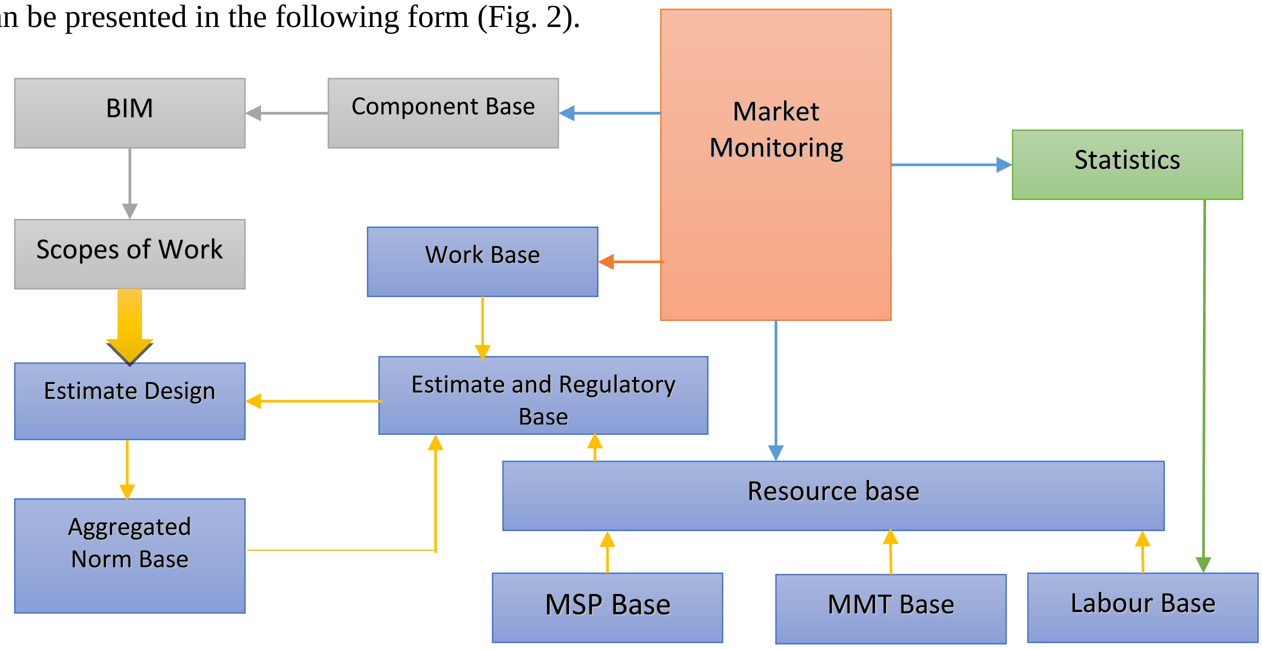

Fig.2. Proposed model of modernization of the estimate standardization in the RA

The main problem of this model is to ensure the conversion of BIM output information on the necessary resources into a standard form of pre-designed resource and work classifiers.

For the initial stage of the implementation of information modeling of construction objects we propose to create a kind of "BIM translator", like "Google translate", capable of recoding the names of resources according to a single standard in the BIM system into the coding system of resources of individual countries.

4. Conclusions

Interstate harmonization of resource coding systems, in our opinion, is a real, but an intractable task. The problems are related to both objective and subjective reasons. Economically developed countries, which are at the forefront of BIM design, do not need any changes in coding systems. For the countries making the first steps in this area, there is a problem of a choice of that or other system.

It seems that the convertibility of codes is inevitable, and this is confirmed by the OPEN BIM platform, created for the harmonization of architectural and engineering design programs.

Acknowledgements

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SUSTAINABLE SEISMIC RESISTANT SYSTEMS

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Abstract. This paper proposes to supplement the recently developed concepts for Seismic Sustainability (SS) of engineering structures through practical detailing and descriptions of structural parts needed to achieve Post Earthquake Realignment and Repairs (PERR). The physical functionalities of the proposed technologies that help achieve economic SS have been discussed in detail. The requirements of Post-earthquake Global Stiffness Reduction (GSR) and Restoring Force Adjustment (RFA) methodologies have been addressed at some length. Attention has been focused on how complete buildings, including gravity framing, Earthquake Resisting Structures (ERS), supplementary devices and non-structural elements can be realigned after predicted earthquakes. SS is a concept that requires a thorough understanding of the mechanics of sequential failures and PERR. In PERR the resilience of the non-ERS system is as relevant as that of the ERS and the nature of the restoring forces are as important as those generated by the earthquake.

1. Introduction

The main purpose of the current exercise is to devise a seismically sustainable structural archetype and its components that can be materialized using conventional means and methods of construction. In short, a building type that can remain stable after an earthquake can be re-centered with no need for relatively large restoring forces and that it can be repaired in a cost effective manner. This is achieved by looking at PERR as the reverse loading cycle after initial unloading. This means, planning and fulfilling the following design operations.

1- Predesignated damaged parts can be repaired as intended for the purpose,
2- The entire building has been designed to lend itself well to GSR and RFA or similar operations,
3- The entire building has been equipped or can be equipped with built in or external means of realignment,
4- The entire building, including nonstructural items, has been designed either to remain articulated after an earthquake, or can be temporarily articulated for re-centering without residual effects.
5- The entire building has been designed to remain stable after the failure of groups of supplementary devices and formation of plastic failure patterns within the ERS and during the PERR processes.

It has been argued that the use of replaceable earthquake resisting devices can be effective if the structure is free from unaccounted stiffnesses, residual and $P\delta$ effects, is designed to sustain limited damage and is capable of being realigned after major earthquakes, otherwise no meaningful repairs can be achieved. Maintaining a large restoring/resisting force is neither practical nor desirable. While the zero restoring force option looks attractive, it is impractical for most structural systems. Logistics aside, it is extremely challenging to stabilize a highly energized building that is at the brinks of failure due to wind, deterioration, aftershocks, $P\delta$ moments, etc. There are several reasons why it is not desirable to maintain a large restoring/resisting force, within a single or limited number of elements of the RRC and/or the MF. These include but may not be limited to;

- The safe planning of the recentering operations that rely on large prestressing forces and the elasticity of non-yielded components is of paramount importance, in that uncontrolled/sudden release of internal energies could trigger impact forces with extremely harmful effects,
- Imbalanced loss of preloading within a single element such as the RRC and/or the MF can result in unforeseen displacements, $P\delta$ effects and a reduction in the global resistance of the structure.
- Unplanned, complete or partial loss of the restoring/resisting forces could jeopardize, even thwart the PERR processes.
- The replacement of concentrated high energy sources, such as the posttensioned cables, after snapping may pose unforeseen challenges before, during and after an earthquake.

In order to defuse or reduce the harmful effects of large concentrated restoring energies, within a single element, the authors propose moderate preloading of as many independent members, such as LBs, SFs and BRBs, Fig.1 (e) and earthquake resisting beams, Fig.7. Furthermore, in order to control and achieve CP and PERR as efficiently as possible, the authors also propose the orderly use of GSR techniques in combination with RFAs.

Two types of recentering strategies and their combinations can be utilized for PERR purposes; *Forced Recentering* where the initial restoring moment is larger than the global moment of resistance of the earthquake resisting system and *Assisted Recentering*, where the magnitude of the initial restoring moment can be reduced to acceptable limits through preplanned GSR and RFA. GSR operation is conducted by controlled removal of Replaceable Energy Dissipating Moment connections (REDMCs), Fig. 7.

Here, the PERR process is looked upon as a controlled static process. The essence of the proposed methodology is the discovery that the stiffness of the proposed archetype with replaceable, controlled strength parts, e.g. the articulated beam joints, is not a function of the strength of the system, while the same is not always true for conventional systems without strength controlling devices.

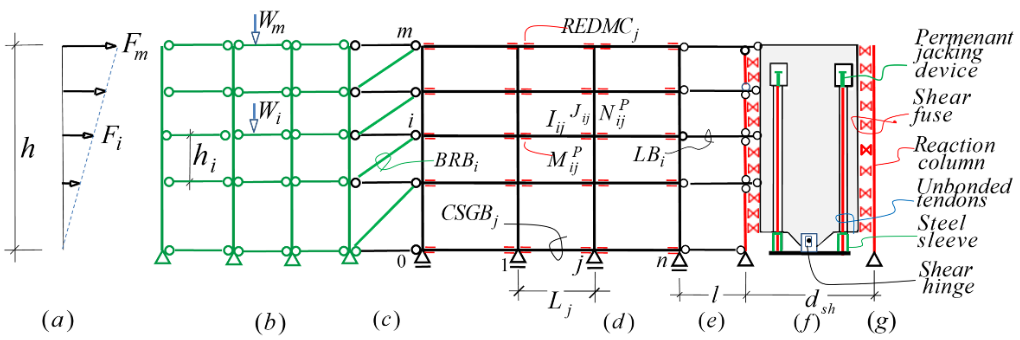

Fig. 1 (a) Loading, (b) Gravity frame, (c) Axially rigid link beams, (d) MF with REDMCs and grade beams, (e) BRBs+ link beams, (f) RRC+ stressed tendons and steel sleeves, (g) Vertical supports for energy dissipating shear links. (Not to scale. Footings not shown)

2. Governing rules and research findings

The rationale leading to the development of the proposed archetype of Fig. 1 and the corresponding design methodologies is essentially based on the results of the following research findings;

- *In SS the response of the structure to unloading and reverse loading ranges is as important as its response to the loading stage,*

- *The residual moment formed at the end of the half cycle of the normal hysteresis curve of a ductile system may be interpreted as the magnitude of the minimum restoring force needed to realign the structure after the quake has subsided,*
- *As the global stiffness is directly related to the global strength of the MF, and that the minimum recentering force is equal to or greater than the global strength, then the minimum restoring force at reduced stiffness should be equal to or greater than the corresponding reduced global strength,*
- *Ordinarily, due to the* $P\delta$ *effect, the post-earthquake restoring moment needed for realignment is larger than the original seismic moment (demand),*
- *The larger the capacity, the smaller the residual drift and the larger the restoring moment needed to realign the system,*
- *The* $P\delta$ *effect tends to reduce the global stiffness of the structure during the loading phase and increase the same during the recentering process,*
- *If the global stiffness of the MF is reduced to zero by removing all replaceable fuses, e.g. damaged flange plates, after unloading, then no restoring moment other than that needed to counter the* $P\delta$ *effect would be needed to realign the system,*
- *The possibility to avoid damage to the body of the beams not only removes the major sources of residual deformations but also facilitates the PERR process by reducing the stiffness of the MF and or adjusting the restoring moment to that of a stable mechanism or residue free frame,*
- *Physical collapse prevention can be achieved by preventing the activation of failure mechanisms rather than strengthening isolated members*.
- *The minimum weight design of closed loop rectangular module is one involving beams and columns of equal strength and stiffness.*
- *Planned articulation is the key to residue free design and successful PERR.*
- *All replaceable parts, fuses and articulated connections should be treated as protected zones.*

3. Essential detailing requirements

3.1 Essential detailing requirements.

Ideal SS cannot be realized unless every part of the system is *designed to remain practically* residue free and/or repairable after earthquakes. In the contexts of SS and PERR, *special detailing* is referred to elements and connections that are neither supposed to dissipate energy nor hinder the realignment process due to accumulation of residual stresses and strains. To alleviate such problems, special items should be designed in such a way as to remain fully articulated at all times, or to be capable of becoming articulated and/or being removed before recentering. For successful planning of the proposed archetype the following detailing issues have been addressed in some detail;

3.2 Gravity structure and RCMF interaction. The large-displacement interactions of the gravity structure with the ERS and realigning system is practically never taken into consideration. Damage sustained by the gravity and non-structural elements can be as pervasive as those of the earthquake resisting members. In almost all conventional frameworks the gravity system tends to resist earthquake forces in proportion to its neglected stiffnesses and hinders the re-centering process due to earthquake induced residual effects. Therefore, it is imperative to design the elements of the gravity systems envisaged for SS in such a way as to be free from seismic forces and not to endure residual strains. Unwarranted deformations of the gravity system can be avoided or at least minimized if pinned base columns and articulated beam–column joints such as those shown in Figs. 2(b) and (c), as opposed to standard connections, Fig. 2(a), are used for the purpose.

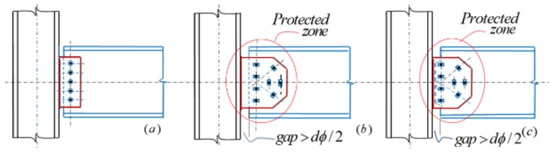

Fig. 2 (a) Standard connection, (b) Articulated connection, (c) Articulated simple connection

3.3 Column supports and footing interaction. The drawbacks of fixed base boundary conditions for MFs can be alleviated by introducing Column Support Grade Beams (CSGB) as shown in Fig. 1(d). Pairs of REDMCs at the ends of the grade beams prevent damage to the footings, base plates and the formation of plastic hinges at column supports. The rotational controllability of the column supports prevents damage to the footings and facilitates the PERR process This in turn helps the structure to respond as an MF of uniform shear (MFUS). Relative settlements tend to cause irreparable damage to structural, nonstructural, lifeline and other elements on all levels. Settlement of supports can be minimized even alleviated by using deeper footings and/or piles resting on non-yielding bedrock.

3.4 Rocking core-shear fuse interaction. The parallel tilting of the RRCs and adjoining columns Figs. 1(f) and (g), provides opportunities to making use of repairable butterfly type SFs and similar devices [1]. There is sufficient evidence that properly designed SFs can improve overall damping, reduce seismic demand on the earthquake resisting system, and prevent collapse. Figs. 3(a) and (b) depict the generic arrangements of energy dissipating steel shear plates with regular openings, bolted or welded to relatively rigid parallel supports. The welded version is less prone to lateral torsional buckling. Steel plate SFs are generally provided with horizontal slots and stiffeners for easy yielding and out of plane stability respectively.

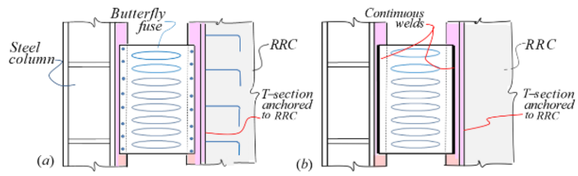

Fig.3 (a) Bolted to continuous side plates, (b) Welded to continuous side plates

3.5 Buckling restrained brace and RRC interactions. BRBs are specially designed biaxial members that can withstand relatively large strains without buckling and are normally used as parts of earthquake resistant braced frames, Fig. 1(e). BRBs have been utilized as supplemental devices for reducing seismic demand on the MF, increase overall damping and possibly prevent plastic collapse. However due to low post-yield stiffness they cannot be relied upon as primary recentering elements. On the other hand, most BRBs exhibit sufficiently stable hysteretic behavior and can be easily installed and removed as needed. Because of these attributes, BRBs can be utilized effectively in conjunction with GSR and RFA operations to assure PERR. Sample design analysis for regular BRBs as part of the proposed archetype has been reported in [2].

3.6 Link beam-Moment frame and Rocking core interaction. The main function of the Link Beams, Figs. 1(e) is to transmit the seismic forces generated within the system to the RRC and to redistribute the restoring forces from the RRC to the entire structure, and if required, to generate restoring moments at one or both ends. LBs should be designed as axial elements that remain elastic and stable during both the seismic event as well as the PERR operations. The single or double shear tabs at both ends are detailed with radially arranged elongated holes that avoid earthquake related residual strains. Both ends of the LBs are specified as protected zones.

3.7 Rocking core and floor diaphragm interactions. Figs. 1 (f) and 4, depict two controllable elastic-plastic core base arrangements with large displacement capabilities, in which the axial and shear forces are decoupled and sustained independently by partially sleeved tendons or direct energy absorbing elements and the central hinge systems respectively. The RRC is the most important feature of the proposed architype. Depending on the type of construction, RRCs can be constructed out of stiffened plywood panels, steel plated shear walls, reinforced concrete and steel braced frames [3]. Diaphragm shears are transferred to the RRC through LBs, unbonded PT tendons, GOLBs, BRBs, as well as shear connectors between the slabs and the RRC. The main function of the RRC is to reduce seismic demand on the MF, impose uniform drift along the height of the system, prevent soft story failure, suppress higher modes of vibrations, help implement the PERR process and to provide support for the supplementary devices. The high rigidity of the core causes all components of the MF and supplementary devices to undergo equal rotations and to absorb proportional amounts of energy. The restoring characteristics of free standing RRCs are defined by their rigidity, ultimate strength and base level rotational stiffness. Fig. 4 shows two different configurations of RRCs with different stabilizing devices and methods of attachment to the horizontal diaphragms. The rotational movement of the RRC tends to induce vertical and horizontal forces along its interfaces with the shear columns, floor and roof level diaphragms. Almost the entire tributary seismic force is transmitted to the RRC through the LBs. While the horizontal components of the rocking movement tend to slide the core against the floor and roof diaphragms, the vertical components tend to twist and damage the connected regions along the interface. The problem is resolved by providing strategically located elongated bolt holes perpendicular to their radii of rotation along each interface, Figs. 4(a) and 4(c). The physical clearances between the slabs and the RRCs prevent the core-slab connections from being damaged during earthquakes. Radially inclined elongated holes allow free movement of the core and provide out of plane stability for the RRC

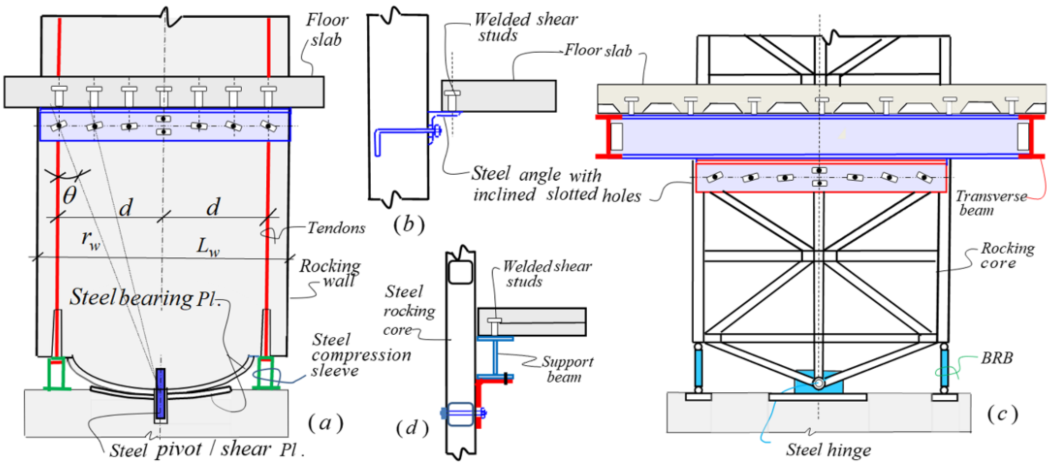

Fig.4 (a) Generic RRC- diaphragm and base connections, (b) Side view of (a), (c) Generic BRB enhanced Steel RRC- diaphragm and base level connections, (d) Side view of (c)

3.8 Other structural and none structural-structural element interaction. Partition Walls, infills, facades, stairways, escalators, nonstructural shafts, life lines and ductworks, mechanical equipment, suspended ceilings and similar items should be secured in place in such a way as not to contribute to seismic resistance nor hinder the realignment process. Fig. 5 depicts a number of undesirable combinations of structural and nonstructural infills and MFs that can cause seismic damage and impede the recentering effort. It also illustrates a number of simple details for MF-infill combinations, where not only seismic damage is prevented, but also recentering can take place without obstructive conditions. Fig. 5(a) represents a solid infill that is capable of withstanding seismic and gravity forces at the same time. The short column phenomenon is avoided. Figs. 5(c) and 5(d) illustrate the same configurations under pure gravity and pure shear conditions respectively. The horizontal gap between the top of the infill and the soffit of the steel beam of case 5(d) help avoid the transmission of axial forces to the infill. The welded steel plates on either side of the infill with horizontal and vertical slotted holes help release the undesired restraint in each case. Fig. 5(e) with gaps on three sides shows a free standing infill supported in such a way as not to fail due to out of plane forces.

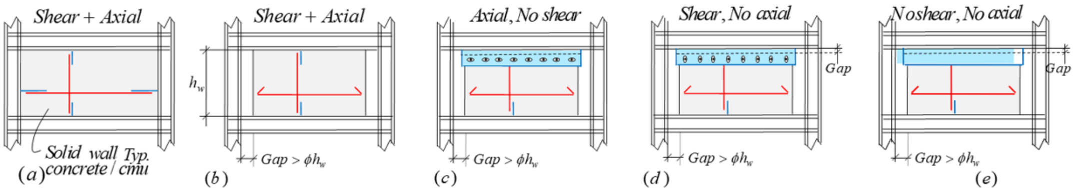

Fig. 5 (a) Shear+axial with column as boundary element, (b) Detached Shear+axial (c) Axial bearing with no shear, (d) Shear transfer, no axial bearing (e) Free standing solid partition

3.9 Development of the Controllable RRC.

Re-centering by means of GSR becomes even more attractive when utilized in conjunction with RFA techniques, i.e. by use of reliable, self-activating or manual control equipment. Some of the more important issues, regarding RRC tendons, can be summarized but may not be limited to the following;

- Accidental or underestimated slacking or decompression of the leeward tendons that may lead to diminished core strength, stiffness and stability,
- Yielding of the windward or front tendons due to overloading, material flaws, etc. that could lead to similar effects caused by the slacking of the leeward tendons,
- Protection of the free lengths of the tendons along the open gaps against fire, corrosion, clogging etc., that may endanger the stability of the RRC and hinder the PERR operations,
- Initial imperfections of the RRC, e.g. uncontrolled leaning of the RRC towards or away from the main structure, during and after construction,
- The need for manual or automated tensioning or de-tensioning of the tendons for adjustments or as needed for PERR purposes,
- The need for a fail-safe or backup system to assure the static stability of the freestanding RRC in the absence of the tendons,
- The need to adjust the initial resistance of the RRC for design and or rehabilitation purposes, and
- The need to adjust the initial resistance of the RRC due to creep, shrinkage, relaxation, etc.

The performance of the rocking core can be enhanced and better controlled by equipping it with cost efficient, secondary systems that ensure continued operation if its primary system fails. In practical terms this implies the implementation of the following ideas,

1- Provision of permanent, ready to operate stressing jacks placed in accessible locations within the core. One such example is illustrated in Figs. 1(f) and 6 (a). The size and capacity of the stressing devices will depend upon the force and nature of the tendons specified for the project.

2- Provision of devices and or details that would compensate the diminished performance of the RRC due to decompression of the leeward tendons.
3- Addition of protective, load bearing steel sleeves (round pipes or square tubes acting as symbolic two way springs) that cover the unprotected lengths of the stressed tendons along the open gap and provide supports for the core in the absence of stabilizing tendons. A symbolic depiction of the proposed sleeves is presented in Figs. 4(a) and 6(a).

The characteristics of the sleeves are dictated by their dual functions as secondary supports for the core and as compensating devices for the slacking of the de-tensioned tendons. The sleeves are anchored to non-yielding supports at their lower ends and pinned to the lower ends of the tendons where the RRC loosely touches the top end of the sleeves. The sleeves are capable of absorbing the compression generated by the tendons as well as the out of balance weight of the core. Both sleeves are tension/compression elements that are designed to remain elastic without buckling throughout the history of loading of the RRC. The tendon-sleeve combination acts as a pseudo tension/compression member and is dubbed as *tensleeve* for convenience. The axial elongation and contraction of the tensleeve can be computed as,

$$\varepsilon = \left[\frac{Th_t}{A_t E_t} + \frac{Th_s}{A_s E_s} \right] = \frac{T}{k} \text{ and}$$

$$\bar{\varepsilon} = \frac{Ch_s}{A_s E_s} = \frac{C}{k_s} \tag{1}$$

where, k and k_s stand for axial stiffnesses of the tendon and the detached sleeve respectively. Let T_0 and $R = 2T_0$ stand for the initial stressing of the tensleeves and the core reaction respectively. In order for the sleeve to compensate the slacking of the tendon, the expected contraction should be absorbed by the sleeve, i.e., $(T_c h_c / A_c E_c) = (C_s h_s / A_s E_s)$ or $f_s = (T_c h_c E_s / A_c h_s E_c)$. where f_s is the compressive stress of the sleeve and subscript *s* refers to sleeves. For sustainable service, both the tendons and the sleeves should remain elastic throughout the service life of the system, i.e. $f_t \le 2 f_{Y,t} / 3,\ f_s \le 2 f_{Y,s} / 3,$ where $f_{Y,t}$ and $f_{Y,s}$ are the yield stresses of the materials of the tendons and the sleeves respectively. Although the sleeves are more likely to act as short columns their slenderness ratios should also be checked for buckling, i.e., $(h_s / r_s) < \pi \sqrt{E_s / f_{Y,s}}$ or as required by the pertinent codes of practice. The maximum compressive force imparted to each tensleeve can be computed as $C_{\max} = T_0 + Fh / 2d$ if both tendons are preloaded, and as $C_{\max} = T_0 + Fh / d$ if only one, say the left hand side tendon is preloaded up to T_0 and the other is totally slack.

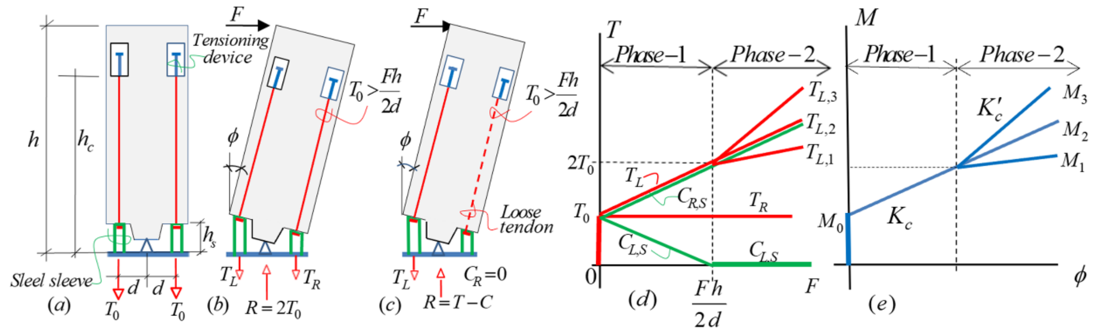

Fig. 6 (a) RRC with unbonded PT tendons and sleeves, (b) Phase1, both ttendon in tension (c) Phase 2, leeward tendon slackened (d) (F-T) diagram, (e) $(M-\phi)$ ***diagram***

Two loading phases can be envisaged**: 1-** Both preloaded tendons remain taut and **2-** The leeward tendon becomes slack.

Phase 1- The overturning moment Fh, Fig. 6 (b), changes the left and right hand tendon forces by as much as $T_L = T_0 + Fh/2d$ and $T_R = T_0 - Fh/2d$ respectively. It also changes the initial compressive forces of the sleeves from $C_{L,S} = C_{R,S} = T_0$ to $C_{L,S} = T_0 - Fh/2d$ and $C_{R,S} = T_0 + Fh/2d$ respectively. The response range for this case is controlled by the condition $T_0 \geq Fh/2d$. Note that in this range the right hand tendon does not slacken due to the compressibility of the sleeve. This allows the pair of tensleeves to resist an initial overturning moment $M_0 \leq (Fh = 2T_0 d)$ until the leeward tendon becomes loose, i.e. $T_R = T_0 - Fh/2d = 0$. As described earlier, $M_0 = 2T_0 d$ is the "at rest" or potential moment of resistance of the core in the range $T_0 \geq Fh/2d$. The moment of resistance of the base of the RRC for this range can be expresses as $M_R = M_0 + K_c\phi$. Following Eq. (1), the elongation and contraction of the left and right hand tensleeves can be computed as $\pm\varepsilon = T/k$ and the corresponding rotation of the core can be estimated as;

$$\phi = \frac{\varepsilon}{d} = \frac{T}{kd} = \frac{M}{2kd^2} = \frac{M}{K_C} \quad \text{and} \quad \frac{1}{K_C} = \frac{1}{2d^2}\left[\frac{h_t}{A_t E_t} + \frac{h_s}{A_s E_s}\right] \tag{2}$$

Phase 2-This condition is characterized by the inequality $T_0 < Fh/2d$, Fig. 6(c). After T_0 reaches $Fh/2d$ at the end of Phase 1, the initial pretension of the left hand tendon and the upward reaction of the pivot for Phase 2 loading become $T_0 + Fh/2d = 2T_0 = Fh/d$ and $R = T - C$ (At the beginning of Phase 2 $T_{L,S} = T_L = 2T_0 = Fh/d$, $C_{R,S} = Fh/2d$, $T_R = 0$ and $R = 2T_0$). Unlike Phase 1, the magnitudes of the internal forces of the two tensleeves, due to slackening of the leeward tendon, become direct functions of their axial stiffnesses. Given $\varepsilon = T/k$ and $\bar{\varepsilon} = C/k_s$, and that the rigidity of the core makes $\varepsilon = \bar{\varepsilon}$ it follows that; $C = Tk_s/k$, $M = (T+C)d = (1+k_s/k)Td$ or $T = M/(1+k_s/k)d$. Next substituting for T in $\phi = \varepsilon/d = T/kd$, it gives,

$$\phi = \frac{M}{(k+k_s)d^2} = \frac{M}{K_c'} \tag{3}$$

Hence, $T_L = k\phi d$ and $C_{R,S} = k_s\phi d$. The variations of $T_L, T_R, C_{L,s}$ and $C_{R,S}$ with F are presented in Fig. 6(d). The fact that T and $\boldsymbol{C}$ can be defined in terms of the two stiffnesses $\boldsymbol{k}$ and k_s, suggest new possibilities for PC of the RRC during Phase 2 loading. Three basic conditions are plausible;

If $k < k_s$ then $T_{L,1} < \frac{Fh}{2d}$, $C_{R,S} > T_{L,1}$ and $\phi = \frac{M_1}{(k+k_s)d^2} > \frac{M_1}{K'_c}$ or $M_1 < K'_c\phi$

If $k = k_s$ then $T_{L,2} = \frac{Fh}{2d}$ $C_{R,S} = T_{L,2}$ and $\phi = \frac{M_2}{2kd^2} = \frac{M_2}{K'_c}$ or $M_2 = K'_c\phi$ $M_1 < K'_c\phi$

If $k > k_s$ then $T_{L,3} > \frac{Fh}{2d}$, $C_{R,S} > T_{L,3}$ and $\phi = \frac{M_3}{(k+k_s)d^2} < \frac{M_3}{K'_c}$ or $M_3 > K'_c\phi$

where, indexes 1, 2, and 3 refer to the branches of the items in Fig. 5(e). Since $M_3 > M_2 > M_1$ the carrying capacity of the RRC can be appreciably upgraded by increasing the stiffness of the sleeves.

3.10 Development and Description of the controllable REDMC

The proposed replaceable steel moment connection of Fig.7 is devised to dissipate seismic energy, control locations of plastic hinges, prevent damage to the body of the beam and adjoining columns, help prevent collapse and re-center the structure after removing the damaged flange plates. In order to prevent loss of tension due to equal gap opening and closing along the same horizontal line X shape tendon profiles have been used in lieu of the parallel option. Note that the profiles are different over the end and intermediate column supports. The location of the REDMCs, distance *a* in Fig.7 is selected in accordance with the requirements of the prevailing codes of practice in the United States. Once distance *a* is established, the minimum initial flange gap *g*, can be determined in such a way as to allow free rotation of the joint $\psi = \beta\phi$, where ϕ is the maximum plastic drift of the system, i.e. $g \geq \beta\phi d_b / 2$ .The splice joint consists of a pair of replaceable, reduced section, perforated, or prismatic flange plates and a shear tab with elongated holes at right angles to the radii of the center of rotation. The stub joint and the rest of the beam are designed to remain stable and elastic while the flange plates develop their full plastic moments of resistance. Two small U-bolts prevent the premature, out of plane buckling of the flange plates. The U-bolts can be eliminated if the slenderness ratio of the flange plates is limited to $Kl_p / r \leq 20$, where l_p is the distance between the first rows of the bolts on either side of the splice gap. Obviously, the flange plates should be designed to develop their full plastic moments of resistance for the expected seismic as well as gravity forces acting on the beam. All other components of the beam including the shear tabs, bolt groups, weldments, the preloaded cables and the entire body of the beam are expected to remain elastic throughout the loading/unloading history of the beam.

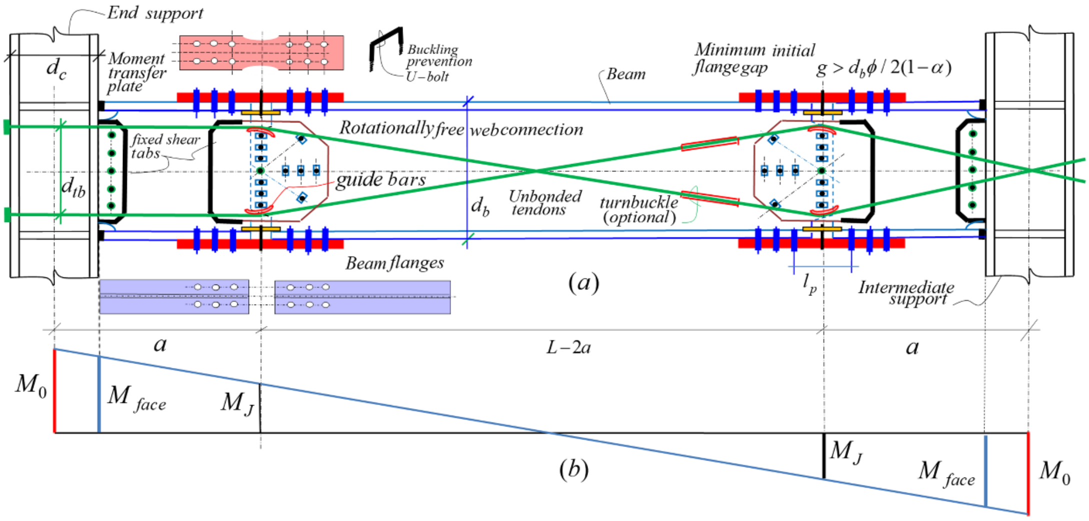

Fig. 7 Self-aligning REDMC arrangement with preloaded X tendons

4. Conclusions

The paper discusses a new structural archetype, based on available kills, knowledge and technologies, that are well suited for seismic sustainability purposes. Some of the more important attributes of the proposed scheme can be summarized as follows.

- The preliminary design process is simple and straightforward, it can be performed manually with or without auxiliary spreadsheets.
- Being a SDOF system, the archetype lends itself well PC and DLA treatment. Its full cycle analysis has been formulated through simple closed form solutions. The analysis is exact and valid within the bounds of the theoretical assumptions.
- Attention to special detailing can facilitate the PERR proceses and help reduce preloading of energy storing elements and devices.
- Under normal circumstances, groups of beams, columns and connections of the MF or the earthquake resisting system including the supplementary devices, can be identical regardless of their location along the height of the structure.
- The earthquake resisting framing can be a structure of minimum weight with potential savings that might offset additional costs related to the RRC and supplementary devices.
- Auxiliary devices, such as high strength tendons can be used to prevent physical collapse, despite formation of failure patterns within the earthquake resisting frameworks.
- The gravity system is detailed neither to absorb seismic energy nor to accumulate residual stresses and strains.
- Tendon arrangements within the RRC can be both pre and post tensioned by means of built-in stressing lacks or otherwise to assure CP and control the PERR operations.
- Strategically located replaceable, energy dissipating flange plates have been provided to help implement the PERR processes.
- The replacement of the REDMCs not only removes the major sources of residual displacements, but also facilitates the PERR process by reducing the stiffness of the MF to that of a partially articulated frame. Removal of the flange plates allows the joints to rotate relatively freely until full PERR is achieved.
- Optional gap closing permanent tendons and turnbuckles have been provided along the beams of the earthquake resisting framing. They can be used to control and enhance the response of the system as required.
- Recentering can be achieved by means of GSR and RFA which minimize and/or adjust the magnitude of the restoring forces needed to realign the system.

- The proposed configuration is construction friendly and satisfies the theoretical conditions of minimum weight design. The use of repetitive members and connections reduces the initial construction costs and increases the reparability of the structure.
- The proposed approach is capable of addressing collapse prevention, self-alignment, and uniform drift as inherent properties of the proposed system. In order to focus greater attention on the conceptual aspects of this presentation the bulk of the preliminary analysis has been excluded from this presentation.
- Extensive computer analysis support the viability of the parametric examples and the proposed solutions presented as the main body of the current presentation..
- The proposed structural schemes are neither perfect nor complete. They are still under development and need the test of time and scrutiny before they become viable earthquake resilient systems.

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OPTIMIZATION OF EARTHQUAKE RESISTING ROCKING CORES

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Abstract. The research leading to this paper was prompted by the need to estimate the strength and stiffness of Rigid Rocking Cores (RRCs) as essential elements of resilient earthquake resisting structures. While a limited number of such studies have been reported, no general study in terms of physical properties of RRCs, their appendages and adjoining structures have been published. Despite the growing knowledge on RRCs there are no design guidelines on their applications for seismic protection of buildings. The purpose of the present article is to propose effective rigidity limits beyond which it would be unproductive to use stiffer cores and to provide basic guidelines for the preliminary design of RRCs with a view to collapse prevention, re-centering and post-earthquake repairs/replacements. Several examples supported by computer analysis have been provided to demonstrate the applications and the validity of the proposed solutions.

1. Introduction

Various applications of RRCs in combination with Earthquake Resisting Frames (RRCERFs) have been reported during the past fifteen years [1-3]. The successful implementation of different types of RRCs for a number of significant projects have been published by [4-6]. Summaries of beneficial attributes of RRCs as integral parts of earthquake resistant structures have been compiled amongst others by [7, 8 &9]. Comprehensive accounts of rocking core innovations have been reported by [10 & 11]. The most recent development in this field is the use of RRCERFs in conjunction with replaceable energy dissipating links [12, 13]. Lately the concept has been extended to resilient earthquake resisting systems [14, 15]. The Seismic response of self-centering concentrically-braced frames as semi-rigid cores has been studied amongst others by [33,34,35,36&37]. One of the most recent earthquake resilient archetypes, proposed by the senior author, [13], Fig.1, is capable of damage control, elimination of residual stresses, Collapse Prevention (CP) and Post-earthquake Realignment and Repairs (PERR) [16].

1.1 System description.

The proposed system is both physically as well as conceptually different from its classical counterparts. The only physical difference between the proposed system and its conventional counterparts is in the purpose specific detailing that leads to resilient, highly reparable earthquake resisting structures that are both economical to build and inexpensive to repair. Conceptually, performance levels are studied in terms of damage control and reparability, rather than expected damage at design level earthquakes. In fact, the proposed system advocates higher performance objectives than those stipulated in current codes of practice. The challenge here lays in the estimation of the minimum rigidity of the rocking core in such a way as to satisfy the expected resiliency conditions of the system. The proposed system [13, 17] is composed of commercially available building materials and components and consists of seven basic integral parts, i.e.

1-A physically articulated gravity system stabilized by adjoining Moment Frames (MF) and RRCs,
2-A steel or reinforced concrete MF with Grade Beam Restrained Column Supports (GBRCSs),
3-Beam end Replaceable Energy Dissipating Moment Connections (REDMCs) or similar devices [13],
4-A RRC, e.g., a pin supported steel braced frame, reinforced concrete or steel plated shear wall,
5-Vertical, unbonded stressed cables or Pre-compressed Springs (PCSs), as stabilizers of the RRC,
6-Axially rigid, pin ended, horizontal Link Beams (LBs) or functionally similar devices,
7-Especially designed and detailed RRC-Diaphragm interfaces [17].

Several sets of supplementary devices can be integrated as part of the proposed system, e.g.

1-Modified post-tensioned Gap Opening Link Beams (GOLBs) or functionally similar devices,
2-Buckling Restrained Columns (BRBs) or similar elements placed between the MF and the RRC

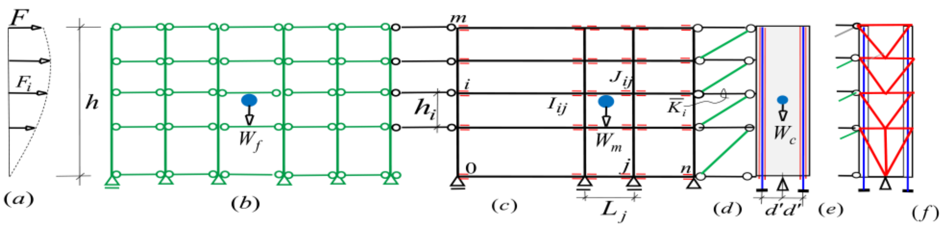

Fig.1. (a) Lateral loading, (b) Articulated gravity frame, (c) Moment frame + Energy dissipating connections, (d) Gap opening link beams and buckling restrained braces, (e) RRC+ stressed Tendons, (f) Braced frame RRC+ stressed Tendons

3-Any set of energy absorbing devices that may be deemed suitable for the project, e.g. Slotted–bolted friction connections [18], Viscoelastic dampers [19], etc.,

The most remarkable attribute of the RRC is its ability to force the companion Earthquake Resisting Frame (ERF) and energy dissipating devices to act as members of Structures of uniform Response (SUR), (Appendix B). SUR are weight optimized lateral resisting systems in which story level drift ratios are constant and members of similar groups such as beams, columns, braces, connections and structural appendages share the same demand-capacity ratios regardless of their location within the system [20, 21]. Since groups of members of SUR can be identical then they would be more efficient to build and repair than their conventional counterparts. However, in order to design efficient RRCERF combinations, it is necessary to first develop realistic RRCs that are practical in size and can function as efficiently as infinitely rigid cores. Similarly, the core and the designated appendages should be able to realign the ERF and the adjoining gravity system after a given seismic event. The general functions of common types of RRCs and their appendages are briefly discussed in the next section.

While commercially available software can be used to analyze and design most complicated RRC related systems, the following manual methods of analysis may also be considered for assessment of the relative rigidities of practical rocking cores.

1-Drift control methodologies [22],
2-Quasi-static analysis of rocking wall systems [23],
3-Maximum core displacements [3], (Appendix A), and
4-The frequency equivalency method introduced in section 6 of the current contribution.

The present article introduces two competing criteria for the preliminary assessment of minimum rigidities above which SDOF behavior can be assured for solid rocking cores, i.e., the frequency related concept, section 6 below, and the minimum displacement criterion, presented under sections

2.1. The remainder of this paper is concerned with establishing a simple technique for practical design of solid RRCs with collapse prevention and re-centering capabilities. This is achieved by selecting a simple theoretical model that lends itself well to manual computations, reflects the true behavior of the prototype without loss of accuracy and helps establish physical limits beyond which neither the drift differential nor higher frequencies of the RRC can influence the response of the combined system.

2. RRC Response and Functions.

Four generic RRCs constructed out of stiffened plywood, steel plated shear walls, reinforced concrete and steel braced frames are shown in Figs.2(a), (b) (c) and (d) respectively. The main function of the RRC and the stabilizing devices is to reduce seismic demand on ERFs, impose uniform drift, prevent soft story failure, suppress higher modes of vibrations, provide support for supplementary elements, and help implement the PERR process. It has been shown [32] that in contrast to RRCs, higher modes of vibrations can have structurally adverse effects on fixed base, non-rigid shear walls, after formation of plastic hinges at the supports. The high rigidity of the core causes its own as well as all components of the ERF and supplementary devices to undergo equal rotations and to absorb proportional amounts of energy. The entire structure including the relatively softer ERF/MF acts as a SDOF system and allows the rigid core to tilt as a statically determinate upright beam. This forces the reference line of displacements to pass through both the pin and the free end of the RRC. It also forces all points of contraflexure to occur at mid-spans and mid-heights of beams and columns respectively. In addition, the RRC tends to redistribute the seismic and P-delta moments and shears rather evenly between groups of similar members such as beams, columns and braces of equal lengths and heights respectively. This is due to the fact that in RRCERFs the shear in the frame tends to be uniform over the height of the ERF [24].

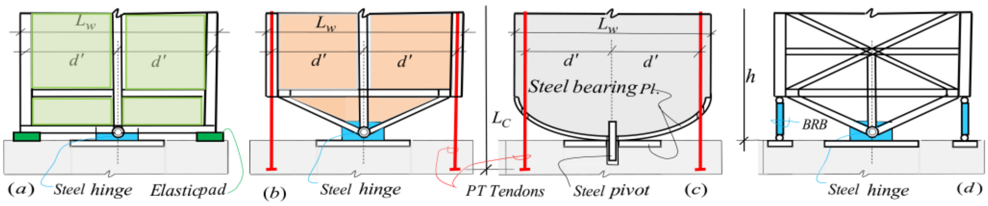

Fig.2. (a) Plywood RRC, (b) Steel plated RRC, (c) Reinforce concrete RRC, (d) Braced frame RRC+BRBs

The physical behavior of the RRCERF can best be visualized by the ERF and the RRC resisting the lateral forces together until the frame becomes a stable mechanism. Seismic shears are transferred to the RRC through LBs, PCSs, BRBs as well as specially detailed connections between the slab and the core, such as that shown in Figs.3 (a) and (b) that allow transmission of seismic shears from the diaphragm to the RRC without damaging the floor-core interface, [17, 25, 26]. Fig.3 (a) also shows that the location of the center of most critical hole at the left hand end of the connecting angle with respect to center of rotation of the RRC can be defined by radius r and radial inclination

An un-stabilized RRC is neither capable of preventing collapse nor re-centering the system. The restoring capabilities of free standing RRCs are defined by their ultimate strength and base level rotational stiffness. An expanded list of attributes of well-designed RRCs is presented in section 7 and Appendix B.

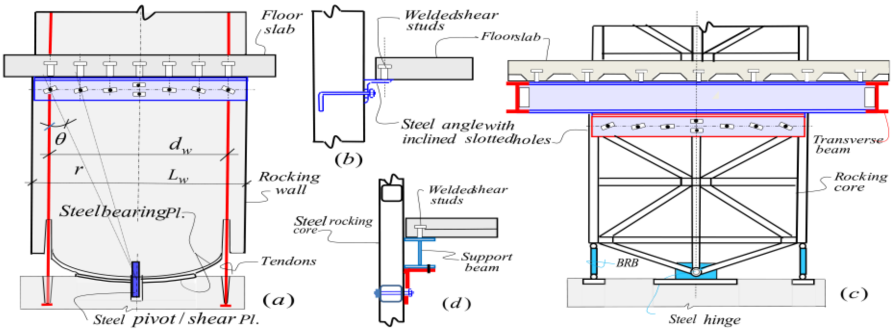

Fig.3. (a) Concrete RRC & diaphragm connection, (b) Side view of (a), (c) BRB enhanced Steel RRC and diaphragm connection, (d) Side view of (c)

2.1 Core stiffness.

Experience has shown that a free-standing rocking core or stiff spine may be considered as sufficiently rigid if its maximum drift differential under lateral forces does not exceed more than ten percent of the uniform drift of the ERF, i.e. [3], Fig. 4 shows the results of one such study where the normalized variations, of the proposed structural system is plotted against the variations of the relative rigidities of the ERF and the core [Constant/], where is the thickness of a prismatic core. The solid and dashed lines correspond to first floor and roof level drift variations respectively. It may be noted that both the roof and first floor level drift differentials are zero at and diverge to 5% and 9% at in (25.4 mm) and in (50.8 mm) respectively. This implies that for all practical intents and purposes the rigidity of the core can be based on or smaller as the case may require.

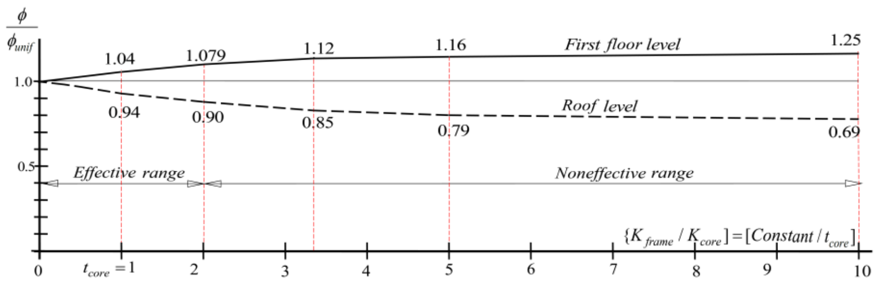

Fig.4. Effect of rocking core rigidity on the uniform drift ratio

2.2 Core base spring stiffness.

The strength and stiffness of the RRC and its appendages are the two most important factors that help sustain the integrity of the damaged structure during the PERR process. The main function of the unbonded tendons, PCSs/BRBs, energy absorbing pads and similar devices is to stabilize the RRC, prevent collapse, to realign the system and to help implement the PERR process. These devices and the pivot at the base constitute energy absorbing springs that are expected to exhibit elasto-plastic response during and after seismic events. The limited purpose of this section is to establish a relationship for the interacting force of the uppermost link beam in terms of the rigidities of the MF and the rocking core. The stress-strain relationship of the wall base spring can be expressed as $\phi = M_S / k_S$, where M_s and k_S are the moment of resistance and the rotational stiffness of the spring respectively. Strain compatibility between tendon stretching and spring rotation before decompression requires that $\phi d' = \pm\varepsilon$. Substituting for $\varepsilon = T_t h / A_t E_t$ and $M_s = 2T_t d'$ in the strain equation gives, $k_s = 2d'^2 A_t E_t / h$. Subscript t refers to core total tendon force, $T_t = T_0 \pm M_S / 2d'$, and the initial tension T_0 should be large enough to realign the collapsing MF to its original position. In order to appreciate the contribution of the RRC in the absence of other auxiliary devices, consider the static interaction of the MF and the RRC as illustrated in Figs.5 (c), (d) and (e).

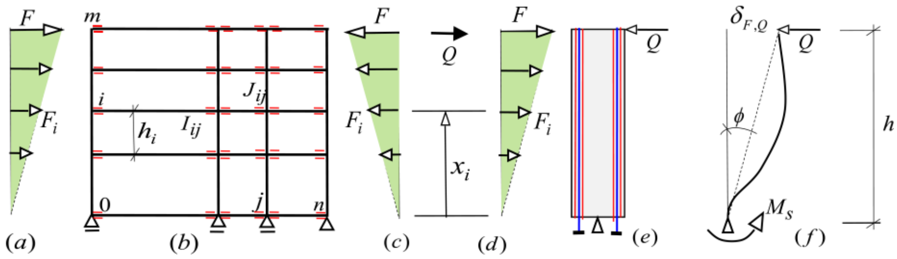

Fig.5. (a) Loading, (b) MF (c) Reactive forces on MF, (d) Reactive forces on RRC, (e) RRC, (f) Drift profile

2.2.1 Seismic load distribution.

Results presented in this work are sensitive to seismic load distribution. However, if the core is sufficiently rigid the seismic load distribution will closely resemble the triangular profile recommended by most codes of practice [20], Fig. 5(a). If the MF is regular i.e. then the magnitude of the story level lateral forces can be estimated as, whence the maximum tip displacement and base moment of the spring supported flexible cantilever of Fig.5(f) can be expressed as;

$$\delta_{C,F.} = \frac{F\bar{h}^3}{360EI}(33m^4 + 60m^3 + 25m^2 + 2) + \frac{M_0(m)}{k_s} = \frac{F\bar{h}^3 f(m)}{360D_C} + \frac{M_0(m)}{k_s} \tag{1}$$

$$M_0(m) = (m+1)(2m+1)\frac{F\bar{h}}{6}, \tag{2}$$

respectively, where m is the number of stories of the MF. Furthermore, the core will tend to resist the entire seismic load by itself [9], as shown in Figs.5 (d) and (e), where Q is the reactive force acting on top of the core. Whether the core is modeled as an upright simply supported beam or a propped cantilever with a spring, as in Fig. 5(f), the static equilibrium of the core requires that; Next, if is the maximum displacements of the MF due to Q and , and are the corresponding displacements of the RRC due Q, and the respectively, then displacement compatibility can be achieved if i.e.

$$\frac{Qm^3\bar{h}^3(1+\rho)}{24D_F} = \frac{M_0(m)\bar{h}}{k_s} + \frac{Fm^3\bar{h}^3 f(m)}{360D_C} - \frac{Qm^3\bar{h}^3}{3D_C} - \frac{Qm^2\bar{h}^2}{k_s} \tag{3}$$

Where, $D_F = E_f J$, $J = (h/2)\Sigma_{i=1}^{m}\Sigma_{j=0}^{n}(J_{i,j}/h_i)$ per Eq. (14), $D_C = E_c I_c$ and $\rho = JL/Ih$. Subscripts *F* and *C* refer to the MF and core respectively. Eqs.1, 3 and 4 are ideally suited for the practical design as well as comparative studies of RRC/MF combinations with different numbers of stories. However, for the purposes of the current study the seismic profile has been assumed to be a continuous function of the variable *i* regardless of number of stories *m*. Eq. (3) can be simplified greatly by replacing the discretized loading profile with its equivalent continuous counterpart ,i.e.,

$$\frac{Qh^3(1+\rho)}{24D_F} = \frac{2\bar{F}h^2}{3k_s} + \frac{11\bar{F}h^3}{60D_C} - \frac{Qh^3}{3D_C} - \frac{Qh^2}{k_s} \tag{4}$$

Here $\bar{F} = Fh/2$ is the total seismic shear force. Substituting for $K_S = k_s/h^2$, $K_F = 24D_F/(1+\rho)h^3$, $K_C = 3D_C/h^3$ and $\bar{K}_C = 60D_C/11h^3 = 20K_C/11$, then Eq. (4) can be rewritten as;

$$\frac{Q}{K_F} = \frac{2\bar{F}}{3K_s} + \frac{\bar{F}}{\bar{K}_C} - \frac{Q}{K_C} - \frac{Q}{K_s} = \left[\frac{2}{3K_S} + \frac{11}{20K_C}\right]\bar{F} - \left[\frac{1}{K_S} + \frac{1}{K_C}\right]Q \tag{5}$$

This leads, after rearrangement to determination of the roof level interacting force;

$$\frac{Q}{\bar{F}} = \left[\frac{2}{3K_s} + \frac{11}{20K_C}\right] / \left[\frac{1}{K_F} + \frac{1}{K_S} + \frac{1}{K_C}\right] \tag{6}$$

Note that as, the interactive force becomes Once load Q is known the flexural deformations of the core acting as a tilted simply supported beam can be estimated as;

$$\delta_{core} = \frac{Fh^4}{360E_cI_c}\left[7(\frac{x}{h}) - 10(\frac{x}{h})^3 + 3(\frac{x}{h})^5\right] + \frac{(2F-3Q)h^3}{18E_cI_c}\left[3(\frac{x}{h})^2 - (\frac{x}{h})^3 - 2(\frac{x}{h})\right]\frac{1}{2} \tag{7}$$

$$\theta_{core} = \frac{Fh^3}{360E_cI_c}\left[7 - 30(\frac{x}{h})^2 + 15(\frac{x}{h})^4\right] + \frac{(2F-3Q)h^2}{18E_cI_c}\left[6(\frac{x}{h}) - 3(\frac{x}{h})^2 - 2(\frac{1}{h})\right] \tag{8}$$

Alternatively, if $\bar{M}_S$ is the spring moment due to bending of the core, and $\theta_{C,F}, \theta_{C,\bar{M}}$, and $\theta_{S,\bar{M}}$ are defined as the lower end rotations of the core and spring acting as a simply supported beam, due to F and $\bar{M}_S$ respectively, then rotational compatibility, $\theta_{C,F} - \theta_{C,\bar{M}} = \theta_{S,\bar{M}}$, gives;

$$\frac{7Fh^3}{360E_cI_c} - \frac{\bar{M}_S h}{3E_cI_c} = \frac{\bar{M}_S}{k_s}$$
or
$$\bar{M}_S = \frac{Fh^2}{120\left[1 + \frac{3D_C}{k_S h}\right]} \tag{9}$$

It follows that δ_F and δ_C corresponding to roof level and core maximum displacements at *x=0.5193h* respectively can be estimated as;

$$\delta_F = \frac{Q}{K_F}$$
and
$$\delta_C = \frac{\delta_F}{1.926} + \frac{0.0652Fh^4}{D_C} - \frac{0.0616\bar{M}h^2}{D_C} \tag{10}$$

3. Statics & Model Transformation

The purpose of this section is not to present an expose on the mathematical treatment of the proposed structure, but rather to take advantage of its abilities to present itself as a SDOF system. The knowledge that the combined structure is forced to tilt through a rigid body rotation, Fig. 5(f), helps reduce the task of otherwise cumbersome analysis to manually manageable solutions. Therefore;

$$\delta_F = \frac{V_f}{K^*} = \frac{V_f h}{hK^*} = \frac{M_0}{hK_F^*} = \frac{M_0}{hK_F}$$
$$\text{and} \tag{11}$$
$$M_0 = \sum_{i=1}^{m} F_i x_i = V_f h$$

M_0 is the total external moment acting on both the prototype, Fig.6 (a), and the equivalent model Fig. 6(b). Eq. 11 can be rewritten in terms of drift ϕ, which is constant along the heights of both the model and the prototype.

$$\varphi = \frac{\delta}{h} = \frac{V_f}{hK^*} = \frac{V_f h}{h^2 K^*} = \frac{M_0}{h^2 K_F^*} = \frac{M_0}{h^2 K_F} \tag{12}$$

K_F^* and $K_F^* = K_F$ are the global angular stiffnesses of the prototype and the equivalent MF respectively, i.e.

$$\phi_F = \frac{M_0}{12E}\left[\frac{1}{\sum_{j=0}^{n}\sum_{i=1}^{m}(J_{i,j}/h_i)} + \frac{1}{\sum_{j=1}^{n}\sum_{i=0}^{m}(I_{i,j}/l_j)}\right] = \frac{M_0}{h^2 K_F^*} \tag{13}$$

The transformation to the single module formulation directly derived from Eq. (13) results in;

$$\phi_F = \frac{V_f h^2}{12E}\left[\frac{h}{2J} + \frac{L}{2I}\right] = \frac{M_0}{h^2 K_F},$$
$$2(I/L) = \sum_{i=0}^{m}\sum_{j=1}^{n}(I_{i,j}/l_J) \quad \text{and} \tag{14}$$
$$(J/h) = \sum_{i=1}^{m}\sum_{j=0}^{n}(J_{i,j}/h_i)$$

Eq. (14) describes completely the elastic response of the prototype under lateral forces 1(a). A brief verification of Eq. (14) can be found in [17, 27]. Since the total gravity force on both models is $P = W_F = W_f + W_c$, then the total external moments in terms of the *P*-delta effect can be expressed as $(M_0 + M_{P\Delta})$, where $M_{P\Delta} = P\varphi h$. Considering the use of the notional shear force $\bar{V}$ which acts in the same location and sense as V_f and results from the notional equilibrium equation $P\delta = P\varphi h = \bar{V}h$, Eq. (2) can be replaced with;

$$\varphi = \frac{M_0}{h^2 K_F^* - Ph} \quad \text{and} \quad \varphi = \frac{M_0}{h^2 K_F - Ph} \tag{15}$$

It follows therefore that $P = hK_F$ can be regarded the critical gravity load of both models.

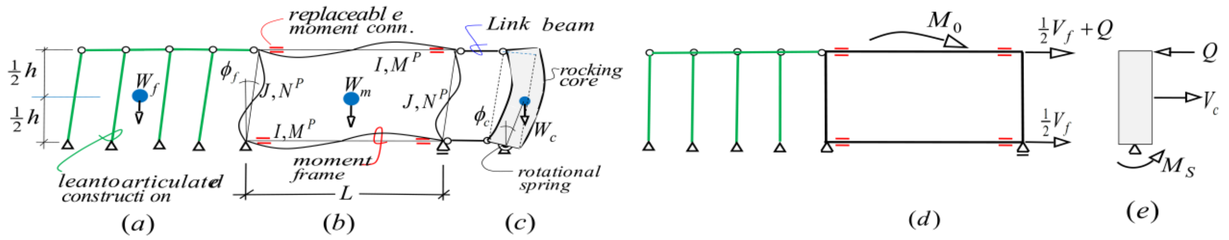

Fig.6. (a) articulated gravity system, (b) Grade beam supported MF, (c) Rigid rocking core, (d & e), Free body diagram

3.1 Plastic analysis.

Seismic response is associated with ultimate loading conditions, and as such maximum carrying capacity of any structure at incipient collapse should be carefully studied [28, 29]. The rocking ability of the wall improves the distribution of displacements but not the maximum drift at roof level, and it does not always improve the ultimate carrying capacity of the MRF. While it is known that wall-mounted and/or base-level energy-dissipating devices can improve both the ultimate capacity and the drift development characteristics of the combined structure, it is deemed rational to ignore the contributions of such devices in favor of higher load factors at incipient collapse. The use of MFs in conjunction with RRCs leads to preferred plastic collapse mechanisms as shown in Figs. 7(b) and (d). Obviously, if the core is to prevent soft story failure then it should be capable of imposing a sway type mechanism upon the ERF without developing plastic hinges along its height, i.e. $M^P_{Core} > M^P_F$. The virtual work equations for the two un-supplemented models can be expressed as;

For the prototype

$$(M_0^P + M_{P\Delta})\theta = \sum_{i=1}^{m} F_i x_i \theta = \sum_{i=0}^{m}\sum_{j=1}^{n} 2M^P_{i,j}\theta \tag{16}$$

For the equivalent model

$$(M_0^P + M_{P\Delta})\theta = \sum_{i=1}^{m} F_i x_i \theta = 4M^P\theta \tag{17}$$

θ is a small virtual rotation. It has been observed that regular MFs combined with RRCs adapt a unique mode of response where all elements undergo the same rotation and drift ratios respectively. Therefore, the prototype, Fig. 7(a), can also be modeled as the transformed option for plastic design purposes. The

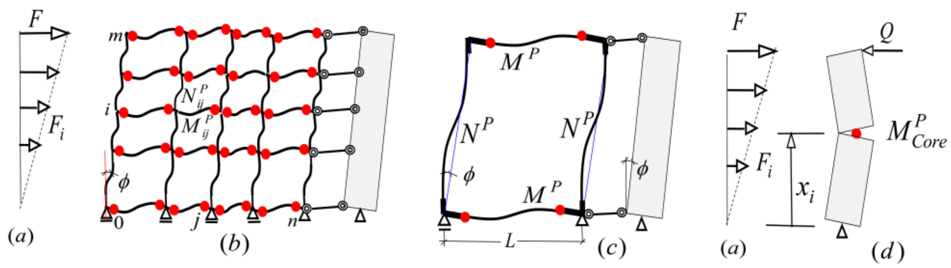

Fig. 7. (a) Loading, (b) Prototype and preferred failure pattern, (c) Single bay equivalent model, (d) RRC failure mode

plastic moment of resistance, M_F^P of both models with no supplementary devices, can be assessed as;

$$(M_0^P + M_{P\Delta}) = M_F^P = \sum_{i=0}^{m} \sum_{j=1}^{n} 2M_{i,j}^P$$
$$= Qh = 4M_{transferred}^P \tag{18}$$

As, F_i is directly transferred to the rigid core as depicted in Fig.7(d), then the plastic moment of resistance of the core can be estimated as;

$$M_{Core}^P = \frac{Pax}{6m}(m^2 - x^2 - x + 1) \tag{19}$$

Where x is the nearest integer to $x = \left[-1 + \sqrt{1 + 4(m^2 - 1)/3}\right]/2$. Eqs.(15, 18) &19) make the proposed configuration amenable to ASD, LRFD, Plastic and Performance based design treatments. Obviously the RRC should also be designed for maximum horizontal shear Q near the upper support. For a rigorous proof of the mathematical transformations (14) and (18) the reader is referred to [17], where transformation models for LBs and BRBs are also discussed.

4. Analyses of Flexible Rocking Cores

An understanding of the influence of flexible cores on global response of RRCERFs is a priori to establishing similar arguments for the effects of RRCs on companion structures. The frame and the core masses can be defined as $m_F = m_f + m_m$ and m_C respectively. Since forces $W_F = W_f + W_m$ and W_m act at mid height of the module only $W_F / 2$ of the envisaged shear force would act at height *h*, Fig. 5(a). However since $(V_F / V_C) = (W_F / W_C) = (m_F / m_C) = \alpha_m$, then the free body diagrams of Figs.5 (d, e), in the absence of the *P*-delta moment, would lead to the equilibrium equation; $M_0 = -M_S + (V_f + V_c)h/2$, where M_S is the moment of resistance of the core base rotational spring. Since the core and the MF are in static equilibrium then the following equation of compatibility for roof level displacements can be written down in terms of V_f, V_c and the interacting force *Q*, as;

$$\frac{(V_f + Q)h^3(1+\rho)}{24D} = \frac{5V_c h^3}{48D_C} + \frac{V_c h^2}{2k_S} - \frac{Qh^3}{3D_C} - \frac{Qh^2}{k_S} \tag{20}$$

$D_F = E_f J_f$, $D_C = E_c I_c$ and $\rho = JL/Ih$. Subscripts *f* and *c* refer to the MF and core respectively. If $K_F = 24D_F/(1+\rho)h^3$, $K_C = 3D_C/h^3$, $\bar{K}_C = 48D_C/5h^3$ and $K_S = k_s/h^2$, then Eq. (20) reduces to;

$$\frac{(V_f + Q)}{K_F} = \frac{V_c}{\bar{K}_C} + \frac{V_c}{2K_S} - \frac{Q}{K_C} - \frac{Q}{K_S} \tag{21}$$

Which leads, after rearrangement, to determination of the link/interacting force;

$$Q = \frac{\left[\frac{V_c}{2K_S} + \frac{V_c}{\bar{K}_C}\right] - \left[\frac{V_f}{K_F}\right]}{\left[\frac{1}{K_F} + \frac{1}{K_S} + \frac{1}{K_C}\right]} \tag{22}$$

Note that as $K_S \to 0$, the interactive force becomes $Q = V_c/2$. Once Q is known, δ_F and δ_C corresponding to roof level and core mid-height displacements respectively can be estimated as;

$$\delta_F = \frac{V_f + Q}{K_F} \tag{23}$$
and
$$\delta_C = \frac{\delta_F}{2} + \frac{V_c h^3}{48 D_C} - \frac{(V_c - 2Q)h^3}{32 D_C}$$

Defining the net drift of the center of mass of the core with respect to its nearest support it gives;

$$\phi_{c,net} = \frac{\delta_C}{h} - \frac{\delta_F}{2h} = \frac{V_c h^2}{48 D_C} - \frac{(V_c - 2Q)h^2}{32 D_C} \tag{24}$$

If $D_C \to \infty$ and $M_0 \to (M_0 + M_{P\Delta})$, then $V_f \to V_f + P\delta_F / h$, subsequently Eqs. (23) and (24) yield;

$$Q = V_c / 2 - K_S \delta_F,$$
$$\delta_F = h\varphi = \frac{(V_f + V_c / 2)h}{[h(K_F + K_S) - P]} \tag{25}$$
$$\delta_C = \frac{\delta_F}{2}$$

The following examples have been devised to demonstrate the applications of the formulations presented under sections 3 and 4 above.

Example1- Relatively flexible rocking core-Determination of δ_F, δ_C and ω. Let E=29000ksi, h=L=10.0ft. $I_f = J_f = 11420.25$ in^{4,} $I_c = 1242.42$ in^4, $W_f = 5000$ kips, $W_c = 500$ kips, $k_s = 5000$ kip-ft. /rad and $\rho = 1.0$.

Solution: $\alpha_m = \frac{5000}{500} = 10$, $\frac{1}{K_F} = \frac{1728 \times 1000}{12 \times 29000 \times 11420.25} = 0.000435$, $\frac{1}{2K_S} = \frac{144 \times 100}{2 \times 5000 \times 12} = 0.12$,
$\frac{1}{K_C} = \frac{1728 \times 1000}{3 \times 29000 \times 1242.42} = 0.01599$, $\frac{1}{\overline{K}_C} = \frac{5 \times 1728 \times 1000}{48 \times 29000 \times 1242.42} = 0.00499$, $\frac{1}{K_S} = \frac{144 \times 100}{5000 \times 12} = 0.24$,

Eq.(22) gives; $Q = \frac{500(0.00499 + 0.12000) - 2500 \times 0.000434}{0.24543} = 239.42$ kips [239.4 kips]

Eq.(23) gives; $\delta_F = \frac{V_f + Q}{K_F} = (2500 + 239.42) \times 0.000434 = 1.19$ *in* [1.191*in*]

Eq.(23) gives; $\delta_C = \frac{1.191}{2} + \frac{500 \times 10^3 \times 12^3}{48 \times 29000 \times 1242.42} - \frac{(500 - 2 \times 239.42) \times 10^3 \times 12^3}{32 \times 29000 \times 1242.42} = 1.067$ *in* [1.06*in*]

Eq. (30) gives; $\omega = \frac{1}{2\pi}\left[\frac{(2500 \times 1.19 + 500 \times 1.06) \times 12}{(2500 \times 1.4161 + 500 \times 1.1236)}\right]^{\frac{1}{2}} = 0.51$ *hertz*.[0.51]

5. Development of Rigid Rocking Cores

While the core is assumed to be rigid, its appendages are allowed to exhibit elasto-plastic behavior. Following Eq.(25) the roof level lateral displacement of the subject model in terms of drift ϕ, the frame and core spring stiffnesses K_F and K_S, can be expressed as;

$$\delta_F = \varphi h = \frac{M_0}{[h(K_F + K_S) - P]} = \frac{M_0}{\bar{K}_F} \tag{26}$$

Where $M_0 = +(V_F + V_C)h/2$ and $P = W_f + W_m + W_c$. The disposition of the interactive forces between the frames and the core is presented in Figs.5 (e) and (f). The lateral displacement of the rocking core composed of a rigid body displacement $\delta_F / 2$ and core bending δ_F can be estimated as;

$$\delta_C = \frac{\delta_F}{2} + \frac{V_C}{K_C} = \frac{\phi h}{2} + \frac{V_C}{K_C} \tag{27}$$

$$\delta_F = \phi h = \frac{(V_F + V_C)h}{2[h(K_F + K_S) - P]} = \frac{(1+\alpha_m)V_C h}{2\bar{K}_F} \tag{28}$$

$$\delta_C = \left[\frac{(1+\alpha_m)h}{4} + \beta_k\right]\frac{V_C}{\bar{K}_F} \tag{29}$$

Example 2-Given the same data as for example 1, verify the validity of Eq. (26).

Solution: $\delta_F = \frac{(2500\times 10 + 500\times 5)\times 12}{[10(2304.147 + 4.167) - 0]} = \frac{330000}{120\times 2308.314} = 1.191 in$ [same as example 1]

6. Dynamics –The Frequency Equation

Rayleigh's method of frequency analysis is ideally suited for the purposes of the current study [30]. It provides great insight into the dynamic behavior of two degree of freedom systems under combined gravity and lateral forces, such as the lean–to, rocking-core and moment-frame configuration depicted in Figs.1 and 5. Rayleigh's method depends on the availability of deformation profiles that closely resemble the position of the structure at maximum amplitude for the fundamental mode of natural vibrations. Ideally the selected shape is expected to be related to a state of static equilibrium that is compatible with all boundary conditions. One such shape may be envisaged by assuming $V_F = W_F = W_f + W_m$ and $V_C = W_C$ corresponding to lateral displacements δ_F and δ_C, in which case the natural cycles per second (*hertz*) can be estimated as;

$$\omega = \frac{1}{2\pi}\left[\frac{g(W_F\delta_F + 2W_C\delta_C)}{W_F\delta_F^2 + 2W_C\delta_C^2}\right]^{\frac{1}{2}} \tag{30}$$
$$= \frac{1}{2\pi}\left[\frac{g(\alpha_m\delta_F + 2\delta_C)}{\alpha_m\delta_F^2 + 2\delta_C^2}\right]^{\frac{1}{2}}$$

Where g=32.2ft/sec^2 is the gravitational acceleration.

6.1 Preliminary design data.

In general, seismic analyses begin with estimation of the first natural frequency of the structure under consideration. The challenge for the preliminary design of RRCERFs is the reliable estimation of the rigidity of a core such that would impose SDOF response on the combined system. It may be seen from Fig.5 and Eq. (22) that as the core rigidity D_C tends towards infinity, the corresponding displacement δ_C tends towards half the maximum displacement of the frame, i.e., $\delta_C \to \delta_F / 2$. ASCE/SEI [31] requires the stiffness of the frame to be sufficient to control the drift of the structure at each story within the limits specified by the building code. If the net drift limit is indicated by $\phi_{all.}$, then the controlling system displacements would be equal to $\delta_F = \phi_{f,all.}h$ and $\delta_C = \phi_{c,all.}h/2$. The required rigidity D_F and D_C can now be estimated by substituting the controlled value of δ_F into the governing Eq. (11) or its expanded forms, Eq. (25). The net drift of the core can now be estimated as $\varphi_{c,net} = (2\delta_C - \delta_F)/2h$. Since Eq. (15), implies a satisfactory degree of rigidity for the core then substitution of the δ_F and δ_C into Eq. (30) would result directly in the design first natural frequency;

$$\omega = \frac{1}{2\pi}\left[\frac{2g(1+\alpha_m)}{(1+2\alpha_m)\phi_{allow.}h}\right]^{\frac{1}{2}} \tag{31}$$

Two limiting conditions come to mind, 1- $\alpha_m \to \infty$, e.g., a highly rigid but lightweight core such an upright steel braced frame, Fig. 2(d), in which case $\omega^2 = g/4\pi^2\phi_{all.}h$, and 2- $\alpha_m \to 0$ a highly rigid but heavy weight core such as a reinforced concrete rocking wall, Fig. 2(c), in which case $\omega^2 = g/2\pi^2\phi_{all.}h$. A simple plot of variations of ω against α_m is presented in Fig.8, where it may be observed that the difference between the two extreme frequencies is $1/\sqrt{2}$ or about %30, and that in the practical range of variations, $\infty > \alpha_m > 0$, the natural frequency is insensitive to minor variations in the mass of the RRC. Eq. (10) can now be utilized in conjunction with Eq. (31) to determine the fundamental period of vibration of the RRCERF for any combination of ratios α_m, D_F/D_C and K_S/D_C, this process is illustrated best by numerical examples 3 and 4 below.

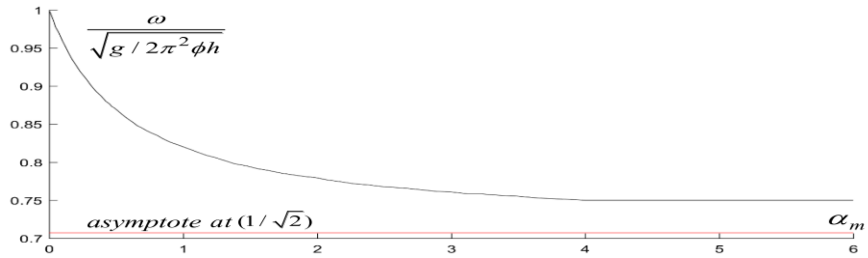

Fig.8. Variations of the system frequency (cps) with variations in RRC mass

Example 3- Infinitely stiff rocking core- Determination of δ_F , δ_C and ω.

Solution: What happens if $D_C = \infty$? Evidently as $1/K_C \to 0$, $1/\bar{K}_C \to 0$ and $\delta_C = \delta_F/2$ $\alpha_m = \frac{500}{5000} = 0.1,$

$\frac{1}{K_F} = 0.000434,$ $\frac{1}{2K_S} = 0.12,$ $\frac{1}{K_C} = 0.,$ $\frac{1}{\bar{K}_C} = 0$ $\frac{1}{K_S} = \frac{144\times100}{5000\times12} = 0.24,$ Eq.(22) gives; $Q = \frac{500\times0.12000 - 2500\times0.00044}{0.24043} = 245.0$ kips [245.07]Eq.(12) gives; $\delta_F = \frac{V_f + Q}{K_F} = (2500+245.0)\times0.000434 = 1.191$ in [1.194in]

Eq.(25) gives; $\delta_C = \frac{\delta_F}{2} = \frac{1.192}{2} = 0.596$ [0.597in]

Eq.(30) gives; $\omega = \frac{1}{2\pi}\left[\frac{(2500\times1.191+500\times0.596)\times12}{(2500\times1.4185+500\times0.3552)}\right]^{\frac{1}{2}} = 0.513$ $hertz$.[0.517] It may be noted that ω is practically the same for both the relatively stiff, Example 1, and infinitely rigid, Example 3 cores. In conclusion, even moderately stiff rocking cores stabilized by relatively stiff rotational (base level) springs can improve the lateral response of the system by as much as that associated with infinitely

RRCs. The remainder of this article is concerned with establishing minimum core rigidities in terms of relative variables α_m, D_C / D_F and K_S / D_C.

Example4- Determine the minimum rigidities of the frame and the core for $\phi = 0.04$ radians, E=3500ksi, h=L=10.0ft., $V_f = 5000$ kips, $V_c = 500$ kips, $K_S = P = 0$, $\rho = 1.0$.

Solution: $\delta_F = \phi_{f,all.} h = 0.04 \times 10 \times 12 = 4.8in$,From Eq.(13) $Q = V_c / 2 = 250$ kips. Eq. (14) gives

$$\varphi_{f,all.} h = \frac{(V_f + V_c / 2)h^3}{12 D_F} \rightarrow D_F = \frac{(2500 + 250) \times 10^2 \times 12^2}{12 \times 0.04} = 82.5 \times 10^6 \text{ kip.in}^2$$

$$\frac{\phi_{c,all} h}{2} = \frac{500 \times 10^3 \times 12^3}{48 D_C} - \frac{(500 - 2 \times 250) \times 10^3 \times 12^3}{32 D_C} = 1.2 \rightarrow D_C = \frac{500 \times 10^3 \times 12^3}{48 \times 1.2} = 15 \times 10^6 \text{ kip.in}^2$$

7. Conclusions.

It has been shown that earthquake resisting rocking core-moment frame combinations can be categorized as resilient provided that the rocking core is designed not to fail at maximum considered earthquake. It has also been argued that since the high rigidity of the core suppresses higher modes of vibrations the structure behaves as a single degree of freedom system, a fact that makes the proposed configuration eligible for linear and nonlinear static analysis. The design approach reported in this paper is different to conventional performance-based philosophies in that instead of looking at severity of damage, attention is focused on the ability of the rocking core and its appendages to prevent plastic collapse, to realign and prepare the system for post-earthquake repairs. In conclusion the following simple steps can be used to arrive at a preliminary design for a relatively rigid rocking core as part of a resilient earthquake resistant system.

1- Establish ϕ_{allow} in accordance with the requirements of the prevailing codes of practice,

2- Use Eq. (31) in to estimate the natural period of vibrations of the system and the seismic loading,

3- Utilize Eq. (13) and/or (25) to estimate K_F, K_s

4- Use Eq. (19) to compute the minimum strength of the un-supplemented rocking core,

5- Use rule 2.1 to estimate the minimum stiffness of the un-supplemented rocking core.

The paper suggests that the most important structural attributes of properly designed RRCs can be summarized as;1-If the RRC is rigid enough the RRCERF can be regarded as a SDOF structure.

2-zero line of reference passes through both ends of RRC.

3-Imposition of uniform drift by the RRC prevents inactive hinges from engaging in plastic rotations.

4-RRCs exert the same internal distribution of forces on the frames as the external forces to the system, plus a roof level single force that acts in the same sense as the external loading.

5-RRC attached supplementary devices can improve the performance of the combined structure.

6-An RRC without auxiliary devices, can improve the drift but not the ultimate strength of the ERF.

7-RRCs can help prevent damage concentration within the members of the primary structure.

8-RRC forces points of inflection of the MF to move towards mid-spans of all beams and columns.

9-Residual drifts significantly contribute to the overall earthquake loss.

10-Residual drifts impact if buildings are safe for occupancy after an earthquake.

11-The drift angle can be used to control the performance of the RCERFs under lateral loading.

12-The normalized drift function remains unchanged throughout the loading history of the structure.

13-Loss of stiffness changes only the value of the drift angle but not the drift profile.

14-The drift profile is a function of the same single variable for all loading conditions.

15-The uniform drift of a RRCERF is given by the total overturning moment divided by the global rotational stiffness of the system.

16-Even the first approximation for core stiffness results in practically acceptable dimensions

17-The degree of effectiveness of RRCERFs, with or without supplementary devices, should be carefully examined for new as well as retrofit projects.

18-A poorly performing free-standing ERF can be turned into a highly efficient RRCERF.

19-RRCERFs are ideally suited for implementing CP and PERR technologies.

20-Supplementary devices such as stressed tendons can be used effectively to increase the equivalent stiffness of the RRCERF combinations.

21-The addition of the base level attachments can considerably improve the drift as well as the carrying capacity of the system.

22-The dominant mode shapes remain unchanged during all phases of loading.

23-The structure is an SDOF system, and as such, lends itself well to equivalent energy studies.

24-RRCs can prevent ERF collapse due to formation of plastic failure mechanisms.

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LANDSLIDES AND THEIR PREVENTIVE MEASURES IN ARMENIA

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Abstract. The authors and many experts are deeply convinced that landslides are the most destructive phenomenon that have been assessed after earthquakes in nature, leading to undesirable consequences ranging from human casualties to material and financial losing. They decompose and paralyzed the population's natural normal life style.

1. Introduction

According to statistics, the widespread occurrence of landslides in Armenia is conditioned by seismic activity of the region, geological and hydrogeological peculiarities, slope levels, climatic and other conditions. According to cadastral registrations, the number of landslides in the Republic of Armenia is about 2,500. Not all existing but also potential landslides are registered, which may appear unexpected.

Recently landslides have intensified also in Noragavit district near Yerevan. When a large-scale greenhouse farm was built in that area, landslides were observed in parallel with land works even at the cemetery nearby. The landslides in that district have been activated since 1960 when the adjacent land has started to irrigate [1].

If we state that the value of the works done to prevent landslides in Armenia has already exceeded $ 50 million and that these works have not produced substantial results, the relevance and importance of the issue becomes clear.

Based on the analyzes and conclusions of the work done to support the landslides, we can mention that these are still under study;

- Deep geological studies and details of landslide zones.
- Data on water availability, penetration and irrigation zones in landslide zones, locations of springs, directions and their movement.
- Images of actual moving masses, their development by time, and so on.

As a result of natural phenomena (earthquake, flood, hostilities, large-scale land and construction works, woodcutting, irrigation, etc.), the slopes and levels of the slopes change. They become unstable, and gravitational force that starts to move, craw, taking the structures with them, in some cases becoming an unplanned disaster [2].

Landslide phenomena are directly dependent on:

- structure location,
- depth of extreme extraction,
- groundwater activity,
- laying of rock layers,
- underground shaking,
- unnecessaryhuman intervention and so on [3,4].

Here is introduce of some techniques that we have developed.

2. Methodology

Concrete backing, combined with drainage. The use of the specified backing wall requires accurate assessment of loads, as well as some requirements for basis. Precast reinforced concrete pillars are considered reliable and stable for smaller crawling layers. The use of the above method also requires high costs.

We have monitored the dynamics of the landslide in the Noragavit district of Yerevan in order to justify the application and expedience of this method. The landslide arose in the course of construction of large-scale earthwork and bring to one level. The difference between smoothed and neighboring levels is approximately 15 meters, which is already a danger phenomenon. Over time (about one year), irrigation and abundant precipitation have contributed to water saturated, causing the ground mass to moveand leaving substantial deep cracks on the surface (Figure 1.2).


Fig.1. Unstable situation of backing wall Fig.2 .Landslide condition

As an anti-landslide measure, we suggested to create retaining wall of large-sized concrete blocks, combined with drainage. Further studies have shown that the pillars had not been builtproperly and had not been lowered from the landslide zone, which had caused the shift of the base (due to the gravitational force, the pressure on the downstream was greater than the built-in resistance). As a result of the specialized consultation, it was proposed to create a new reinforcing wall with deeper level to bring it down to a lower slope of the landslide mass, simultaneously combining with the transverse drainage system [5]. Further exploration has shown that the mass movement had ceased.

Fig.3. New retaining wall image

Gabione-reinforced retaining wall, combined with transverse drainage. The Gabion retaining walls are classified as flexible structures and are capable to stand without collapsing the main structureand to absorb possible sediments of the soil and resist external loadings.
Studies show that the use of retaining walls from gabion for stabilization of slopes in landslides is not always effective. As a typical example is the actual state of the gabione basements providing stability to structures and adjacent slopes connecting them in sports zone of the Military Academy of the RA Ministry of Defense located in Dilijan.

The landslide phenomena on this area were formed in 1982 in mid-August. 2013 The complex surveys have shown that the slope is in imbalance condition from the point of view of landslide phenomena and the groundwater level fluctuates at a depth of 3 to 5m [6].

In recent years, an up-to-date watching exploration revealed that the upper rectangular platform of the gabione (at the height of about 9m), which provides stability to adjacent slopes of the 1st slope, has been found to have transverse cracks, some of which (according to the beacons) "are actual”.

The asphalt-concrete road leading to the top of the canal has been particularly devastated. The sedimentary crack along the road has significantly increased (Fig.4.5).

Fig. 4,5 Sedimentary cracks
a) on reinforced concrete platform; b) on asphalt concrete road

According to the study, one of the main causes of partial loss of slope stability is the increase in hydrostatic pressure, which affects the base, which is caused by the reduction of the possibility of groundwater leakage by the gabione constructions. That is why groundwater, during the filtration bringing silt, plant, soil particles, etc. partially closed the holes in the structures, reducing drainage capability, which caused the increase in hydrostatic pressure.

Taking into account the results of the study, we propose to combine the gabione retained walls with simplified transverse drainage systems for stabilization of water saturated slopes in landslide zones. The need for gabione drainage system is toprevents the collapse of the retaining wall, excluding the hydrostatic pressure on it.

Drainage system consists of polymer pipes of 70-100mm in diameter, placed in the first and second rows of gabione construction, with 0.5 and 1m in height from the bottom, with chess style 1.5 to 2m distance betweenand from the filter layer (sand, rubble, crushed stone, hard stone scrap, etc.) (Fig. 6.7) [7]:

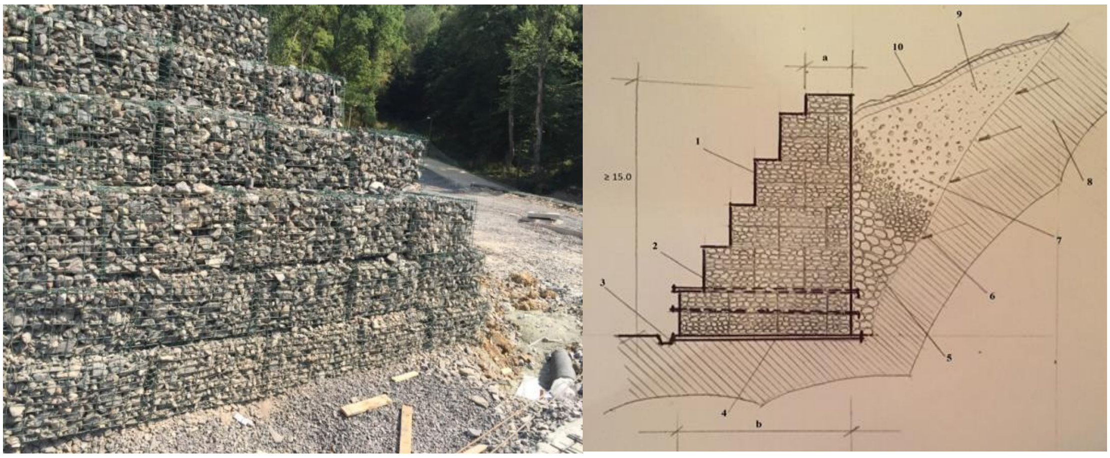

Fig. 6.7. Gabione retaining wall,
a) veritable image; b) simplified combined with transverse drainage;
1-gabion, 2-drainage polymer pipe (70-100mm), 3- drainage brook, 4- preparation concrete layer, 5-crushed stone (15-25cm), 6-gravel (40-80mm), 7- rubble, 8- sand, 9-vegetative layer, 10-soil

Transverse drainage allows the groundwater to be removed from the back of the support by means of polymer pipes.

Gabione and simplified transverse drainage system have a number of advantages,

- It is built within a short period of time;
- It is effective to use in irrigated soils, at different levels of water,
- Simple with its structure and not costly,
- Local raw material (sand, sandstone, crushed stone, hard crushed stone) is used for filtration.
- Flexible, stableandhasinstallationcapabilityforweakbasis.

3. Results

According to the information obtained from the comments in the article, we will make practical proposals, and then specific options and projects for their application. It is also planned to organize monitoring of predictable landslides in order to prevent collapse in any unexpected time.

4. **Summary**

In order to prevent landslides and avoid adverse events, it's necessary to

- Exclude construction and other land works without deep and fundamental geological and hydrogeological investigations and conclusions,
- Consider the dynamics of the landslide phenomena as a continuation of the process as they do not emerge at once and can be prevented on time,
- While using retaining walls as version of landslide prevention, we recommend the structure to be compulsory combined with drainage system to exclude the hydraulic pressure on the base of structure.

Acknowledgements

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AXIALLY-SYMMETRIC BOUNDARY VALUE PROBLEM FOR UNIFORMLY LAYERED COMPOSITE WITH PARALLEL INTERPHASE DISK-SHAPED CRACKS

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Keywords: Periodical mixed boundary value problems; disk-shaped crack; circular rigid inclusion.

Abstract. On the basis of discontinuous solutions of the equations of axisymmetric theory of elasticity, the axisymmetric stress state of a piecewise homogeneous, uniformly layered space is obtained by alternately connecting two heterogeneous layers of the same thickness, which on the junction planes of different layers contain a periodic system of circular disc-shaped parallel cracks. The displacements are given on one, and the stresses on the other of the edges of cracks. A governing system of integral equations with Weber-Sonin kernels with respect to the dislocation of points of edges of cracks and jumping of stresses on edges of cracks was obtained. Using rotation operators the system was deduced to a system of singular second-kind integral equations for complex combinations of reduced jumps of stresses and dislocations of points of cracks. The solution of system is constructed by the method of mechanical quadrature.

1. Introduction

Few studies are devoted to the axial symmetric stress state of an elastic piecewise-homogeneous composite, modeled as a uniformly layered space of two heterogeneous layers with interphase disc-shaped defects. Of these, we note the work [1], where discontinuous solutions of the equations of the axial symmetric theory of elasticity are constructed for a piecewise homogeneous, uniformly layered space, formed by regular sequence of junction of two heterogeneous layers of the same thickness, which contain a periodic system of circular disc-shaped parallel interphase defects. As a result, solutions for two specific problems are found in regard to a defect which is an absolutely rigid disk-shaped inclusion and one which is a disk-shaped crack. References contain complete overview of the works directly related to this article. Many basic results on axial symmetric contact and mixed boundary value problems of the theory of elasticity are represented in the works [2–4]. Note also the works [5-8], which are directly related to this article. In the work of Popov G.Ya. [5] the axial symmetric stress state of a homogeneous elastic space with a disc-shaped crack, on one side of which stresses are given, and a smooth stamp is pressed on the other side is considered. With the help of rotation operators, a closed solution of the problem is constructed. The closed solutions of similar problems for a two-component space with a disk-shaped and semi-infinite ring-shaped crack on the banks of which the mixed conditions are given is constructed by the same method in [6–7].The study of the axial symmetric stress state of a piecewise-homogeneous layered composite obtained by regular sequence of junction of two dissimilar layers with a periodic system of circular disk-shaped parallel interphase cracks, on one side of which stresses are given, and on the other side the displacements which, in our opinion, is interesting and relevant not only from a scientific point of view, but also for the calculations for the strength and durability of various construction objects and structures conducted here in the first.

2. Problem statement and derivation of discontinuous solutions

In a cylindrical coordinate system $Or\varphi z$, the axial symmetric stress state of a piecewise-homogeneous elastic space, obtained by regular sequence of junction of two heterogeneous layers with thickness of $2h$ with Lame coefficients λ_1, μ_1 and λ_2, μ_2, respectively is considered. In this case, we assume that on the junction planes of heterogeneous layers $z = 2nh\ (n \in Z)$ there is a periodic system of identical circular disk-shaped interphase parallel cracks with radius a with given stress components on some banks and same displacements given on the other banks of heterogeneous layers.

It is obvious, that under such a formulation of the problem, all the middle planes $z = (2n+1)h\ \ (n \in Z)$ of heterogeneous layers are planes of symmetry. Based on this, the problem can be formulated for the base cell: a two-component layer occupying a region $\Omega\{|z| \le h; 0 \le r < \infty; 0 \le \varphi \le 2\pi\}$ in space, on the external planes $z = \pm h$ of which symmetry conditions are given, and on the middle plane there is a circular disk-shaped interphase crack of radius a, on one bank, the upper, the normal $q_1(r)$ and tangential $\tau_1(r)$ components of stresses, and, on the other, the lower bank, respectively, the normal $w_2(r)$ and radial $u_2(r)$ components of the displacement and the resultant $P_0^{(2)}$ of acting stresses are given. The problem is to build solutions for the problem and determine the patterns of changes in crack opening, contact stresses acting on the side of cracks where the displacements and intensity factors of destructive stresses on circles are given depending on the physical, mechanical and geometric characteristics of heterogeneous layers. Using indices 1 and 2 to all the quantities describing the stress state of heterogeneous layers respectively, the following conditions on the crack sides are considered:

$$\begin{cases} \sigma_z^{(1)}(r,h) = -q_1(r) \\ \tau_{rz}^{(1)}(r,0) = \tau_1(r) \\ u_z^{(2)}(r,0) = w_2(r) \\ u_r^{(2)}(r,0) = u_2(r) \end{cases}, \tag{2.1}$$

where $q_1(r)$ and $\tau_1(r)$ the given stresses components on the upper bank of cracks, and $w_2(r)$ and $u_2(r)$ the given components of the displacements on the lower bank of cracks.

Using of discontinuous solutions from [1] satisfy the conditions on the crack edges (2.1). As a result, preserving all the notation [1], to determine the dislocations of the radial $u(r)$ and vertical $w(r)$ components of the points of cracks' edges, as well as the jumps of normal $\sigma(r)$ and tangential $\tau(r)$ stresses the following system of governing equations is obtained:

$$\frac{b_0}{\Delta} L_{0,0}^{(1)}[\sigma] + \frac{b_1}{\Delta} L_{0,1}^{(1)}[\tau] + \frac{b_2}{\Delta} L_{0,1}^{(2)}[u] + \frac{b_3}{\Delta} L_{0,0}^{(2)}[w] +$$
$$+ L_{0,0}^{(1,3,1)}[\sigma] + L_{0,1}^{(1,3,2)}[\tau] + L_{0,1}^{(2,3,3)}[u] + L_{0,0}^{(2,3,4)}[w] = -q_1(r);$$

$$\begin{gathered}\frac{b_1}{\Delta}L_{1,0}^{(1)}[\sigma]+\frac{b_0}{\Delta}L_{1,1}^{(1)}[\tau]+\frac{b_3}{\Delta}L_{1,1}^{(2)}[u]+\frac{b_2}{\Delta}L_{1,0}^{(2)}[w]+\\
+L_{1,0}^{(1,4,1)}[\sigma]+L_{1,1}^{(1,4,2)}[\tau]+L_{1,1}^{(2,4,3)}[u]+L_{1,0}^{(2,4,4)}[w]=\tau_1(r);\\
-\frac{d_1}{\Delta}L_{0,0}^{(0)}[\sigma]+\frac{d_0}{\Delta}L_{0,1}^{(0)}[\tau]-\frac{b_1}{\Delta}L_{0,1}^{(1)}[u]-\frac{b_0}{\Delta}L_{0,0}^{(1)}[w]+\\
+L_{0,0}^{(0,2,1)}[\sigma]+L_{0,1}^{(0,2,2)}[\tau]+L_{0,1}^{(1,2,3)}[u]+L_{0,0}^{(1,2,4)}[w]=w_2(r)\\
\frac{d_0}{\Delta}L_{1,0}^{(0)}[\sigma]-\frac{d_1}{\Delta}L_{1,1}^{(0)}[\tau]-\frac{b_0}{\Delta}L_{1,1}^{(1)}[u]-\frac{b_1}{\Delta}L_{1,0}^{(1)}[w]+\\
+L_{1,0}^{(0,1,1)}[\sigma]+L_{1,1}^{(0,1,2)}[\tau]+L_{1,1}^{(1,1,3)}[u]+L_{1,0}^{(1,1,4)}[w]=u_2(r)\end{gathered}\quad. \tag{2.2}$$

System (2.2) should be considered under conditions of equilibrium of inclusions and continuity of displacements on a circle $r=a$:

$$\begin{gathered}\int_0^a\sigma(r)rdr=P_0;\quad\int_0^a\tau(r)rdr=0;\ w(a)=u(a)=0;\\
\left(P_0=P_0^{(2)}-P_0^{(1)};\ P_0^{(1)}=\int_0^a q_1(r)rdr\right).\end{gathered} \tag{2.3}$$

Where as in [1]

$$L_{m,n}^{(k)}[\varphi]=\int_0^a W_{m,n}^{(k)}(r,\xi)\xi\varphi(\xi)d\xi;\quad W_{m,n}^{(k)}(r,\xi)=\int_0^\infty t^k J_m(tr)J_n(t\xi)dt\quad;$$

$$L_{m,n}^{(k,i,j)}[\varphi]=\int_0^a W_{m,n}^{(k,i,j)}(r,\xi)\xi\varphi(\xi)d\xi;\quad W_{m,n}^{(k,i,j)}(r,\xi)=\int_0^\infty K_{i,j}(ht)t^k J_m(tr)J_n(t\xi)dt\ ;$$

$$b_0=\theta_2^{(1)}\left(\theta_2^{(1)}+\theta_2^{(2)}\right)-\theta_1^{(1)}\left(\theta_1^{(1)}-\theta_1^{(2)}\right);\ b_1=\theta_1^{(1)}\left(\theta_2^{(1)}+\theta_2^{(2)}\right)-\theta_2^{(1)}\left(\theta_1^{(1)}-\theta_1^{(2)}\right);$$

$$b_2=2\left(\theta_1^{(1)}b_0+\theta_2^{(1)}b_1-\theta_1^{(1)}\Delta\right);\ b_3=2\left(\theta_1^{(1)}b_1+\theta_2^{(1)}b_0-\theta_2^{(1)}\Delta\right);\ \Delta=\left[\left(\theta_2^{(2)}+\theta_2^{(1)}\right)^2-\left(\theta_1^{(2)}-\theta_1^{(1)}\right)^2\right],$$

$$d_0=\frac{\theta_1^{(1)}-\theta_1^{(2)}}{2};\quad d_1=\frac{\theta_2^{(2)}+\theta_2^{(1)}}{2};\ \theta_1^{(j)}=\frac{\mu_j^2}{\lambda_j+3\mu_j};\ \theta_2^{(j)}=\frac{\mu_j\left(\lambda_j+2\mu_j\right)}{\lambda_j+3\mu_j}\ \ (j=1,2),$$

and functions $K_{i,j}(x)$ are regular functions, the values of which are given in [1].

To construct a solution for system (2.2) under conditions (2.3), as in [1, 4], we use integral representations of Bessel functions and consider the functions

$$\{\sigma_*(t),w_*(t)\}=\frac{2}{\pi}\int_t^a\frac{\xi\{\sigma(\xi),w(\xi)\}d\xi}{\sqrt{\xi^2-t^2}};\quad\{\tau_*(t),u_*(t)\}=\frac{2t}{\pi}\int_t^a\frac{\{\tau(\xi),u(\xi)\}d\xi}{\sqrt{\xi^2-t^2}},$$

and continue the functions $\sigma_*(t)$ and $w_*(t)$ up to the interval $(-a,0)$ in an even way and $\tau_*(t)$ and $u_*(t)$ in an odd way. Next, apply the operator I to both parts of the first and third equations (2.2), and the operator I_1 to the other two:

$$I\left(\varphi(x)\right)=\int_0^x \frac{\varphi(r)\,rdr}{\sqrt{x^2-r^2}};\quad I_1\left(\varphi(x)\right)=\frac{d}{dx}\int_0^x \frac{ydy}{\sqrt{x^2-y^2}}\int_0^y \varphi(r)\,dr\,.$$

Then, after some mathematical calculations, differentiating the last two equations with respect to x and using the values of some well-known integrals [4], we come to the following system of singular integral equations:

$$\begin{gathered}
\frac{\pi b_3}{2}w'_*(x)-\frac{\pi b_1}{2}\tau_*(x)+\frac{b_0}{2}\int_{-a}^{a}\frac{\sigma_*(t)\,dt}{t-x}+\frac{b_2}{2}\int_{-a}^{a}\frac{u'_*(t)\,dt}{t-x}+\int_{-a}^{a}R_{11}(t,x)\sigma_*(t)\,dt+\\
+\int_{-a}^{a}R_{12}(t,x)\tau_*(t)\,dt+\int_{-a}^{a}R_{13}(t,x)w'_*(t)\,dt+\int_{-a}^{a}R_{14}(t,x)u'_*(t)\,dt=-\Delta\sigma_1^*(x)\\
\frac{\pi b_1}{2}\sigma_*(x)+\frac{\pi b_3}{2}u'_*(x)+\frac{b_0}{2}\int_{-a}^{a}\frac{\tau_*(t)\,dt}{t-x}-\frac{b_2}{2}\int_{-a}^{a}\frac{w'_*(t)\,dt}{t-x}+\int_{-a}^{a}R_{21}(t,x)\sigma_*(t)\,dt+\\
+\int_{-a}^{a}R_{22}(t,x)\tau_*(t)\,dt+\int_{-a}^{a}R_{23}(t,x)w'_*(t)\,dt+\int_{-a}^{a}R_{24}(t,x)u'_*(t)\,dt=-\Delta\left[\tau_1^*(x)-c_*\right]\\
\frac{\pi b_1}{2}u'_*(x)+\frac{\pi d_1}{2}\sigma_*(x)-\frac{b_0}{2}\int_{-a}^{a}\frac{w'_*(t)}{t-x}dt-\frac{d_0}{2}\int_{-a}^{a}\frac{\tau_*(t)\,dt}{t-x}+\int_{-a}^{a}R_{31}(t,x)\sigma_*(t)\,dt+\\
+\int_{-a}^{a}R_{32}(t,x)\tau_*(t)\,dt+\int_{-a}^{a}R_{33}(t,x)w'_*(t)\,dt+\int_{-a}^{a}R_{34}(t,x)u'_*(t)\,dt=-\frac{\Delta dw_2^*}{dx}\\
-\frac{\pi b_1}{2}w'_*(x)+\frac{\pi d_1}{2}\tau_*(x)-\frac{b_0}{2}\int_{-a}^{a}\frac{u'_*(t)}{t-x}dt+\frac{d_0}{2}\int_{-a}^{a}\frac{\sigma_*(t)\,dt}{t-x}+\int_{-a}^{a}R_{41}(t,x)\sigma_*(t)\,dt+\\
+\int_{-a}^{a}R_{42}(t,x)\tau_*(t)\,dt+\int_{-a}^{a}R_{43}(t,x)w'_*(t)\,dt+\int_{-a}^{a}R_{44}(t,x)u'_*(t)\,dt=-\frac{\Delta du_2^*}{dx}
\end{gathered}\tag{2.4}$$

Here we use the following notation:

$$u_2^*(x)=I_1\left[u_2(r)\right];\; w_2^*(x)=I\left[w_2(r)\right];\; \sigma_1^*(x)=I\left[q_1(r)\right];\; \tau_1^*(x)=I_1\left[\tau_1(r)\right];$$

$$c_*=\frac{\pi b_1}{2\Delta}\sigma_*(0)+\frac{\pi b_3}{2\Delta}u'_*(0)+\frac{b_0}{2\Delta}\int_{-a}^{a}\frac{\tau_*(t)}{t}dt+\frac{b_2}{2\Delta}\int_{-a}^{a}\frac{w'_*(t)}{t}dt,$$

and kernels $R_{ij}(t,x)$ $(i,j=1-4)$ are regular functions from both arguments, the values of which are not presented here because of space limitations. Next, we introduce into consideration complex combinations of displacements and stresses $\chi(x)=\sigma_*(x)+i\tau_*(x)$, $V'(x)=\theta_2^{(2)}\left[u'_*(x)-iw'_*(x)\right]$. The system (1.4) is written as a system of two singular integral equations with respect to these functions. Then, in case where the equation $a_1^*\lambda^2+\lambda\left(a_2^*-b_1^*\right)+b_2^*=0$ has two different roots $\lambda_1\neq\lambda_2$, by using the functions

$$\varphi_j(x)=\chi(x)+\lambda_j V'(x);\quad F_j(x)=\lambda_j f_1(x)+f_2(x)\quad (j=1,2)$$

we write the system in canonical form:

$$\varphi_j(x)+\frac{iq_j}{\pi}\int_{-a}^{a}\frac{\varphi_j(s)ds}{s-x}+\sum_{i=1}^{4}\int_{-a}^{a}Q_{ji}(s,x)\varphi_j(s)ds=F_j(x)\quad(-a<x<a;\ j=1-4). \tag{2.5}$$

The conditions (1.3) are written as follows:

$$\int_{-a}^{a}\varphi_j(x)dx=P_0\quad(j=1,2). \tag{2.6}$$

here

$$\varphi_3(x)=\bar{\varphi}_1(x);\quad \varphi_4(x)=\bar{\varphi}_2(x);\ f_1(x)=-\frac{2i}{\pi\theta_2^{(1)}}\left[d_1\sigma_1^*(x)+id_1\tau_1^*(x)-id_1c_*+b_1V_2'(x)\right];$$

$$f_2(x)=\frac{2i}{\pi\theta_2^{(1)}\theta_2^{(2)}}\left[b_1\sigma_1^*(x)+ib_1\tau_1^*(x)+b_3V_2'(x)-ib_1c_*\right];\qquad V_2(x)=\frac{du_2^*(x)}{dx}-i\frac{dw_2^*}{dx},$$

and the kernels $Q_{ij}(t,x)\ (i,j=1-4)$ are a linear combination of functions $R_{ij}(t,x)\ (i,j=1-4)$

3. Solution of governing equation

We construct the solutions of system (2.5) by the method of mechanical quadratures. Changing the variables $t=x/a$ and $\xi=s/a$, we are formulating the system (2.5) and the conditions (2.6) on the interval $(-1,1)$ and introducing the dimensionless functions

$$\psi_j(t)=a\varphi_j(at)/P_0^{(2)};\ Q_{ji}^*(\xi,t)=aQ_{ji}(a\xi,\mathrm{a}t);\ F_j^*(t)=aF_j(\mathrm{a}t)/P_0^{(2)};$$

written in the following form:

$$\psi_j(t)+\frac{iq_j}{\pi}\int_{-a}^{a}\frac{\psi_j(\xi)d\xi}{\xi-x}+\sum_{i=1}^{4}\int_{-a}^{a}Q_{ji}^*(\xi,\mathrm{t})\psi_j(t)dt=F_j^*(t)\quad(-1<t<1;\ j=1-4) \tag{3.1}$$

$$\int_{-1}^{1}\psi_j(t)dt=P_0/P_0^{(2)}\quad(j=1-4)\ . \tag{3.2}$$

Considering the main parts of the equations in (3.1) it is not difficult to establish [8], that functions $\psi_j(t)$ can be represented in the form $\psi_j(x)=\psi_j^*(x)\omega(x)\ (j=1,2)$, where

$$\omega_j(x)=\left(\frac{x-1}{x+1}\right)^{\gamma_j};\quad \gamma_j=\begin{cases}\gamma_j', & if\quad 0<\theta_j=\arg(g_j)\le\pi\\ -1+\gamma_j', & if\quad \pi<\theta_j=\arg(g_j)<2\pi\end{cases};$$

$$\left(\gamma_j'=\frac{1}{2\pi i}\ln|g_j|+\frac{\theta_j}{2\pi};\ g_j=\frac{1+q_j}{1-q_j}\right).$$

$\psi_j^*(x)$ is a continuous function, bounded up to the ends of the interval $[-1,1]$.

Further, substituting the representation of the function $\psi_j(t)$ in (3.1) and in conditions (3.2) according to the standard procedure [9], the following system of algebraic equations for unknowns $\psi_k^*(\xi_i)\left(k=1-4;\ i=\overline{1,n}\right)$ and c_* is obtained. After determination $\psi_k^*(\xi_i)$, it is not difficult, using the Lagrange interpolation polynomial, to restore the functions $\psi_j(t)\ (j=1-4)$ and determine all the necessary quantities characterizing the stress state in the two-component layer. We also write formulas with the help of which, after determining the function $\psi(x)$, it is possible to determine the dimensionless crack opening and the complex intensity factor of the destructive stresses on the circle $r=a$. To determine the crack opening using the inversion operators' rotation formulas [4] and moving to the interval $(-1,1)$, we get the formula:

$$\frac{w(ax)}{a}=\frac{P_0^{(2)}}{a^2\theta_2^2}\operatorname{Im}\int_x^1\frac{\psi_1(x)-\psi_2(x)}{(\lambda_1-\lambda_2)\sqrt{s^2-x^2}}dx. \tag{3.3}$$

We also give a formula for determining the intensity factor of destructive stresses in case when the characteristic quadratic equation has different complex roots, i.e. $\lambda_2=\overline{\lambda_1}$ and $0<\operatorname{Re}\gamma_1<1/2$. In this case [4] $g_2=\overline{g_1}$ and $\gamma_1=-\overline{\gamma}_2$ and therefore we will have:

$$\psi_1(x)=\psi_1^*(x)\left(\frac{1-x}{1+x}\right)^{\gamma};\quad \psi_2(x)=\psi_2^*(x)\left(\frac{1+x}{1-x}\right)^{\overline{\gamma}}\quad (\gamma_1=-\overline{\gamma}_2=\gamma).$$

Then, using the representations of stresses with the help of the introduced functions on the plane $z=0$ at $r>a$, is similar to the works [1,4], for their complex combination we get the expression

$$\sigma_z^{(1)}(ax,0)+i\tau_{rz}^{(1)}(ax,0)=\frac{\pi i\overline{\gamma}2^{\overline{\gamma}}\left(\theta_2^{(2)}\lambda_1 b_1+b_3\right)P_0^{(2)}\psi_2(1)}{a^2\sin\pi\overline{\gamma}\left(\theta_2^{(2)}(\lambda_1-\lambda_2)\Delta\right)}\frac{(x+1)^{-\frac{1}{2}}}{(x-1)^{\overline{\gamma}+\frac{1}{2}}}+\Phi(x), \tag{3.4}$$

where the function $\Phi(r)$ on the circle $r=a$ has a lower order than the singularity of the first addend. From here, to determine the dimensionless complex coefficient of the intensity of destructive stresses, we obtain the following expression:

$$K_I^*+iK_{II}^*=\frac{(K_I+iK_{II})a^2}{P_0^{(2)}}=\frac{\pi i\overline{\gamma}2^{\overline{\gamma}-\frac{1}{2}}\left(\theta_2^{(2)}\lambda_1 b_1+b_3\right)}{\sin\pi\overline{\gamma}\left(\theta_2^{(2)}\lambda_1 b_1+b_3\right)}\psi_2^*(1). \tag{3.5}$$

4. Conclusion

The axisymmetric stress state of a piecewise-homogeneous, uniformly layered space (composite containing a periodic system of circular disk-shaped parallel cracks on the junction planes of various layers, on the edges of which mixed conditions are given, is considered. The solution of the problem in case when the characteristic quadratic equation has two different roots is reduced to solving a system of singular integral equations of the second kind with respect to the Abelian images of complex combinations of stress jumps and dislocation of crack points and build to solve it using the method of mechanical quadratures. It is shown that in the case under consideration, the unknown functions have a power singularity. The simple formulas for determining the opening of the crack and the complex coefficient destructive stress intensity is obtained.

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CONSTRUCTION OF HEALTH MONITORING AND EARLY WARNING SYSTEM FOR ANCIENT WOOD STRUCTURAL BUILDINGS ON DIFFERENT SCALES OF CHARACTERIZATIONS

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Keywords: Chinese ancient building, Health monitoring, Intellectualization

Abstract. Ancient architecture is a unique architectural system in China. The existing ancient architecture has great research value because of its long history and rich cultural connotation. The long service time and environment of ancient buildings often lead to their structural fragility. Therefore, monitoring the structural health of ancient buildings on the basis of not destroying the authenticity of ancient buildings is the most important task in the protection of ancient buildings. In this paper, the existing health monitoring and early warning system of ancient wooden buildings is analyzed, and the direction for the future protection of ancient buildings is clear.

1. Contents and methods of health monitoring of ancient buildings

Through the analysis of the appearance and structural form of ancient buildings in Linqing section of the Grand Canal, the structural safety of buildings is monitored with advanced monitoring equipment, the main factors affecting their health are analyzed, the causes of structural damage of ancient buildings are analyzed, and effective protection and reinforcement schemes are put forward [1]. The exterior of ancient buildings such as the Shrita, Canal Pass and Mosque in Linqing City was investigated and compared with the exterior protection of other ancient buildings [2]. Applying advanced monitoring equipment, the changes of the internal structure of these ancient buildings are detected through the changes of sound waves, and their structural forms and principles are analyzed.

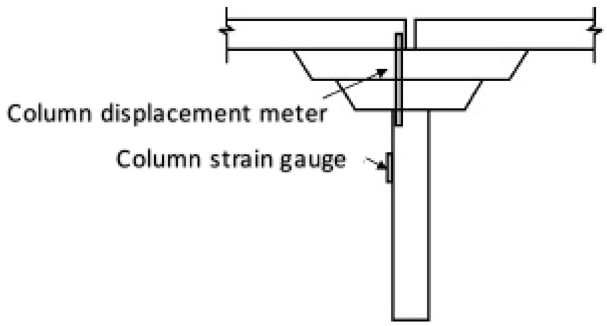

Fig.1. Column Sensor Layout Diagram

2. Application of Health Monitoring System for Ancient Timber Buildings

In recent years, the application of structural health monitoring technology in ancient buildings (or historic protective buildings) in China is generally less. However, related studies show that the introduction of structural health monitoring system can achieve win-win results in structural reliability and maintenance cost. As the core of the whole monitoring system, the structural state assessment system embodies the monitoring function of the plant monitoring system, and the early warning system is an important part of the structural state assessment system, so it is of great significance. Because of the specific monitoring object and content of ancient timber structure, its early warning system has its particularity. Taking Tibetan ancient architecture as an example, the main manifestations are as follows: 1) timber structure has undergone a long time of complex effects, and its material properties, mechanical and deformation properties of components are quite different from modern structures; 2) it is mainly designed on the basis of the experience accumulated by previous generations of craftsmen. At the same time, in the process of continuous renovation and reinforcement, some parts have undergone great changes (or replaced or added new components); 3) their service life has far exceeded the reference period stipulated by modern structures, so the reliability evaluation of ancient building timber structures can not be applied to modern norms (***ch.1***).

Time	Building	structure type	Start-up time	Remarks
2004	Shanghai Changde Apartment	concrete structure	1936	Structural Detection
2005	Shanghai Chenxiang Pavilion	Wood structure	1600	Real-time monitoring of short-term structure
2007	Yingxian Wood Tower	Wood structure	1056	Regular Real-time Monitoring of Structures
2008	Shanghai World	concrete and wood Structure	1924	Real-time monitoring of short-term structure
2008	Baoguo Temple, Ningbo	Wood structure	Eastern Han Dynasty	Long-time monitoring of long-term structure

Chart 1: Examples of Protective Engineering of Ancient Buildings (or Historic Protective Buildings) Applied Structural Health Monitoring Technology

3. Collaborative Platform of Ancient Architectural Structural Health Monitoring System Based on BIM

The core idea of BIM technology is synergy. The essence of BIM technology is that different specialties of work participants can coordinate in the same platform, share and update information in one platform, and realize the integration of professional information. Specifically, the synergy of ancient buildings is to enable owners, repair units, historians, government departments and other related parties to access and manage on a platform according to their own authority. Information of different levels and depths, such as rehabilitation plan, service status, health status, etc. However, compared with the traditional bridge engineering and housing engineering, the application of structural health monitoring system in ancient buildings is different. There are still some problems in the BIM-based structural health monitoring system for ancient buildings, and there is still a lack of safety analysis theory and health status evaluation system for ancient buildings. Overall, the application of BIM technology to health monitoring and protection of ancient buildings is the development direction in this field (fig.2). The characteristics of BIM life cycle and the concepts of visual management and collaborative work can play an important role in the field of health monitoring and protection of ancient building structures, and bring considerable benefits and remarkable efficiency. At present, there are still few practical cases of applying BIM to health monitoring of ancient buildings. In order to make BIM technology more widely used in the field of health monitoring of ancient buildings in China, we should improve it from the development and expansion of relevant software functions, simplification of ancient building modeling methods, training of BIM professionals and support and encouragement of government policies. Informatization and intellectualization of building monitoring system.

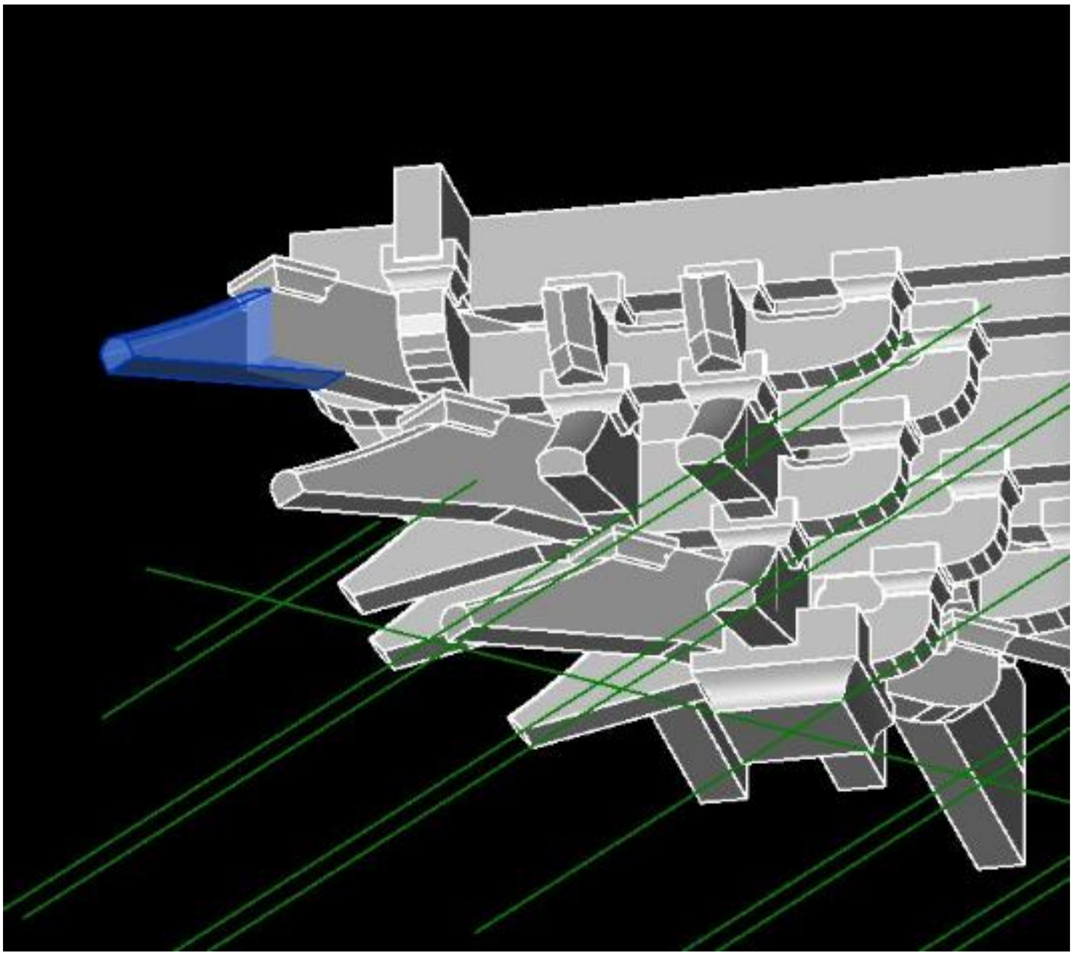

Fig.2. Application of BIM Technology in the Protection of Ancient Buildings

4. Engineering examples

For the method of determining early warning limit according to bearing capacity requirement and normal use requirement, because it has very clear meaning and is widely used in modern structure, and involves material property test, this paper will not verify it. The method of setting limits according to statistical characteristics is explained in the following part, which is mainly based on the monitoring data of a test. In December 2008, the project team carried out a field test on health monitoring of a Tibetan ancient timber structure. The correctness of the test was verified by the application of the above-mentioned theory in this project. Because of the short duration of the test, the collected data cannot reflect the continuous response of components in real situations, but it can still be considered as representative. Taking the Z1 column as an example, the column strain gauge S3 was installed and tested under two working conditions (Fig. 1). Work condition 1: Move the sand bag to the top of the Z1 column and load it step by step three times, 1 t (20 sand bags) at a time, and add it to 3 T. Work condition 2 : The same number of sand bags are stacked in K and B spans on both sides of Z1 to load synchronously and symmetrically. The method of step-by-step loading is adopted, 1 t is loaded at a time, and 3 T is added. Using the software of matlab, the monitoring data under two working conditions are processed, and the frequency histogram of the monitoring data and the fitting normal state are obtained (ch.2).

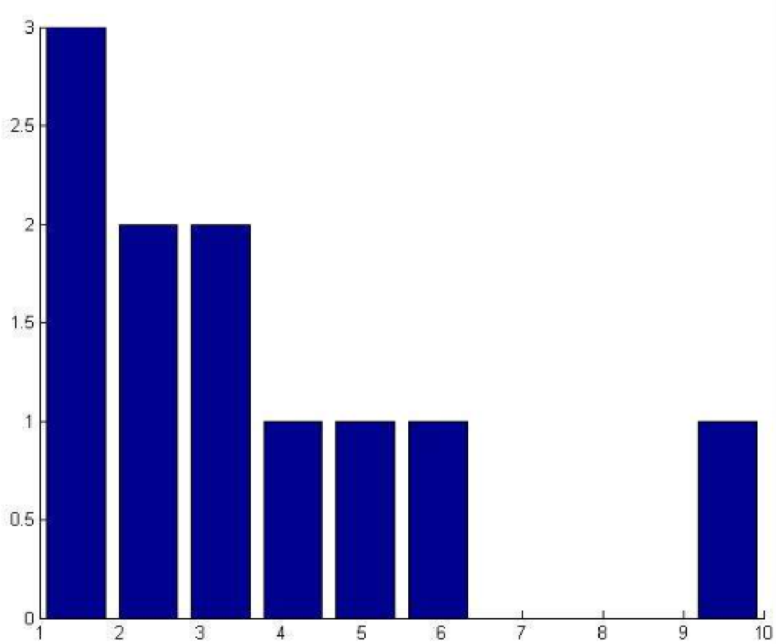

Chart 2: Frequency histogram by Matlab

Density curve (Fig. 3). It is obvious that the measured data basically obey the normal distribution and slightly deviate to the left. The analysis shows that this situation is mainly caused by the non-continuity of the two working conditions.

5. Conclusions

At present, the early warning system for health monitoring of ancient wooden structures has not been formed, and the reliability evaluation of ancient wooden structures can not be applied to modern norms. The design of early warning system of ancient wooden structures has its particularity. The design of early warning mechanism for single component should consider three factors: bearing capacity requirement, normal use requirement and statistical characteristics of monitoring data. The complex monitoring data should be processed by using statistical knowledge, and the limit of early warning mechanism can be obtained by comprehensive consideration.

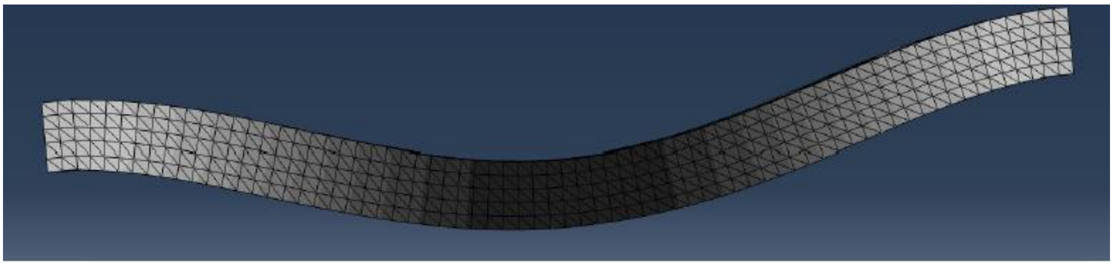

Fig.3. First-order natural frequencies of solid finite element wooden column model

6. Design according to statistical characteristics of monitoring data

Recognition of Central Limit Theorem in Statistics. Sum for a large number of statistically independent random variables. The distribution tends to be normal, according to which the conclusion is that other probability distributions can be positive. The state distribution is approximated [9]. For monitoring numbers. According to the case of strain value, it will be exposed to external factors. Part Load, Temperature, Sensor Accuracy, Size, etc. The influence of several parameters, that is, the measured strain value can be expressed as a function of the above parameters, which can be expanded in some form. The first-order differential form near the heart value is the algebraic sum of N parameters, that is, the algebraic sum of N random variables. Therefore, the static data obtained by monitoring are as follows: Subject to normal distribution. For data subject to normal distribution, the 3_criterion of its distribution (Fig. 2) can be used as a basis for determining the warning limit. Have the body process is described as follows:1) Statistical processing of monitoring data for at least one day or one period to remove abnormal values; 2) Drawing distribution histogram of monitoring data, and preparing

Combine the distribution curve to judge whether it conforms to normal distribution or not. 3) Use the 3_criterion to find the values of 2 and 3_as three levels of alarm. Limit, for non-standard normal distribution, we select the quantile values of 68.27%, 95.45% and 99.73% of the enclosure area as the early warning one. There are three bases. It should be noted that in practice, if the classification of early warning is not very strict, only one or two of the indicators can be selected as the setting. To determine the basis, of course, other transcendental probabilities can be selected according to actual needs.

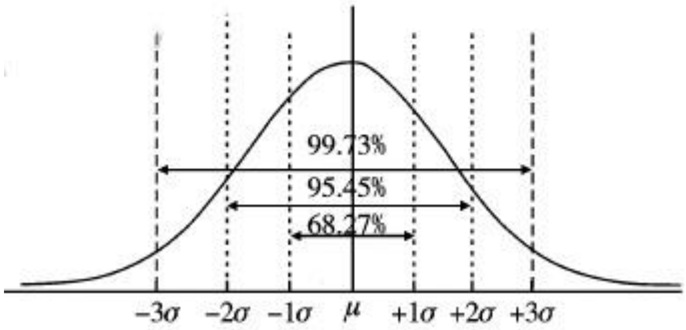

Fig.4. Quasi-survey schematic map of normal distribution

7. Concluding remarks

The reliability evaluation of ancient timber structures cannot be applied to modern codes, and the design of its early warning system has its particularity. Early Warning Mechanism of Single Component considering three factors: bearing capacity requirement, normal use requirement and statistical characteristics of monitoring data, we should make use of statistical knowledge to carry out complicated monitoring data. Processing and comprehensive consideration to obtain the limit of early warning mechanism. The design idea proposed in this paper is feasible, but it has been established through the verification of an engineering example. Good monitoring system early warning mechanism also needs to use the data after the normal operation of the system, combined with material properties test, structural component test and so on.

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DETERMINATION OF LARGE DISPLACEMENTS OF CURVILINEAR SHAPE PLATES WITH CONSIDERATION OF JUMP CHANGES OF CERTAIN FACTORS

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Abstract. Is offered and developed methodology for analysis of depressed shells and plates with discontinuous parameters with taking into account of large displacements. It is grounded on theory of Sh. Mikeladze that in turn stipulates the application of MacLoern generalized formula, theory of second order Volterra integral equations and normal fundamental functions. Based on this method is developed the program and are solved the tasks on depressed shells and plates with discontinuous parameters.

1. Introduction

The thin-walled spatial structures as plates and shells are widely applied in the engineering. Improvement of their effectiveness is related with perfection of new design schemes and analysis methods.

It is known the research of each structure is grounded on certain simplifications that are related of displacements as well as deformations values and relation between them, law of stress distribution, stiffnesses, action of loadings and so on. The consideration of real conditions for structure behavior requires the critical evaluation of mentioned simplifications and in each specific case, if necessary, it's perfection. The thin-walled structures often are undergoing the action of such loadings, at that displacement will be comparable with thickness and linear theory of analysis does not meet the maintaining of arisen requirements. The application of low-modulus prejudice the stipulated by technical theory requirement on infinite stiffness related to shear in perpendicular to middle surface planes.

Based on the above mentioned the actual problem of structural mechanics is presented by development of analysis methodology of shells and plates with discontinuous parameters.

Then powerful stimulus for development of analysis methods for elastic plates makes the application of metal in aircraft engineering. Were arisen the tasks of on consideration of impact of initial curvature on circular plates, on determination of deflections and stresses in orthogonal and circular plates. One of the first attempt on analysis of transversally loaded elastic plates was made by A. Foppl [1], who apply the solution for rigid plate and absolutely elastic membrane. The determination of large deflections at action of transversal loadings are stated in the works of P.M. Varvak [2], V.M. Darevski [3], B.I. Slepov [4], in that is applied Ritz method. Further by D.I. Panov [5] starts also the application of Bubnov-Galerkin method.

In the several works with taking into account of through cracks the displacement vector is presented as summation of regulated and discontinuous functions with unknown coefficients. They describe the discontinuous nature of displacement and are determined by condition of equalization of forces and moments to zero on edge of crack. The reviews on plates and shells analysis are stated in the works of V. Vlasov [6], I. Vorovich [7], L. Kurshin [8], B. Mikhailov and G. Kipiani [9], I. Preobrazhebski [10], G. Kipiani [11].

The new method of analysis of corrugated structures was offered by A. Nazarov [12], who introduce the value of middle surface break in the curvature expression by application of δ-function. At analysis the δ-function will be the expansion of trigonometric series. This approach is applied in the works of D. Vainberg and I. Roitfarg [13], V. Novitski [14], I. Obraztsov and G. Onanov.

By application of this method B. Mikhailov [16,17] makes contribution not only in differential equations but also in their solutions construct the effective algorithm for analysis of structures with discontinuous parameters. The B. Mikhailov and G. Kipiani [18, 19] write down the equation of breaked surface for discontinuous functions.

2. Basic part

Let's consider the plate that is limited by two circuullar arch and twp radiuses. (Fig. 2.27). On the circullar edges is stipulated that they are hingedly supported. The curvilinear edges ($r = a$, $r = b$, $b > a$) are arbitrary supported. At determination of such displacements let's apply the written down by Karaman-Vlasov equation in polar coordinates [20,21,22]:

$$\left.\begin{aligned} \Delta\Delta F &= -\frac{E}{2} L(W,W), \\ \Delta\Delta W &= \frac{h}{D} L(W,F) + \frac{q}{D}, \end{aligned}\right\}, \tag{1}$$

where

$$L(W,F) = \frac{\partial^2 W}{\partial r^2}\left[\frac{1}{r}\frac{\partial F}{\partial r} + \frac{1}{r}\frac{\partial^2 F}{\partial \theta^2}\right] + \left(\frac{1}{r}\frac{\partial W}{\partial r} + \frac{1}{r^2}\frac{\partial^2 W}{\partial r^2}\right)\frac{\partial^2 F}{\partial r^2} - 2\frac{\partial}{\partial r}\left(\frac{1}{r}\frac{\partial F}{\partial r}\right)\frac{\partial}{\partial r}\left(\frac{1}{r}\frac{\partial W}{\partial \theta}\right).$$

Let's introduce the dimensionless values:

$$U = \frac{W}{h}, \ \ \psi = \frac{E}{Eh^2}, \ \ \xi = \frac{r}{a}, \ \ \eta = \frac{\theta}{\alpha},$$

where 2α is the central angle, the written down in these values system (1) will be as:

$$\Delta\Delta\psi = -\left[\frac{2}{\xi}\frac{\partial^2 U}{\partial \xi^2}\frac{\partial U}{\partial \xi} + \frac{1}{\xi^2\alpha^2}\frac{\partial^2 U}{\partial \xi^2}\frac{\partial^2 U}{\partial \eta^2}\right] - \frac{1}{\xi^2\alpha^2}\left(\frac{\partial U}{\partial \xi}\right)^2 + \frac{2}{\xi}\frac{\partial U}{\partial \xi}\frac{\partial^2 U}{\partial \xi\partial \eta} - \frac{1}{\alpha^2\xi^2}\left(\frac{\partial^2 U}{\partial \xi\partial \eta}\right)^2,$$

$$\Delta\Delta U = 12(1-\nu^2)\left[\frac{1}{\xi}\frac{\partial^2 U}{\partial \xi^2}\frac{\partial \psi}{\partial \xi} + \frac{1}{\xi^2}\frac{\partial^2 U}{\partial \xi^2}\frac{\partial^2 \psi}{\partial \eta^2} + \frac{1}{\xi}\frac{\partial U}{\partial \xi}\frac{\partial^2 \psi}{\partial \eta^2} + \frac{1}{\alpha^2\xi^2}\frac{\partial^2 U}{\partial \eta^2}\frac{\partial^2 \psi}{\partial \xi^2} - \frac{2}{\alpha^2\xi^2}\frac{\partial U}{\partial \eta}\frac{\partial \psi}{\partial \eta} + \frac{2}{\alpha^2\xi^2}\frac{\partial U}{\partial \eta}\frac{\partial^2 \psi}{\partial \eta\partial \xi} + \right.$$
$$\left. + \frac{2}{\alpha^2\xi^2}\frac{\partial \psi}{\partial \eta}\frac{\partial U}{\partial \eta} - \frac{2}{\alpha^2\xi^2}\frac{\partial^2 \psi}{\partial \xi\partial \eta}\frac{\partial^2 U}{\partial \xi\partial \eta}\right] + \frac{qa^4}{hD}.$$

The system will be solved by method of succesive loadings.

For each i-stage of loading with respect of $(\bar{\psi}, \bar{U})$ gradient the simultaneous equations will be as:

$$\Delta\Delta\bar{\psi}_i = -\left[\frac{1}{\xi}\frac{\partial^2 \bar{U}}{\partial \xi_1^2}\frac{\partial U}{\partial \xi_{i-1}} + \frac{1}{\xi}\frac{\partial^2 U}{\partial \xi_{i-1}^2}\frac{\partial U}{\partial \xi_i} + \frac{1}{\alpha^2\xi^2}\frac{\partial^2 \bar{U}}{\partial \xi_1^2}\frac{\partial^2 \bar{U}}{\partial \eta_{i-1}^2} + \frac{1}{\alpha^2\xi^2}\frac{\partial^2 \bar{U}}{\partial \xi_{i-1}^2}\frac{\partial^2 \bar{U}}{\partial \eta_{i-1}^2} - \frac{2}{\alpha^2\xi^4}\frac{\partial \bar{U}}{\partial \eta_i}\frac{\partial \bar{U}}{\partial \eta_{i-1}} + \frac{2}{\alpha^2\xi^3}\frac{\partial \bar{U}}{\partial \eta_i}\frac{\partial^2 \bar{U}}{\partial \xi_i\partial \eta_{i-1}} + \right.$$
$$\left. + \frac{2}{\alpha^2\xi^3}\frac{\partial \bar{U}}{\partial \eta_{i-1}}\frac{\partial^2 \bar{U}}{\partial \xi\partial \eta_i} - \frac{2}{\alpha^2\xi^2}\frac{\partial^2 \bar{U}}{\partial \eta\partial \xi_i}\frac{\partial^2 \bar{U}}{\partial \eta\partial \xi_{i-1}}\right],$$

$$\Delta\Delta\bar{U}_i = 12(1-\nu^2)\left[\frac{1}{\xi}\frac{\partial^2 \bar{U}}{\partial \xi_{i-1}^2}\frac{\partial \bar{\psi}}{\partial \xi_i} + \frac{1}{\xi}\frac{\partial^2 \bar{U}}{\partial \xi_i^2}\frac{\partial^2 \bar{\psi}}{\partial \xi_{i-1}} + \frac{1}{\xi^2}\frac{\partial^2 \bar{U}}{\partial \xi_i^2}\frac{\partial^2 \bar{\psi}}{\partial \eta_{i-1}^2} + \frac{1}{\xi^2}\frac{\partial^2 \bar{U}}{\partial \xi_{i-1}^2}\frac{\partial^2 \bar{\psi}}{\partial \eta\xi_i^2} + \frac{1}{\xi}\frac{\partial \bar{U}}{\partial \xi_{i-1}}\frac{\partial^2 \bar{\psi}}{\partial \xi_{i-1}^2} + \frac{1}{\xi}\frac{\partial \bar{U}}{\partial \xi_i}\frac{\partial^2 \bar{\psi}}{\partial \xi_{i-1}^2} + \right.$$
$$+ \frac{1}{\alpha^2\xi^2}\frac{\partial^2 \bar{U}}{\partial \eta_i^2}\frac{\partial^2 \bar{\psi}}{\partial \xi_{i-1}^2} + \frac{1}{\alpha^2\xi^2}\frac{\partial^2 \bar{U}}{\partial \eta_{i-1}^2}\frac{\partial^2 \bar{\psi}}{\partial \xi_i^2} - \frac{2}{\alpha^2\xi^2}\frac{\partial^2 \bar{U}}{\partial \eta_i}\frac{\partial^2 \bar{\psi}}{\partial \eta_{i-1}} - \frac{2}{\alpha^2\xi^2}\frac{\partial \bar{U}}{\partial \eta_{i-1}}\frac{\partial \bar{\psi}}{\partial \eta} + \frac{2}{\alpha^2\xi^2}\frac{\partial \bar{U}}{\partial \eta_i}\frac{\partial^2 \bar{\psi}}{\partial \xi\partial \eta_{i-1}} + \frac{2}{\alpha^2\xi^2}\frac{\partial \bar{U}}{\partial \eta_{i-1}}\frac{\partial^2 \bar{\psi}}{\partial \xi\partial \eta_i} +$$
$$\left. + \frac{2}{\alpha^2\xi^3}\frac{\partial^2 \psi}{\partial \eta_i}\frac{\partial^2 \bar{U}}{\partial \xi\partial \eta_{i-1}} + \frac{2}{\alpha^2\xi^3}\frac{\partial \bar{\psi}}{\partial \eta_{i-1}}\frac{\partial^2 \bar{U}}{\partial \xi\partial \xi\eta_i} - \frac{2}{\alpha^2\xi^2}\frac{\partial^2 \bar{\psi}}{\partial \xi\partial \eta_{i-1}}\frac{\partial^2 \bar{U}}{\partial \xi\partial \eta_i} + \frac{2}{\alpha^2\xi^2}\frac{\partial \psi}{\partial \eta}\frac{\partial U}{\partial \eta} - \frac{2}{\alpha^2\xi^2}\frac{\partial^2 \bar{\psi}}{\partial \xi\partial \eta_i}\frac{\partial^2 \bar{U}}{\partial \xi\partial \eta_{i-1}}\right] + \frac{qa^4}{hD}. \tag{3}$$

It is evident that

$\psi_i = \sum_{j=1}^{1-i} \bar{\psi}_i, \quad U_i = \sum_{j=1}^{1-i} \bar{U}_i$.

For separion of variables let's apply the Kantorovich-Vlasov variation method, accordingly of that $\bar{\psi}_i$ and $\bar{U}_i$ functions are presented as [23-27]:

$\bar{U}_i = \chi_i(\eta) w_i(\xi), \quad \bar{\psi}_i = \zeta_i(\eta)\Phi_i(\xi),$

where $\chi_i(\eta)$ and $\zeta_i(\eta)$ are the preliminary selected functions that meets the boundary conditions on linear sdges η=–1 and η=1. As for $w_i(\xi)$ and $\Phi_i(\xi)$, they are unknown, in general discontinuous functions that will be determined due the system of ordinary differential equation

$$a_4 \frac{d^4\Phi}{d\xi^4} + a_3 \frac{1}{\xi}\frac{d^3\Phi}{d\xi^3} + a_2 \frac{1}{\xi^2}\frac{d^2\Phi}{d\xi^2} + a_1 \frac{1}{\xi}\frac{d\Phi}{d\xi} + a_0 \frac{1}{\xi^4}\Phi + b_1 \frac{d^2 w}{d\xi^2} + b_2 \frac{dw}{d\xi} + b_3 w = 0;$$

$$c_4 \frac{d^4 w}{d\xi^4} + c_3 \frac{1}{\xi}\frac{d^3 w}{d\xi^3} + c_2 \frac{1}{\xi^2}\frac{d^2 w}{d\xi^2} + c_1 \frac{1}{\xi}\frac{dw}{d\xi} + c_0 \frac{1}{\xi^4} w - 12(a - v^2)\left[d_1 \frac{d^2\Phi}{d\xi^2} + d_2 \frac{d\Phi}{d\xi} + d_3 \Phi + g_1 \frac{d^2 w}{d\xi^2} + \right.$$

$$\left. + g_{21} \frac{dw}{d\xi} + g_3 w\right] - \frac{4\bar{q}a^4}{\pi h D} = 0, \qquad (4)$$

where

$a_4 = \int_{-1}^{+1} \zeta^2 d\eta$, $\quad a_3 = 2a_4 = 2\int_{-1}^{+1} \zeta^2 d\eta.$ $\quad a_2 = \int_{-1}^{+1} \frac{2}{a^2}(\zeta''\zeta - \zeta^2) d\eta,$

$a_1 = \int_{-1}^{+1} \left(\zeta^2 - \frac{2}{a^2}\zeta''\zeta\right) d\eta,$ $\quad a_0 = \int_{-1}^{+1} \left(\frac{4}{a^2}\zeta'' + \frac{1}{a^4}\zeta^{IV}\right) d\eta.$ $\quad b_1 = \frac{b_{21}}{\xi} + \frac{b_{22}}{\xi^2},$

$b_2 = \frac{b_{11}}{\xi} + \frac{b_{12}}{\xi^2} + \frac{b_{13}}{\xi^3},$ $\quad b_3 = \frac{b_{02}}{\xi^2} + \frac{b_{03}}{\xi^3} + \frac{b_{04}}{\xi^4};$ $\quad d_1 = \frac{d_{21}}{\xi} + \frac{d_{22}}{\xi^2};$

$d_2 = \frac{d_{11}}{\xi} + \frac{d_{12}}{\xi^2};$ $\quad d_3 = \frac{d_{02}}{\xi^2} + \frac{d_{03}}{\xi^3};$ $\quad g_1 = \frac{g_{21}}{\xi} + \frac{g_{22}}{\xi^2},$

$g_2 = \frac{g_{11}}{\xi} + \frac{g_{12}}{\xi^2} + \frac{g_{13}}{\xi^3};$ $\quad g_3 = \frac{g_{02}}{\xi^2} + \frac{g_{03}}{\xi^3};$ $\quad b_{21} = \int_{-1}^{+1} \zeta^1 \chi\left(\sum_j^{i-1} w'\chi\right) d\eta,$

$b_{22} = \frac{1}{a^2}\int_{-1}^{+1} \zeta\chi\left(\sum_j^{i-1} w\chi''\right) d\eta,$ $\quad b_{11} = \int_{-1}^{+1} \zeta\chi\left(\sum_j^{i-1} w''\chi\right) d\eta,$ $\quad b_{12} = -\frac{2}{a^2}\int_{-1}^{+1} \zeta\chi'^{\left(\sum_j^{i-1} w'\chi'\right)} d\eta,$

$b_{13} = \frac{2}{a^2}\int_{-1}^{+1} \chi'\zeta\left(\sum_j^{i-1} w\chi'\right) d\eta,$ $\quad b_{02} = \frac{1}{a^2}\int_{-1}^{+1} \chi''\zeta\left(\sum w''\chi\right) d\eta,$ $\quad b_{03} = \frac{2}{a^2}\int_{-1}^{+1} \chi'\zeta\left(\sum w'\chi'\right) d\eta,$

$c_1 = \int_{-1}^{+1} \left(\chi - \frac{2}{a^2}\chi''\right)\chi d\eta,$ $\quad c_2 = \int_{-1}^{+1} \left(\frac{2}{a^2}\chi'' - \chi\right)\chi d\eta,$ $\quad c_3 = 2c_4 = 2\int_{-1}^{+1} \chi^2 d\eta,$

$c_4 = \int_{-1}^{+1} \chi^2 d\eta,$ $\quad c_0 = \int_{-1}^{+1} \left(\frac{4}{a^2}\chi'' + \frac{1}{a^4}\chi^{IV}\right)\chi d\eta,$ $\quad d_{21} = \int_{-1}^{+1} \zeta\chi\left(\sum w'\chi\right) d\eta,$

$d_{11} = \int_{-1}^{+1} \zeta\chi\left(\sum w''\chi\right) d\eta,$ $\quad d_{22} = \frac{1}{a^2}\int_{-1}^{+1} \zeta\chi\left(\sum w''\chi\right) d\eta,$ $\quad d_{02} = \int_{-1}^{+1} \left(\zeta\chi \sum w''\chi - \frac{2}{a^2}\zeta\chi' \sum w'\chi'\right) d\eta;$

$d_{12} = \int_{-1}^{+1} \frac{2}{a^2}\zeta'\chi\left(\sum w\chi' - \sum w'\chi'\right) d\eta,$ $\quad d_{03} = \frac{2}{a^2}\int_{-1}^{+1} \zeta'\chi \sum \chi' w' d\eta,$ $\quad g_{22} = \int_{-1}^{+1} \chi^2 \sum \zeta''\Phi\, d\eta,$

$g_{11} = \frac{1}{a^2}\int_{-1}^{+1} \chi^2 \sum \Phi''\zeta\, d\eta,$ $\quad g_{11} = -\frac{2}{a^2}\int_{-1}^{+1} \chi'\chi \sum \Phi'\chi'\, d\eta,$ $\quad g_{13} = \frac{2}{a^2}\int_{-1}^{+1} \chi'\chi \sum \Phi\zeta'\, d\eta,$

$g_{02} = \int_{-1}^{+1} \left(\frac{1}{a^2} \chi'' \chi \sum \Phi'' \zeta - \frac{2}{a^2} \chi \chi' \sum \Phi \zeta' \right) d\eta, \qquad g_{03} = \frac{2}{a^2} \int_{-1}^{+1} \chi' \chi \sum \Phi' \zeta' \, d\eta.$

Due the linear edges are hingedly supported is possible to accept that:

$\zeta = \chi = \cos \frac{\pi \eta}{2},$

that provides the satisfaction of boundary conditions η=±1 on the sides. with taking into account of this we will have:

$a_4 = 1, \qquad a_2 = -\frac{2}{a^2}\left(\frac{\pi^2}{4} + 1\right), \qquad a_1 = 1 + \frac{\pi^2}{2a^2}, \qquad a_2 = +\frac{\pi^3}{4a^4},$

$b_{21} = \frac{8}{3\pi} \sum w', \qquad b_{22} = -\frac{2\pi^2}{a^2} \sum w, \qquad b_{11} = \frac{8}{3\pi} \sum w'', \qquad b_{12} = -\frac{2\pi^2}{a^2} \sum w',$

$b_{13} = -\frac{2\pi}{3a^2} \sum w \,, \qquad b_{02} = -\frac{2\pi}{3a^2} \sum w'' \,, \qquad b_{03} = b_{12} = -\frac{2}{3}\frac{\pi}{a^2} \sum w' \,, \qquad b_{04} = -b_{13} = -\frac{2}{3}\frac{\pi}{a^2} \sum w \,,$

$d_{21} = b_{21} = \frac{8}{3\pi} \sum w', \quad d_{11} = b_{11} = \frac{2}{3\pi} \sum w'', \quad d_{22} = b_{22} = -\frac{2\pi}{a^2} \sum w\,; \qquad d_{12} = -\frac{2\pi^2}{3a^2} \left(\sum w - \sum w'\right),$

$d_{02} = d_{11} + b_{04} = \frac{8}{3\pi} \sum w'' - \frac{2\pi^2}{3a^2} \sum w, \qquad d_{03} = -b_{12} = -\frac{2\pi^2}{3a^2} \sum w', \qquad C_4 = 1, \qquad C_3 = 2,$

$C_2 = -a_1 = -\left(1 + \frac{\pi^2}{2a^2}\right), \qquad C_1 = a_1 = 1 + \frac{\pi^2}{2a^2}, \qquad C_0 = a_0 = -\frac{4\pi}{a^2} + \frac{\pi^3}{4a^4}, \qquad g_{21} = \frac{8}{3\pi} \sum \Phi',$

$g_{22} = -\frac{2\pi}{3} \sum \Phi, \qquad g_{13} = \frac{2\pi}{3a^2} \sum \Phi, \qquad g_{02} = \frac{2\pi}{a^2} \sum \Phi'' - \frac{2}{3}\frac{\pi}{a^2} \sum \Phi, \qquad g_{11} = \frac{8}{3\pi} \sum \Phi'',$

$g_{12} = -\frac{2\pi^2}{3\alpha^2} \sum \Phi', \qquad g_{03} = \frac{2\pi}{3\alpha^2} \sum \Phi',$

In the both equations of (4) in order to reduce the third derivativelet's introduce the variables: $\overline{w} = \sqrt{\xi} w$ and $\overline{\Phi} = \sqrt{\xi} \Phi$, as result we eill obtain the followign simultaneous equations:

$\overline{\Phi}^{IV} = B_1 \overline{\Phi}'' + B_{12} \overline{\Phi}' + B_3 \overline{\Phi} + B_4 \overline{w} + B_5 \overline{w}' + B_6 \overline{w}'' + B_7,$

$\overline{w}^{IV}(\eta) = A_1 \overline{w}'' + A_{12} \overline{w}' + A_3 \overline{w} + A_4 \overline{\Phi} + A_5 \overline{\Phi}' + A_6 \overline{\Phi}'' + A_7,$

where

$B_1 = -\frac{1.5 + a_2}{\xi^2}; \quad B_2 = \frac{-3 - a_2 + a_1}{\xi^3}; \, B_3 = \frac{-\frac{45}{16} + \frac{3}{4} a_2 - \frac{a_1}{2} + a_0}{\xi^{42}}; \; B_4 = \left[\sum w'' \left(-\frac{4}{3\pi\xi^3} - \frac{2\pi}{3\alpha^2\xi^2}\right) + + \sum w' \left(\frac{2}{\pi\xi^3} - \frac{2\pi}{3\alpha^2\xi^3} + \frac{\pi}{3\alpha^2 4}\right) + \sum w'' \left(-\frac{3\pi^2}{2\alpha^2\xi^4} - \frac{2\pi}{3\alpha^2\xi^4} - \frac{2\pi}{3\alpha^2\xi^5}\right)\right]; \; B_5 = -\left[\sum w'' \frac{8}{3\pi\xi} + + \sum w'^{\left(\frac{8}{3\pi\xi^2} - \frac{2\pi}{3\alpha^2\xi^2}\right)} + \sum w \left(\frac{2\pi^2}{\alpha^2\xi^3} + \frac{2\pi}{3\alpha^2\xi^3}\right);\right.$

$B_6 = -\frac{8}{3\pi\xi} \sum w' + \frac{2\pi^2}{\alpha^2\xi^2} \sum w\,; \quad B_7 = 0; \; A_1 = -\left(\frac{1.5 + c_1}{\xi^2} - \frac{8\mu}{3\pi\xi} \sum \Phi' + \frac{2\pi\mu}{3\xi^2} \sum \Phi\right); \, A_2 = -\left[\frac{-3 - c_2 + c_1}{\xi^3} - \right.$ $\left. - \frac{8\mu}{3\pi\xi} \sum \Phi' + + \left(\frac{8\mu}{3\pi\xi^2} + \frac{2\pi\mu}{3\alpha^2\xi^2}\right) \sum \Phi' + \left(\frac{2\pi\mu}{3\xi^3} - \frac{8\mu\pi}{3\alpha^2\xi^3}\right) \sum \Phi\right]; \, A_3 = -\left[\frac{\frac{75}{16} - 0.75 c_2 - 0.5 c_1 + c_0}{\xi^4} + \left(\frac{4\mu}{3\pi\xi^2} - \frac{2\pi\mu}{\alpha^2\xi^2}\right) \sum \Phi'' + \left(\frac{2\mu}{\pi\xi^3} + \frac{\pi\mu}{3\alpha^2\xi^3} + + \frac{2\pi\mu}{3\alpha^2\xi^3}\right) \sum \Phi' + \left(\frac{0.5\pi\mu}{\xi^4} + \frac{\pi\mu}{3\alpha^2\xi^4} + \frac{2\pi\mu}{3\alpha^2\xi^2}\right) \sum \Phi\right]; \, A_4 = \frac{8\mu}{3\pi\xi} \sum w' - - \frac{2\pi^2\mu}{\alpha^2\xi^2} \sum w\,;$

$A_5 = \frac{8\mu}{3\pi\xi} \sum w'' + \left(-\frac{8\mu}{3\pi\xi^2} + \frac{2\pi\mu}{3\alpha^2\xi^2}\right) \sum w' + \left(\frac{2\pi^2\mu}{\alpha^2\xi^2} - \frac{2\pi\mu}{3\alpha^2\xi^3}\right) \sum w\,; \; A_6 = \frac{4\mu}{3\pi^2\xi^2} \sum w'' + + \left(\frac{2\mu}{\pi\xi^3} - \frac{\pi\mu}{3\alpha^2\xi^2} + \frac{2\pi\mu}{3\alpha^2\xi^2}\right) \sum w' + \left(\frac{3\pi^2\mu}{2\alpha^2\xi^4} + \frac{\pi\mu}{3\alpha^2\xi^3} - \frac{2\pi\mu}{3\alpha^2\xi^2}\right) \sum w\,; \, A_7 = \frac{4\bar{q}a^4}{\pi h D} \sqrt{\xi}.$

Thus for consideration of large displacements of curvilinear plate is possible to apply the developed for orthogonal plate algoritmns and program if in it will be properly substituted the coefficients of simultaneous differential equations by states ones

3. Conclusions

In the case of discontinuous loading with taking into account the geometrical non-linmearity, for depressed cylindrical shell are constructied the curves that gives the possibility to select the curvature radius of structure accordingly of preliminary stated stiffness.

For the depressed shells with disconituous parameters is outlines the class of boundary tasks, for that is possible to take into account of shear deformation without increasing in decisive simultaneous equations order.

For the transversal isotropic geometrically non-linmear shells the known system of decisive differential equations is written down with taking into account of anisotropy.

At settlement of simply supported non-loaded structure support the maqsimal bending moment new have on support and it is linearly dependent on value of settlement.

In the loaded structure the dependence of maximal bending moment with respect of settlemen is non-linear.

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CHEMICAL MODIFICATION OF KUCHAK PUMICE DEPOSIT SURFACE

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Keywords: Pumice, surface modifier, modification, sodium organosiliconate, watersorption capacity, oil sorption capacity, sodium methylsilliconate

Abstract. Modified sorbents are widely used in water treatment processes. In this article the process of surface chemical modification of Kuchak pumice deposit which is located in the Republic of Armenia with grain sizes from 2.5 to 5 mm is presented. Kuchak pumices are natural materials which are non-toxic in water. Sodium methylsiliconate is used as a modifier. The results of surface modification have been confirmed by IR spectroscopy method. The properties of the modified materials have been determined by means of sorption test. As a result of modification, the surface of the sorbent is hydrophobized, resulting in water sorption capacity decrease in 60% - 65%, oil sorption capacity increase in average from 25 to 30%.

1. Introduction

Oil spill pollution refers to the negative polluting effects that oil spills have on the environments and living organisms, including humans, due to the environmental discharge of various organic compounds that make up crude oil and oil distillate products, the majority of which include various individual hydrocarbons and petroleum. Aromatic hydrocarbons (PAHs) are an important class of the persistent organic pollutants (POPs) containing two or more fused aromatic rings of carbon and hydrogen atoms that are commonly found in the environment. POPs are long-lived organic compounds and originate almost entirely from anthropogenic activities such as chemical industry, combustion, and agriculture [1-3]. In the modern context of advanced and developing industrialization, petroleum products and their derivatives constitute one of the major sources of environmental pollution. During the extraction, transport, distribution and storage of crude oil and its products, these may be released into the environment in an uncontrolled manner, causing pollution of the atmosphere, lithosphere, hydrosphere and biosphere [4-6].

Currently, many oil sorbents for water surface clean up are produced and applied. The latter are either natural or artificial origin. Taking into account a number of advantages of natural materials, the availability of sufficient quantity of raw materials and non-toxicity, it is more appropriate to use sorbents on a natural base. In order to increase the efficiency of the latter, extensive efforts has been exerted in the direction of surface modification of the sorbents in the last years [7, 8].

2. Materials and methods

In this article Kuchak pumice deposit is used as an oil sorbent. The pumices on the territory of the Republic of Armenia according to their petrographic, physical and mechanical characteristics are divided into two types: Ani and lithoidal types. Kuchak pumice is one of Ani type pumice varieties.

It is located at an altitude of 2050 meters above sea level. On the southern side of the pumice deposit there is a powerful layer of pumice grains with a capacity of 6 ... 7 m and pumicite with a capacity of 4 ... 6 meters.

These include volcanic black sand, glacial sediment and a little to west, under the mighty soil layer, there is an approximately six-meter layer of pumice sand and pimmocite.

The average thickness of the layer is three meters and the useful surface is 400000 m^2. Studies have shown that the pumice is composed of alumicillicates in which the alkali oxide content varies from 1.5 to 5%, SiO_2 from 71% to 75%, and Al_2O_3 from 12% to 14%.

In the Kuchak pumice deposit used samples, the content of alkaline oxides varies from 0.03 to 0.1%, SiO_2 from 70% to 73% and Al_2O_3 from 12 to16% [9]. The analysis of the data obtained shows that the Kuchak pumice deposit is environmentally safe and is a chemically neutral silicate rock in water medium [10]. Organosiliconate has been used for the modification of the pumice surface [11]. Chemical modification of the surface of the sorbent has been accomplished by sodium organosiliconate having the following general formula: HO [RSi (OMe) O] nH (where n = 3/16, Me-Na; R-CH3, C2H5, CH2 = CH, CH2 = CHCH2, etc.). *CH_5NaO_3Si* has been used as a modifier in the process of modification.

Before modification, the pumice is dried in a furnace at a temperature of 1150 ° C for 2 hours. The optimal concentration of the modifier is determined experimentally. The water emulsion of the modificator is heated to 50 ° C and then added to the pumice. To remove the excess water, the sorbent has been heated for 8 hours from t = 120 to 1500 ° C. The sorbent obtained hydrophobic properties. The structure of modified and non- modified pumices were *determined by* Specord 75 IR spectrophotometer. after 24 ... 48 hours.

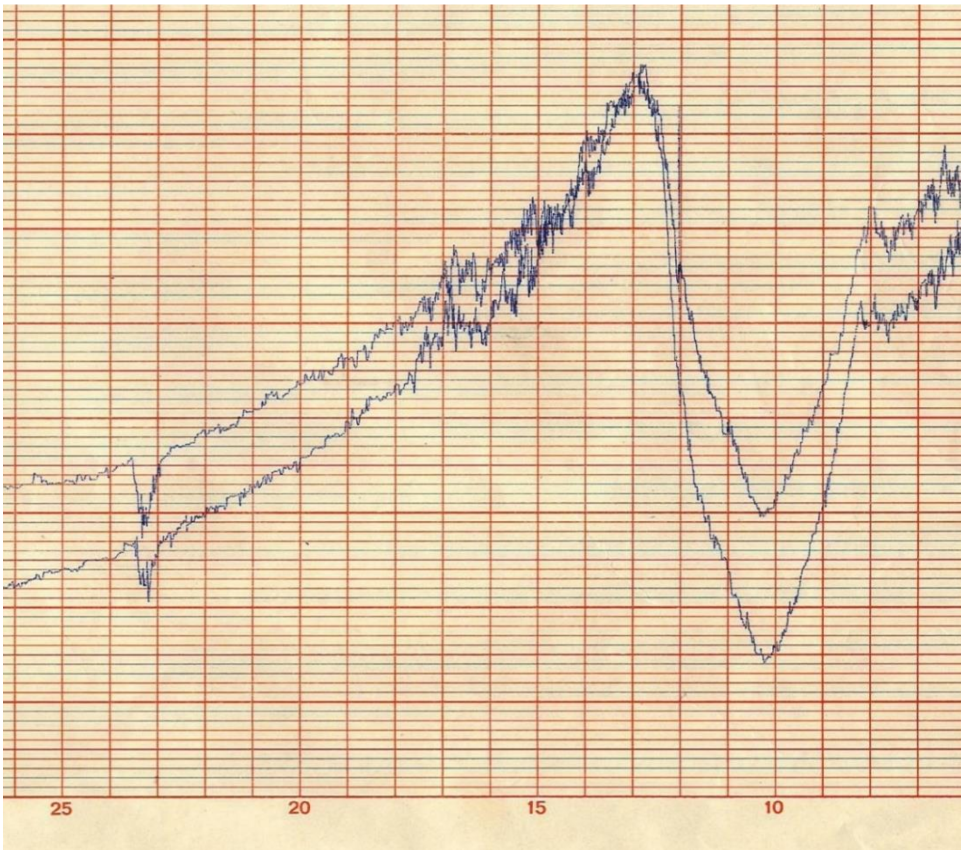

Fig.1. Kuchak pumice modified surface IR Spectra

The upper curve is the spectrum of the pumice surface before modification, and the lower curve is the spectra of the pumice surface after modification.

The absorption frequency of 1550 cm $^{-1}$ characterized the stretching vibrations of C = C-H bonding.

The study of two spectra shows that the molecules of the modifier are adsorbed on the pumice grains.

3. Results and discussion

The modification of pumices using organic compounds influences their sorption abilities towards oils in various ways, depending on the essential properties of the mineral (its type, surface area, etc.), on the properties of the organic compound (the length and multiplicity of an organic chain), and lastly on the process and efficiency of the incorporation of the organic compound into the pumice structure. This is due to the fact that the hydrophilic properties of the surface of pumice change to hydrophobic, and the interlayer spaces within the structure of these minerals increase as a result of organic compound incorporation. This kind of surface modification blocks the pores of pumice, thus reducing their specific surface area and limiting the access of oil into the pores [4].

Kuchak pumice have *a porosity* of 1.64 to 32.70 µm.

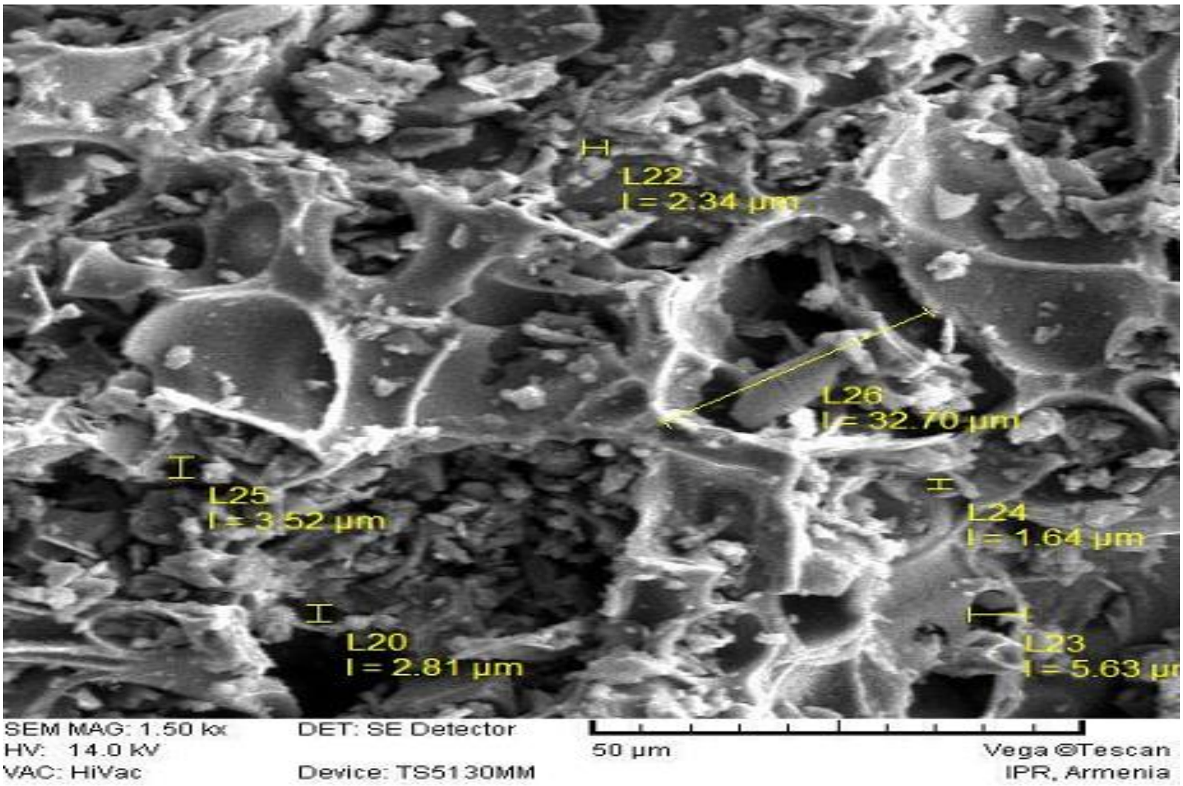

Fig.2. Pore sizes of Kuchak pumice deposit from 1.64 to 32.70 µm [10]

The data of water and oil sorption capacities before and after the surface modification of 2.5 to 5.0 mm pumice grains are presented below (Table 1-4).

Table 1. Water sorption capacity after modification

N	Water sorption capacity before modification			Water sorption capacity after modification		
	[*min*]	Purification degree. [%]	Sorption capacity. [*g/g*]	[*min*]	Degree. [%]	Sorption capacity. [*g/g*]
1.	15	100	1,00	15	25	0,25
2.	30	120	1,20	30	28	0,28
3.	60	100	1,00	60	24	0,24
4.	90	110	1,10	90	27	0,27
5.	120	110	1,10	120	27	0,27

Table 2. Machine oil sorption capacity

N	Machine oil sorption capacity before modification			Machine oil sorption capacity after modification		
	[*min*]	Purification degree. [%]	Sorption capacity. [*g/g*]	[*min*]	Purification degree. [%]	Sorption capacity. [*g/g*]
1.	15	42	0,42	15	72	0,72
2.	30	45	0,45	30	75	0,75
3.	60	44	0,44	60	74	0,74
4.	90	58	0,58	90	74	0,74
5.	120	58	0,58	120	71	0,71

Table 3. Transformer oil sorption capacity

N	Transformer oil sorption capacity before modification			Transformer oil sorption capacity after modification		
	[*min*]	Purification degree. [%]	Sorption capacity. [*g/g*]	[*min*]	Purification degree. [%]	Sorption capacity. [*g/g*]
1.	15	41	0,41	15	65	0,65
2.	30	43	0,43	30	64	0,64
3.	60	50	0,50	60	65	0,65
4.	90	61	0,61	90	63	0,63
5.	120	62	0,61	120	64	0,64

Table 4. Kerosene sorption capacity

N	Kerosene sorption capacity before modification			Kerosene sorption capacity after modification		
	[*min*]	Purification degree. [*%*]	Sorption capacity. [*g/g*]	[*min*]	Purification degree. [*%*]	Sorption capacity. [*g/g*]
1.	15	42	0,42	15	71	0,71
2.	30	44	0,44	30	74	0,74
3.	60	43	0,43	60	71	0,71
4.	90	58	0,58	90	70	0,70
5.	120	58	0,58	120	70	0,70

Studies have shown that transformer oil sorption capacity has the maximum value at 120 minutes and is 0.58 g / g.

4. Conclusions

According to the results of this work it was found that after chemical treatment of the Kuchak pumice deposit surface with sodium methylesiliconate the surface gained hydrophobic properties. The modification of pumices using organic compounds influences their sorption abilities towards oils in various ways, depending on the essential properties of the mineral (its type, surface area, etc.), on the properties of the organic compound (the length and multiplicity of an organic chain), and lastly on the process and efficiency of the incorporation of the organic compound into the pumice structure. This is due to the fact that the hydrophilic properties of the surface of pumice change to hydrophobic, and the interlayer spaces within the structure of these minerals increase as a result of organic compound incorporation. This kind of surface modification blocks the pores of pumice, thus reducing their specific surface area and limiting the access of oil into the pores As a result the sorbent surface was modified, after which it obtained hydrophobic properties, resulting in water sorption decrease from 60 to 65 %, oil sortion capacity increase in average from 25 to 30 %.

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THEORY OF SEISMIC SUSTAINABILTY

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Keywords: Sustainability; rocking; collapse prevention; stiffness reduction; re-centering; repairability

Abstract. This paper peruses two complementary purposes. First, to link Performance Based Seismic Design (PBSD) to Performance Control (PC) with a view to Post-Earthquake Realignment and Repairs (PERR), and then to discuss the applications of new technologies that help achieve Seismic Sustainability (SS) for Earthquake Resisting Structures (ERS). SS involves two facets, theoretical development and physical functionality. Post-earthquake Global Stiffness Reduction (GSR) and Restoring Force Adjustment (RFA) are innovative technologies that have been devised to achieve SS through PC. While there is abundant data on element design for ERS, such as energy absorbing devices, rocking cores, etc., there is little to no information on PERR of complete buildings equipped with such components. SS is a concept that requires a thorough understanding of the mechanics of Collapse Prevention (CP) and PERR. In PERR the resilience of the gravity and nonstructural systems are as relevant as that of the ERS and the nature of the restoring forces are as important as those generated by the earthquake. A new archetype with supporting details has been presented.

1. Introduction

The use of replaceable earthquake resisting devices can be effective if the structure is free from unaccounted stiffnesses, residual effects, is designed to sustain limited damage and to realign itself after earthquakes, otherwise no meaningful repairs can take place [1,2]. Figs. 1(a) and (b) summarize the intent of the conceptual developments presented in this paper. Fig.1 (a) depicts the half cycle response of an idealized, elastic perfectly plastic structure under monotonically increasing lateral forces. Fig. 1(b) demonstrates that PBSD can be extended to forward looking design strategies such as damage control, physical CP and PERR. Here, the plastic plateau, segment bc, is looked upon as the energy absorbing region where CP is achieved, segment cd is viewed as the unloading stage of the seismic event and segment def is regarded as the post-earthquake re-centering path of the system. The residual moment at the end of the half cycle, point f, may be interpreted as the magnitude of the minimum force needed to realign the structure after the quake has subsided. The linear segment 0ab (shown in blue) signifies the elastic response range of the system, designed by PBSD from zero to incipient collapse at c. In Fig.1 ϕ_y , $\phi_{res.}$ and ϕ_u represent the yield, residual and the maximum anticipated drift ratios respectively.

The multilinear plot bcdef (drawn in red) highlights PC as physical actions that lead to PERR. The effect of the $P\delta$ moment can be shown by the black dashed line 0g as a phantom element, with negative stiffness. Fig. 1(a) also indicates that even if CP is achieved (segment bc) the structure will still retain residual deformations and that the force needed to re-center the system, point f, may be larger than $(-M)$. This is a hint that global strength and stiffness are interdependent quantities which may be manipulated to achieve PERR. Fig. 1(b) suggests that the global stiffness of the system can be reduced to zero by removing the Replaceable Energy Dissipating Moment Connections (REDMCs) of Fig. 8(a), at the end of the earthquake, (line d0). Two types of re-centering operations can be used for PERR purposes; Forced Re-centering as in Fig. 1(a), where the initial restoring moment is larger than the global moment of resistance of the ERS, and Assisted Re-centering as in Fig. 1(b) where the magnitude of the initial restoring moment can be reduced through preplanned GSR and RFA. Fig. 1(b) shows that re-centering of a simple MF, e.g., Figs. 3(c) or 4(a), can take place if the global stiffness K_f of the system is reduced to zero by removing all four sets of damaged flange plates.

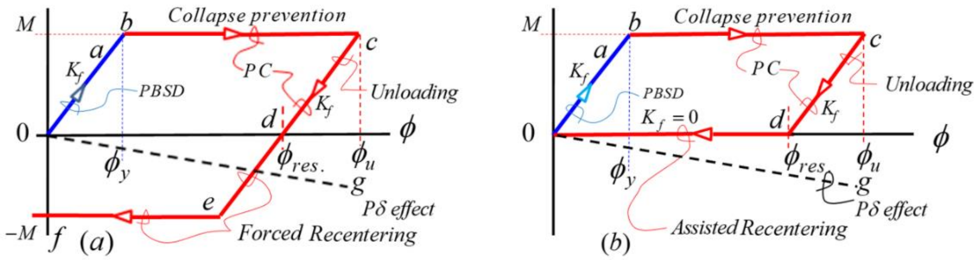

Fig. 1.(a) PBSD extension to PC, forced recentering, (b) Recentering by GSR, and replaceable fuses

2. Development of the PBSD-PC Methodology

Current building codes do not address SS. However, if SS is also stipulated, then physical CP, re-centering and low cost PERR should also be considered. Amongst most recently developed archetypes, RCMFs and MF+Buckling Restrained Brace (BRB) combinations, e.g., Fig. 2, where the proposed methodology CP is achieved by preventing the activation of failure mechanisms [3]. PERR takes place against the same mechanisms with minimal resistance rather than by overwhelming preloading and resilience against large concentrations of plastic strains. Damaged parts are replaced rather than repaired. An exact, short cut solution based on equivalent SDOF model, Fig. 3(a) or 9(a) is presented. It is shown that the proposed archetype is structure of minimum weight and lends itself well to PERR.

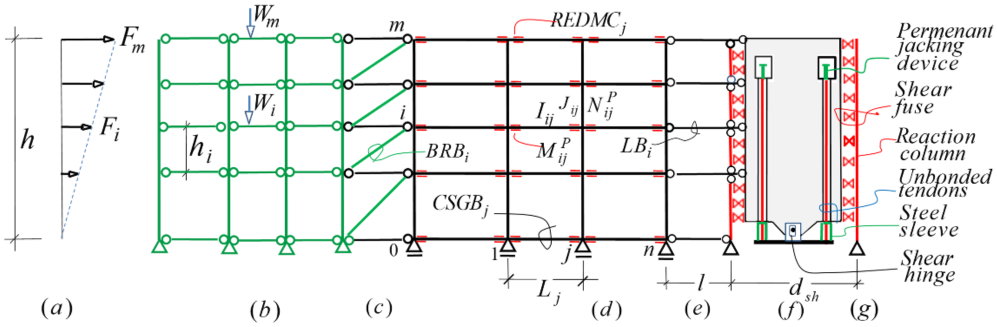

Fig. 2. (a) Lateral (b) Gravity frame, (c) Link beams (LBs), (d) MF with REDMCs and grade beams, € BRBs+ LBs, (f) RRC+ stressed tendons and steel sleeves, (g) Vertical supports for energy dissipating shear links.

3. Performance Control-The basic concept

PC was originally devised to study the mechanics of free standing MFs of Uniform Response (MFUR) and Uniform Shear (MFUS) under seismic conditions [4]. MFUR and MFUS are weight optimized lateral resisting frames in which story level drift is constant along the height of the structure and members of similar groups such as beams, columns and braces share the same demand-capacity ratios regardless of their location within the group. MFUS are special cases of MFUR where seismic shears are constant along the height of the structure. Therefore, PC may be regarded as the ability to design a structure in such a way as to expect predetermined modes of response at all stages of seismic loading, unloading, re-centering, extents of damage and means of repairs. Performance levels, failure mechanisms and stability conditions are enforced rather than tested. Unlike traditional design procedures, PC enables the designer to control the response of purpose-specific structures at preselected performance stages such as before and at first yield, any fraction of the failure load, specified drift ratios up to and including incipient collapse as well as PERR. It looks at seismic performance levels from both theoretical as well as physical control points of view, rather than investigative analysis.

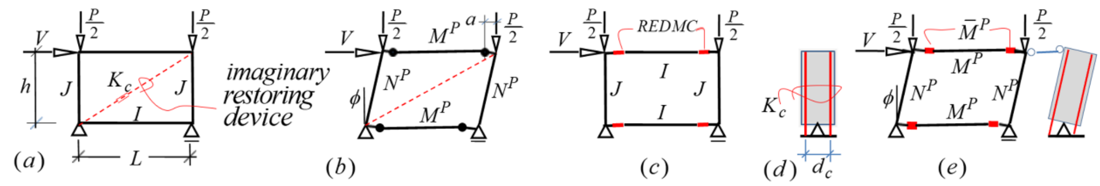

Fig.3. (a) MF, (b) Failure mode of (a), (c) MF with REDMCs, (d) RRC, € MF-RRC at failure

The quarter cycle or multilinear graph 0abcdef of the original frame, Fig. 1(a), indicates that a minimum restoring moment of magnitude $(-M)$ is needed to re-center the system while leaving a residual moment of the same magnitude within the structure, with the obvious conclusion that the stronger and stiffer the structure the larger the restoring forces needed to realign it to its original position, an important consideration that has to be taken into account if PERR were to be considered. The $P\delta$ moment reduces the global resistance of the structure to $[4 f_{cr} M^P / (1-\alpha)]$ and increases the magnitude of the restoring moment from $(-M)$ to $-[M+(\phi_u - 2\phi_y)K_{P\delta}]$. Note that the magnitude of the post-earthquake restoring moment needed for realignment can be larger than the original seismic moment M. A rational way to reduce the magnitude of the restoring moment to a practical level is to deploy the GSR and RFA technologies. Several parametric examples have been provided to demonstrate the safety, simplicity, economy and efficiency of the proposed GSR and RFA techniques.

4. Example 1- Introduction to GSR+RFA by removing repairable parts one at a time

Consider the sequential response of the single loop MF of Fig. 3I or 4(a), with no initial restoring force, equipped with REDMCs, similar to Fig. 8(a), with no crisscrossing tendons. $\bar{M}^P$ is the reduced plastic moment of resistance of the proposed REDMCs, such that $0 < \bar{M}^P \le M^P$. Fig.4 illustrates the sequential PC of the subject MF under lateral loading. and the steps involved in controlled GSR, produced by removal of all damaged flange plates one at a time. M_f^R and $K_{f,r}$ represent the ultimate moment of resistance of the MF and the corresponding stiffness of the weakened structure during the re-centering process. The suffix r in $M_{f,r}^R$ or $K_{f,r}$ relates the quantity to the r number of remaining intact plastic hinges.

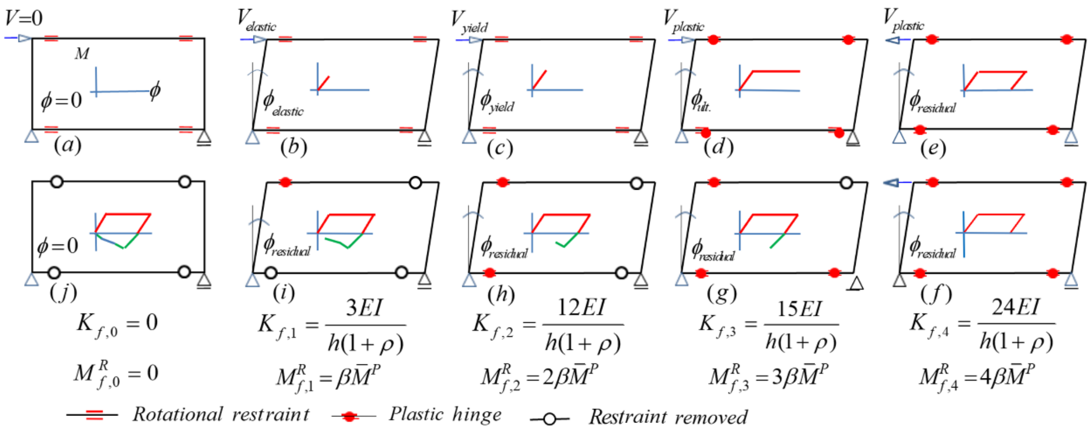

Fig.4. (a) MF, (b) Elastic, (c) First yield, (d) Plastic, I Unloading, (f) Unloaded, (g) 1 pair of flanges removed, (h) 2 pairs of flanges removed, (i) 3 pairs of flanges removed, (j) All flanges removed.

Fig. 5(a) portrays the individual responses of the MF (shown in red), the restoring device (shown in blue) and the $P\delta$ element (shown in green) to the same scale. The magnitude of the restoring moment is expressed as $M_t^R = M_{t,0} + K_c\phi$. The distinction between the normal (red dotted line) and reduced stiffness (red solid line) paths of the re-centering operation is clearly illustrated in Fig. 5(a). The return cycle of the MF, in the negative quadrant of Fig. 5(a), describes the effects of the one by one removal of the flange plates on the deformations of the structure. Note that the $P\delta$ effect tends to reduce the global stiffness of the structure during the loading phase and increase the same during the recentering process. This phenomenon is illustrated in Fig. 5(b) where the flag shaped dashed line represents the combined response of the system to all three effects. However, if CP is to be achieved then the inequality $M^R_{f,4} + (M_{t,0} + K_c\phi_u) > M_o + K_{P\delta}\phi_u$ should be satisfied. Similarly if re-centering is to take place at any stage r, in a safe and controlled manner, then the corresponding initial restoring moment should be larger than the global strength of that stage, i.e. $M^R_{t,0,r} > M^R_{f,r}$ and that $M^R_{t,0,r} + K_c\phi > K_{P\delta}\phi$ for all ϕ. The challenge for the assisted re-centering case, $M^R_{t,0,r} < M^R_{f,r}$, is to either increase $M^R_{t,0}$ up, by RFA or to reduce $K_{f,r}$ through GSR, down to the desired level.

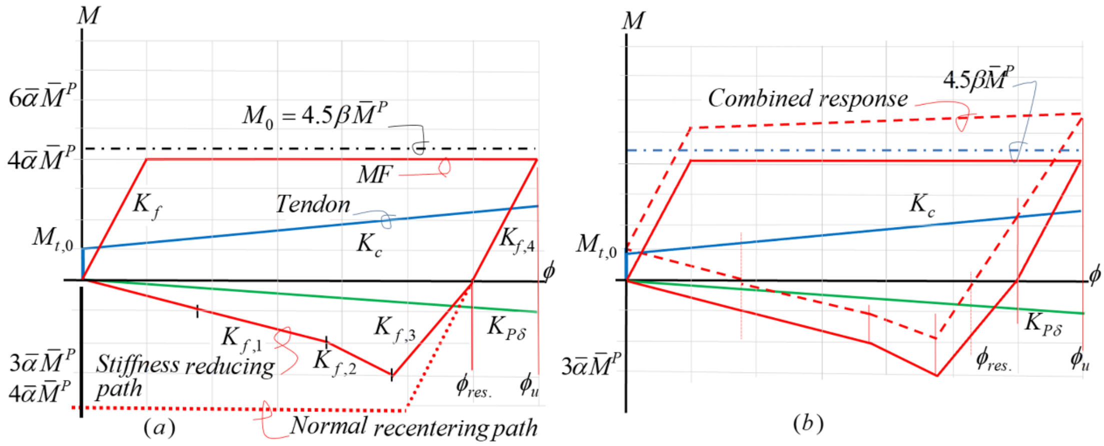

Fig.5. Example 1 (a) Individual responses of MF, M_t^R and $P\delta$, (b) Combined system response

5. Assisted re-centering by means of GSR

Fig. 6 demonstrates an attempt to elevate the performance level of the subject MF to SS, without resorting to RFA. Three conditions; $M^R_{t,0} > M$, $M^R_{t,0} = 0$ and $M^R_{t,0} < M$ have been considered. Fig. 6(a) shows the combined (line 0ghijkl) and individual responses of the MF (line 0abcde), the restoring force Assisted re-centering with small pre-tension, $M_{t,0} < M$ (line 0gm) and the $P\delta$ moments (dashed line 0f) during and after a predicted seismic event have been plotted to the same scale. Note that the restoring force (device1+2, line 0gm) could be representing the sum of restoring forces of devices 1 and 2 (the green lines). The flag shaped response plot (red dashed line 0ghijkl) suggests that re-centering can be achieved if the originally designed restoring force $M^R_t = M_{t,0} + K_c\phi$ is fully activated during and at the end of the seismic cycle. Inevitably, the restoring force needs to be larger than the ultimate capacity of the MF, a condition that poses complicated design challenges and leads to additional construction costs. However, the shape of the MF plot (0abcde) suggests the existence of alternative re-centering paths (red dashed line $0a'b'c'0$) of Fig.6 (b) and (red dashed line $0a'b'c'0$) of Fig. 6(c), associated with certain physical conditions that require a smaller restoring force with little to no preloading and zero residual effects. For instance, if $M_{P\delta} = M^R_t = 0$ then the residual deformations can be estimated as $\phi_{res.} = (\phi_u - \phi_y)$.

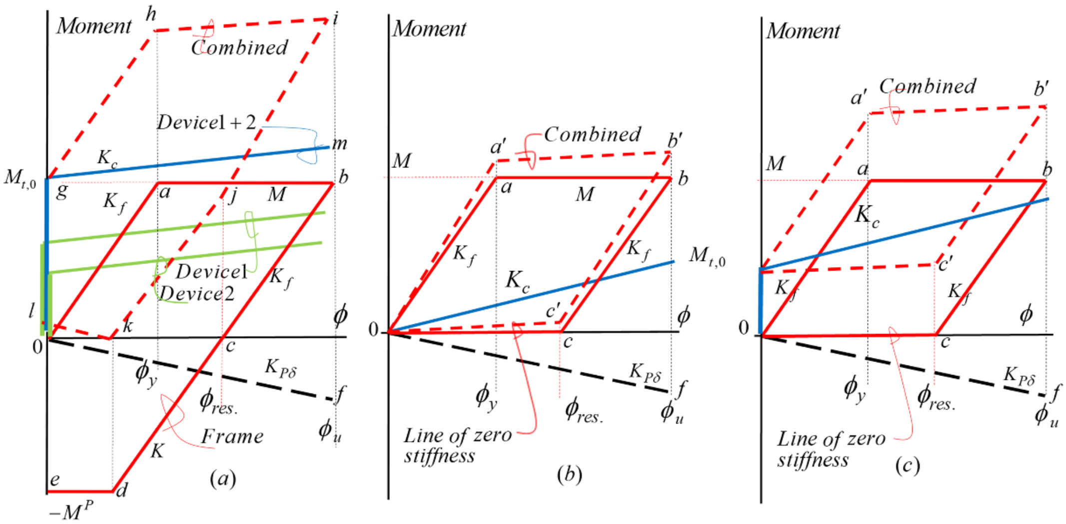

Fig.6. (a) Forced re-centering MF, $M_{t,0} > M$, ***(b) Assisted re-centering with no pre-tension,*** $M_{t,0} = 0$, ***(c) Assisted re-centering with small pre-tension,*** $M_{t,0} < M$

In other words, if the global stiffness of the MF is reduced to zero by removing all flange plates after unloading then no restoring moment other than that required to counter the $P\delta$ effect would be needed to realign the system. Since the only external moment acting on the articulated MF after unloading is that due to the $P\delta$ effect, then the minimum force needed to activate the restoration process can be computed as $M^R_t \geq P\phi h$. The flag shaped dotted plot of Fig. 6(b) shows that a much smaller restoring force can be utilized to realign the structure, with zero residual effects, provided that the system is strong enough to resist the prescribed seismic forces. Fig.6(c) presents a more favorable alternative to strategies 6(a) and 6(b), where realignment is achieved by means of smaller preloading. The restoration parameters $M_{t,0}$ and K_c for all three cases 6(a, b and c) can be computed using the simple formulations outlined in Examples 1 and 2 above.

6. Special conditions

Unlike traditional methods of design and construction, SS involves three distinct but interrelated stages of response. First, the structure is designed to sustain seismic damage in the form of large residual strains, without falling apart. Next, the system is anticipated to remain stable against accidental lateral forces., during the post-earthquake period needed to mobilize the recentering effort. For the last instance, the system is designed to overcome large residual forces that in many cases may exceed that of the original design level earthquake. To address these issues in a practical manner, two areas of detailing concerns have been identified;

a-Special Items-These include partition walls, infills, facades, stairways, escalators, utility shafts, life lines, ductworks, mechanical equipment, suspended ceilings and similar items that should be secured in place in such a way as not to contribute to seismic resistance nor hinder the realignment process.

b-Special systems and devices that are needed to PERR during loading, unloading, rest and reloading phases. These include the RRCs, LBs, REDMCs, Buckling restrained braces (BRBs), Shear fuses (SFs), etc. The characteristics of the special devices incorporated in the construction of the proposed archetype have been summarized below.

Shear fuses–The proposed archetype is capable of supporting different types of energy dissipating devices including rows of SFs and friction grip plates. SFs are usually made out of high strength, ductile, rectangular plates welded or bolted to two rocking, parallel vertical runners as in Fig. 2(g). Assuming an elastic-perfectly plastic mode of response for each generic unit displayed in Fig. 2(g), i.e. $\phi = f_{sf} / k_{sh}$, where f_{sf} is the carrying capacity of each set of SFs per floor for each supporting column then the total resistance or vertical reaction per column can be computed as $F_{sf} = (m+1) f_{sf}$. The Butterfly shear fuses have been tested successfully amongst others [5]. And if the horizontal distance between the two columns is d_{sh} then the total moment of resistance of the SF system can be estimated as $M_{sf} = F_{sf} d_{sh} = (m+1) d_{sh} k_{sh} \phi = K_{sh} \phi$ or

$$\phi = \frac{M_{sf}}{K_{sh}} \tag{1}$$

Buckling restrained braces–BRBs are pin ended members that can withstand relatively large strains without buckling and are normally used as parts of earthquake resistant braced frames, as in Fig. 2I. Here, BRBs are used to reduce seismic demand on the MF, increase overall damping and possibly prevent plastic collapse. BRBs can be utilized effectively in conjunction with GSR and RFA operations to assure PERR. The purpose of this section is to assess the contribution of the BRBs of Fig. 2I to the global strength and stiffness of the subject archetype. The braced frame undergoes the same uniform drift ϕ as the rest of the structure. Therefore the axial deformation, $\Delta_{b,i}$ and the corresponding resistance, $C_{b,i}$ of the i^{tch} level BRB in terms of drift ϕ can be expressed as $\Delta_{b,i} = \beta \phi h_i l / \bar{L}_i$ and $C_{b,i} = \Delta_{b,i} A_{b,i} E_b / \bar{L}_i = \beta \phi h_i l A_{b,i} E_b / \bar{L}_i^2$ respectively, $\bar{L}$ is the length of the BRB. $\beta = l / (l - 2d)$, and d is the depth of the adjoining columns. The moment of resistance of the braced frame can be expressed as $M_b = F_b h$, where $F_b = C_{b,m} l / \bar{L}_m$ is the roof level brace resisting force, i.e.,

$$\phi = \frac{M_b}{K_{br}} \tag{2}$$

$K_{br} = \bar{L}_m^3 / A_{b,m} E_b \beta h_m^2 l^2$, can be interpreted as the rotational stiffness of the braced frame. Since the force along the height of the braced frame is constant, then $C_{b,i} = (\bar{L}_i / \bar{L}_m) C_{b,m}$, and the optimized cross sections $A_{b,i}$ can be related to say the roof level cross section $A_{b,m}$, thus $A_{b,i} = (\bar{L}_i / \bar{L}_m)^3 (\alpha_m h_m / \beta_i h_i) A_{b,m}$.

Link beams- LBs are pin ended, axially rigid collectors that have been designed to transfer seismic forces from the MF and the gravity structure to the RRC, Fig. 7. They are designed to remain elastic throughout the history of loading of the structure. Both ends of the proposed link beam have been truncated to avoid full contact between the ends of link and the adjoining columns Four types of interactive conditions between the RRC, the LBs and the floor beams with REDMCs can be expected;

1-LBs with no tendons, no interaction takes place. Floor beam tendons are anchored at far sides of both end columns. **2**- LBs with parallel tendons extended from the common columns with the floor beams and anchored within the RRC. No tension is developed in the tendons due to equal opening and closing of consecutive gaps. No interaction takes place. **3**- LBs are equipped with crisscrossing tendon profiles and act as natural extensions of the floor beams. The multi span tendon system generates resisting/restoring moments equal to $M_t = T_t d_{t,lb}$ at both anchored ends. The resulting moment is influenced by as many pairs of gap openings as there are continuous spans, including the LB. The RRC side moments directly reduce the global moment demand on the entire structure, whereas the far side moments tend to deform the MF in an opposing sense to those caused by seismic forces. **4**- LBs are equipped with crisscrossing tendon profiles that are anchored at far sides of the adjoining RRC and the steel column. Beam tendons do not extend into the LBs.

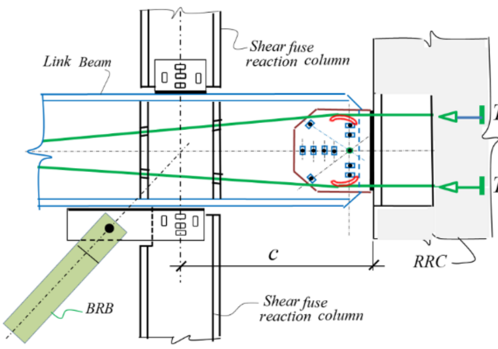

Fig.7. Steel LBs with optional stressed tendons and different boundary supports (details not shown)

The independent, single span tendon system also generate equal anchorage moments and as in condition 3, the RRC side moments directly reduce the global moment demand on the system, whereas the far side moments tend to deform the MF in an opposing sense to those caused by seismic forces. Unlike case 3, M_t moment is influenced by only one pair of gap openings. Condition 4 is discussed at some length in this section. If T_0 stands for initial tension, then two limiting conditions for the two tendons can be expected, $T_t = (1+\delta^T)T = \mu T$ in the range $0 < T_i < T_0$ where $\delta^T = 1$ and $\mu = 2$, both tendons remain taut, $T_t = (1+\delta^T)T = \mu T$ in the range $T_i > T_0$ where $\delta^T = 0$ and $\mu = 1$, one of the two tendons slacken. Condition $T_0 = 0$ is not desirable. Provided that neither decompression nor overextension takes place, the relationship between the gap opening end moments and the equivalent rotational stiffness of the proposed LBs, with discontinued tendons beyond the steel column can be expressed as $\varphi = \mu M_{t,lb} / K_f$. Since $\phi = M_{t,lb}(l / \mu\beta d_{t,lb}^2 A_t E_t) = M_{t,lb} / \mu K_{t,lb}$ where $M_{t,lb} = T_t d_{t,lb}$ and $\beta = L/(L-a-b)$, then $\varphi = M_{t,lb} / K_f = \mu K_{t,lb}\phi / K_f$. It has been shown that the drift reduction on the equivalent module due to frame side moments $M_{t,lb}$, can be computed as;

$$\psi = \frac{(2M_{t,lb})L}{24EI} = \frac{\mu K_{lb}\phi L}{12EI} = \mu\bar{K}_{lb}\phi \tag{3}$$

where $\bar{K}_{lb} = (\beta A_{lb} E_t d_{lb}^2 L_b / 12EIl)$ is the characteristic parameter of the LB. Note that both φ and ψ, are directly related to ϕ, and that the net effect of the LB moments on the combined structure, in the absence of other devices, can be computed as;

$$\phi = \frac{M_0 + M_{P\Delta} - 2M_{t,lb}}{K_f} - \psi = \frac{M_0}{[(1+\mu\bar{K}_{lb})K_f - K_{P\Delta} + 2\mu K_{lb}]} \tag{4}$$

The importance of initial tension T_0, as represented by μ, is clearly reflected in (8) and (9). As plasticity propagates and the relative stiffness I/L of the beams become zero, (8) reduces to;

$$\phi = \frac{M_0^P}{4\mu K_{lb} - K_{P\Delta}} \tag{5}$$

Condition 3 is the preferred case for safer PERR operations and is studied as part of development of earthquake resisting beams with REDMCs discussed in forthcoming sections of this article.

7. Development and Description of the REDMC

The proposed **REDMCs** of Fig. 8(a) is devised to dissipate seismic energy, control locations of plastic hinges, prevent damage to the beam, help prevent collapse and re-center the structure after removing the damaged flange plates. The beam system consists of prequalified beam-column connections, code compliant beam sections, repairable splice joints and a pair of crisscrossing, continuous, preloaded tendons with optional turnbuckles. In order to prevent loss of tension due to equal gap opening and closing along the same horizontal line X shape tendon profiles have been used in lieu of the parallel option. Once the distance a is established, the minimum initial flange gap g, can be determined in such a way as; to allow free rotation of the joint $\psi = \beta\phi$, where ϕ is the maximum plastic drift of the system, i.e. $g \geq \beta\phi d_b / 2$ .The splice joint consists of a pair of replaceable, reduced section, perforated, or prismatic flange plates and a shear tab with elongated holes at right angles to the radii of the center of rotation. The stub joint and the rest of the beam are designed to remain elastic while the flange plates develop their full plastic moments of resistance. Two small U-bolts prevent the premature buckling of the flange plates. The U-bolts can be eliminated if the slenderness ratio of the flange plates is limited to $Kl_p / r \leq 20$, where l_p is the distance between the first rows of the bolts on either side of the splice gap.

The flange plates are designed to develop their full plastic moments of resistance for the expected seismic as well as gravity forces acting on the beam. The seismic response of the tendons depends upon the magnitude of the initial tension T_0. $T_0 = 0$ is not a desirable option. Two limiting conditions can be envisaged; $T_{tb} = (1+\delta^T)T = \mu T$ in the range $0 < T_i < T_0$ where $\delta^T = 1$ and $\mu = 2$, both tendons remain taut, $T_{tb} = (1+\delta^T)T = \mu T$ in the range $T_i > T_0$ where $\delta^T = 0$ and $\mu = 1$, one of the two tendons slackens, The combined RCMF + supplementary devices act as a SDOF system. Therefore, the response of each part can be related to the same variable ϕ for all stages of elasto-plastic loading. For instance, if the change of length of each tendon within each beam of the MF of Fig.3I, due to change of tension $\pm\mu T_{tb}$, at distance $\pm d_t/2$ from the neutral axis is $\pm\mu TL/2A_{tb}E_t$, then it may be equated to the corresponding aperture at the same height, i.e. $\pm\mu\beta\phi d_{tb}$, which gives after simplification $\pm T=\mu\beta\phi d_{tb}A_{tb}E_t/L$.The elastic moment absorbed by the pair of tendons at each splice joint can be computed as $m_{tb}=Td_{tb}=\mu\beta\phi d_{tb}^2 A_{tb}E_t/L.$ Tendon stretching increases the moment of resistance of the MF of Fig.3I by as much as $M_{tb}=4\beta m_{tb}$ which in turn leads to the drift-tendon moment relationship;

$$\phi=\frac{M_{tb}L}{4\mu\beta d_{tb}^2 A_{tb}E_t}=\frac{M_{tb}}{\mu K_{tb}} \tag{6}$$

where K_{tb} may be interpreted as the stiffness of the preloaded tendon system for the case under consideration. The drift-cable moment $(\phi-M_c)$ relationship of the RRC can be rewritten as;

$$\phi=\frac{M_c}{K_c} \tag{7}$$

Suffix c relates to the RRC. And, if there are other earthquake resisting elements, such as LBs, BRBs, SFs and miscellaneous devices, their individual responses can also be related to drift ϕ, i.e.,

$$\phi=\frac{M_{lb}}{\mu K_{lb}},\qquad \phi=\frac{M_{tb}}{\mu K_{tb}}\qquad \phi=\frac{M_{sh}}{K_{sh}}$$

and $$\phi=\frac{M_m}{K_m} \tag{8}$$

where, suffixes tb, lb, br, sh and m refer to beam tendons, LBs, BRBs, SFs and miscellaneous devices respectively. However, if the crisscrossing tendons of the continuous beams of the MF are extended into the RRC through the LBs as in Figs. 2(d) and I, then the total length of the tendon to be considered would be the sum of lengths of all beams and the LB along the same horizontal line. Let for convenience $l=L_{n+1}$ and $d_{t,j}=d_t$ for all j. Total tendon extension due to uniform drift ϕ for level i beams= $\varepsilon_{t,i}=T_i\sum_{j=1}^{n+1}L_j/A_tE_t=2\sum_{j=1}^{n+1}(\mu\beta_j\phi d_{tb,j}/2)$ hence, $T_{t,i}=A_tE_t[\sum_{j=1}^{n+1}(\mu\beta_j\phi d_{tb,j})]/\sum_{j=1}^{n+1}L_j$. Therefore, $M_{t,i}=T_{t,i}d_{t,i}=A_tE_t[\sum_{j=1}^{n+1}(\mu\beta_j\phi d_{tb,j}^2)]/\sum_{j=1}^{n+1}L_j=\mu K_{tb}\phi.$ The total moment acting on the RRC and the nodes of the first column of the MF of Fig. 2 at j=0 can be computed as $\sum_{i=0}^{m}M_{t,i}$, which in turn reduces the uniform drift ϕ by as much as $\psi=(\sum_{i=0}^{m}M_{t,i})/12E\sum_{0=1}^{m}\sum_{j=1}^{n+1}(I_{i,j}/L_j)=\mu\bar{K}_{tb}\phi,$ [or the sum of all (ML/12EI)s of beams of the MF], then (5) may be modified as;

$$\phi=\frac{M_0+M_{P\Delta}-\sum_{i=0}^{m}M_{lb,i}}{K_f}-\psi=\frac{M_0}{[(1+\mu\bar{K}_{tb})K_f-K_{P\Delta}+\mu K_{tb}]} \tag{9}$$

Note that if the beam tendons are continued through the LBs then $K_{lb}=\bar{K}_{lb}=0,$ however, for most practical purposes it is expedient to selec $K_{t,i=0}=K_{t,i=m}=K_t/2$.

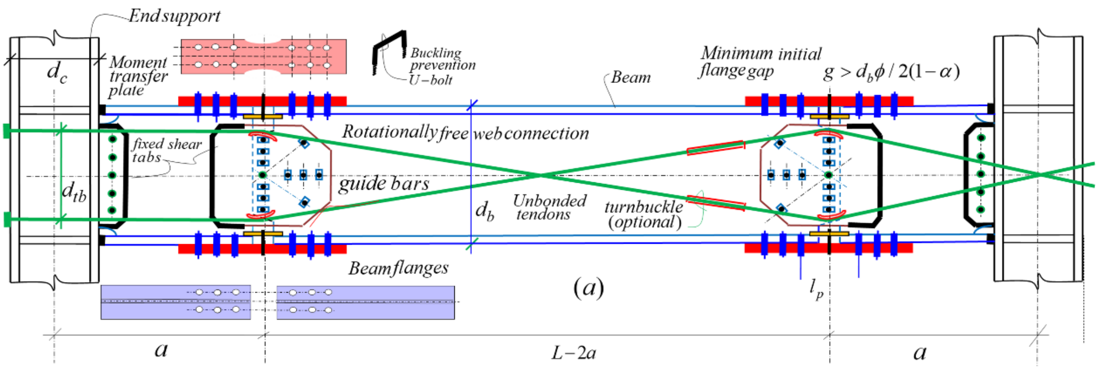

Fig.8. (a) Self-aligning REDMC arrangement with preloaded X tendons, (b) Moment diagram

8. System analysis

The elastic force-deformation relationship of the symbolic RCMF of Fig. 2, (segment 0ab Fig.1), in terms of story-level racking moment

$M = Vh + P\delta$ and the stiffnesses of the proposed MF and supplementary devices $K_{f,r}$, $K_{tb,r}$, $K_{c,r}$, $K_{lb,r}$, $K_{br,r}$, $K_{sh,r}$ and $K_{m,r}$ can be expressed as;

$$\phi = \frac{M}{f_{cr}[(1+\bar{K}_{tb,r}+\bar{\delta}_{lb}\bar{K}_{lb,r})K_{f,r}+K_{tb,r}+K_{c,r}+\bar{\delta}_{lb}K_{lb,r}+K_{br,r}+K_{sh,r}+K_{m,r}]} = \frac{M}{f_{cr}K_r^*} \quad 0 < M \le M_y \tag{10}$$

Here, $\bar{\delta}_{lb} = 0$ if beam tendons are continued through the LB and $\bar{\delta}_{lb} = 1$ if there are no beam tendons. $f_{cr} = (1 - Ph/K_r^*)$. Since all moment resisting elements are connected to each other in parallel, then the elasto-plastic response of the system may also be expressed by the modified version of (10), thus;

$$\phi = \frac{M}{f_{cr}[(1+\delta_{tb}^P\bar{K}_{tb,r}+\bar{\delta}_{lb}\delta_{lb}^P\bar{K}_{lb,r})\delta_f^P K_{f,r}+\delta_{tb}^P K_{tb,r}+\delta_c^P K_{c,r}+\bar{\delta}_{lb}K_{lb,r}+\delta_{br}^P K_{br,r}+\delta_{sh}^P K_{sh,r}+K_{m,r}]} = \frac{M}{f_{cr}\sum\delta_{device}^P K_{device}} \tag{11}$$

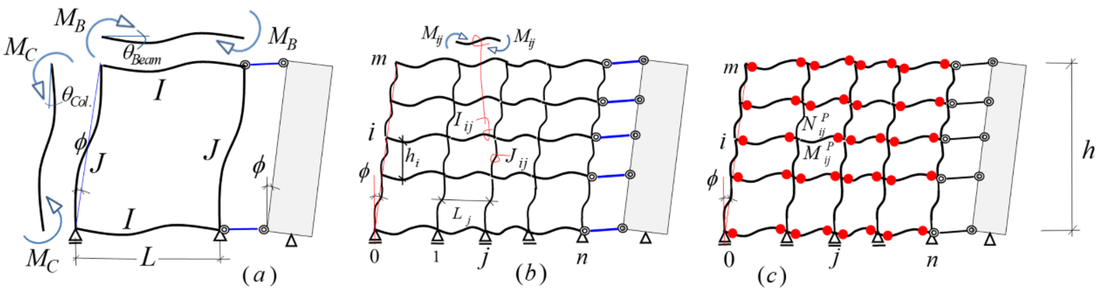

Fig.9. (a) Basic module (b) Equivalent RCMF, elastic state, (c) Equivalent RCMF, plastic state

where, $M_y < M \le M^P$ and K_{device} is the stiffness of any device $K_f, K_{tb}, K_c, K_{lb}, K_{br}, K_{sh}$, etc.

The Kronecker's delta δ_{device}^P has been introduced to signify the loss of stiffness of a single device as it reaches its plastic limit of resistance. For instance, $\delta_{device}^P = 1$, if $M_{device} < M_{device}^P$ and $\delta_{device}^P = 0$ if $M_{device} = M_{device}^P$. Condition $\delta_{device}^P = 0$ also implies structural damage or loss of stiffness of the subject device or structural element as a continuum. Global stiffness $K_{f,r}$ represents the resistance of the MF to re-centering with r=0, 1, 2, 3 … N groups or number of restraints e.g., REDMCs. Condition r=0, (no restraints removed) corresponds to the flag shape response curve of Fig. 6(a) that involves the largest preloading needed to return the system to its original position. By contrast, $r = N = 2n$ (all restraints removed) corresponds to the flag shaped curve of Fig. 6(b) that indicates little to no need for preloading of the recentering mechanism. Fig. 9(a) is a replica of the RCMF of archetype of Fig.2 with no gravity system or supplementary devices. Since the gravity system is a mechanism and that due to the rigidity of the core the entire structure acts as a SDOF system, the addition or deletion of supplementary devices does not affect the transformation of the constitutive equation of the single module of Fig. 9(a), to that of the multimember RCMF of Fig. 9(b). The fact that rotational compatibility of members of the system are enforced rather than estimated helps reduce the task of otherwise complicated analysis to closed form, manually manageable solutions. Consequently, the constitutive equations of both systems can be expressed in terms of (3), (10) and (11). Consider the deformations of the beams and columns of the basic module of Fig. 9(a) under overturning moment M. If the two beams were to oppose the external moment by their own, as if the columns were infinitely rigid, then the end rotations θ_B of the beams could be related to their end moments as $M_B = 6EI\theta_B / L$. For static equilibrium $M = 4M_B = 24EI\theta_B / L$ or $\theta_B = ML/24EI$. Similarly if the beams were assumed to be infinitely rigid then the column end moments could be expressed in terms of the corresponding rotations θ_C as $M = 4M_C = 24EJ\theta_C / h$ or $\theta_C = Mh/24EJ$. The total rotation of the module can now be computed as,

$$\phi = \theta_B + \theta_C = \frac{M}{12E}\left[\frac{h}{2J} + \frac{L}{2I}\right] = \frac{M}{K_f} \tag{12}$$

Following a similar rationale for the beams and columns of the multimember MF of Fig. 9(b), it can be shown that $M_{B,i,j} = 6EI_{i,j}\bar{\theta}_B / L_j$ and $M_{C,i,j} = 6EJ_{i,j}\bar{\theta}_C / h_i$, where $\bar{\theta}_B$ and $\bar{\theta}_C$ stand for uniform end rotations of the beams and columns of the MF respectively. The following convention was adopted to relate the quantities $I_{i,j}$ and $J_{i,j}$ to system coordinates i, j ; $I_{i,j} =$ Moment of inertia of beam *ij* located along line i, to the left of joint j, and $J_{i,j} =$ Moment of inertia of column *ij* located along line j, below joint i. Consider the static equilibrium of each set of beams or columns independently, this gives $M = \sum_{i=0}^{m}\sum_{j=1}^{n} M_{B,i,j} = 12E\bar{\theta}_B \sum_{i=0}^{m}\sum_{j=1}^{n} I_{i,j} / l_i$ and $M = \sum_{i=1}^{m}\sum_{j=0}^{n} M_{C,i,j} = 12E\bar{\theta}_C \sum_{i=0}^{m}\sum_{j=1}^{n} J_{i,j} / h_i$ .The compatibility condition $\phi = \bar{\theta}_C + \bar{\theta}_B$ gives;

$$\phi = \frac{M}{12E}\left[\frac{1}{\sum_{j=0}^{n}\sum_{i=1}^{m}(J_{i,j}/h_i)} + \frac{1}{\sum_{j=1}^{n}\sum_{i=0}^{m}(I_{i,j}/l_j)}\right] = \frac{M}{K_f} \quad \text{or} \quad \phi = \frac{M_F}{K_f} \tag{13}$$

A solution previously derived by long hand analysis for MFUS as part of economic design of RCMFs and was verified by computer data, Grigorian et al. (2017). (13) also yields highly dependable results for non MFUS systems. Solutions (12) and (13) are equally valid with mutually transferable results; $2(I/L) = \sum_{i=0}^{m}\sum_{j=1}^{n}(I_{i,j}/l_J)$ and $2(J/H) = \sum_{i=1}^{m}\sum_{j=0}^{n}(J_{i,j}/h_i)$. The global $P\delta$ effects and the total moment of resistance of both models can be expressed as $(M + M_{P\Delta})$.

The use of RRCs in conjunction with reduced beam sections can lead to controlled plastic hinge patterns, such as those shown in Fig. 9 I, provided that the RRC does not fail first. If the RCMFs of Figs. 9(a) and (b) with zero $P\delta$ moments are assumed to undergo small virtual rotations θ, and that plastic hinge offsets are a_i for each span l_i then the corresponding virtual work equations can be expressed as; $\lambda M\theta = 4M^P\theta/(1-\alpha_i) = 4\beta_i M^P\theta$, for the single loop MF and as

$$\lambda M\theta = \sum_{i=0}^{m}\sum_{j=1}^{n} 2\beta_i M_{i,j}^P \theta \tag{14}$$

for the multimember MF. Here λ and $\beta_i = 1/(1-2a_i/l_i)$ describe the over-strength and rotation magnifying factors respectively. The global $P\delta$ effects and the total moment of resistance of both models can also be expressed as $\lambda(M + M_{P\Delta})$. The effect of development of $M_{i,j}^P$ on the response of span ij can be incorporated in (14) through the introduction of the Kronecker's delta $\delta_{i,j}^{P}$ and $\bar{\delta}_{i,j}^{P}$ for the individual beams and columns respectively.

$$\phi_{f,r} = \frac{(M + M_{P\Delta})}{12E}\left[\frac{1}{\sum_{j=0}^{n}\sum_{i=1}^{m}\bar{\delta}_{i,j}^{P}\bar{k}_{i,j}} + \frac{1}{\sum_{j=1}^{n}\sum_{i=0}^{m}\delta_{i,j}^{P}k_{i,j}}\right] = \frac{(M + M_{P\Delta})}{K_{f,r}} \tag{15}$$

The Kronecker's deltas $\bar{\delta}_{i,j}^{P}$ and $\delta_{i,j}^{P}$ have been introduced to help track the post-earthquake unstiffening of the structure as a continuum. They refer to the effects of formation or lack of formation of plastic hinges at the ends of beams i, j. For instance, $\delta_{i,j}^{P} = 1$, if $M_{i,j} < M_{i,j}^{P}$, and $\delta_{i,j}^{P}$ = 0, if $M_{i,j} = M_{i,j}^{P} \cdot \delta_{i,j}^{P} = 0$, also implies structural damage or loss of stiffness with respect to member i, j. $\bar{\delta}_{i,j}^{P}$ has been introduced to include the contribution or lack thereof column stiffness to overall stiffness $K_{F,r}$ due to the formation of plastic hinges at the ends of the adjoining beams. For example, if the beams on either side of top and bottom ends of a column developed plastic hinges the column would become zero, implying that $\bar{\delta}_{i,j}^{P} = 0$.

9. Conclusions

- The preliminary design process is simple and straightforward and can be performed manually.
- Being a SDOF system, the archetype lends itself well to PC and DLA treatment. Its full cycle analysis has been formulated through simple closed form solutions. The analysis is exact and valid within the bounds of the theoretical assumptions.
- Attention to special detailing can facilitate the PERR processes and help reduce preloading of energy storing elements and devices.
- Under normal circumstances, groups of beams, columns and connections of the ERS including the supplementary devices, can be identical regardless of their locations within the structure.
- The earthquake resisting framing can be a structure of minimum weight with potential savings that might offset additional costs related to the RRC and supplementary devices.
- Auxiliary devices, such as high strength tendons can be used to prevent physical collapse, despite formation of failure patterns within the earthquake resisting frameworks.
- The gravity system is detailed neither to absorb seismic energy nor to accumulate residual strains.
- Tendon arrangements within the RRC can be both pre and post tensioned by means of built-in stressing lacks or otherwise to assure CP and to control the PERR operations.
- Replacement of the REDMCs not only removes the sources of residual strains, but also facilitates the PERR process by reducing the stiffness of the MF to that of a partially articulated frame.
- Optional gap closing tendons and turnbuckles have been provided along the beams of the MF. They can be used to control and enhance the response of the system as required.
- Recentering can be achieved by means of GSR and RFA which minimize and/or adjust the magnitude of the restoring forces needed to realign the system.

- The proposed configuration is construction friendly and satisfies the theoretical conditions of minimum weight design. The use of repetitive members and connections reduces the initial construction costs and increases the reparability of the structure.

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BASIC PRINCIPLES OF ANALYSIS OF THIN-WALLED SPATIAL SYSTEMS WITH DISCONTINUOUS PARAMETERS

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Abstract. In the work are stated the methods of analysis of shells and plates with ribs, breaks, cuts, holes, undergoing to action of distributed and concentrated loadings based on the application of generalized (discontinuous) function, are given the solutions of tasks, often arising in the calculation practice.

1. Introduction

In this article are presented initial relations and are obtained decisive equations for plates with cuts and ribs of limited extent, i.e. limited length, parallel to the sides of a rectangular contour. The ribs of a limited length, smaller than length of the rectangular contour side, are considered as ribs of step-wise variable stiffness, moreover, based on the ratios for plates with ribs of variable stiffness. Thus, the obtained dependencies and decisive equations turn out to be quite general and would be extended to a wider class of problems than studied in this article.

Although the solution of specific problems relating to the definition of the mode of deformation of ribbed shells was found at the beginning of the century, the creation of the theory of ribbed shells, as a section of the theory of shells, should be attributed to the end of the 40s. The main ideas of the theory of ribbed shells were expressed by Z. Vlasov [1] and A.I. Lurie [2], which, when presenting the basic relations, suggested that the ribbed shell can be viewed as a structure consisting of the shell itself (skin) and one-dimensional elastic elements supporting it (thin-walled rods – V.Z. Vlasov, or Kirchhoff-Clebsch- A.I Lurie). V.Z. Vlasov, as well as A.I. Lurie assumed that the skin and the edges interact along the intersection line of the axial (normal to the middle surface of the shell) section of the rib and the movement of the skin and the edges along the contact line are equal.

E.S. Greben develops the technical theory of shells by introducing the concept of generalized forces and moments using the Dirac delta functions [3] and calculated the supported shells by the method of local distributions. The use of special functions allowed us to obtain compact differential equations of ribbed shells. This method was developed in the works of B.K. Mikhailov [4] and V.V. Karpov [5].

In the works of B.K. Mikhailov [4] developed a method for calculating bent plates and shells with discontinuous parameters. When introducing generalized functions into the solution of the resolving equations, the characteristic features breaks, discontinuities, ribs) of the mode of deformation components are taken into account in a very small area of violation of the regularity of the shell geometry or the area of application of local loads.

The desired function is constructed as a combination of regular and I discontinuous functions, which allows us to obtain an analytical solution in the form of rapidly converging series. Further development of the ego direction I received in the works of F.F. Gayanova [6].

V.V. Karpov derives the equilibrium equations of ribbed shells using the Lagrange variational principle [5]. The ribbed shell in is considered as a two-layer shell consisting of an isotropic casing layer and an orthotropic discrete layer of fins. Such a model of construction allows to take into account the discrete location of the edges, their influence on the shift and torsion of the middle surface.

In the works [7, 8] are stated and developed the exact theories of anisotropic plates and shells, are taking into account the phenomena of transversal shears and compression. Let's consider the numerous issues of strength, stability and oscillations of plates and shells. The obtained results represents interest for analysis of plates and shells from composite materials.

In the works [9, 10] are stated the theory of anisotropic plates and shells based on unified approach of asymptotic method of integration of equation of spatial tasks of theory of elasticity. Is revealed relation of obtained equations with equations of Bernulli-Euler orthogonal beams. The theory of plates and shells based on the hypothesis of Kirchhoff-Lave by exact theory. Is shown that these theories would be explained as various stages of asymptotic integration of equations of spatial problem, are indicated the ways of obtaining of more exact results.

2. Basic part

In the paper is stated the derivation of initial equation is applied the expression of curvature, internal forces and moments, as well as components of deformation by discontinuous (unit and impulsive) functions.

With taking into account that curvature of surface with breaks are transformed in the infinity on line of breaks, the expressions for major curvatures will be stated as [11-26]

$$K_1^* = K_1 + \sum_{i=1}^{m} \Theta_i\, \delta(\alpha_1 + \alpha_{1i}),$$
$$K_2^* = K_2 + \sum_{j=1}^{m} \Theta_j\, \delta\big(\alpha_2 + \alpha_{2j}\big), \tag{1}$$

where K_1, K_2 – are teh curvatures of sur in the intervals between breaks;

Θ_i, Θ_j – are the angles of „break" of median sur.

In the case of ribs the forces and moments are presented as:

$$T_1^* = T_1 + \sum_{i=1}^{m} (E_i F_i \varepsilon_1 + E_i S_i \chi_1)\delta(\alpha_2 + \alpha_{2i});$$
$$T_2^* = T_2 + \sum_{j=1}^{m} \big(E_j F_j \varepsilon_2 + E_j S_j \chi_2\big)\delta\big(\alpha_1 + \alpha_{1j}\big);$$
$$M_1^* = M_1 + \sum_{i=1}^{m} (E_i J_i \chi_1 + E_i S_i \varepsilon_1)\delta(\alpha_2 + \alpha_{2i}); \tag{2}$$
$$M_2^* = M_2 + \sum_{j=1}^{m} \big(E_j J_j \chi_2 + E_j S_j \chi \varepsilon_2\big)\delta\big(\alpha_1 + \alpha_{1j}\big),$$

where $E_i F_i$,, $E_j F_j$ – are the stiffness's of ribs on tension-compression;

$E_i J_i$, $E_j j$ – are the stiffness's of ribs on bending;

S_i, S_j – are the static moments of ribs cross-sections related to the median surface.

For taking into account, the cuts angles of rotation and components of displacement vector are stated as:

$$\gamma_1^* = \gamma_1 + \sum_{i=1}^{m} \Delta\gamma_i \cdot 1(\alpha_1 + \alpha_{1i}) \cdot \tilde{1}_i(\alpha_1);$$
$$\gamma_2^* = \gamma_2 + \sum_{j=1}^{n} \Delta\gamma_j \cdot 1\big(\alpha_2 + \alpha_{2j}\big) \cdot \tilde{1}(\alpha_1);$$
$$w^* = w + \sum_{i=1}^{m} \Delta w_i \cdot 1(\alpha_1 + \alpha_{1i}) \cdot \tilde{1}_i(\alpha_2) +$$
$$+ \sum_{j=1}^{n} \Delta w_j \cdot 1(\alpha_2 + \alpha_{2i}) \cdot \tilde{1}(\alpha_1);$$
$$u^* = u + \sum_{i=1}^{m} \Delta u_i \cdot 1(\alpha_1 + \alpha_{1i}) \cdot \tilde{1}_i(\alpha_2) + \tag{3}$$
$$+ \sum_{j=1}^{n} \Delta u_i \cdot 1\big(\alpha_2 + \alpha_{2j}\big) \cdot \tilde{1}(\alpha_1);$$
$$v^* = v + \sum_{i=1}^{m} \Delta v_i \cdot 1(\alpha_1 + \alpha_{1i}) \cdot \tilde{1}_{i1}(\alpha_2) +$$
$$+ \sum_{j=1}^{n} \Delta v_i \cdot 1\big(\alpha_2 + \alpha_{2j}\big) \cdot \tilde{1}(\alpha_2),$$

where γ_1, γ_2 – are the angles of breaks as result of deformation; Δw_i, Δu_i, Δv_i, Δw_j, Δu_j, Δv_j – are the values of mutual divergence of points on edges of cut.

$\tilde{1}(\alpha_2) = 1(\alpha_2 + \alpha_{2j}) - 1(\alpha_2 + \alpha_{2j} - b_i)$;

$\tilde{1}(\alpha_2) = 1(\alpha_1 + \alpha_{1i}) - 1(\alpha_1 + \alpha_{1i} - a_i)$;

$(\alpha_2 + \alpha_{2j})$, $1(\alpha_1 + \alpha_{1i})$ – are the unit functions;

a_j, b_j – are the lengths of cuts.

As a result of introduction of expressions (1)-(3) in the known dependencies and relations of theory of shells are obtained the equation and plates with various types of violation of regularity. Written down in the matrix from for shells with ribs and breaks these equations will be as.

$$
\begin{aligned}
&A_1^0\bar{T} + C_1^0\bar{M} = \bar{P} - A_1'\bar{\varepsilon} - A_1''\bar{T} - C_1'\bar{M} - C_1''\bar{\varepsilon};\\
&A_2^0\bar{T} + C_2^0\bar{M} = -A_2'\bar{\varepsilon} - A_2''\bar{T} - C_2'\bar{M} - C_2''\bar{\varepsilon},
\end{aligned}
\qquad (4)
$$

where $\bar{T}$, $\bar{M}$, $\bar{\varepsilon}$ – are accordingly the vectors of forces, moments and components of deformations in the shell; A_1^0, C_1^0, A_2^0, C_2^0 – are the matrices from differentia,operators of classical tehory of shells; A_1', A_1'', C_1', C_1'' , A_2', A_2'', C_2', C_2'' – are the matrix operator as with discontinuous parameters depending on character of breaks and stiffnesses of ribs.

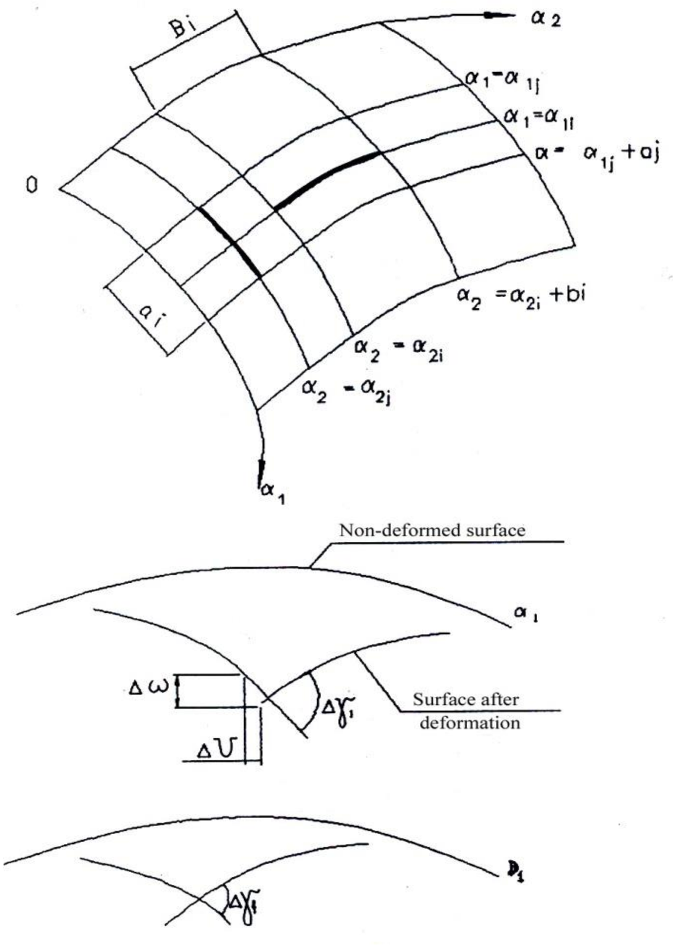

Fig. 1. Surface prior and after deformation

The equations for shells with cuts written down with respect of displacements in matrix form will be as:

$$A_1^0 BI\bar{u}^0 + C_1^0 DL^0\bar{u} = \bar{P} - [A_1^0 BI^0 + C_1 D(M'F + M)] \times$$
$$\times\left(\sum_{i=1}^{m} \Delta\bar{U}_i I_i + \sum_{j=1}^{n} \Delta\bar{U}_j I_j\right) -$$
$$-C_1 DM\left(\sum_{i=1}^{m} \Delta\bar{U}_i I_i + \sum_{j=1}^{n} \Delta\bar{U}_j I_j\right). \quad (5)$$

The elements of matrixes A_i^0, I^0, C_i^0, M, F, A_2^0, C_1^0, M' contains operations of differentiation of first order, elements of matrixes B and D represents the simple coefficients.

3. Basic relations and decisive equations for plates with ribs and cuts

The method of taking into account the ribs is based on introduction of singular functions in elasticity relations of theory of thin plates bending, at this is introduced the concept of generalized forces and moments. This method was earlier applied by other authors but not for limited length ribs.

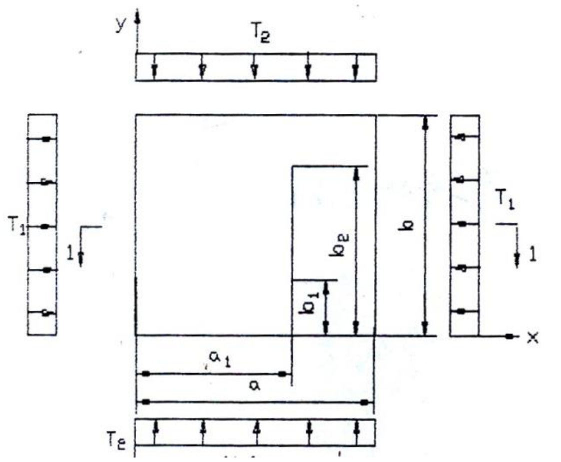

Fig. 2. Design diagram for plate with cut

For plates with cut, in parallel to one of sides of plate (Fig. 2) the functions of deflection and angle of rotation are represented as

$$W^* = W - \Delta W 1_x 1_{yy};$$
$$\gamma_2^* = W_y^{*1} = \gamma_2 - \Delta\gamma_2 1_x 1_{yy}; \quad (6)$$
$$\gamma_1^* = W_x^{*1} = \gamma_1 - \Delta W \delta_x 1_{yy} - \Delta\gamma_2 1_x 1_{yy}.$$

After introduction of these relations due relations of elasticity in equation of bending of plate, written down with respect of bending and torque moments we will obtain

$$D\Delta^4 W - D\big[\big(\Delta W \delta_x''' + 2\Delta W_y'' \delta_x + \Delta W_y^{IV} \cdot 1_x +$$
$$+\Delta\gamma_I \cdot \delta_x'' + \Delta\gamma_{1y}'' \delta\big) \cdot 1_{yy} + 2\Delta W_y''' \cdot 1_x \cdot \delta_{yy} +$$
$$+\Delta W_y'' \delta_{yy}' \cdot 1_x + \Delta\gamma_{1y}' \delta_{yy} \cdot \delta_x\big] = P. \quad (7)$$

where

$$1_{yy} = 1(y - b_1) - 1(y - b_2); \quad 1_x = 1(x - x_1);$$
$$\delta_{yy} = \delta(y - b_1) - \delta(y - b_2); \quad \delta_x = \delta(x - x_1).$$

The solution of this equation with taking into account of first term of series is presented by the expression

$$W = [W_{01} + \Delta W_1 A_1(\psi_{1x}''' - 2\beta_1^2 \psi_{1x}''' + \beta_1^4 \Phi_{1x}) +$$
$$+\Delta\gamma_I A_1(\psi_{1x}'' - \beta_1^2 \psi_{1x}) + 2\Delta W_1 A_2 \beta_1^3 \Phi_{1x} -$$
$$-\Delta W_1 A_1 \Phi_{1x} + \Delta\gamma_1 \beta_1 A_2 \psi_{1x}] \sin\beta_1 y. \quad (8)$$

From the last formula is clear that diagram of deflection sof plate with cut consists from diagram of deflections added to diagrams of moments and shear force from applied on line of cut by external loading multiplied on certain dimension coefficients.

In the case of existence of break without divergence of edges would be assumed that

$\Delta W = 0.$

The forces and moments calculated on the basis of obtained formulae are determined at the ends of cuts with the same accuracy as in continuous part of plate at reducing of two or three terms of series in the divergence of desired function. Is stated the numerical case of analysis of bending plate with cut that indicates that components of stressed state after the second approximation are calculated with common for engineering practice error.

For the case of cuts arranged on the whole length of plate is obtained the solution that corresponds to the bending of plate with one free edge. In the work is shown that in this case the solution, expressed by formula (8) coincides with solution obtained in the ordinary series by known methods of classical theory of bending of thin plates.

The offered method would be applied in the analysis of beam on the elastic foundation, having the intermediate hinges. The obtained solution in this case also coincides with known exact solution of classical theory of bending of beams on the elastic foundation.

The obtained results are generalized on the cases of bending of plate with several parallel cuts arranged in the mutual perpendicular directions.

The cuts that creates the rectangular closed contour (Fig. 3) are simulating the rectangular hole.

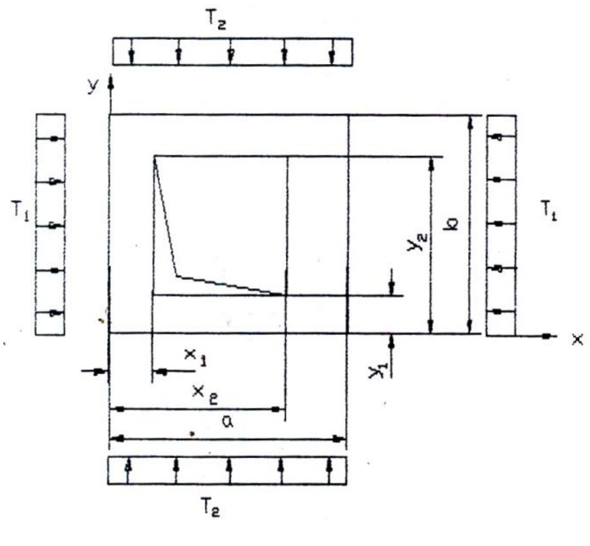

Fig. 3. Design diagram for plate with hole

4. Conclusions

Developed method of analysis of shells and plates with wholes and cuts in the conditions of linear and non-linear deformation gives the possibility with same accuracy to determine the forces and moments in continual area as well as in the adjacent of edges and vertexes of cuts.

Developed method of analysis of shells with breaks and ribs in linear and non-linear statement and obtained at this design formulae gives the possibility to describe all singularities in adjacent of violations of regularity reflects the variation and redistribution of forces and moments in the loading process.

Based on the offered methodology would be developed the practical recommendations on analysis and design of sandwich panels applied as precast elements at construction of buildings.

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ON THE INTERFERENCE ISSUE OF SEISMIC WAVES EXTENDING IN RANDOMLY INHOMOGENEOUS ELASTIC MEDIUM

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Keywords: randomly inhomogeneous elastic medium, seismic waves, building site, range of space correlation

Abstract. The probabilistic model of propagation and superposition of seismic waves in randomly inhomogeneous medium (soils) is considered. The solution of the spectrum of the spatial correlation of the wavefront is given. The expressions of the mathematical expectation of the displacement functions, the cross-correlation of the elastic constants of the soil medium, the amplitude of the seismic wave are obtained.

1. Introduction.

The problem of an interference of seismic waves repeatedly rose in the field of geophysics, seismic exploration [1,2]. Attempts of the analysis in the determined statement became also specialists in the field of aseismic construction. Unfortunately, such approach does not give the chance to study influence directly around a building site. Probabilistic representation leads to the results allowing to answer a question and in strict accordance with the classical theory of an interference of partial and coherent fluctuations [3] to which it is possible to carry seismic waves of various type.

Considering a problem of an interference, it is previously necessary to define statistical characteristics of the seismic wave front extending in randomly inhomogeneous elastic medium.

In the offered calculations is decided to refuse research of a problem, allocating to heterogeneity of parameters either on time, or on coordinate, and to consider process in general, using concept of a range of space correlations $S_u(x, x'|\omega)$ [4]. These functions, being Fourier transform on time of correlation function $K_u(x, x'|\tau)$, possess on coordinates properties of correlation functions, and on frequency - properties of spectral densities, and boundary conditions for a range of space correlations $S_u(x, x'|\omega)$ remain same, as well as for correlation $K_u(x, x'|\tau)$ function [4].

We will consider the solution of a task for the zone remote from epicenter that allows to conduct for waves of R-type research in one-dimensional statement [2].

One-dimensional wave equation registers in the form of [2,5]:

$$\frac{\partial^2 u(x,t)}{\partial x^2} - \frac{1}{b^2}\frac{\partial^2 u(x,t)}{\partial t^2} = 0, \tag{1}$$

where $u(x,t)$ - shift, $b = \sqrt{E/\rho}$ - the speed of distribution of a wave, E - a distribution environment elastic modulus, ρ - environment density.

Let's present $u(x,t)$ in the form of direct Fourier transform on time:

$$u(x,t) = \int_{-\infty}^{\infty} U(x,\omega)\exp(i\omega t)d\omega . \tag{2}$$

Substituting (2) in (1), we will have:

$$\int_{-\infty}^{\infty}\left[\frac{d^2U(x,\omega)}{dx^2}+\left(\frac{\omega}{b}\right)^2U(x,\omega)\right]\exp(i\omega t)d\omega=0\,. \qquad (3)$$

The condition (3) is satisfied if the expression standing in square brackets is equal to zero. Therefore, we can write down:

$$\frac{d^2U(x,\omega)}{dx^2}+\left(\frac{\omega}{b}\right)^2U(x,\omega)=0\,. \qquad (4)$$

(size $U(x,\omega)$ in (4) is *function* x, and ω plays a parameter role).

Let's provide the member $(\omega/b)^2$ and $U(x,\omega)$ in the form of the sum of mathematical expectation and a fluctuation component:

$$(\omega/b)^2=k_0^2+c(x,\omega) \qquad (5)$$

$$U(x,\omega)=U_0(x,\omega)+V(x,\omega). \qquad (6)$$

Substituting (5) and (6) in (4), we will receive system of the connected differential equations [5]:

$$\begin{cases}\dfrac{d^2U_0(x,\omega)}{dx^2}+k_0^2U_0(x,\omega)+c(x,\omega)V(x,\omega)=0\\ \dfrac{d^2V(x,\omega)}{dx^2}+k_0^2V(x,\omega)+c(x,\omega)U_0(x,\omega)=0\end{cases} \qquad (7)$$

Multiplying the second equation of system (7) by the size $c^*(x',\omega')$ (the asterisk - means the complex interfaced size, and a stroke - the "shaded" variable), averaging taking into account conditions of stochastic orthogonality and, setting the function $S_c(x,x'|\omega)$characterizing heterogeneity of the environment of distribution of wave front at the chosen positive direction $x'-x\geq 0$, we will have [4-6]:

$$\begin{cases}\dfrac{d^2U_0(x,\omega)}{dx^2}+k_0^2U_0(x,\omega)+S_{cu}(x,x|\omega)=0\\ \dfrac{d^2S_{cu}(x,x'|\omega)}{dx^2}+k_0^2S_{cu}(x,x'|\omega)=-U_0(x,\omega)S_0(\omega)\exp[-\alpha(x'-x)]\end{cases} \qquad (8)$$

(in (8) it is necessary that exponential are correlated heterogeneity of the environment and time process; $S_0(\omega)$ - spectral density (temporary characteristic of accidental process)).

The decision of system (8) is defined in a look:

$$U_0(x,\omega)=\sum_i C_i\exp(r_ix). \qquad (9)$$

$$S_{cu}(x,x'|\omega)=\sum_i B_i\exp(r_ix)S_1[(x'-x)|\omega], \qquad (10)$$

where B_i, C_i - unknown quantities, r_i - roots of characteristic equation:

$$\left(r^2+k_0^2\right)\left[(r+\alpha)^2+k_0^2\right]-S_0(\omega)\sigma_c^2=0\,, \qquad (11)$$

which is formed for the second equation of system (8).

Having chosen direction of propagation of wave front, discarding roots with negative imaginary parts, we will receive:

$$U_0(x,\omega)=C_1\exp(r_1x)+C_2\exp(r_2x) \tag{12}$$

where C_1 *and* C_2 are defined from the determined boundary conditions.

On the basis of (10) it is easy to write down expression and for $S_{cu}(x,x'|\omega)$.

For definition of a range of space correlation $S_u(x,x'|\omega)$ it is necessary to copy the second equation of system (7) in the form of dependence on the "shaded" variable. Further, multiplying by a range $V^*(x,\omega)$, taking into account a condition of stochastic orthogonality we will have:

$$\frac{d^2S_u(x,x'|\omega)}{(dx')^2}+k_0^2S_u(x,x'|\omega)=-U_0(x',\omega')S_{cu}(x,x'|\omega). \tag{13}$$

The decision (13) does not represent considerable difficulties.

Applying further direct Fourier transform on time, taking into account the received expressions for $U_0(x,\omega)$, $S_{cu}(x,x'|\omega)$ and $S_u(x,x'|\omega)$, we find mathematical expectation $u_0(x,t)$, mutual correlation function of fluctuations *of elastic constants* E , ρ and wave amplitudes $K_{uc}(x,x'|\tau)$, and also autocorrelation function of wave amplitude $K_u(x,x'|\tau)$:

$$u_0(x,t)=\int_{-\infty}^{\infty}U_0(x,\omega)\exp(i\omega t)d\omega .$$

$$K_{uc}(x,x'|\tau)=\int_{-\infty}^{\infty}S_{uc}(x,x'|\omega)\exp(i\omega\tau)d\omega . \tag{14}$$

$$K_u(x,x'|\tau)=\int_{-\infty}^{\infty}S_u(x,x'|\omega)\exp(i\omega\tau)d\omega .$$

With the purpose to investigate a problem of an interference of partial and coherent fluctuations we will consider two wave fronts described by ranges $U_1(x,\omega)$ and $U_2(x,\omega)$.

According to [4] intensity of a total wave representing superposition of two interfering partial and coherent processes it is described in the set *zone Q* as follows:

$$I(Q)=I_1(Q)+I_2(Q)+$$
$$+2\sqrt{I_1(Q)I_2(Q)}|\gamma_{12}(\tau)|\cos[\alpha_{12}(\tau)-\varphi]. \tag{15}$$

$$I_1(Q)=K_{u1}(0)=K_{u1}(\tau)|_{\tau=0}=\int_{-\infty}^{\infty}S_{u1}(x,x'|\omega)d\omega . \tag{16}$$

$$I_2(Q)=K_{u2}(0)=K_{u2}(\tau)|_{\tau=0}=\int_{-\infty}^{\infty}S_{u2}(x,x'|\omega)d\omega . \tag{17}$$

$$\gamma_{12}(\tau)=\frac{K_{u12}(\tau)}{\sqrt{K_{u1}(0)}\sqrt{K_{u2}(0)}} . \tag{18}$$

$$K_{u12}(\tau)=\int_{-\infty}^{\infty}S_{u12}(x,x'|\omega)\exp(i\omega\tau)d\omega . \tag{19}$$

In (15) $\alpha_{12}(\tau)=2\pi\bar{\nu}\tau+\arg\gamma_{12}(\tau)$; $\varphi=\left(2\pi/\bar{\lambda}\right)(l_2-l_1)$, where $\bar{\nu}$ - an average value of frequency, $\gamma_{12}(\tau)$ - complex power of coherence [4], $\bar{\lambda}$ - an average value of length of the corresponding seismic wave, (l_2-l_1) - a difference of the course of two interfering waves.

Expressions (16) and (17) describe intensity of wave fronts through autocorrelation functions in the set point (dispersion), and size $K_{u12}(\tau)$ represents mutual correlation function of two studied wave processes.

The condition $\gamma_{12}(\tau)$ = 1 corresponds to simple harmonic waves and problems of seismicity does not approach. The condition $\gamma_{12}(\tau)$ = 0 - to lack of an interference that is possible, but has no relation to the considered problem.

It is obvious that for a case of an interference of seismic waves the inequality 0 < $\gamma_{12}(\tau)$<1 will be carried out $\gamma_{12}(\tau)$. Such waves are also called partial and coherent [3].

As for problems of aseismic construction it is necessary to define the greatest possible value of intensity $I(Q)$, in (15) it is necessary to put $\cos[\alpha_{12}(\tau)-\varphi]=1$.

If to believe that heterogeneity of the environment of distribution for both wave fronts distinctions in the description of the "first" and "second" fronts perhaps only through boundary conditions, that is through *C_1 and C_2* are characterized by the same function (in the studied problem of heterogeneity exponential are correlated).

Leaning on the received expression for $S_u(x,x'|\omega)$ it is possible to write down easily expressions for $S_{u1}(x,x'|\omega)$ and $S_{u2}(x,x'|\omega)$.

For the purpose of definition of the range of space correlations $S_{u12}(x,x'|\omega)$ entering in (19) it is necessary to write down the second equation of system (7) in the form of dependence on the "shaded" variable, for example, of the "second" wave front:

$$\frac{d^2V_2(x',\omega')}{(dx')^2}+k_0^2V_2(x',\omega')+c(x',\omega')U_{20}(x',\omega')=0 . \qquad (20)$$

Multiplying (20) by a range $V_1^*(x,\omega)$, taking into account conditions of stochastic orthogonality [4,5], we will receive:

$$\frac{d^2S_{u12}(x,x'|\omega)}{(dx')^2}+k_0^2S_{u12}(x,x'|\omega)=-U_{20}(x',\omega')S_{cu1}(x,x'|\omega) . \qquad (21)$$

The decision (21) also does not present considerable difficulties.

Substituting expressions for $S_{u1}(x,x'|\omega), S_{u2}(x,x'|\omega)$ and $S_{u12}(x,x'|\omega)$ in (15), taking into account (16) - (18), we will receive:

$$I(Q)=\left[\int_{-\infty}^{\infty}S_0(\omega)\psi_{u1}(\omega)d\omega+\int_{-\infty}^{\infty}S_0(\omega)\psi_{u2}(\omega)d\omega+\right.$$
$$\left.+\int_{-\infty}^{\infty}S_0(\omega)\psi_{u12}(\omega)\exp(i\omega\tau)d\omega\right]\sigma_c^2 . \qquad (22)$$

The last member in (22), as well as in the classical theory, is interferential and has the defining impact on process of strengthening or weakening of influence.

2. Conclusions

Research of a difference between intensity of the possible influence, which served as the reason of destructions, and value of the total intensity of influence received analytically without the interference phenomenon shows that the order of this size, even according to preliminary estimates, corresponds to the third, interferential member of expression.

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THE HISTORY OF AN EXCEPTIONAL CONSTRUCTION INVESTOR IN CZESTOCHOWA AT THE TURN OF THE 19TH AND 20TH CENTURIES

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Keywords: History of architecture, the prince's house, Czestochowa at the turn of the 19th and 20th centuries, Czestochowa architecture.

Abstract. The article presents the economic activity of Prince Michał Aleksandrowicz II Romanow. Major investment decisions of the Grand Duke were presented, for example the construction of a profitable tenement house. Attention was paid to building objects and their incredible architecture created during the times of Michał Aleksandrowicz II Romanow in Czestochowa and its surroundings.

1. Introduction

In Poland, the Construction Law does not contain the Investor's definition. Nevertheless, the position of the Investor within the meaning of Article 17 of the Construction Law states that it should be understood as a natural or legal person or other organizational unit that initiates construction activity necessary to carry out the intended investment, allocates financial resources for this purpose, and in the final stage performs the activities necessary to take up the use of the object. Therefore, the investor is the organizer of the construction process. According to the quoted definition, the Grand Duke Michał II Aleksandrowicz Romanow, the brother of czar Russia, Nicholas II Romanov was an industrial and construction investor in Częstochowa. The Grand Duke Michał Aleksandrowicz II Romanow came into possession of significant landed estates in Częstochowa and its vicinity at the end of the twentieth century. He received them from his father Alexander III and brother Nicholas II Romanowych. These goods were acquired earlier by his father Alexander III Romanow from magnate Guido Henckel von Donnersmarck. In 1891, for the amount of 1 700 000 rubles paid to the German magnate [1-3]. The property was included; property with a palace in Zagórz near Częstochowa, the Blachownia glassworks with the Olszów settlement, mines in Gnaszyn and Szarlejka, and plots in Częstochowa on Wolności Street, as well as extensive estates in the vicinity of Częstochowa. In Częstochowa, on the plots acquired, the Grand Prince Michał II Aleksandrowicz built an exclusive apartment building named "Domem Księcia" to this day. Investments were carried out in 1912-1913 at the corner of ul. Teatralny and Nowa. Grand Duke Michał II Aleksandrowicz Romanow decided to build in Częstochowa the largest apartment building at that time suitable for the dynamically developing city. According to the design assumptions, the building was to be even bigger, as shown by the sketches published in the Warsaw Investment Weekly in 1912. The project was carried out by the design office of the Polish architect graduate of the Wawelberg and Rotwand schools in Warsaw and the École des Beaux-Arts School in Paris was built as the most suitable building, whose projects were evaluated by prof. Benua from the tsarist Academy in St. Petersburg. Construction supervision was performed by D.M. Matulewicz, the buildings were implemented by the local enterprise of L. W. Sobieraj.

2. Economic activity of an exceptional Investor

The Grand Duke Michał Aleksandrowicz II Romanow, under the decree of Tsar of Russia Nikolai II from June 17, 1899, received the goods of the "Zagórski State". Grand Duke Michał II

Aleksandrowicz Romanow visited his property in September 1900. Forests in the area abounded in animals, so the Grand Duke hunted, visited the church in Kłobuck, Zakrzew farm, the church in Czestochowa, Saints Cyril and Methodius, Jasna Góra, where he saw the image of Our Lady of Czestochowa and the Pauline Fathers monastery. In October 1900, the Grand Duke Michał II Aleksandrowicz also visited the Blachownia steelworks view presented in Fig.1. [2]. His tsar's Highness watched the exhibition, where the exhibition of dishes and iron products was arranged.

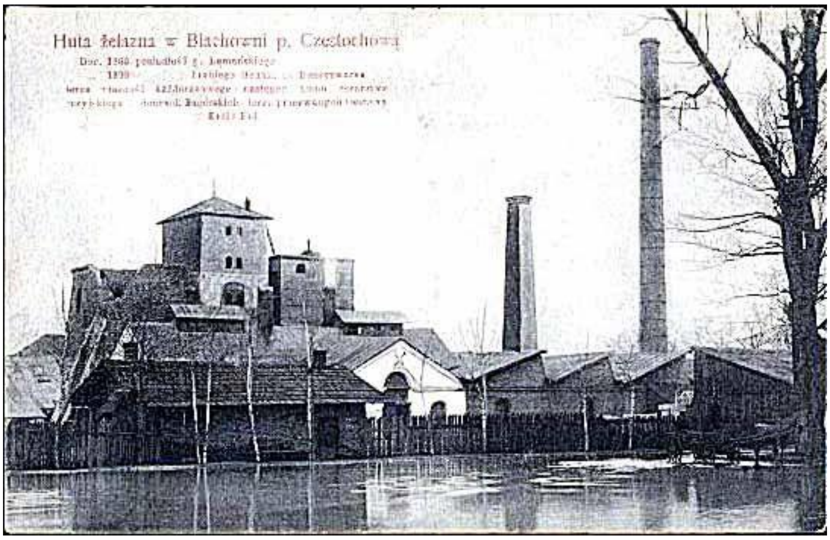

Fig. 1. Engraving of the Blachownia steelworks until 1918 [2]

As already mentioned, the tsarist family owned many estates in the vicinity of Częstochowa with Zagórze near Kłobucka as the main seat. The Palace of Zagórz was built in 1795-1800 by Christian Graf von Haugwitz, the Prussian minister of foreign affairs. Zagórze's estate was a copy of his Berlin home. In 1833, the palace was bought by Benedykt Lemański, and after his tragic death the palace was sold to Count Guido Henckel von Donnersmarck, the magnate owner of Bytów, Tarnowskie Góry and many mines in Silesia, which in 1891, the estate Zagorze sells to tsar Alexander III, who in 1894 after the death of the Czar was taken over by his son Czar Nicholas II. In 1899, Tsar Nicholas II, with a decree, handed over to his brother Michał II Aleksandrowicz a property with an area of over 12,000 ha.

Fig. 2. Portrait of the Grand Duke Michał II Aleksandrowicz Romanow [4]

From the beginning of the 20th century, the new owner grew rapidly in Częstochowa, often visited Kłobucku, ran his industrial interests related to the possession of the Blachownia steelworks, the mine in Gnaszyn and Szarlejka, and several lime kilns. He came to the conclusion that the dynamically developing city of Częstochowa, which in 1880 had 18 thousand citizens, already in 1908 Częstochowa inhabited 70 thousand inhabitants, not counting the adjacent populated industrial settlements of Rakow, Stradom Grosz in which the metal and textile industry developed would be appropriate a place for the development of profitable investments [5,6].

The Grand Prince Michał Aleksandrowicz II Romanow came to the conclusion that it would be advisable to build a large, profitable tenement house, perhaps it was also prompted by personal experiences from that period. It should be noted that the architect Paprocki, who designed the tenement house, also participated in the design of the Agricultural and Industrial Exhibition. In the organization, which also recorded the participation of the Grand Duke Michał Aleksandrowicz II Romanowa. The mentioned increase in the number of inhabitants in Częstochowa was undoubtedly an effect of accelerating the industrial development of cities. In 1908, there were already 42 large companies employing 15 581 workers and small factories in which 1734 people worked, the total value of production is estimated at 33 million rubles, of which 28 million brought goods produced for sale outside the city limits. Częstochowa was one of the five largest industrial centers of the Kingdom before the First World War, it was the center of textile and metallurgy.

The heart of the Grand Duke of Michał Aleksandrowicz II's estate was the "Zagórskie state", areas with Ostrów industrial facilities with an area of 12,271 ha, of which 10,861 ha included forests. As already noted, property estates constituted four granges; Zagórze, Łobodno, Zakrzew and Nowa Wieś. Income also brought distilleries, forest farms, sawmill, mills, lime kilns, iron ore deposits and limestone. The seat of the estate was the Palace in Zagórze, shown in Figures 3 and 4.

Fig. 3. View of the front from the eastern side of the palace in Zagórze (drawing by D. Jończyk)

Fig. 4. Front view from the west side of the palace in Zagórze (drawing by D. Jończyk)

The palace was built in the classicist style in the years 1795 ÷ 1800, it was built on the plan of the letter L, the terry facade fig. 3 and 4. has one floor. The palace has ogival apertures and a tower, which referring to Gothic art, fig. 5, and a general view of the palace surrounded by the English landscape park shown in Fig. 6.

Fig. 5. A front view of the palace in Zagórze with an adjoining park (drawing by D. Jończyk)

Fig. 6. View of the tower of the palace in Zagórze (drawing by D. Jończyk)

Not only the construction of the apartment building owes Czestochowa to the Grand Duke Michał II Aleksandrowicz, his support decided about the construction of an important railway connection from the borders of Herb to Kielce [7,8].

The new railway line was commissioned in 1903. It had a branch to Huta Blachownia and a connection with Huta Czestochowa and a mine in Łojki. In this way, the problem of supplying raw materials to the Częstochowa plants and disposing of production was solved.

3. Częstochowa construction investment of Grand Duke Michał II Aleksandrowicz

From 1900 to the Grand Duke Michał Aleksandrowicz II in Częstochowa itself, there was an undeveloped property in the vicinity of the railway station at the current Wolności street. On this land property, the Grand Duke decided to build one of the largest residential buildings in the city at that time. A young Warsaw architect Brunon Paprocki designed the most modern tenement house in the Kingdom. The tenement house as a three-storey building was built on a square plan surrounded on three sides by streets, the façades were decorated with semicircular bay windows and balconies with brick balustrades. The front of the building is located on Wolności Street, from which an entrance gate leads to the yard, and the second entrance gate to the yard from Sobieskiego Street. From Boya – Żeleńskiego Street a separate one-story pavilion intended for the casino was created. The roof was decorated with two main intricately finished metal sheet copper machining. Tenement house in October 1913 was put into service, residential apartments were intended for senior officers and Russian officials. On the ground floor of the tenement house there were exclusive stores and the already mentioned military casino, the infrastructure adjacent to the apartment building met the requirements of the highest European standards. Fig. 7-8. presents the Prince's House with a view from the front on ul. Wolności and from the south side from Boya – Żeleńskiego Street from the time shortly after construction of the building, Fig. 7 and the building from the beginning of the 21st century in Fig. 8.

Fig. 7. View from the front of the apartment building „Dom Księcia" after putting into service [6]

Fig. 8. View of the facade of the building from the beginning of the 21st century (drawing by D. Jończyk)

In the vicinity of the apartment building, the Grand Duke Michał II Aleksandrowicz Romanow also built a modernist storey villa surrounded by a small garden. The building served as a marina after frequent trips to Vienna. The general view of the villa is illustrated in Fig. 9 and elements of the interior architecture are shown in Fig.10.

Fig. 9. View of the general's villa (drawing by D. Jończyk)

Fig. 10. Elements of interior architecture in the general's villa (drawing by D. Jończyk)

4. The ruined Prince's House

The President of the City of Częstochowa, Mr. K. Matyjaszczyk, after more than a century of turbulent history of the House of Grand Duke Michał II Aleksandrowicz Romanow in early 2019, puts an application before the City Council to give permission to sell the ruined Prince's House. It is purposeful that this important historic building for the city of Częstochowa survives in its historically renovated shape, which will not only be a symbol of a significant memory of the city's development, but also a historical memory of the architecture of Częstochowa. In the light of the information provided, it should be emphasized that the Grand Duke Michał II Aleksandrowicz initiated and supported many development projects for the city and its surroundings, including the organization of the organization in Częstochowa. Exhibition of industry and agriculture in 1909, at that time the largest in the Russian partition. The exhibition was a manifestation of the economic strength of the reviving Polish nation. At the exhibition, the Ostrów estate was founded by a separate Forestry pavilion, in which, apart from the presentation of agricultural products and livestock, a model of a school building in Zagórze funded by the Grand Duke was presented. In November 1918 Poland gained its independence, but it did not erase the good memories of the Grand Duke Michal II Aleksandrowicz Romanów, as can be seen in the incident from the beginning of the First World War presented in the publication [2, 6]. When German troops occupied Kłobuck, the Russian cavalry fighting with them was spontaneously supported by the local population, Kłobuck was shot and burned as a punishment, and the head of the commune and several other residents were shot. Grand Duke Michał II Aleksandrowicz Romanow is killed by Chekists in Russia on June 13, 1918 in the town of Perm. His wife Natalia Brassov Romanova, who left Russia together with her son Jurij Michałowicz Romanowe, who died tragically in Paris in July 1931. Countess Natalia Brassow in 1931 attempted to obtain rights to the property of Ostrów, the Prince's House and the "villa of the general". The trial took place in Częstochowa and Warsaw. The final verdict was issued by the Supreme Court on January 9, 1937, the cassation appeal was rejected. Natalia Brassow Romanowa died in Paris on January 26, 1952.

5. Conclusions

The decision to sell the historical building of the city of Częstochowa, the "Prince's House", is the proper bold and courageous decision, in order to bring this object back to life, which is a souvenir of turbulent history and beautiful architecture.

It would also be advisable to commemorate the truth of historical memory by commemorating and commemorating the table of historical events and the connection with the city of Częstochowa of the Grand Duke Michał II Aleksandrowicz Romanow.

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STABILITY ANALYSIS AND LONGITUDINAL SECTION DESIGN OF THE BARS IN COMPRESSION

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Abstract: This paper analyzes the stability of the cantilever bars in compression, obtains the critical stress through Euler's method and then explores the failure point when the cantilever bars are in the condition of critical stability. Under the satisfied condition of basic assumptions, the expression of true stress of the bars in compression is derived, and it is concluded that the maximum true stress appears at where the total rotation angle of the bars in compression is zero. Therefore, true stress of the bars can be reduced by cross section design. At last, the bus function linked with cross section and described by Matlab is basically in line with actual situation, which further verifies the feasibility of the method in this paper.

1. Introduction

It has been nearly 300 years since the stability of the bars in compression was first proposed by Euler in 1744. Although many scholars have analyzed it, at present there are still many frequently-occurred disasters related to stability due to natural or human factors. For example, on June 13th, 2007, the scaffolding of Huangpu Bridge of Pearl River in Guangdong collapsed, resulting in two deaths and two injuries; On January 12th, 2010, eight people were killed and three injured when their scaffolding collapsed at the site in a cultural and technological industrial park in Wuhu. Factors, such as improper construction, lead to these scaffolding accidents. The Quebec Bridge is one of the largest bridge collapses related to structural instability in the history of architecture. The main reason is the designer's overconfidence, which led to an excessive load that caused the instability of the lower chord of the bridge structure, which finally caused the collapse of the whole structure. This accident brought about a large number of casualties and economic losses. Therefore, structural stability analysis has become an indispensable part of architectural design.

Structural stability can be divided into global instability and local instability. As to instability, there are three types. The first type is the bifurcation buckling meaning that the structure keeps an equilibrium either in the original state or in the new state. The second type is the limit point buckling meaning that the form of structure equilibrium does not change but deformation increases rapidly based on the original form so that the structure loses its bearing capacity. The last type is the snap-through buckling meaning that the load has a maximum and a minimum value; when the load reaches the maximum value, deformation quickly increases and develops in a new form.

At present, many Chinese scholars have tried to obtain the critical load of stability of structures, which meanwhile generated many methods to determine the stability of complex structures. Yang Lvfeng [1] proposed EMRM (elastic modulus reduction method), the essence of which is to make the simulation close to reality by reducing the elastic modulus of the structure when stress is redistributed. With an iterative calculation of computer, EMRM can quickly calculate the critical load of the structure. Zhou Weixing [2] mainly proposed an efficient method to identify the types of structural instability (global or local), which is an improvement on the consistent imperfect buckling analysis method (CIBAM). It is mainly realized through the sudden change of the strain energy of the members, and with this method the critical load can be calculated. Yang Lvfeng [1], Zhou Weixing [2] and other scholars mainly focused on the checking calculation of structure but didn't study how to prevent structural instability, especially how to reduce the harm of structural instability.

Therefore, in order to prevent structural instability and reduce its harm, this paper explores the causes of instability from structural constitutive relationship. It ascribes the stability failure of the member to the fact that true stress of the member is greater than its ultimate true stress. Based on the mechanical analysis of the simple cantilever bars in compression, the expression of true stress is obtained. It is found that true stress is positively correlated with the cosine of the rotation angle and is negatively correlated with the initial area. Through these two groups of correlation, the most vulnerable position of the bar in compression is found and the cross-sectional area of the bar is designed to reduce the possibility of structural instability.

Fig.1. The collapse of scaffolding on Huangpu Bridge in the Pearl River, Guangdong Province

2 The theoretical analysis of elasticity

2.1 The basic assumptions

Consider the following assumptions : (1) the structure is an ideal elastomer; (2) all the basic assumptions of elasticity are satisfied; (3) it is believed that the failure mechanism of the member is that the limit value of true stress is exceeded; (4) the elastic modulus does not change with stress and deformation state; (5) the deformation of the section of the bar is not constrained at the fixed end; (6) the shapes before and after section deformation are similar; (7) the change of sectional area and axial length is homogeneous.

Table.1 Symbol Definitions

symbol	meaning
M	bending moment
F，P	the loading
F_N	axial force
F_S	shearing force
E	the modulus of elasticity
F_{Rx}	support reaction
δ	deflection
θ	rotation angle

A_0	initial sectional area
A	actual sectional area
I_0	inertia moment of the initial section
I	inertia moment of the actual section
W_0	flexural stiffness of the initial section
W	flexural stiffness of the actual section
l_0	initial bar length
l	actual bar length
Δl	change of bar length
ΔA	change of bar area
μ	Poisson's ratio
S^*	moment of area
σ	normal stress
τ	shear stress
y_τ	the width of the longitudinal section of the member

2.2 The derivation of stable critical stress

The cantilever structure is shown in Fig. 2. Point A is fixed while point B is free; Bar parameters: I_0, E, l_0, W_0, A_0, and μ. There is an axial force at point B, and its size is F. The rod is slender and made with A_3 steel.

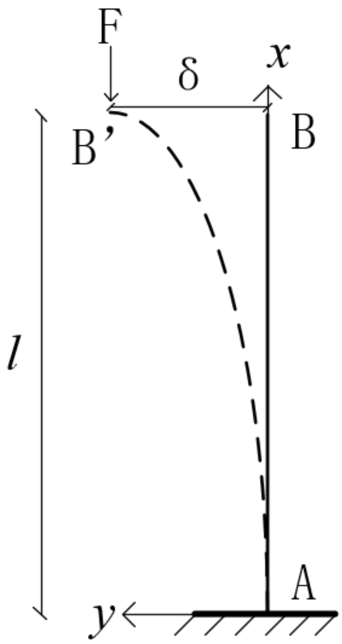

Fig.2. The bar in compression

At point A, by $\sum M_A = 0$ and $\sum F_y = 0$, we can get:

$$M_A = -F\delta\, , F_R = F \tag{1}$$

By $EIw^{''} = -M(x)$, we can get:

$$EIy^{''} = F(y-\delta) \tag{2}$$

Namely:

$$y^{''} + n^2 y = n^2\delta\, ,(n^2 = \frac{F}{EI}) \tag{3}$$

This is a second order constant coefficient differential equation. The general solution is:

$$y = C_1\cos(nx) + C_2\sin(nx) + \delta \tag{4}$$

From the boundary conditions:

$$\begin{cases} When \quad x = 0\text{:}\ \ y = 0,\ \ y^{'} = 0 \\ When \quad x = l\text{:}\ \ y = \delta \end{cases}$$

We can get (ignore axial deformation):

$$\begin{cases} C_1 + \delta = 0 \\ C_2 n = 0 \\ C_1\cos(nl) + C_2\sin(nl) + \delta = \delta \end{cases} \tag{5}$$

When C_1, C_2, δ is all zero, it represents that the bar is a standard axial compression member. When all of C_1, C_2, δ is not zero, by linear algebra, we can get:

$$D = \begin{vmatrix} 1 & 0 & 1 \\ 0 & n & 0 \\ \cos(nl) & \sin(nl) & 0 \end{vmatrix} = 0 \tag{6}$$

Namely:

$$\cos(nl) = 0 \Rightarrow nl = \frac{\pi}{2} + k\pi\ ,\quad k = 1,2......$$

So, the minimal F is the critical force when the bar in compression is stable:

$$F_{cr} = \frac{\pi^2 EI}{(2l)^2}$$

2.3 The mechanical analysis of the elastic bar in compression

When the bar AB deviates as shown in Fig. 2, any section of the bar is taken for analysis, and F along curvilinear orthogonal is decomposed into axial force and shearing force. By orthogonal decomposition of the force F , we can get:

$$\begin{cases} F_N = F\cos\theta \\ F_S = F\sin\theta \end{cases} \tag{7}$$

Obviously, it is thought that under the influence of shearing force, the bar forms a bending moment, and under the effect of axial force, tension and compression deformation occurs. By mechanics of materials, we can get:

$$\frac{F_N}{EA} = \frac{\Delta l}{l_0} = \frac{l - l_0}{l_0} \tag{8}$$

$$-\mu\frac{F_N}{EA} = \frac{\Delta h}{h_0} = \frac{h - h_0}{h_0} \tag{9}$$

Obviously we can get:

$$\mu^2 \frac{F_N{}^2}{E^2} = \frac{(A-A_0)A^2}{A_0} \tag{10}$$

Substitute $\lambda_n{}^2 = \frac{A}{A_0}$, $\lambda_\tau = \frac{l}{l_0}$,into formula (10) :

$$\lambda_n{}^6 - \lambda_n{}^4 = (\frac{\mu F_N}{EA_0})^2 \tag{11}$$

$$\lambda_n = -\mu\lambda_n \tag{12}$$

Observe formula (12). According to the basic assumptions, the two cross sections before and after deformation can be regarded as similar shapes. λ_n is the similarity ratio and the area is the square of the similarity ratio, then we can get:

$$I = \lambda_n{}^4 I_0 , W = \lambda_n{}^3 W_0 , S^* = \lambda_n{}^3 S_0{}^*$$

If the material mechanics formula is satisfied, the solution of each stress is:

$$\begin{cases} \sigma_a = \dfrac{M}{W_0 \lambda_n{}^3} \\ \sigma_b = \dfrac{F_N}{A_0 \lambda_n{}^2} ,(\psi = \dfrac{S^*}{b}) \\ \tau = \dfrac{F_S \psi_0}{I_0 \lambda_n{}^2} \end{cases} \tag{13}$$

Equivalent stresses can be expressed according to the four theories of material mechanics:

$$\sigma_{ri} = \Gamma(\sigma_a, \sigma_b, \tau), i = 1,2,3,4 \tag{14}$$

The similarity ratio omits the biquadrate in formula (11), and according to the small deformation hypothesis, axial force has the greatest influence in this problem, and the normal stress derived from axial force can be expressed as:

$$\sigma_b = C_3 \cos^{1/3}\theta \tag{15}$$

Observe formula (15) again. When $\theta = 0$, σ_b has a maximum value at origin A, which is the most vulnerable to destruction.

2.4 The design method of the bar section

According to the above stress expressions, the instability of the bar in compression can be prevented by changing the size of longitudinal section in actual engineering. The following is the design method of longitudinal section based on Fig. 2.

Let $\lambda_n{}^6 \approx (\frac{\mu F_N}{EA_0})^2$, and we can get:

$$\sigma_b = \frac{E^{2/3}}{\mu^{2/3} A_0^{1/3}} \times F_N^{1/3} = \frac{E^{2/3}}{\mu^{2/3}} \times F^{1/3} \times \frac{\cos^{1/3}\theta}{A_0^{1/3}} \tag{16}$$

It is found that σ_b produced by axial force is positively correlated with $\cos^{1/3}\theta$ and is negatively correlated with $A_0^{1/3}$. The true stress σ_b can be reduced by increasing the initial area A_0 of the section. The longitudinal section is directly related to the bus.

Then according to (16) , we can get:

$\Phi = A_0 \cos\theta$, Φ is the cross-sectional area function. (17)

True stress produced by axial force is:

$$\sigma_b = \frac{E^{2/3}}{\mu^{2/3} A_0^{1/3}} \times F_N^{1/3} = \frac{E^{2/3}}{\mu^{2/3}} \times F^{1/3} \times \frac{\cos^{1/3}\theta}{\Phi^{1/3}}$$
$$= \frac{E^{2/3}}{\mu^{2/3}} \times F^{1/3} \times \frac{1}{A_0^{1/3}} \quad (18)$$

From $EIw'' = -M(x)$, we can get:

$$\theta = -\frac{\int M(x)dx}{EI} \quad (19)$$

Formula (17) and (19) being combined, the design formula of longitudinal section can be obtained.

3. The analysis of the stability of the plastic bar in compression

In real engineering, many members under load effect change from elastic stage into plastic stage, when it is assumed that the structure enters plastic stage due to the critical force of structural instability. Traditional plasticity analyses describe stress state of the structure with engineering stress. Within the elastic range, errors made with this method are controllable. However, once the structure enters plastic stage, engineering stress analysis will probably lead to distorted results. Therefore, this paper adopts the analytical method of true stress, and divides the structure into two stages: elastic stage and plastic stage. When the structure enters plastic stage, the elastic limit state is considered as the initial state, so that the member becomes perfectly plastic materials. Through the analysis of the structure, the index of the structure after the structure enters plasticity are obtained through the relationship between plastic stage and initial stage.

When the material enters plastic stage, the true stress-strain curve is still used in the analysis. The figure below shows the true stress-strain curve of A_3 steel, which was obtained by Ren Weijie[4][4] through experiments.

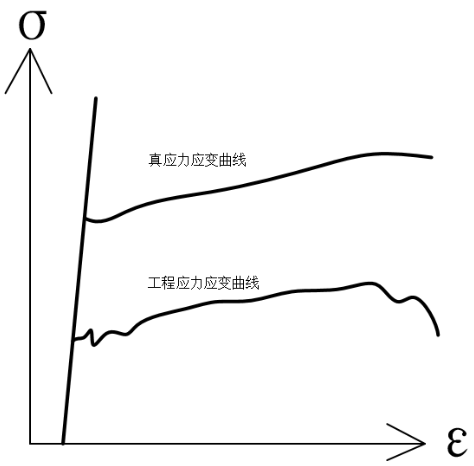

Fig.3. True stress-strain curve

It can be seen from the true stress-strain curve of A_3 steel that if the error is ignored, the image can be approximately understood as two straight lines. The modulus of the material is divided into two parts: (1) E is the modulus of elasticity in elastic phase. (2) E_p is the modulus of plastic phase. From this we can get the relationship between the two:

$$E_p = \mu_p E \tag{20}$$

μ_p is defined as the elastic-plastic modulus coefficient, which represents the change of the modulus of the material in both stages of elasticity and plasticity. In essence, it represents the change of the microstructure of the material after entering plastic stage. Obviously, the coefficient of μ_p of A_3 steel is between 0 and 1.

When the member enters plastic stage, it can be understood that the basic assumptions are satisfied in the case of piecewise. The modulus is replaced by equation (20). Therefore, the formula for calculating normal stress should be:

$\sigma = E\varepsilon_e + \mu_p E(\varepsilon - \varepsilon_e)$,where ε_e is the maximum of elastic stage.

3.1 The design method of the plastic bar section

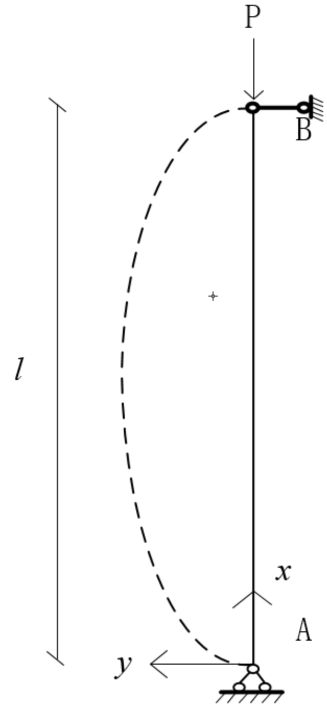

Fig.4. The bar in compression

The bar in compression is used as shown in Fig. 4. As is defined, under the effect of the external force F , the bar enters the elastic limit state, and at the same time, no instability or deflection is found in the bar and the parameters of the bar in the elastic critical state are:

$$\lambda_\tau = 1 + \varepsilon_e, \lambda_n = \mu(1 + \varepsilon_e)$$

$$I_e = \lambda_n^{\,4} I_0, W_e = \lambda_n^{\,3} W_0, S_e^{\,*} = \lambda_n^{\,3} S_0^{\,*} \quad , l_e = \lambda_\tau l_0, A_e = \lambda_n^{\,2} A_0$$

(Here the data of ε_e can be measured experimentally.)

When the bar is in elastic limit state, an axial force P is added to the member.

From the deflection line, we can simply get:

$$\frac{dM(x)}{ds} = P_S, (P_S \text{ is the shearing force.}) \tag{21}$$

According to mathematical relation, we can get:

$$\cos\theta ds = dx \tag{22}$$

namely:

$$\frac{dM(x)}{dx} = P\tan\theta \tag{23}$$

From the material mechanics formula $\frac{y''}{(1+y'^2)^{3/2}} = -\frac{M(x)}{EI}$ and $y' = \tan\theta$, we can get:

$$y''\cos^3\theta = -\frac{M(x)}{EI} \tag{24}$$

Formula (24) is $y(x)$'s second order differential equation, whose solution is very difficult. However, if the member is analyzed from the perspective of potential energy column [5], the $y(x)$ can be set up by Rayleigh - ritz method, and then the function Φ can be resolved by formula (24). It is assumed that when the bar enters the second state, instability of the member causes itself to move sideways, resulting in deflection and rotation angle. In order to simplify the calculation, bar length changes are ignored, and it can be seen from the true stress-strain curve of A_3 steel that the deflection curve form in the second state is similar to that in the first state. The equation of deflection line can be set up by Rayleigh - ritz method:

$$y = \sum_{i=1}^{n} a_i \sin\frac{\pi ix}{l_e} \tag{25}$$

Namely:

$$y' = \tan\theta = \sum_{i=1}^{n} a_i \frac{\pi i}{l_e}\cos\frac{\pi ix}{l_e} \tag{26}$$

According to the mechanical analysis of the structure, the support reaction at A point can be expressed as:

$$F_{Rx} = 0 \tag{27}$$

The expression of bending moment on any section of the bar in compression can be obtained as follows:

$$M = Py \tag{28}$$

According to equation (24), it can be concluded that:

$$E_p I_e \lambda'^4_n \times y''\cos^3\theta = -Py \tag{29}$$

According to equation (26), it can be concluded that:

$$\theta = \arctan\left(\sum_{i=1}^{n} a_i \frac{\pi i}{l_e}\cos\frac{\pi ix}{l_e}\right) \tag{30}$$

According to equation (11), it can be concluded that:

$$\lambda'^6_n - \lambda'^4_n = \left(\frac{\mu P\cos\theta}{E_p A_e}\right)^2 \tag{31}$$

Substitute equations (31) and (30) into equation (29), and get the relative value $a_i\,(i=1,2,...,n)$ through $a_1, a_2,..., a_n$ all of which are not zero. If the midspan deflection is known, the absolute value $a_i\,(i=1,2,...,n)$ can be obtained. Then we can get a function $\theta(x)$.

Then the method of solving Φ in plastic stage is the same as that in elastic stage.

3.2 The analysis of the section design method of the plastic bar in compression

The plastic design is based on the special A_3 steel. Fig. 5 below [6] is the true stress-strain curve obtained through the same kind of steel material tensile testing. Their common feature is that they have the same material with basically unchangeable plastic modulus in specific domain. Constitutive relations vary with different materials, accordingly the longitudinal section curve obtained will also be different. When the shape of the true stress-strain curve is different from that in Fig.5, we can simplify the curve through regression line.

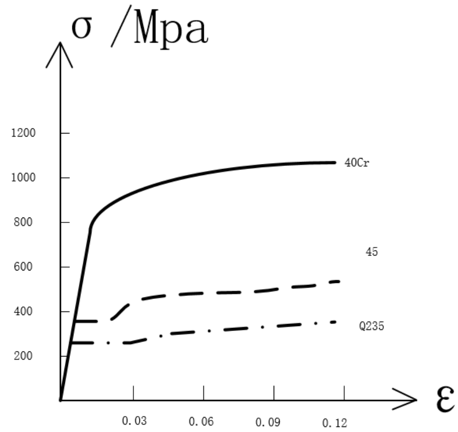

Fig. 5. True stress-strain curve

Although equations (21) and (23) are not applied here, they are analyzed from another perspective, which is more convenient in some cases. Equations (25) and (31) can be substituted into the energy equation, and critical stress can be directly solved by Rayleigh - ritz method [5], which is not described here.

4. The design procedure of elastic column in actual engineering

In actual engineering, the design of instability of the member is a checking part in the whole design. The design steps are given here based on the method in this paper:

① According to external load, through strength conditions, the sectional area A_0 is calculated.

② Analyze the column stability, check the critical engineering stress in normal use, and modify the sectional area A_0 (A_0 is related to I).

③ The stress condition of the column is analyzed to express true stress, and A is modified to solve the busbar equation of the longitudinal section.

The steps of ③ are as follows:

a. Solving the function $\theta(x)$

b. Solving the relationship between stress and $\theta(x)$

c. Solving the function $A(A_0, \theta)$

4.1 An example of an elastic problem

Now the section design of the slender rod in Fig. 2 is designed according to the method described in section 2.4.

It can be obtained from equation (5):

$$\begin{cases} C_1 = -\delta \\ C_2 = 0 \end{cases} \tag{32}$$

According to equation (19), we can get:

$$\theta = -\frac{\delta F}{EI_0}\sin(nx) + C_4 \tag{33}$$

Substitute equation (33) into equation (17):

$$\Phi = A_0\cos\theta = A_0\cos[-\frac{\delta F}{EI_0}\sin(nx) + C_4]$$

The rotation angle of point A is zero, so we can get:

$$\Phi = A_0\cos\theta = A_0\cos[-\frac{\delta F}{EI_0}\sin(nx)] \tag{34}$$

Observe formula (34), in the expression of the area function Φ, only δ is unknown, which either can be obtained by experiments or can be satisfied according to design requirements:

$$\delta \le [\delta] = \frac{\delta_{\max}}{K} \tag{35}$$

According to equation (34), the mathematical analysis shows that the area function of the member in Fig. 2 has the following characteristics:

1) The area function Φ has a maximum at point A. That is, there is a maximum at where the rotation angle is zero.
2) The area function Φ is a monotone decreasing function of x ($x \in [0, \frac{l_0}{2}]$), and the minimum value is obtained at point B.

According to the similarity relation, the longitudinal section busbar function Θ is deduced:

$$\Theta = \frac{1}{2} \times \sqrt{\frac{\Phi}{A_0}} \times y_\tau \tag{36}$$

(y_τ is a constant and related to the initial cross-sectional area A_0 .)

The shape of the bus function is approximately as shown in Fig. 6:

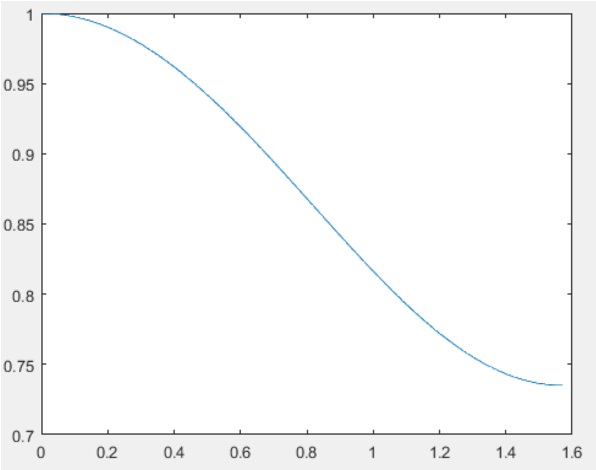

Fig.6. The approximate curve of bus

```
>>  clear
x=[0:0.005:1.57];
y=sqrt(cos(sin(x)));
>> z=sqrt(cos(atan(cos(x))));
>> plot(x,y)
>> plot(x,z)
>>
```

Fig.7. The program

Formula (36) and (34) are equivalent and are selected according to the degree of difficulty. The figure below is the rough shape of the column after area correction.

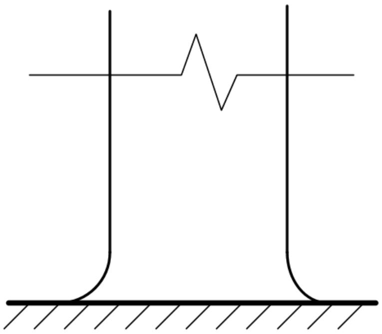

Fig.8. The rough shape of the column after correction

In the structure in Fig. 2, the cross section in Fig. 8 is obtained. When the bar in compression is fixed at both ends, the shape can be obtained as shown in Fig. 9.

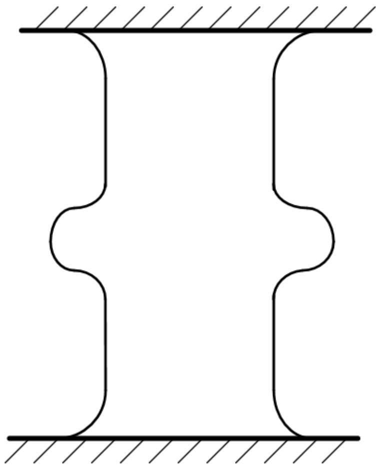

Fig.9. The rough shape of the column after correction

It is also easily obtained if the bearing is in other forms.

4.2 An example of a plastic problem

Now the section of the slender rod in Fig. 4 is designed according to the method described in section 3.2.

From [5] the instability deflection curve equation of the bar in compression hinged at both ends we can get:

$$y = a\sin\frac{\pi}{l_e}x \tag{37}$$

The equation of the rotation angle is:

$$y' = \tan\theta = \frac{a\pi}{l_e}\cos\frac{\pi}{l_e}x \tag{38}$$

Namely:

$$\theta = \arctan(\frac{a\pi}{l_e}\cos\frac{\pi}{l_e}x) \tag{39}$$

According to equation (17), we can get (only taking σ_b into consideration):

$$\Phi = A_e\cos\theta = A_e\cos[\arctan(\frac{a\pi}{l_e}\cos\frac{\pi}{l_e}x)] \tag{40}$$

The analysis of equation (40):

1) The area function Φ has a minimum at both point A and point B. That is, there is a maximum at where the rotation angle is zero.
2) The area function Φ is a monotone increasing function of x ($x \in [0, \frac{l_e}{2}]$), and it maximizes at the point of $x = \frac{l_e}{2}$.

The shape of the bus function is approximate to Fig. 10:

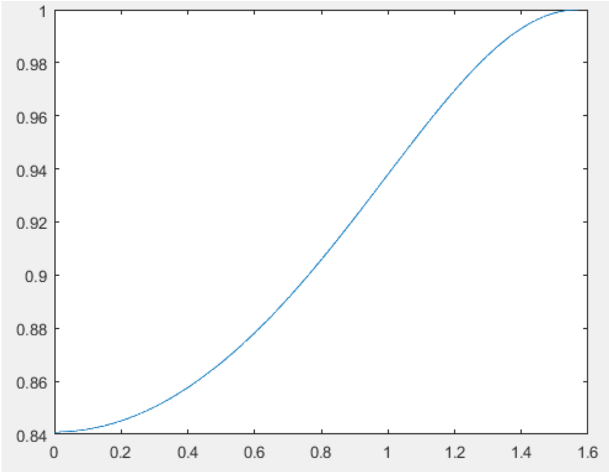

Fig.10. The approximate curve of bus

In Fig. 6 and 10, the ordinate represents the distance between the busbar and X axis (relative values). The larger the ordinate is, the "fatter" the bar in compression is; the abscissa is X.

5. Summary of advantages and disadvantages

In this paper, the stability analysis of the bar in compression mainly covers some special structures (such as the columns of long-span bridges, the columns of the overpass bridges, etc.). Because of the limitations of the environment, slender columns, instead of short and thick ones, have to be used as stressed members. The traditional design solution is to set more compression columns to share the load or to increase the sectional area of compression columns. Both ways are comparatively wasteful. The modification of the section area of the compression column described in this paper can save materials and improve the bearing capacity of the members if the requirement of the ultimate bearing capacity is satisfied. Shapes of columns in some actual projects are shown in Fig. 11 to 13, and their longitudinal section busbars are basically consistent with the analytical results in this paper, which further illustrates the rationality and applicability of the method described in this paper.



Fig.11. Pillars ***Fig.12. Pillars*** ***Fig.13. Pillars***

The derivation in this paper is based on many assumptions, which are under an ideal condition. It is assumed that for (5) there will be some reduction in actual situation. When the fixed support embeds itself in the soil, the area of the section of the compression member will not increase too much because it is constrained by the surrounding soil. Compared with actual situation, this paper needs to adopt certain safety reservation; it is assumed that (7) also does not exist in actual situation, especially for the compression member both ends of which are fixed. There will be an enormously increasing area at the half of the length of the bar, but this area will reduce the stress at the middle, so the method in this paper is conservative for this situation. In addition, for some special materials, such as materials with positive Poisson ratio, this method may no longer be applicable. Saint Venant's principle mentioned in elastic mechanics is also ignored in the case discussed in this paper.

6. Conclusions

1) If the basic assumptions are satisfied, the maximum true stress appears at where the total rotation angle of the bar in compression is zero.
2) Longitudinal design can efficiently prevent structural instability and reduce its harm.

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3,4. ENVIRONMENTAL ENGINEERING, ENGINEERING MAINTENANCE OF BUILDINGS AND STRUCTURES (ENERGY, HYDRAULIC, ETC.)

DEVELOPMENT OF TECHNOLOGICAL SCHEMES FOR PHOSPHORUS REMOVAL FROM WASTEWATER

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Keywords: Eutrophication of reservoirs, phosphorus removal, waste liquid, reagents, sea water

Abstract. This article assesses three fundamentally different methods of phosphorus removal. It is established that the most effective, promising and easily implemented method is physico-chemical. To select the optimal method of phosphorus removal, the data of laboratory and production control of municipal sewage facilities were analyzed. It was revealed that the main objects of phosphorus enrichment of waste liquid are preparatory, primary sedimentation tanks, aeration tanks, seals, excess activated sludge, sealant sludge and raw sludge, digesters, centrifuges, filter presses, and sludge drying beds. Since the maximum release of phosphorus from the cell into the environment is observed during centrifugation, the objectives of the study included: determining the effect of centrifugation on the process of ion phosphates isolation from the microorganisms cell. Studies have shown that with the number of revolutions at 4000 rpm phosphorus concentration in the fugate, increases more than 10 times if compared with the original. In the process of research, the influence of reagents on the degree of phosphorus removal from the waste liquid was studied, two types of reagents were used: calcium chloride and magnesium chloride. The results of the study showed that when using these reagents, the phosphorus concentration reaches the MPC, at a pH value of 10-10.5. For treatment facilities that discharge effluents into the sea or oceans, it is of interest to use sea water, which contains calcium and magnesium ions, to remove phosphorus. Experiments have shown that MPC is achieved with pH=10 and with the introduction of 25% of sea water. Based on the results of the study, two technological schemes of phosphorus removal from on-site sewage have been developed and proposed. Also the effect of phosphorus removal from biologically purified wastewater by sea water was investigated.

1. Introduction

Currently, one of the main problems in the field of wastewater treatment is the removal of nutrients (nitrogen, phosphorus, sulfur compounds) that cause eutrophication of water bodies. Soluble phosphorus is the main limiting element, affecting the process of eutrophication to a greater extent. The aim of the study was to develop technological schemes of phosphorus removal from waste liquid. The work was divided into three stages. The first stage was devoted to the study of the effect of centrifugation on the phosphorus release process; during the second stage the optimal dose of environmentally friendly reagents for phosphorus removal was selected; the final stage included the selection of the ratio of waste liquid and sea water to reduce phosphorus to MPC.

To date, there are three fundamentally different methods of phosphorus removal from wastewater: biological, physico-chemical and combined. The biological method is the most environmentally friendly method, but it allows to remove phosphorus only by 50% [1]. Physico-chemical method is the most effective and easily implemented. This method requires the introduction of reagents used to bind free ion phosphate in the insoluble salt of orthophosphoric acid. The reagent can be introduced at different stages of wastewater treatment. Unfortunately, when using iron and aluminum salts, a chemical sediment is formed, which must be disposed at specialized landfills. The combined method combines biological and physico-chemical methods. The method consists in the excretion of phosphorus in the form of ion-phosphate from activated sludge microorganisms cells in anaerobic conditions and their binding to the insoluble salt $Ca_5OH(PO_4)_3$ at the stage of physico-chemical purification. The organic-mineral sediment formed in the sedimentation tanks in its properties can be referred to low-grade fertilizer. Among these three methods, the combined method shows the high efficiency of phosphorus removal, at the same time being the most expensive one, both in construction and in operation.

In identifying areas of maximum allocation of phosphorus from waste water two sites of the urban WWTP (Novosibirsk and Iskitim) were examined. Studies have shown [2.3] that there are several places of intensive enrichment of silt water with ion-phosphates: seals of excess activated sludge, methane tanks, seals of raw sludge and excess sludge, filter presses, centrifuges and silt sites in Novosibirsk. At the Iskitim WWTP, places of the greatest concentration of phosphorus in waste liquid are: preaerator, where excessive activated sludge is sent, primary sedimentation tanks, aeration tanks with a large percentage of activated sludge regeneration, mechanical sludge dewatering section and sludge drying beds.

Table 1.1 summarizes the comparative data on phosphorus, ammonium nitrogen, COD, calcium and magnesium ions, as well as the pH of the studied objects of Novosibirsk.

Table1.1. Indicators of on-site sewage liquid [concentration, mg/l]

Name of structures	Waste water quality indicators						
	Phosphorus, mg/l	Ammonium nitrogen, mg/l	COD, mg/l	Iron, mg/l	Calcium, mg/l	Magnesium, mg/l	pH
A horizontal grit chamber	2,6-4,5	26,2-43,0	200-465	0,5-1,2	62,7-80,0	16,0-18,5	6,7-7,2
Radial primary sedimentation tank	2,7-10,7	27,1-43,5	177,0-250,0	0,2-0,9	67,1-75,1	16,2-18,2	6,9-7,1
Aeration tank	0,1-1,1	0,8-6,7	28,7-49,7	-	64,0-73,2	14-,7-15,2	6,9-7,2
Secondary radial settling tank	0,1-3,5	2,9-9,3	11,5-44,6	0,1-0,2	32,6-62,0	8,9-14,7	7,0-7,2
Sludge water mixture after seals	35,6-42,1	29,1-35,0	579,0-659,0	-	69,2-72,1	15,1-16,7	6,2-6,5
Sludge water	11,0-20,0	18,4-21,8	21,8-115,0	-	45,7-68,7	16,7-20,5	6,5-6,8
Filtrate	7,7-33,2	17,5-55,4	370,0-578,0	-	72,5-108,0	19,8-22,2	6,5-6,5
Fugat	18,1-60,5	36,0-86,0	373,0-856,0	-	55,6-111,0	22,1-40,9	6,3-6,7
Crude residue	10,0-57,3	34,0-63,0	121,0-2720,0	-	79,1-144,0	24,1-32,6	5,9-6,2
Sludge water from sludge beds	18,4-34,1	56,0-85,0	139,0-200,0	-	-	-	7,0-7,1

As can be seen from the table, the lowest phosphorus content was found in the filtrate of the sludge mixture selected from the end of the aeration tank (0.1–1.1 mg/l), and the maximum in the fugate centrifuges (18.1–60.5 mg/l). Since the concentration of phosphorus in the fugate was the highest, it was decided to check which factors have a greater impact on the degree of phosphorus release from the sediment particles: the rotation speed of the rotor or the duration of centrifugation process.

2. Methodology and results

Studies were carried out using two laboratory centrifuges with a rotor speed of 2000, 3000 and 4000 rpm; compacted activated sludge and crude sludge at WWTP of Novosibirsk were subjected to centrifugation. The initial concentration of phosphorus in active sludge was 1.5 mg/l, and in raw sludge - 1.23 mg / l, the raw sludge sample had to be diluted to obtain approximately the same initial phosphorus concentration. Determination of phosphorus was carried out after 5,6,7,8,9,10 minutes from the beginning of the experiment. The results showed that the increase in the rotor speed to 4000 rpm increases the concentration of phosphorus by almost 9 times compared to the initial concentration. According to the results of the study of raw sediment, it was found that at a rotation speed of 4000 rpm, ceteris paribus, there is the greatest release of phosphorus from the bacterial cell, and, compared with the initial concentration, the increase was approximately 11 times.

At the second stage of research, the optimal doses of environmentally friendly reagents were determined: calcium chloride and magnesium chloride. In the experiments, the following ratios were adopted: 1:1,3, 1:2, 1:4 - for calcium chloride and 1: 1,3, 1:3 and 1: 6 - for magnesium chloride, i.e. 1,3, 2, 3 or 6 parts of magnesium ions were introduced for 1 part of phosphorus. Natural wastewater from WWTP with an initial concentration of phosphorus of 2.6 mg/L was used. The results are presented in tables 2.1 and 2.2, and in (Fig. 1, 2).

Table 2.1. Effect of phosphorus removal at the ratio of the input Ca^{2+} [C_p, mg/l; E, %]

Investigated range of pH	The initial concentration of phosphorus, [mg / l]	1:1,3		1:2		1:4	
		C_p, [mg / l]	E, [%]	C_p, [mg / l]	E, [%]	C_p, [mg / l]	E, [%]
8.5	2,60	1.04	20.0	1.02	21.5	0.98	24.6
9.0		1.03	20.8	1.02	21.5	0.96	26.2
9.5		0.93	28.5	0.58	55.4	0.57	56.2
10.0		0.45	65.4	0.37	71.5	0.22	83.1
10.5		0.30	76.9	0.34	73.8	0.22	83.1

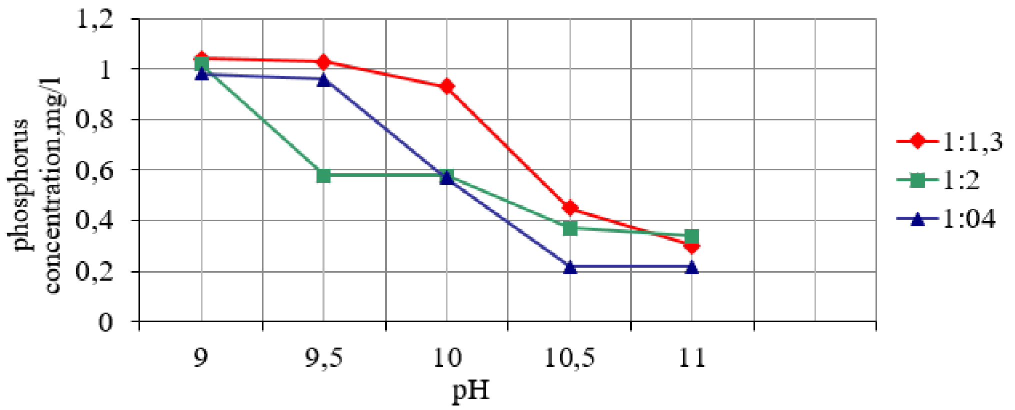

Fig.1.

Table 2.2 Effect of phosphorus removal when the ratio of the input Mg^{2+} [C_p, mg/l; E, %]

Investigated range of pH	The initial concentration of phosphorus, mg / l	1:1,3		1:3		1:6	
		C_p, [mg / l]	E, [%]	C_p, [mg /l]	E, [%]	C_p, [mg /]	E, [%]
8.5	2.60	1.81	54.7	3.47	58.7	3.27	61.0
9.0		1.23	85.4	1.23	85.4	1.20	85.7
9.5		0.78	90.7	0.69	91.8	0.64	92.4
10.0		0.50	94.0	0.48	94.3	0.48	94.3
10.5		0.34	95.6	0.21	97.5	0.19	97.7

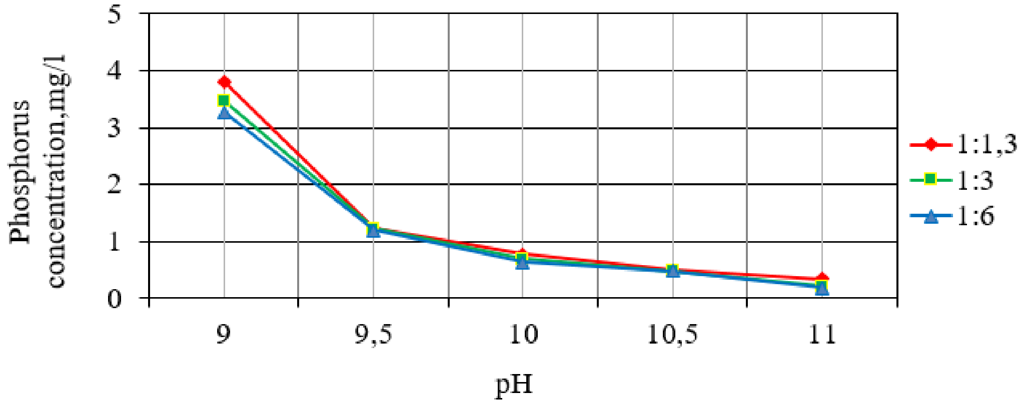

Fig. 2.

The results of studies have shown that the greatest effect of removing phosphorus from the waste liquid corresponding to MPC (0.2 mg / l) is achieved by introducing calcium chloride in a ratio of 1:4, and for magnesium chloride in a ratio of 1:2.

As noted earlier, during the study of places of intensive enrichment of the liquid with phosphorus, it was found that in the samples of silt water, filtrate and fugate concentrations of calcium and magnesium ions are high enough. In this regard, it was decided to conduct experiments on their use for binding ion-phosphates into a hardly soluble salt, creating alkaline conditions [5], introducing sodium hydroxide. The results of this experiment are presented in table 2.3 and fig. 3. As it can be seen from the above data, it is possible to achieve the required degree of treatment of waste liquid by phosphorus at pH=10.5.

Table 2.3. Effect of NaOH on phosphorus removal from wastewater [C_p, mg/l; E, %]

Investigated range of pH	The initial concentration of phosphorus, [mg / l]	Phosphorus concentration in the designated samples [mg / l]	Cleaning effect, phosphorus, [%]
9.0	2.60	2.50	3.8
9.5		0.79	69.6
10.0		0.262	89.9
10.5		0.226	91.3
11.0		0.061	97.6

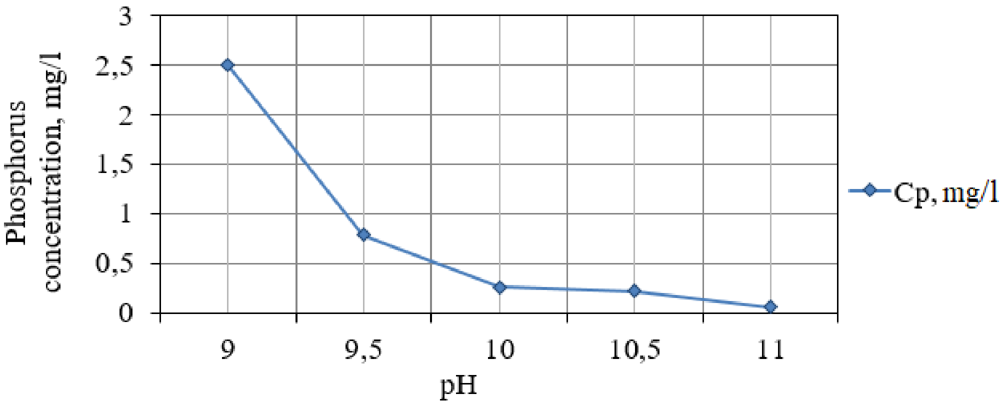

Fig. 3.

According to the results of the study, a technological scheme of physico-chemical phosphorus removal in on-site sewage effluents was proposed (Fig. 4, 5). Since at all WWTP of the Russian Federation all on-site sewage (sludge and drainage water, fugate, filtrate, domestic waste water) is collected in the reservoir of common faecal drains and from there is pumped to the head of the facilities, increasing phosphorus concentration in the sewage incoming to treatment, it is suggested to include a subunit for these drains treatment into WWTP structure.

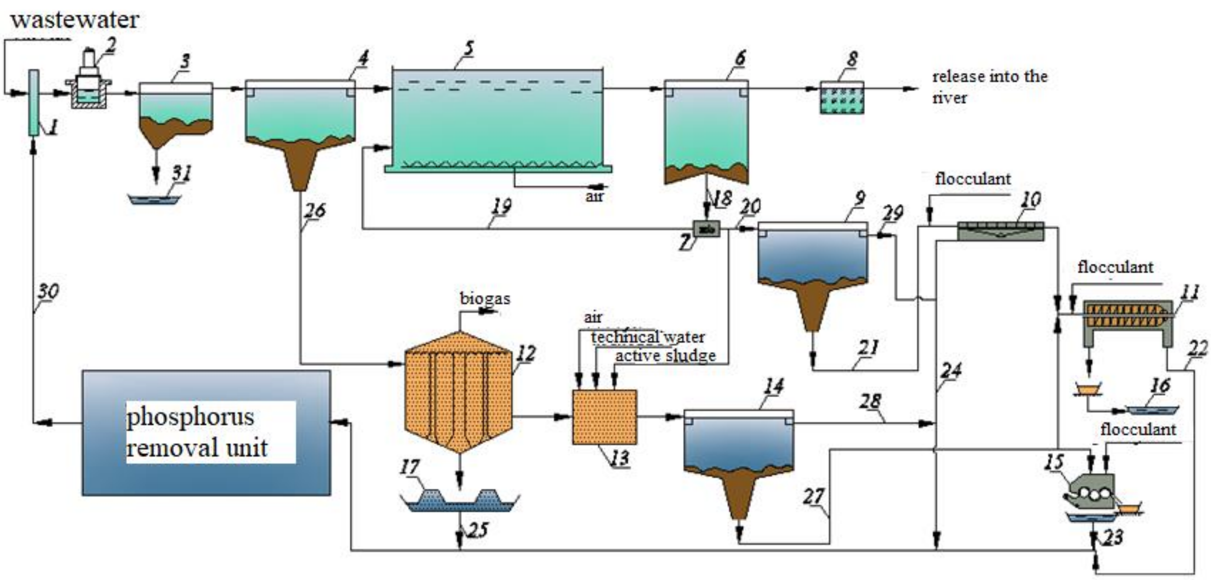

Fig. 4. The proposed technological scheme of phosphorus removal from waste liquid
1 – the damping chamber pressure; 2 – lattice; 3 – a horizontal grit chamber; 4 – radial primary sedimentation tank; 5 – aeration tank; 6 – secondary radial settling tank; 7 –pump station secondary clarifiers; 8 – UFO; 9 – radial sludge thickener excess activated sludge; 10 – belt thickener activated sludge; 11 – decanter; 12 – digester; 13-anaerobically fermented sludge washing tank; 14-anaerobically fermented sludge seal; 15-filter press; 16-dehydrated sludge storage area; 17-emergency sludge areas; 18-activated sludge; 19-circulating activated sludge; 20-excess activated sludge; 21-compacted activated sludge; 22-sludge water from the decanter; 23-sludge water from the filter press; 24-sludge water from the thickener;25 drainage water from the sludge sites; 26 – raw sludge; 27 – compacted anaerobic digested sludge leaves; 28 – water sludge from anaerobic digested sludge; 29 – water sludge after the sludge thickener excess activated sludge; 30 – a mixture of sludge water;31-sand pads

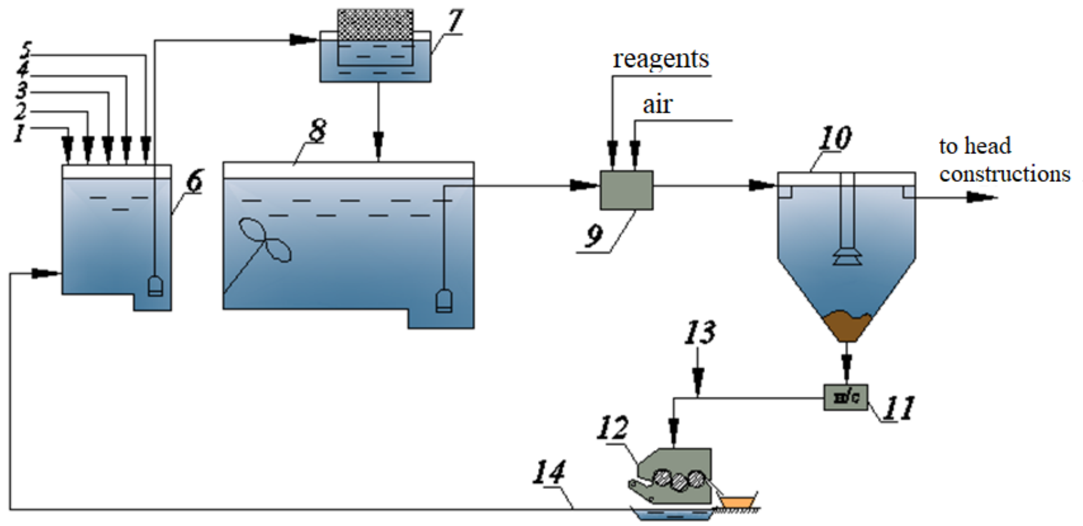

Fig. 5. Physical and chemical wastewater treatment unit of on-site sewage
1-silt water from the decanter; 2-silt water from the filter press; 3-silt water from the thickener; 4-drainage water from the silt sites; 5-silt water from anaerobically fermented sediment; 6-the existing tank of household drains;7-drum sieves; 8-tank averager; 9-reaction chamber; 10-sump physico-chemical cleaning; 11-pumping station; 12-filter press; 13-flocculant;14 – filtrate into the tank of domestic wastewater

Parts of the unit are: the existing tank of household - faecal wastewater, in addition there will be a drum sieve to trap large waste coming from domestic sewage to onsite sewage systems, tank-averager, providing stable operation of the physical-chemical treatment of wastewater, the reaction camera for input of the reagent, sedimentation tank for physico-chemical treatment and filter press for crystalline sediment. For sedimentation of phosphates the use of sodium hydroxide or a complex reagent (lime and sodium hydroxide) are recommended.

The third stage of the research was devoted to the study of the effect of phosphorus removal from biologically treated wastewater by sea water, which is characterized by a high content of magnesium and calcium ions. The objectives of the study were to determine the amount of input sea water, providing at high pH values to reduce the concentration of phosphorus to MPC. In the experiments, sea water in the amount of 100, 50, 25 and 10% was introduced into the natural biologically treated waste liquid. In the obtained mixture, the pH rose to 10.5 with sodium hydroxide. The results of the experiments are presented in table 2.4 and Fig. 6. Studies have shown that the introduction of 25 % (by volume) sea water into biologically treated wastewater and increasing the pH of the mixture to 10, the required degree of phosphorus reduction is achieved (0.19 mg/l).

Table 2.4. Effect of phosphorus removal with seawater input ratio [C_p, mg/l; E, %]

Investigated range of pH	1:1		1:0,5		1:0,25		1:0,1	
	C_p, [mg / l]	E, [%]	C_p, [mg / l]	E, [%]	C_p, mg / l]	E, [%]	C_p, mg / l]]	E, [%]
8.5	0.7	30	0.93	31.1	1.2	25	0.9	19
9.0	0.7	30	0.8	40.7	1.16	27.5	0.897	19.4
9.5	0.61	39	0.7	48.1	0.64	60	0.882	20.5
10.0	0.35	65	0.15	88.9	0.19	88.1	0.657	40.8
10.5	0.013	87	0.013	99	0.07	95.6	0.649	41.5

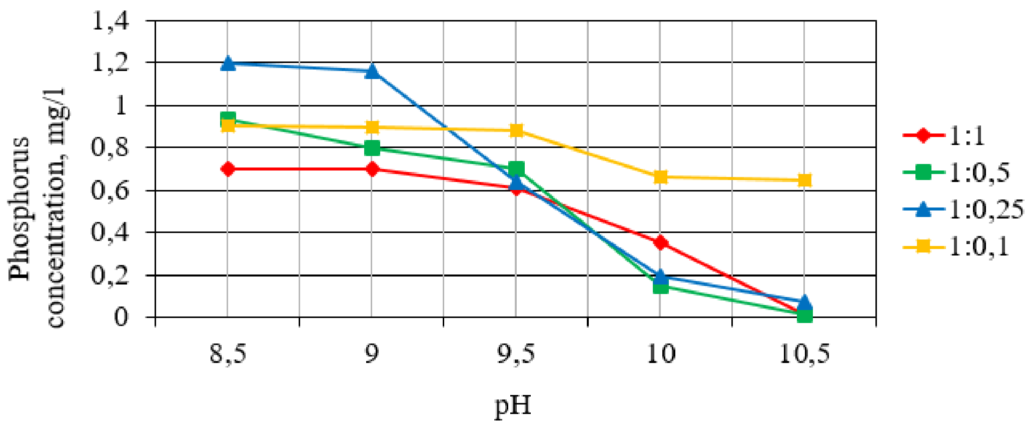

Fig. 6.

On the basis of the data obtained the technological scheme of phosphorus removal by sea water with the subsequent release of treated waste water into the sea or ocean was presented (Fig.7).

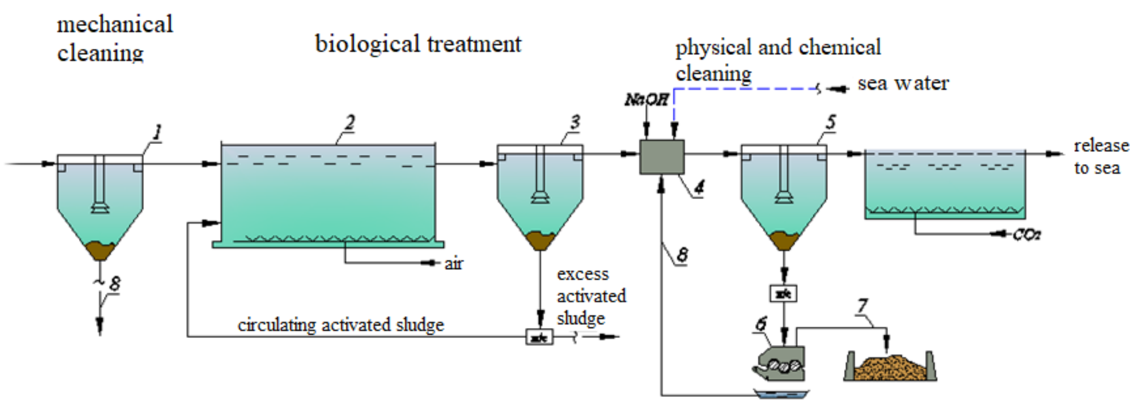

Fig. 7. The proposed technological scheme of phosphorus removal from waste liquid 1-primary sump; 2-aeration tank; 3-secondary sump; 4-reaction chamber;5 –physico-chemical treatment sump; 6 – filter press; 7 –crystalline sediment area; 9 – sludge water from filter presses

3. Conclusion

Recommended scheme includes the classic technology for the purification of wastewater and phosphorus removal, which includes: reaction chamber, which served, wastewater, sea water and sodium hydroxide, physico-chemical treatment sump where crystals sediment, filter press for dewatering of organic and mineral sludge and carbonization for waste water neutralization. It is economically and technologically expedient to direct the filtrate to the reaction chamber to reduce the reagent consumption (NaOH) and accelerate the crystallization process.

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PROHIBITED AND OBSOLETE PESTICIDES IN RIVERS SEVJUR AND QASAKH OF ARMENIA

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Keywords: prohibited pesticides, heptachlor, DDT, food

Abstract The problem of prohibited and obsolete pesticides remains unsolved in Armenia. As persistent organic pollutants, organochlorine pesticides accumulate in biological tissues, appear in the food chain and harm the environment and human health. As a result of human exposure to pesticides, cancer, allergies and hypersensitivity, damage of the central and peripheral nervous systems, reproductive disorders and the destruction of the immune system of several generations of people, the effect on the growth and formation of children are manifested.

There is a need to carry out monitoring and systematic research on the presence of pesticides in the air, soil and water, to organize a system of recording and control of the import, usage and storage of pesticides. The aim of this study was to identify the presence of organochlorine pesticides heptachlor and DDT in the waters of the rivers Sevjur and Qasakh of the Armenia by Gas chromatographic method. It was realized that pesticides' concentrations in the waters were higher than accepted norms. It can be assumed that it is the result of the leaching of pesticides from the soil, but it's not excluded that pesticides appear in the waters via precipitation and dust from the air. Prohibited and obsolete pesticides remain beyond control, in "burial" that are met in several regions of Armenia. Non-official surveys show that some of these pesticides are among the population. It is recommended to collect these quantities and keep them under control until the storage house construction is completed.

1. Introduction

The problem of prohibited and obsolete pesticides remains unresolved in the Transcaucasian region and in Armenia [1]. As persistent organic pollutants (POP) these chemicals do not decompose or slowly decompose under natural conditions. Resistant to photolysis, biological and chemical destruction, easily volatile, their trace amounts easily spread over long distances and are continuously in a wide circulation - polluting the air, water, soil, feed and agricultural products.

They accumulate in biological tissues, appear themselves in the food chain and harm the environment and human health [2, 3, 4]. As a result of human exposure to pesticides, cancer, allergies and hypersensitivity, damage of the central and peripheral nervous systems, reproductive disorders and the destruction of the immune system of several generations of people, the effect on the growth and formation of children are manifested.

The 2001 Stockholm Convention on Persistent Organic Pollutants aims to protect public health and the environment from exposure to POPs. The following 12 POPs were originally targeted: pesticides: aldrin, dieldrin, chlordane, heptachlor, DDT, endrin, hexachlorobenzene (HCB), mirex, toxaphene; industrial chemicals: polychlorinated biphenyls (PCBs); by-products: dioxins and furans.

After 1970, the production and use of DDT, hexachlorocyclohexane and other organochlorine pesticides was banned in number of countries, as in Armenia [5].

2. The current state

In 1982 in the landslide zone, near the Yerevan deep fault and the Jrvezh active fault, a 110 m long and 10–15 m wide cemetery was built without the necessary preparation of the cemetery base and without a surface water drainage system (formed during precipitation and melting snow).

About 600 tons of pesticides of 60 items were buried here. As a result of landslide processes and the washing out of pesticides and their derivatives by surface waters, as well as unattended treatment and plundering by the local population, now there are about 150 tons of toxic chemicals and derivatives from their decomposition.

In addition, about 1029 tons of DDT were buried near the Erebuni district of Yerevan. This dump threatens the environment, and it's real ecological problem.

Nowadays, there are abandoned repositories of expired pesticides in different parts of the republic, in particular, in the marzes (regions) Vayots Dzor, Shiraki, Ararat (ss. Kakhtsrashen, Narek, Jrashen), Armavir (s. Khanjyan), Gegharkunik (s. Geghmasar, Avazan), Taush. An informal survey among the population from different areas revealed that certain stocks of banned and expired Soviet-made pesticides exist in different localities. Literary data indicate the presence of pesticides both in surface waters and in the soils of traditional agricultural regions of Armenia [6].

Pesticides enter the surface waters mainly as a result of their washout from the soil and application in agriculture, and some of them appear as a result of chemical decomposition of the pesticides introduced into the soil. Such a situation is dangerous, and the risks of environmental pollution and damage to human health are high.

The issue of recording and controlling the use and storage of pesticides on the territory of Armenia still remains particularly important, the republic lacks information on the type and amount of pesticides actually used, in the literature there are only stale data. The probability that prohibited and expired toxic chemicals may be used in agriculture is large. The state does not conduct systematic research and monitoring of their presence in the air, soil, water, nor did it work out a food safety strategy related to contamination with prohibited and expired pesticides of both imported goods and agricultural products, which is produced in the country.

3. Aim and methodology

The task of this work was to identify and quantify organochlorine pesticides heptachlor and DDT in the waters of the Sevjur and Qasakh rivers in 2017 and 2018.

Sampling, preservation, extraction and concentration of organochlorine pesticides were carried out according to standard methods [7]. Identification and quantification was performed using gas-liquid chromatography on a Varian CP-3800, capillary column VF-5ms, l = 30m, d = 0.25 mm, electron capture detector.

The MPC of pesticides in surface waters is 10 ng / l.

4. Results and discussion

Figures 1 show data on the availability of DDT and heptachlor in the Sevjur and Qasakh rivers in 2017 and 2018 rivers (Water sampling times are given on the abscissa. Maximum allowable concentrations of pesticides in surface waters are 10 ng / l).

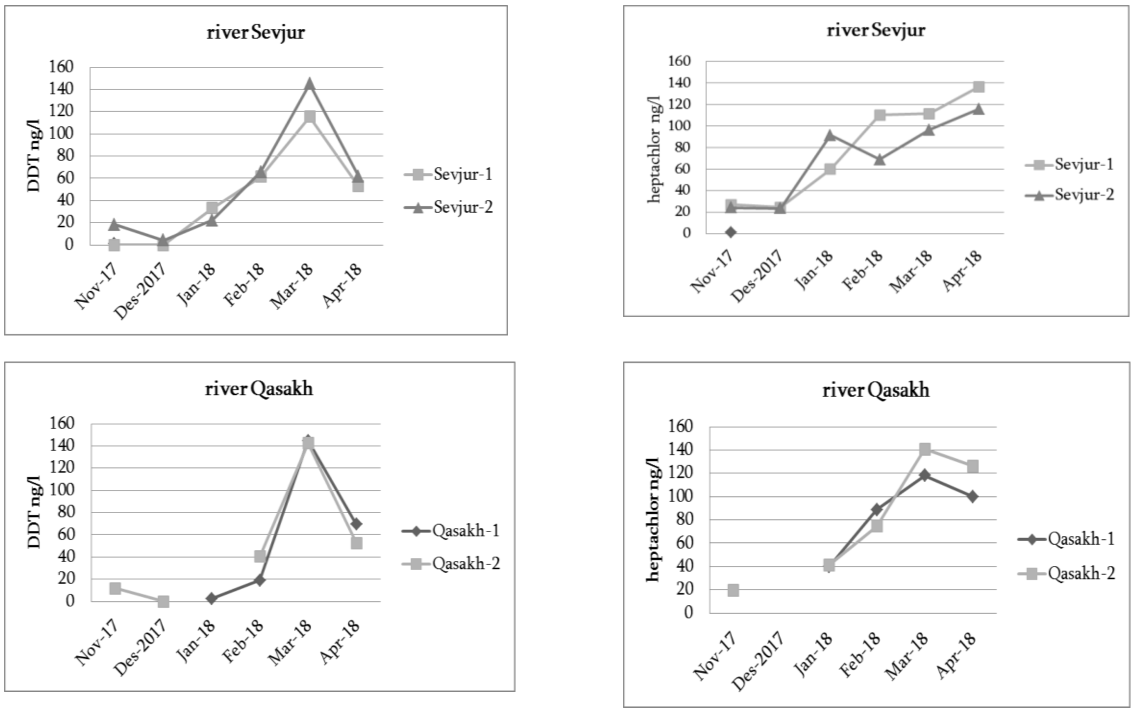

Fig.1. Organochlorine pesticides in the waters of the Sevjur and Qasakh rivers (Water sampling times are given on the abscissa. Maximum allowable concentrations of pesticides in surface waters are 10 ng / l) in 2017 and 2018

Based on the data obtained in the waters of the Sevjur and Qasakh rivers, the concentrations of heptachlor and DDT exceed the MPCs during the snow and long rain season. It can be assumed that this is the result of leaching of pesticides from the soil.

Previous studies have shown the presence of a number of organochlorine pesticides in the waters of the Hrazdan river [8].

5. Conclusion

Our data on the availability of pesticides heptachlor and DDT in the waters of the Sevjur and Qasakh rivers indicate that organochlorine pesticides are widely represented in the surface waters of Armenia with quantities exceeding MPC. Similar problems have also been identified in the UIS [9, 10].

The current situation requires the implementation of a number of activities, the need and importance of which are obvious.

- To prevent further ingress of pesticides into the soil and into surface water from abandoned storage facilities, and in order to avoid their use in the farm, it is necessary to urgently collect stocks of pesticides from both the population and from abandoned storage facilities.
- Arrange temporary storage of collected pesticides prior to construction of storage for expired chemicals.
- Apply emergency strategy to eliminate the consequences of abandoned pesticides cemeteries in all regions of Armenia.
- The state is obliged to immediately organize and conduct systematic research, objective and reliable monitoring of the presence of organochlorine pesticides, as persistent organic pollutants, in the air, soil and water.
- Create a system of accounting and control of the importation, use and storage of pesticides in Armenia.

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THE EQUATION OF ONE-DIMENTIONAL UNSTEADY MOVEMENT OF A DROPPING LIQUID IN ANY MASS FORCE FIELD

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Keywords: liquid, mass forces, acceleration, incompressible, inertia

Abstract. The equation of one-dimensional unsteady (non-stationary) movement of an incompressible liquid is introduced for the case of mass forces being the essence of the force of gravity, i.e. when the liquid is influenced only by acceleration g .

In the case of movement of a liquid in systems installed on aircrafts or moving devices, other active mass forces may also exist or emerge.

The aim of this study is to obtain the equation of one-dimensional non-stationary movement of a dropping liquid in any mass force field and to study the nature of movement of a liquid in pipes, in the case of existing mass forces or of those emerging due to a sudden change, for instance, in case of an earthquake.

1. Introduction

The development of technological progress poses problems of automatization of various production processes. In this context, problems of studying the non-stationary processes come forward to the first place.

There is an equation of one-dimensional unsteady movement of an incompressible liquid in the field of gravity, i.e. when the liquid is influenced only by mass force $\vec{g}$ [1]. In this case, one considers that the pipeline is stationary in relation to the Earth's surface. Problems [1, 2] at studying non-stationary hydromechanical processes in diverse specific systems are solved applying this equation. In particular, the work [2] studies the acceleration of a liquid in a pipe of constant diameter, in the case of constant pressure oscillations. The work [3] examines the problems of an unsteady movement in ramified systems.

The aim of this study is to obtain the equation of one-dimentional movement of an incompressible liquid in pipes, in the case of existence of any mass forces.

2. Methodology

The Euler's equation for a one-dimensional movement of an ideal fluid is as follows:

$$S-\frac{1}{\rho}\frac{\partial p}{\partial s}=\frac{\partial u}{\partial t}+\frac{\partial}{\partial s}\left(\frac{u^2}{2}\right), \tag{1}$$

where S is the projection of mass force in movement direction, p - pressure , u - velocity, ρ - liquid density.

In the case of an unsteady movement the pressure and velocity at every point of the flow depend not only on the coordinates but also on the time t. Hence, for a one-dimensional movement $u=u(s,t)$ and $p=p(s,t)$.

In the case of presence of forces of gravity and other existing external forces, the vector of mass force $\vec{F}$ related to the unit of the mass of a liquid, at every point is the sum of the single force of weight $\vec{g}$ and the single force of inertia $\vec{j}$ of the bulk motion (Fig. 1):

$$\vec{F} = \vec{g} + \vec{j}; \qquad \vec{j} = -\vec{a},$$

where $\vec{a}$ is the drag acceleration at a given point of a streamline (Fig. 2).

If one takes into consideration that direction s is the movement direction, and S is the projection of mass force $\vec{F}$ in the movement direction, one will have the following (Fig. 1):

$$S = F\cos\left(\hat{f,s}\right)$$

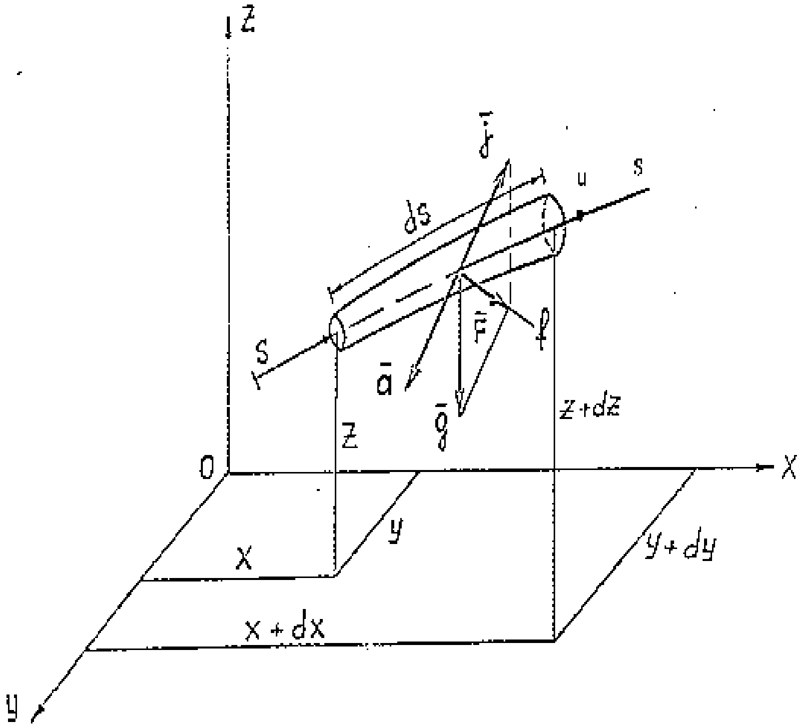

Fig. 1. An element of the fluid tube

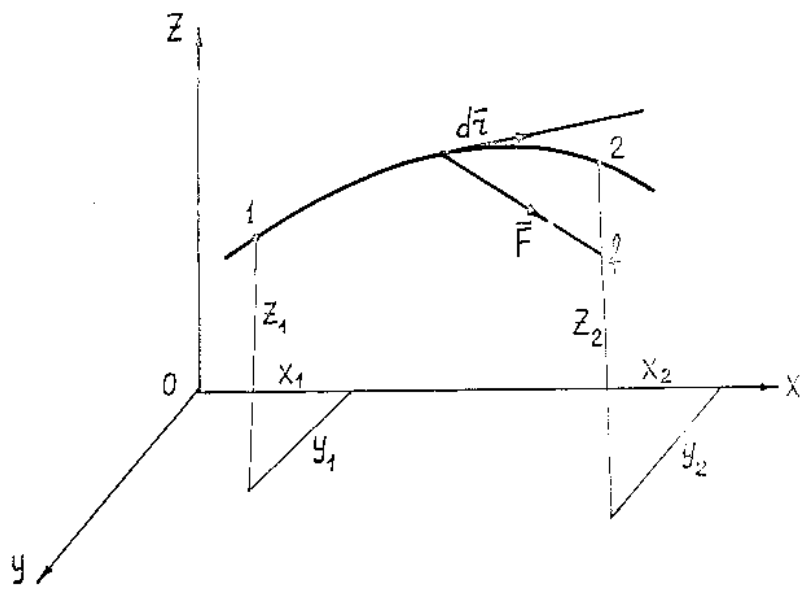

Fig. 2. The segment of the curve in the mass forces' vector field

Entering the value of the projection of mass force in (1) and taking into consideration that one can accept $\rho = const$ for dropping liquids, one will have the following:

$$F\cos\left(\widehat{f,s}\right) - \frac{\partial}{\partial s}\left(\frac{p}{\rho} + \frac{u^2}{2}\right) = \frac{\partial u}{\partial t}.$$

When multiplying by ds and integrating along the streamline, one will obtain the equation of unsteady movement of a non-viscous incompressible liquid:

$$\frac{p_1}{\rho} + \frac{u_1^2}{2} = \frac{p_2}{\rho} + \frac{u_2^2}{2} + \int_{s_1}^{s_2} \frac{\partial u}{\partial t}\, ds - \int_{s_1}^{s_2} F\cos\left(\widehat{f,s}\right) ds\,. \tag{2}$$

Acting in a similar manner as with Bernoulli's equation, one will obtain the following for the flow of real liquid:

$$\frac{p_1}{\rho} + \frac{\alpha_1 v_1^2}{2} = \frac{p_2}{\rho} + \frac{\alpha_2 v_2^2}{2} + \frac{1}{2Q}\int_{s_1}^{s_2} \frac{\partial}{\partial t}\left(\alpha_0 v^2 A\right)\, ds - \int_{s_1}^{s_2} F\cos\left(\widehat{f,s}\right)\, ds + gh_n \text{ ,(3)}$$

where v is the average velocity of the flow, h_n - the instant value of pressure loss, α_0 - the coefficient of movement quantity or Busineska coefficient, α - the coefficient of unequal distribution of free area velocity, or the coefficient of kinetic energy, Q - the discharge at the very moment of time.

In the equation (3), the expression $gh_{\text{ин}} = \frac{1}{2Q}\int_{s_1}^{s_2}\frac{\partial}{\partial t}\left(\alpha_0 v^2 A\right)ds$ is the change in kinetic energy of liquid, relating to the unit of immediate mass discharge [1].

In analogy with circulation of the velocity vector, let us introduce the concept of vector circulation of mass forces along the given contour. If one draws the streamline segment 1-2 (Fig. 2) in the vector field of mass forces, then by the curvilinear integral

$$M = \int_{s_1}^{s_2} F\cos\left(\widehat{f,s}\right) ds = \int_{s_1}^{s_2}\left(\overline{F}d\overline{r}\right) = \int_{s_1}^{s_2} F_s d_s$$

The value of circulation of the vector of mass forces along the given contour on Fig. 2 will be exposed. If X, Y and Z are the projections of the single mass force $\vec{F}$, then one will have the following:

$$M = \int_{s_2}^{s_1}\left(Xdx + Ydy + Zdz\right). \tag{4}$$

In the case when the movement takes place in a uniformly accelerated field, i.e. the mass force at the very moment of time is the same at all points of the fluid medium, then one has the following:

$$M = X\left(x_2 - x_1\right) + Y\left(y_2 - y_1\right) + Z\left(z_2 - z_1\right),$$

where x, y, z are the point coordinates, and X, Y, Z correspond to the projection of mass force, in case of which

$\vec{F} = X\hat{i} + Y\hat{j} + Z\hat{k}$.

For the accepted values, the equation of an unsteady movement for the flow of real dropping liquid will become the following:

$$\frac{p_1}{\rho} + \frac{\alpha_1 v_1^2}{2} = \frac{p_2}{\rho} + \frac{\alpha_2 v_2^2}{2} + gh_n + gh_{ин} - M \quad . \tag{5}$$

3. Results

1. While studying the movement of liquid in a pipe of constant diameter, taking into account that the free area $A = const$ and that at this point of time the average velocity v in all free areas and the distribution of velocity u on the free area are identical, one will have (3):

$$\frac{p_1}{\rho} = \frac{p_2}{\rho} + \alpha_0 l \frac{dv}{dt} - M + gh_n \, , \tag{6}$$

where $l = s_2 - s_1$ (fig. 2).

2. When gravity is the only acting force and the z axis is directed vertically upwards, then:

$$X = 0; \;\; Y = 0; \;\; Z = -g; \;\;\; M = g\left(z_1 - z_2\right),$$

from (5) one will have the Bernoulli's equation for one-dimentional non-stationary movement of an incompressible liquid:

$$z_1 + \frac{p_1}{\rho g} + \frac{\alpha_1 v_1^2}{2g} = z_2 + \frac{p_2}{\rho g} + \frac{\alpha_2 v_2^2}{2g} + h_n + h_{ин} \, . \tag{7}$$

3. When the movement takes place in the force of gravity field and the pipe is of constant diameter, then from (7) it will be:

$$z_1 + \frac{p_1}{\rho g} = z_2 + \frac{p_2}{\rho g} + \alpha_0 l \frac{du}{dt} + h_n \, . \tag{8}$$

4. In case when the pipeline moves in relation to the Earth, the study takes place in the moving coordinate system. The coordinate system is moving together with the pipeline along a set trajectory. In this case, one has to take into account also the systems emerging as a result of the movement.

If one takes into account that in case of an unsteady movement of a liquid the energy losses h_n and the coefficients α and α_0 differ from the case of stationary flow, one may apply approximating functions for their determination. However, for choosing of the relevant approximating functions, one has to have the nature of the movement. Aiming at obtaining analytical solutions for studying of the nature of the movement, the unsteady movement is viewed as a sequence of quasi-stationary flows.

4. Conclusions

The obtained equation allows one to study the one-dimensional unsteady movement of a dropping liquid under the influence of any mass forces.

Such an unsteady movement can occur from the state of rest of a liquid, as a result, of changes in the mass forces.

The equation also allows us to study the liquid oscillations in various cases, e.g. in hydrodynamic levelling systems.

Acknowledgements

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RETENTION CANALS AS AN EFFECTIVE MEAN FOR CONTROLLING OF STORM WATER HYDRAULIC TRANSPORT

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Keywords: Sewage systems, storm water, retention canals, innovation

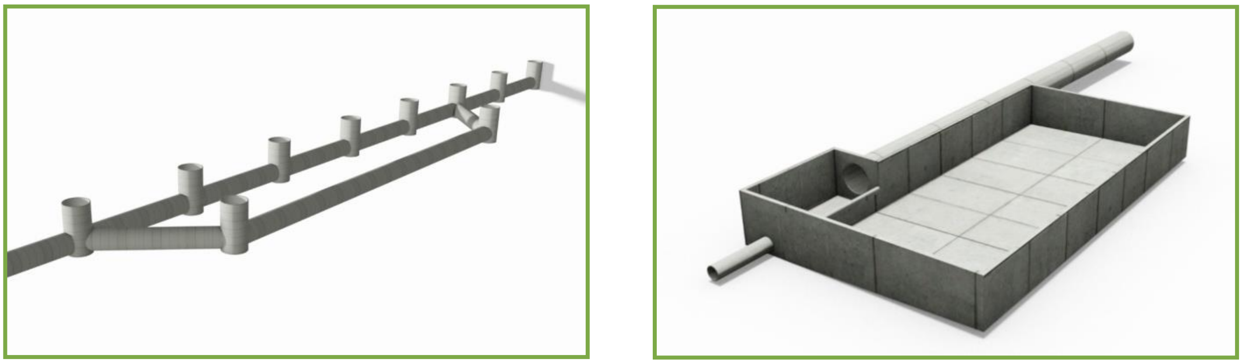
Abstract. Gravitational drainage systems are the most expensive elements of urban infrastructure and characterized by a limited possibility of the extension. An increase of rainfall phenomena of high intensity creates the operation problems connected with hydraulic overloading of sewage systems and facilities. There are various technical solutions for increasing the hydraulic capacity, flow intensity control and retention of storm water excess. Such solutions are expensive and require the availability of free areas for the building of cubic and linear objects. The solution of these problems is the application of retention canals performing the function of wastewater transport and retention. It is an innovative way to control storm water transport, which increases significantly the hydraulic capacity of the existing and new network. The idea of solution patented and implemented in Poland comes to the full use of the canals' retention capacity. The results of research of sewage system transformed into a system of retention canals equipped with damming partitions on the base of SWMM hydrodynamic modelling according to author's algorithm are presented. The essence of the created hydraulic system consists in the transformation of a typical sewage network into a number of mini retention reservoirs arranged in series, connected by partitions with bottom drains and frontal overflows. The results of simulation tests of hydraulic processes of storm water transport and accumulation in retention canals showed significant methodological differences in the design and dimensioning of the systems with retention canals, in relation to traditional sewage network.

1. Introduction

The main part of the costs incurred for the construction of the sewerage network is allocated to the construction of a network for draining rain sewage due to the need to transport large volumes of it. With an increase of buildings, the percentage of hardened surfaces grows, which in turn contributes to an increase in the volume of rainwater supplying the sewage network, becoming rainwater sewage. For many years, there has been a tendency to decrease the average number of rainfall during the year to increase their intensity, which in practice translates into an increase in the number of extreme precipitation. The growth in the area of paved areas in urbanized catchments and the intensification of the degree of development results in an increase in the volume of rainwater that flows into organized sewerage systems. This causes hydraulic overloading of the network of different systems, and consequently more frequent operation of pressure canals and precipitation of rainwater on urbanized areas, significantly increasing the damage associated with it. The consequence of both the increase in the quantity of rainwater and the number of precipitation from the group of high intensities is the unfavorable functioning of the rainwater drainage and the combined sewage system. To remedy to this, various forms of retention and control of their runoff from the catchment area and in exploited drainage systems are applied. It should be noted that the very widespread use of retention reservoirs with various hydraulic models as cubic objects allows solving this problem, but has numerous limitations. One of the basic problem is with the availability of land for development of retention reservoirs in places of their effective location, such as in the central districts of cities and historical areas. As hydraulically unloading storage reservoirs, they can perform various functions at particular stages of sewage generation and disposal, allowing mainly in addition to relieving hydraulic networks and sewage facilities, increasing the efficiency of operation of sewage treatment plants, reducing investment costs when connecting new catchments and saving sewage investments by limiting canal geometry and network objects. The design of the selected hydraulic tank model is in essence to determine the usable height of its filling and the method of filling and emptying as well as the geometry in the plan of its construction. Using appropriate calculation procedures (simplified methods or hydrodynamic modeling) and taking into account its position in relation to the whole drainage system, its required usable volume is determined for the designated reliable (critical) duration of rain, assuming a specific frequency of its occurrence. These issues, together with the methodology for dimensioning single and multi-compartmental retention reservoirs, are given in the habilitation monograph [1].

2. The importance and timeliness of the subject of retention and controlling the transport of rainwater

With the use of both complementary canals or a replacement of existing ones with new and larger geometries, a number of disadvantages of these solutions have to be expected. For example, the need to incur high expenditure for the construction of tanks and a long investment cycle, costly and complex operation and the necessity of their frequent rinsing, and above all the fulfillment of the condition for the availability of a plot of land for this type of buildings.



a b

Fig. 1. Widely used sewerage objects for unloading hydraulic networks and sewage facilities
a- Supplementary canal operating in a bypass, b- Multi-chamber retention reservoir

In order to meet the expectations of investors, designers, and especially the operators of gravity dehydration systems, an innovative system consisting of a system of retention canals was developed [2], the scheme of which is shown in Fig. 1. The idea of this engineering solution boils down to transforming the previously designed and operated sewerage networks for the hydraulic transport of rainwater into retention canal systems. It consists in introducing baffles inside the ducts with the form of specially profiled fittings that allow a continuous liquid flow through appropriately selected sections of bottom flow holes. Both the dimensions of the partitions and their intervals are each time selected based on the formulated computational algorithm [3, 4] as part of the simulation using hydrodynamic modeling. The system of retention canals has two functions at the same time, ensuring proper transport of rainwater and at the same time retention of excess water in the available, unused until now upper space of wires up to the ceiling.

3. An idea and advantages of the functioning of retention sewage canals

Thus, the basic advantages of the presented solution are mainly: (1) full use of retention capacities of existing and designed sewerage systems, (2) elimination of hydraulic overloads in the sewerage networks operated, (3) minimizing financial outlays earmarked for the construction and expansion of systems, (4) improving the stability of the cable construction and, which is of particular importance, this innovation does not require the isolation and often costly purchase of land for building existing facilities.

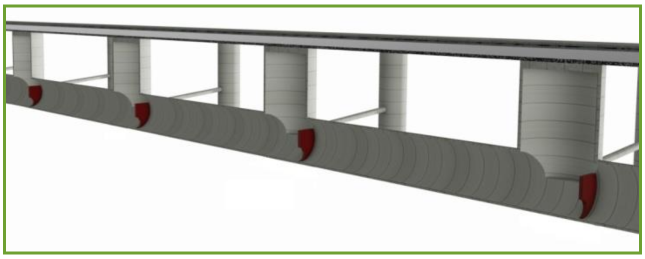


Fig. 2. Longitudinal section of a sewage network equipped with a system of retention canals with four baffles [2]

As part of completed research and application tasks, it has been determined that as a result of the use of damming booms, full utilization of the previously unused space in the upper sewerage zones takes place. However, the implemented innovation [2] to design practice [5-10] and investment [11-13] ensures the occurrence of three very important processes during hydraulic transport of rainwater in the system of retention canals. The research was carried out with the assumption that geometries of individual canals (diameters) were selected for reliable calculation flows of rainwater, commonly used in design offices. The principle was adopted, according to the German recommendations, that selected canals are to lead to about 90% of the flow determined at full filling, which corresponds to the filling of canals within 80% of their diameters.

First, there is a significant, a gradual decrease in the intensity of outflow of rainwater at subsequent stages of their flow through the damming partitions. However, what is very important, the largest reduction of outflow from the catchment was shown on the last outlet canal, which on average ranged from 40% to 70% of the computational flow from the network in the classic system. Simulation studies using hydrodynamic modeling using the SWMM program [12] have shown that it is even possible to reduce the outflow from the basin to 26% in relation to the flow established when dimensioning the final collector.

Secondly, when designing a sewerage network equipped with a system of retention canals, in addition to ensuring the transport of predetermined streams of rainwater, additionally retention of a given volume without the need to use other retention facilities is obtained. The retention volume of the retention canals is compared to the total capacity of the network calculated as the quotient of the cross section of the individual network parts and their length. It turns out that it is significant and amounts to an average of 12% to 27%, and in special cases to even one third. And that's the value that shows the specificity and effectiveness of the patented solution. Looking ahead, one can assume that the design of sewerage networks and facilities must take place using the available knowledge and experience in the use of an innovative solution system consisting of a system of retention canals. And at the stage of designing new and previously used gravity systems, having rain and combined networks. Therefore, instead of building a retention reservoir on the outlet canal from the planned catchment, the designed network can be equipped with a system of retention canals or, if this is not enough, increase some canal dilatations accordingly in order to fully eliminate the need to build a retention facility.

Another, third parameter that is changing as a result of the conversion of the classical network into a system of retention canals is a reduction in the average speed of flow of rainwater at subsequent stages of their flow through the flow openings of damming baffles. Regardless of the slowdown of rainwater runoff in the innovative network, the time of their run-off in the network increases at the same time, and this directly affects the prolongation of the critical rainfall time to determine the value of their reliable flow in any calculation method used. This phenomenon was confirmed in each case, and the largest reduction of the average flow velocity of the stream was observed in the analyzed canals, which show a greater decrease, and even show the necessity of using wells. The results of simulation tests have even confirmed almost a two-fold reduction in the speed of average rainwater flow from the value of 2.62 m/s to 1.34 m/s, only thanks to the implementation of a system of retention canals.

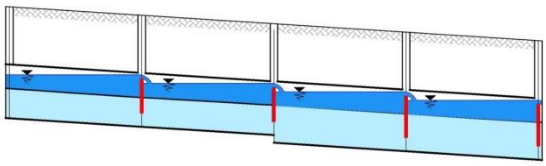


Fig. 3. The scheme of the sewerage network equipped with a system of retention canals (Serial system of retention chambers, damming bays, bottom holes as culverts, upper emergency overflows, average level of transported rainwater stream in canals, distribution of rainwater table during their transport with a retention canal system, space constituting retention capacity created in the network with retention canals)

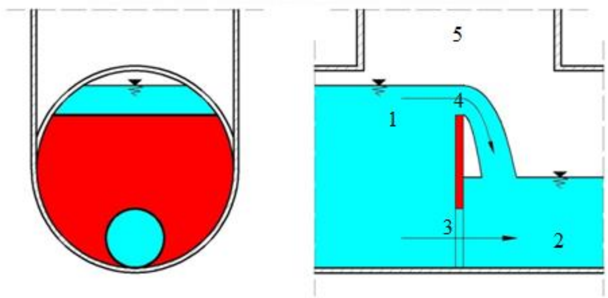


Fig. 4. Cross-sections through the canal at the location of the septic tank in the control well on the rainwater sewage system
a -Subdivision, b- Longitudinal (1 - damming sewer, 2 - rain canal, 3 - flow/drain port, 4 - transfer emergency, 5 - control well)

4. Efficiency of the retention canal system

The simulation tests conducted confirmed the exceptional suitability of the retention canal system in rainwater drainage systems by gravitational storm water and general sewage systems, and their effectiveness depends on a number of parameters, mainly characterizing the innovative solution. First of all, the drop in the bottom of the canal should be distinguished and the smaller it is, the greater the retention effect in the form of canal retention and, at the same time, the greater reduction of the stream water stream at the outflow from the retention canal system.

The second parameter significantly affecting the size of the canal retention and indirectly reducing the size of the rainwater stream at the outflow is the distance between damming baffles in the retention canals. The smaller the distance, the more efficient the retention canals are. However, at distances of 400 meters and more, their efficiency does not change significantly. The smallest distance should be considered 50 meters, also for practical reasons.

In order to determine the principles of functioning of retention canals and hydraulic phenomena, various mutual location of pipes in the planned sewerage network was analyzed on the given catchment, assuming the same number of canals of a specific length and sub-basins with the same area and runoff coefficient. In order to ensure equal conditions for the operation of canals, a similar drop of their bottoms is assumed. The initial scheme was a linear system of retention canals as serially connected single-chamber tanks, separated by damming baffles. Other diagrams were characterized by a compact system of canals, slightly elongated and with variable proportions of their distribution in the plan. The results of simulation tests confirmed that the most efficient system is a system of retention canals, which (1) have the smallest drop within one per mile, (2) damming seasons are spaced apart from each other at a distance of 50 meters, and the network has a shape similar to a linear system. The retention efficiency of the retention canal system accurately characterizes the adopted coefficient of storage capacity utilization (cubic capacity) of an innovative solution. It determines the ratio of the retentive capacity utilized by the retention canals to the total capacity of the network resulting from the multiplication of the cross-sections of wires of a given geometry through their length. The results of the research have shown that it is possible to achieve, in specific boundary conditions, the value of this cubic capacity coefficient even within 95 %! Then the retention canal system becomes a single long retention reservoir, filled up to 95% of the diameter of individual canals on average.

As can be inferred from the functional characteristics of the innovative drainage system, the applied damper stacking water at the subsequent stages of their hydraulic transport transforms a typical sewage network designed for a specific temporary flow (point) into a linear arrangement of single-chamber retention tanks cooperating with each other in places where dams are fitted in the lower part in the flow openings, each with a determined geometry and emergency overflows located on appropriate elevations for the transfer of excess rainwater to downstream retention canals.

5. Summary and final conclusions

The implementation of an innovative solution to the design and an implementation practice involving the conversion of a classical sewerage network into a retention system is a landmark moment in the modernization of drainage systems for draining rainwater from urbanized areas, providing enormous progress in their gravitational transport.

The effects resulting from the implementation of the new system, counted on only one investment, reach several million Euro. In contrast, the design of the retention canal system requires the use of a different methodology, which takes into account the hydraulic processes taking place simultaneously in a complex model of all its components, while determining a critical case of rain, which in any case takes values greater than the reliable for dimensioning of the classical sewage network.

Considering the application values of a network equipped with a system of retention canals, it has been clearly demonstrated by simulation tests that an innovative system allows effective control of hydraulic transport of rainwater along the entire flow route. However, the highest degree of reduction in the size of the stream of flowing rainwater occurs on the last part of the separated retention chamber from the defined catchment. In practice, this means the possibility of abandoning the construction of an expensive retention reservoir or other object hydraulically unloading the sewage system located below the designed catchment with the system of retention canals.

The assignment of the role that can be performed by the classical exploited sewerage network after its provision in well-arranged damming seams becomes of particular importance. The implementation of this innovation will ensure a colossal increase in the hydraulic capacity of existing sewage systems, regardless of the existing local conditions and parameters characterizing the network itself, as well as the catchment. Even the thesis that an implementation of an innovative system will ensure an increase of at least 30 percent on average the capacity of each exploited rainwater and combined sewage system.

On the other hand, the conversion of a typical combined sewage system, which is a collectors connecting storm water overflows with sewage treatment plants into a system of retention canals, becomes of particular importance. In this case, the collectors will experience full retention of combined wastewater during the occurrence of intense rainfall, which in effect will allow for a significant reduction in the number of rainfall, at which transfers will work during the year of their observation. This is of strategic importance, with a view to protecting the quality of the receiver's water during the drainage of urbanized catchments. We are of the opinion that all general systems should be transformed into retention canal systems on strictly defined sections. The widespread implementation of this innovation will ensure a significant improvement in the quality of waters flowing in all rivers that flow through cities and settlement units. The measurable financial and ecological benefits will be huge and counted in tens or even hundreds of billions of Euro only on the national scale. And the system of retention canals can be used in every operated and designed sewerage network for organized drainage of rainwater on all continents [14].

Another, very important advantage resulting from the use of the retention canal system in combined systems is the possibility of even abandoning the construction of new or exclusion from operation of already operating averaging tanks located after the last storm transfer and before the sewage treatment plant. Under certain conditions, the role of an averaging reservoir may, in whole or in part, be provided by an effectively designed retention canal system, which, as mentioned above, will also cause less frequent storm transfers with the discharge of the excess of combined wastewater to the waters receiver.

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MANAGING URBAN REDEVELOPMENT IN THE CONDITIONS OF PROPERTY TRANSITION FROM PUBLIC TO PRIVATE. THE CASE OF YEREVAN

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Keywords: Post-socialist societies, urban space quality, value added approach

Abstract. According to New Urban Agenda, if well-planned and well-managed, urbanization can be a powerful tool for sustainable development for both developing and developed countries. In the conditions of ever growing urbanization and increasing prominence of sustainability agenda the issue of urban quality is subject to prior consideration worldwide. The issue is even more alarming in the countries of Eastern Europe and Post-Soviet Union due to existing urban decay as a result of major institutional transformations, economic crisis and political discrepancies. The paper reflects on the actuality of post-socialist societies in urban research and explores specific urban development problems derived from their recent history of transition from public to private. It aims to introduce an approach, which, based on the power of the private ownership and collaborative management, improves the quality of urban space by adding value in both social and economic context. The allocation of value-added among property owners is introduced through a land/property readjustment algorithm, which is assumed to be of use if it is adapted to the specificities of private property ownership, particularly through co-operation schemes once value enhancing features are evidenced to the property owners.

1. Introduction

According to New Urban Agenda, 2017 [1], if well-planned and well-managed, urbanization can be a powerful tool for sustainable development for both developing and developed countries.

In the conditions of ever growing urbanization and continuous societal transformations as well as the increasing prominence of the sustainability agenda the issue of urban quality is subject to prior consideration worldwide [2].

As acknowledged by Healey [3], it is difficult to avoid the impact of economic restructuring on the landscape and social and economic life of many cities which were used to grow within certain economic structure and also supported by the state.

The present discussion addresses issues reflected also in the New Urban Agenda, p.13(d), in particular "the cities and human settlements shall meet the challenges and opportunities of present and future sustained, inclusive and sustainable economic growth, leveraging urbanization for structural transformation, high productivity, value-added activities and resource efficiency, harnessing local economies and taking note of the contribution to informal economy while supporting a sustainable transition to the formal economy".

In the countries of Eastern Europe and Post-Soviet Union this issue is even more alarming due to existing urban decay as a result of major institutional transformations, economic crisis and political discrepancies. In particular, the collapse of the socialist system in these countries was followed by a number of economic, social and legal reforms, due to which the land and property ownership in most of the countries has been transferred from public to private sector. However, in most cases the state transferred to private hands not only the ownership to the property but also the problems related to the quality of that property as well as the responsibility for its further maintenance.

Armenia is a post-socialist country and presents a certain specificity concerning urban decline which derives from its recent history. Main focus in the discussion is put on the period of societal transformations starting from late 1980s.

2. Methodology

The paper reflects on the actuality of post-socialist societies in urban research and explores specific urban development problems derived from their recent history of transition from public to private. It aims to introduce an approach, which, based on the power of the private ownership and collaborative management, improves the quality of urban space by adding value in both social and economic context.

The conceptual framework will briefly explore the *post-socialist societies in urban research, urban space quality and its determinants* and *collaborative entrepreneurial approaches* through literature review. The urban space quality problems and proposed solutions will be further illustrated as a result of case-study conducted for certain delimited area in Yerevan, Armenia, based on analytical approach.

3. Theoretical framework

Post-socialist society in urban research

Based on certain academic research in this field the term "post-socialist" (or post-communist, post-Soviet, etc.) remains widely used to describe CEE (and not only) societies and the changes that are still taking place within them [4]. As an example, a number of recently published journal articles reflect on "cycling in the post-socialist city" [5], "experiencing post-socialism" [6], and "regeneration projects in Central and Eastern European post-communist cities" [7]. The authors further argue that the discussion on the meaning and value of the concept of post-socialism in urban research has neither been concluded, nor has it been conclusive.

As to Golubchikov [8] cities are considered as "an important social framework and material locale for the production and reproduction of the new relationships of (neoliberal) capitalism, including class (trans) formation and the production of uneven development. The urbanization of transition is thus a major institutional dimension of transition, not simply its playground".

According to Ferencuhova [9] actual field of study of post-socialist cities have(has as it refers to field of study) been recently reflected more intensively in connection to general urban theory (e.g., Ferenčuhová, 2012;2016; Grubbauer, 2012; Hirt, 2013; Kubeš 2013;Sjöberg 2014; Sýkora and Bouzarovski 2012; Tuvikene 2016; Wiest 2012).

Pickles and Smith [10] developed the idea of "path-shaping" post-socialist transformations, stressing the role of the years of the political and economic reforms in shaping subsequent developments, including urban.

However, in majority of cases the discussion on post-socialist cities refers to the impacts of specific economic and political changes on urban structures and urban life in former socialist countries. Those impacts consider mainly deteriorating housing infrastructure, unregulated urban development, poor urban management, which explicitly implicate urban space quality problems.

Urban space quality and its determinants

Historically, in British planning debate the discussion of the impacts of development has been closely linked to the question of betterment, or in other words to the improvement of urban quality [11].

When considering the quality of urban space with regard to urban design and architectural issues the definition of the concept is provided through more specific features within the framework of the Bristol Accord. Among these features are included: (1) *"Sense of place – a place with a positive 'feeling' for people and local distinctiveness"* (2) "*Appropriate size, scale, density, design and layout, including mixed-use development, that complement the distinctive local character of the community"* (3) *"High quality, mixed-use, durable, flexible and adaptable buildings, using materials which minimise negative environmental impacts".* A valuable attempt has been made in UK to combine expert assessments with the opinions of stakeholders (end users, investors, developers, building managers, neighbourhood associations, etc.), which is the Design Quality Indicators (DQI) - "*a method of evaluating the design and construction of new buildings and the refurbishment of existing buildings*" [12].

The concept of urban quality is differently explored by Insch and Florek [13]. The authors tried to illustrate the interrelation of the value, quality and expectations of residents with regard to place satisfaction. Some indicators of the quality of urban space are considered as an important factor also for attracting future investments. According to Sarău [14], in order to be a strong competitor in attracting investments, a place must demonstrate convincingly that their city residents enjoy a higher level of well-being and satisfaction than the competitive places.

Quite a different approach to the quality of urban space is introduced by Cilliers et al. [15], who argue again that the urban space is valuable due to people attached to it and that the old spaces which have story behind them and thus are characterized by their identity, can be much more valuable than the new developments.

Collaborative entrepreneurial approaches in urban planning

While the above exploration of various quality determinants was conducted within wider framework, including different social, economic, environmental and design aspects, it may be definitely stated that the problems of urban space quality are in direct relation to urban planning and management solutions. According to planning theorists throughout history the urban planning or town planning has been defined as a comprehensive and universal system of land use control [16].

While rethinking of the urban question [17] and debating on old and new urban ideologies [12] the authors claim that the urban is a collective project since it is produced through collective action, negotiation, imagination, experimentation and struggle.

In general, while speaking on collaborative approach we are led by the ideas of P. Healey who interprets collaborative planning as "collaborative approach in developing local strategies for managing coexistence in shared spaces", and considers it "as a key element in building positive institutional capacities for proactive economic development" (p.136). The author reviews collaborative planning as a set of possible policy responses aimed at understanding of local economies from the point of view of private sector, thus exploring this through two dimensions – the local economy and the land and property development [3].

Another issue raised by Healey [3] refers to particular strategies for "…deliberate shaping of the terms in which entrepreneurial opportunities can arise and investment offers be bargained over…" (p.151). Such strategies according to the author shall have further rationale to develop "economic assets of places", and among them more important are environmental features, such as physical and social infrastructure, land and property supply and the social and environmental qualities of places.

Following the aforementioned ideas and regarding the present issue of discussion it may be definitely stated that for successful improvement of urban space quality, the collaborative entrepreneurial approach is required particularly with integration of residents and everyday users of the urban space, thus proving the importance and requirement of consideration of the value added in each urban development project.

Based on literature review and conducted surveys the following practices, such as condominium management schemes, land readjustment, BIDs, provide viable schemes for collaborative management and maintenance of common interest properties and can successfully serve as basis for management of urban spaces as well as in redevelopment projects within the city neighbourhoods.

Within the *condominium scheme* each private owner has got a share of the common property of the building and surrounding land and other facilities that the private owners own or control in common. This share can be based on e.g. equality, relative size or relative value of each private space, or a combination of such. The ownership fraction can determine the responsibility each owner has for the costs of management of the building and association, as well as for maintaining and repairing the common parts of the property [18].

Land readjustment (LR) is an entrepreneurial tool for land redevelopment that governments, private developers, and communities have employed or experimented within many industrialized and developing countries [19]. According to the authors the continuous implementation and promotion of LR schemes is mostly combined with its following features: 1) land readjustment can assemble land for urban expansion and revitalization with minimal displacement; 2) land readjustment can help recover a portion of the project costs; 3) it can promote maximization and intensification of land use thereby enhancing land value for landowners and expanding property tax basis for the municipalities; 4) land readjustment can distribute land redevelopment costs and benefits equitably among landowners and other stakeholders such as local governments, private developers, and the communities, especially the urban poor and landless; 5) land readjustment can encourage public participation in policy decision-making.

BIDs (Business Improvement Districts) represent a relatively new form of sub-governance that relies on a functioning partnership between the public and private sectors at the neighbourhood level. BIDs are privately directed and publicly sanctioned organizations that supplement public services within geographically defined boundaries by generating multiyear revenue through a compulsory assessment on local property owners and/or businesses [20].

However, all the above stated property-based collaborative schemes contain one crucial element which is the calculation of the ex-ante *value added*. In the context of urban management the value added can be interpreted as planning gains, which principally differ from planning obligations, since the latter are non-negotiable compulsory contributions of real estate developer to the public domain required by the profile of the specific development business. Whereas the planning gains are the outcome of a voluntary negotiation between the public and private parties, through which a share of the developer's normal business margin is given up in favour of the local community or private property owners. It is quite important for the urban development project to potentially contain this share of added value, since it has to be the part of the global value derived from the urban development project that is not assigned to costs and to the minimum business margin the developer requires. This share or the so called "shareable value" is indeed the value added of the urban project. We must however acknowledge that the minimum business margin the developer might be willing to accept may not correspond to the normal business margin regarding his other previous real estate developments. This is the core concern for revision of the urban intervention project and negotiating on higher expected returns [15, 16, 21].

4. Problem discussion - Case study in Yerevan, Armenia

Urbanization trends of transition

Major transformations in the country took place mainly from the late 1980s and beginning of 1990s associated with the collapse of the Soviet planned system and commence of movement towards capitalism. In particular, global socio-economic and legal reforms have taken place, including privatization of the almost entire real property stock of the country which was previously owned by the state.

As a result of privatization almost all real estate property belonging to the state both in urban and rural areas was transferred into private ownership of the users/dwellers[1]. With regard to apartment buildings the residents of apartments became owners thereof; however, the right to common property within the apartment buildings as well as to the land attached to the buildings remained uncontrolled due to lack of supportive legislation. The uncertainty between public-private ownership rights had its negative impact on most of the urban neighbourhoods throughout the territory of Armenia, and especially in Yerevan. In many cases the common use properties in the urban neighbourhoods, including within apartment buildings have been left to their own fate and were subject to volunteer intervention by the residents. Also, due to imperfect regulation of management and maintenance of apartment buildings and lack of urban and property management in practice the buildings started to deteriorate rapidly thus lowering the quality of urban space (Fig. 1).

a)

b)

c)

a, b - Residential 5-story buildings of Soviet period (1971-1976) in residential district of "Ajapnyak" community, Yerevan (photos taken by the author, 2016),

c - Residential urban space in Arabkir community, Yerevan (photo taken by the author in September, 2017)

Fig. 1. Lack of management and maintenance of urban space

The urbanization boom in the country and especially in the capital Yerevan started from 2000, following various legal and economic reforms, the economic blockade and a continuous war situation. However, the period of 2000-2008 was the most prosperous within the whole history of the country, from the very beginning of transition to market economy. During this period the right

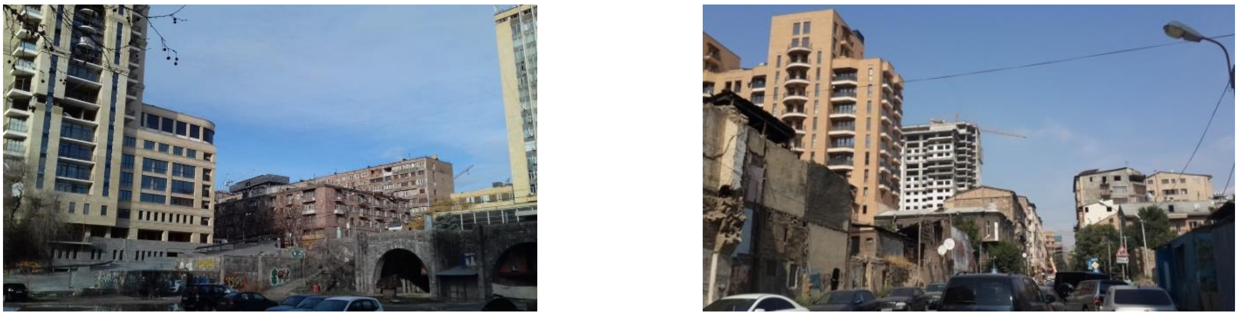
[1] In fact, 96% of the republic's housing stock was privatized by 2000 [22].

to develop was introduced legally and implemented in practice, thereby stimulating the real estate market development in the country. On the one hand the city was benefited from new construction by reviving with new commercial and residential districts. On the other hand massive demolition and redevelopment of urban spaces according to neoliberal urbanization trends was accompanied by extensive violation of residents' rights to the place they were appropriated with.

Capitalism movements in Armenia secured with recently emerged private ownership led to rapid and vast transformations of urban fabric. However, changes appeared during that period were mostly of chaotic nature due to imperfect public regulations and institutional basis (Fig. 2).

In spite of Armenia's recent downward trend in urbanization, it remains highly urbanized with over 63 per cent of its population in urban areas. More than half of the country's urban population (1,068.3 million as of 1 January 2014) is concentrated in the capital of Yerevan [23].

Notwithstanding the appearance of neoliberal movement in urban development of Yerevan, as well as a number of state-supported projects on management and maintenance of apartment buildings, the quality of urban space has been suffering intensively and continuously up to now. Hence the declining quality of urban space in Yerevan can be represented in two main directions: 1) low quality and unplanned new developments mostly in the centre of the city paralleled with 2) lack of maintenance and management of existing housing and real property stock, inherited from the Soviet period.



a) P.Buzandi str., Yerevan (photo taken by the author, Mar. 2019)

b) Arabkir community, Yerevan (photo taken by the author in September, 2017)

Fig. 2. New urban developments of chaotic nature

<u>Case Study - proposed model for collaborative approach and illustration of the value added in the urban redevelopment project</u>

The pilot case study introduced hereby has been conducted in 2017 to support the methodology proposed within the framework of on-going research project and has been presented at AESOP Congress 2017[2]. Based on the power of the private ownership and collaborative management it is proposed to improve the quality of urban space by adding value in both social and economic context. The model is aimed to highlight that the urban area upgrading project may become viable even without major participation of the state (regarding public funding) if the involvement of the private owners is guaranteed, which has to go through evidencing that a significant part of net benefits of the intervention will be allocated to them.

A mixed-use urban space within an urban neighbourhood in Yerevan (Fig. 3) shall serve as a sample for illustration of the improved quality of urban space and enhancement of value-added for

[2] "Value added as a tool in participatory approach to urban rehabilitation projects. A case study in Yerevan", July 2017, AESOP Annual Congress 2017, ISBN: 978-989-99801-3-6 (E-Book)

the residents and project stakeholders. The proposed design solution of the case study object based on *Land Readjustment* principles is presented hereunder (Fig. 4), however detailed proposal, including illustration of the area quality and calculation of the value added of proposed upgrading scheme is available in the above-mentioned reference.

The allocation of value-added among property owners is proposed to be introduced through a land/property readjustment algorithm, which is assumed to be of use if it is adapted to the specificities of private property ownership, particularly through co-operation schemes once value enhancing features are evidenced to the property owners. However, it is worth mentioning that in order to maintain the quality achieved by the proposed urban plan the case study urban space has to be duly managed and maintained which supposes additional constant expenses by residents. Thus sharing costs through condominium management schemes could probably provide a quite effective solution for the raised issues.

Present plan of delimited urban space according to property types and ownership types (the scheme is developed by the author based on data provided in www.e-cadastre.am)

Fig. 3. Present plan of delimited urban space within urban neighbourhood in the big centre of Yerevan

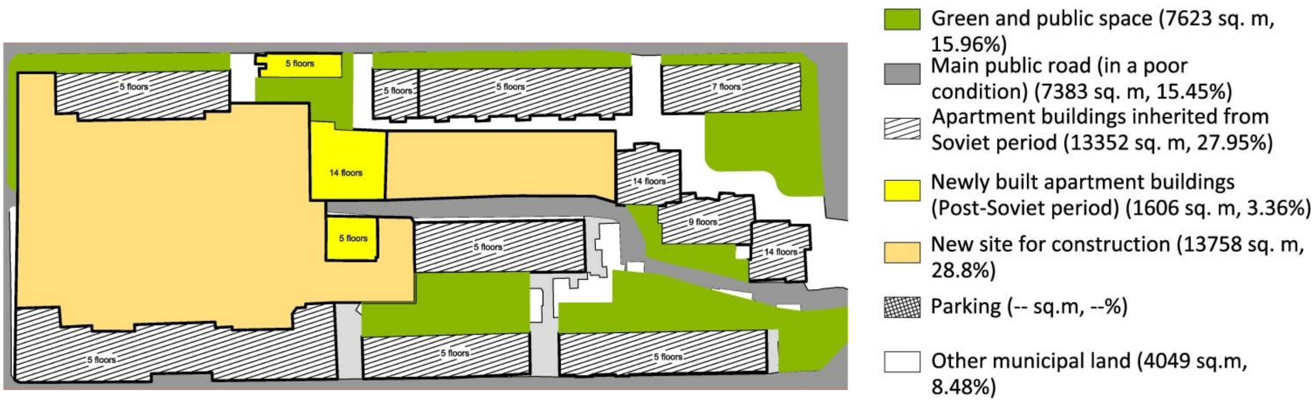


Illustration of proposed plan of the urban space according to property types (the scheme is developed by the author based on data provided in www.e-cadastre.am)

Fig. 4. Collaborative approach to urban design solution for the purpose of area upgrading

5. Conclusion

The above discussion tried to reflect on the actuality of post-socialist societies in urban research and to explore specific urban development problems derived from their recent history of transition from public to private.

An attempt was made to reveal that in the conditions of scarce public resources the promotion of private property-based investment projects may become a sound solution in regenerating urban residential spaces and in overcoming urban decay. Such projects shall become successful if applying a collaborative approach through public-private partnership models where enhancement of value added to the project shall serve as a main tool. Moreover, these collaborative schemes will provide sustainable basis when adapted to the specificities of particular society.

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MODERNIZATION OF THE SEISMIC SAFETY OF BUILDINGS ENGINEERING SYSTEMS

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Abstract. Building security issues that ensure compliance with earthquake safety requirements are presented. Most of the residential and public buildings currently using in Armenia, about 80%, were built before the devastating Spitak earthquake and do not meet seismic safety standards. Unfortunately, current national codes of the Republic of Armenia, do not include standards for the design and installation of mechanical systems in seismic hazard conditions [1].

Additional safety requirements have been taken from international sources such as the Federal Emergency Management Agency (FEMA). The methodology proposed in the article is not associated with the risk of structural elements of buildings falling, such as walls, partitions, columns or roofs. The following recommendations do not guarantee the safety of an individual building during an earthquake and should be applied in accordance with the specifics of each building individually. The provisions described in this article do not contradict the rules of technical supervision or commissioning of buildings adopted in accordance with the legislation of the Republic of Armenia, but supplement with additional safety requirements in accordance with international practice [4].

1. Introduction

On September 22, 2015, the Asian Development Bank (ADB) approved the $ 88.5 million SSIP program for improving seismic safety (SSIP) for Armenia. SSIP, the first results-based lending program (RBL) in Armenia, will reconstruct or modernize 46 schools by the end of November. 2023 and is being implemented as part of a broader government program to strengthen schools that are seismically vulnerable. The SSIP program is financed by ADB and run by ATDF [5].

RA seismic-structural norms, construction norms and rules and norms aimed at minimizing seismic risks were developed after the 1988 Spitak earthquake. In general, the current building codes of Armenia include provisions on seismic safety for structural elements of buildings and meet the requirements of sustainable construction. With regard to the seismic safety of non-structural components of buildings, existing regulations do not properly disclose the potential earthquake risks for non-structural parts of school buildings and do not provide recommendations for mitigating these hazards [6, 7].

During an earthquake, engineering elements may slip, break, fall or bend, creating a hazard to the life and health of people in the building.

We are concerned that there is a risk not only for schools, but also for residential buildings, hospitals and other buildings.

2. Safety features of buildings engineering systems

Buildings are risky not only because of the structure collapse. Damage can also occur on mechanical systems, ceiling systems, luminaires, furniture and other unsecured, non-fixed elements.

2.1 Ceiling Recessed Light Fixtures & HVAC Registers: Unsecured ceiling mounted light fixtures and HVAC registers may fall, striking occupants below or locking exit ways for evacuation during an emergency [3].

Fig.1. Ceiling Recessed Light Fixtures & HVAC Registers

Recommendations: Fasten light fixtures, and HVAC registers to the ceiling grid with sheet metal screws on all four sides. Install minimum of two hanger wires at diagonal corners of light fixtures or HVAC registers. Attach hanger wires to beams or floors above. If light fixtures or HVAC registers weighs 25 kg. or more, use four hanger wires (one at each corner). Use flexible cables to wire light fixtures to existing/new electrical cables in the building. Use flexible duct to hook up HVAC registers to existing/new ducts in the building.

2.2 Hanging Light Fixtures: Unsecured light fixtures: May fall, striking occupants below, or damaging electrical wiring that could start a fire or electrocute nearby occupants. May swing, damaging nearby light fixtures, ducts, or pipes [8].

Fig.2. Hanging Light Fixtures

Recommendations: Secure light fixtures to structural floor or beam above with bracing cables or wires. Provide transverse and longitudinal bracing. Secure single pendant fixture to structural floor or beam above with four-way splay wires. As an alternative to bracing, provide clear space around light fixtures to allow them to swing without contracting obstruction in any direction. Light fixture must have swivel joint at top so that they can swing freely in all direction. Bracings and hangers for pendant light fixtures should be installed into structural floor slab, beams, or blocking above.

2.3 Heaters, A/C units: Unsecured suspended space heaters/AC units may fall, striking occupants below, damaging electrical wires that may cause electrical shocks and fire, or blocking doors and exit ways during an emergency. May sway, damaging nearby pipes, ducts, ceilings, walls, or conduits.

Recommendations: Provide diagonal braces that are attached to the equipment at four corners. Provide diagonal braces that are attached to hanger rods. Space heaters/AC units must be suspended by hanger rods or steel angles. Space heaters/AC units must have flexible pipes or conduits connected to them. Relocate space heaters/AC units away from doors, and exit ways [8].

2.4 Conduits / Piping: Pipes may fall, striking occupants below. Gas pipe may break, causing fire or explosion. Pressure pipe may break, becoming a live "whip" that could injure nearby occupants. Hot pipe may break, burning occupants below or nearby.

Recommendations: Installation of water supply, sewerage, heating and gas supply systems should be made to allow for relative movement in suspended piping, especially at locations of anti-seismic joints, as provided in Section 7.7 of RABC II-6.02-2006, Earthquake Resistant Construction Design Codes. Water pipes, heating main lines must be made of steel or high density polyethylene pipes. It is not allowed to use cast iron, glass tubes, as well as "light" and "medium" polyethylene pipes. In case of crossing the basement walls, pipes shall be provided with space not less than 100 mm between the pipe and the wall. The space should be filled with dense, elastic, non-flammable, water and gas-fired materials. Use pipe fittings to attach bracing to pipe. Attach bracing to structural floor beams or blocking above. Do not attach bracing to suspended ceilings. Bracing not required for fuel piping less than 25 mm diameter. Bracing not required for other piping less than 75mm diameter if there is enough clearance for the pipes to swing without obstruction. Bracing not required for piping suspended by individual hangers 30 sm. or less in length. The general requirement is to install the hangers only on flat areas, the distance to the bend should be at least 15 cm [10, 11].

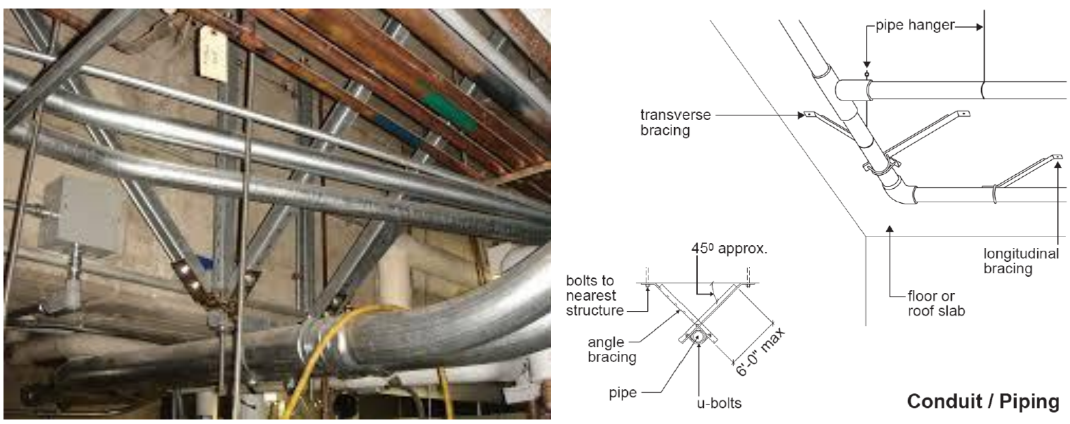
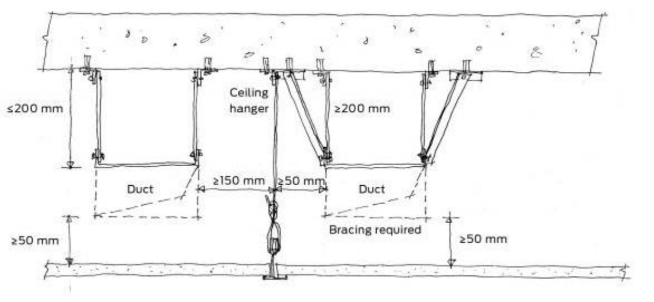


Fig.3. Conduits / Piping

2.5 Ductwork: Unsecured ducts may fall, injuring occupants below. Fallen ducts may block exit ways.



Ducting systems that do not require restraint.

Fig.4. Ductwork

Recommendations: Secure ducts with transverse and longitudinal braces. Attach braces to ducts with proper duct fittings. Attach braces to structural floors or beams above with concrete drill-in anchor bolts or lag bolts. Design of transverse and longitudinal bracing should be determined by a qualified architect, structural engineer, or mechanical engineer. Use concrete drill-in anchor bolts for concrete construction. Use lag bolts for wood construction. Lag bolts should be installed in beams or blocking. Bracing not required for rectangular ducts when the section width (W) and height (H) dimensions in meters such that W x H is less than 0.55 sq. meter, or weigh less than 25kg per meter, if there is enough clearance for them to swing without obstruction. Consult a qualified architect or structural engineer for seismic bracing requirements. Fixation of horizontal metal ducts (clamps, hangers, supports, etc.) should install at a distance of not more than 4 m from one another.

2.6 Heating devices: Wall-mounted heating devices, radiators, convectors, fan coil units can move, fall, block exit ways, hot water may cause burns.

Recommendations: Radiators and other types of heating devices can be hanging on the main walls only. The number and type of hanging are determined by the device's passport requirements [2].

2.7 Mechanical, Electrical, and Plumbing equipment: More details on installation of Mechanical and HVAC systems can be found in FEMA E-74. This FEMA product describes sources of nonstructural earthquake damage in simple way and provides methods for reducing potential risks. In addition, current seismic codes and standards also exempt mechanical and electrical components from bracing or anchoring, regardless of seismic area, in nonessential facilities, if they weigh less than 180 kg and are mounted at a height 1,2 m or less above the floor or, if elevated, weigh less than 9 kg. Distributed systems in nonessential facilities, such as piping or HVAC ducting, are also exempt from bracing or anchoring if they weigh less than 7,5 kg per meter and are provided with flexible connections [2, 8].

2.8 Gas Boilers: If the school has a water heating boiler with a capacity of 60 kW and more, before commissioning or re-commissioning, it is necessary to check the conformity of the project documentation. It is forbidden to start the boiler without a positive opinion of a technical safety expert. The National Technical Security Center and accredited persons may conduct an expert review. The boiler-house shall be exploited in the manner prescribed by this law as a hazardous production facility after its registration in the Register.

2.9. **Gas Cylinders and Tanks:** Unsecured cylinders or tanks, including oxygen and compressed air tanks, may fall over and damage the shut-off valve, releasing hazardous or flammable contents. A tank with a damaged shut-off valve may result in the tank or valve becoming a projectile. Unsecured cylinders may fall over, striking or rolling and striking nearby occupants [9].

Recommendations: Secure each cylinder or tank to a wall with two restraints (one restraint at the upper and the other at the lower portion of the cylinder). Alternatively, to providing wall restraints, cylinders or tanks may be kept within a storage rack or compartment that is secured to a wall or floor. Store gas cylinders or tanks in non-occupied areas, and away from exit routes or exit doors

2.10 Mechanical Equipment: Unsecured mechanical equipment (Chiller, AHU, ACU, Fan) may slide or fall: striking occupants nearby, damaging electrical wiring, water lines, or gas lines, causing interruption to vital, utility services, exposing nearby occupants to electrical shocks. Starting a fire.

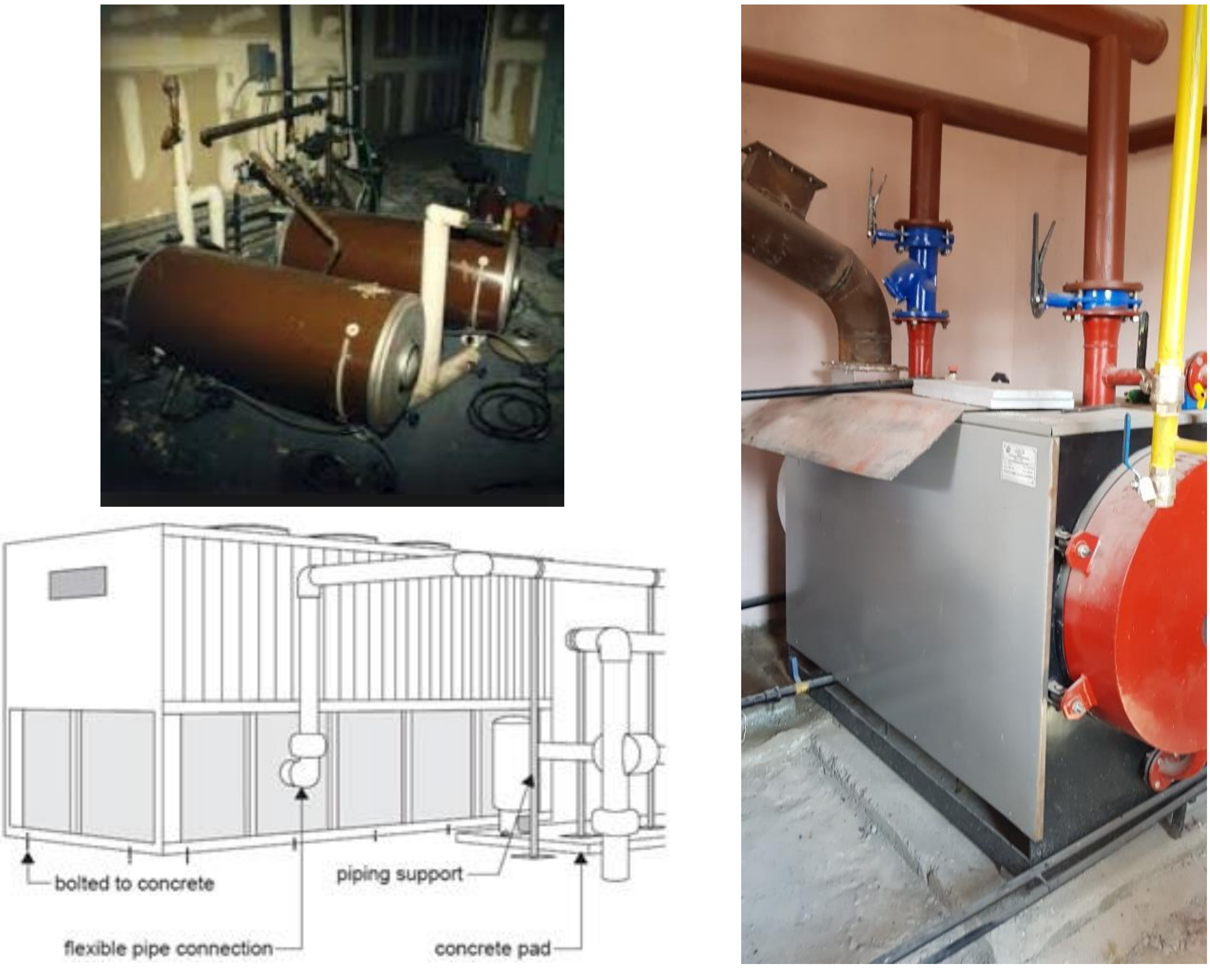


Fig.5. Mechanical Equipment

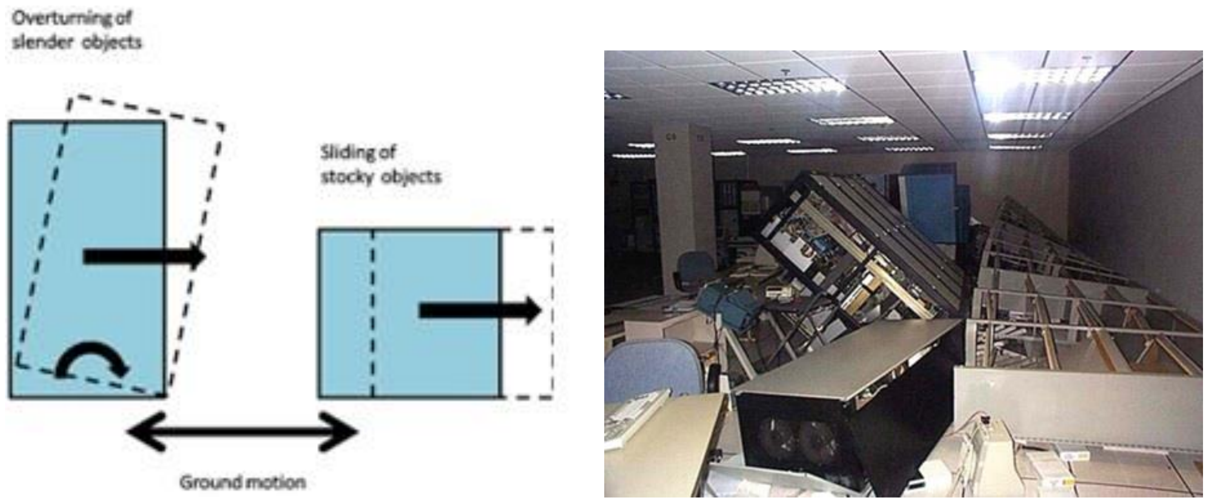


Fig.6. Causes of nonstructural damage

Recommendations: Do not install outdoor mechanical equipment on the roof, as the roof is generally pitched. Outdoor units can be installed in the school yard, and indoor equipment - in technical rooms. Clip angles may be used. Mechanical equipment must have flexible conduits or pipes. When vibration isolation is required, consider using vibration isolators that are preapproved by the equipment installation instruction and manual [3, 8].

2.11 Plumbing Equipment: Unsecured plumbing equipment such as a water heater may slide or fall: striking nearby occupants, spilling hot water on floor or nearby occupants, or rupturing gas lines.

Recommendations: Secure base of water heater by bolting to floor and, secure water heater to wall with plumber's tapes. Use concrete drill-in anchor bolts for concrete floor, and wall. Use lag bolts for wood floor and wall. Lag bolts must be installed into floor beams, wall studs, or blocking. Space between wall and water heater must be shimmed tight with non-combustible at the locations of the plumber's tape. Water tanks should be secured from all sides so that they cannot topple. There must be enough vertical support and strapping so that that the tank will not jump up out of its seat, during the vertical and lateral motion of an earthquake. Stabilizing wires must be secured to concrete rooftop, or beams, not to parapet [10].

2.12 Electrical Equipment: Unsecured electrical equipment may slide or fall: interrupting vital utility services in an emergency, injuring nearby occupants, damaging electrical wiring that would cause electrical shocks or fires.

Recommendations: Secure electrical equipment to floor. Provide flexible cable connection to equipment. Use concrete drill-in anchor bolts for concrete floor. Use lag bolts for wood floor. Lag bolts must be installed into floor beams or blocking. Bolts must be installed through metal framing of electrical equipment. Do not install through thin gauge housing panels [8].

2.13 Anchoring mechanical components:

How to assess the risk of installing engineering equipment in a building in seismic hazard conditions? At first, we need to understand how to find horizontal and vertical forces on connection, which is found by these formulas [11].

According to RABC II-2006. Par 6.12

Horizontal force: $S_K = Ak_0 k_1 Q_k^E \sqrt{\sum_{i=1}^{n} \beta_i^2 \eta_{ki}^2},$ (1)

Vertical force: $S_k^V = 2 \cdot 0.70 \cdot Ak_0k_1Q_k^E$. (2)

Where Q_k^E - weight of the element, kg

$$\eta_{ki} = \frac{X_{ki}\sum_{j=1}^{n} Q_j X_{ji}}{\sum_{j=1}^{n} Q_j X_{ji}^2} \quad (3)$$

β - is found by diagrams

X_{ki} – is the structure's k^{th} point displacement (amplitude) during free oscillations by the i^{th} mode;

n- is the number of concentrated masses (Fig.7)

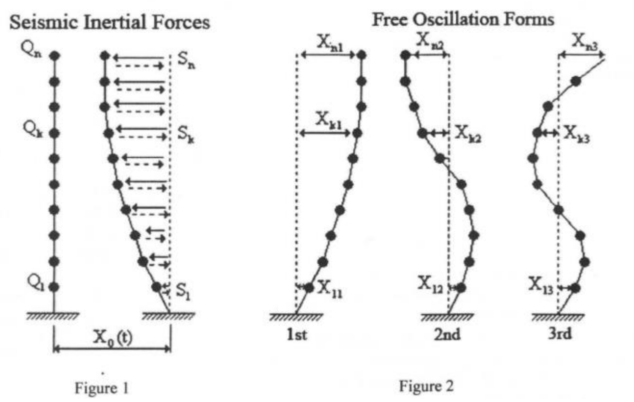


Fig.7. Seismic Inertial Forces and free Oscillation Forms

Here we have two problems:

- k_2 is missing (k_2=1.3 for schools)
- When element is on ground

Z=0 → β_i=0 → S_k=0

but should be Ak_0k_1

where:

Z is an equipment installation height

Also, this method is not very useful for quick calculation of Mechanical and Plumbing engineers.

According to Eurocode 8 me have:

$$F = \frac{\gamma_a S_a W}{q_a} \quad , \quad (4)$$

where:

F=S_k from (1)

g_a=k_2 from (1)

W=Q_k^E from (1)

q_a=1/k_1 but for the nonstructural element

Where: Sa is similar to $Ak_0\sqrt{\sum \beta_i^2 \eta_{ki}^2}$

According to Eurocode 8 [12].

$$S_a = \alpha S\left[\frac{3\left(1+\frac{Z}{H}\right)}{\left(1+\left(1-\frac{T_a}{T_1}\right)^2\right)} - 0.5\right] \quad , \tag{5}$$

where:

α=A from (1)

S=k_0 from (1)

T_a =period of vibration of non-structural component

T_1 =first period of vibration of the structure

Ta=period of vibration of non-structural component → 0

H- Building height [12]

After calculation me get the following:

$$S_a = \alpha S\left[\frac{3}{2}\left(1+\frac{Z}{H}\right) - 0.5\right] \tag{6}$$

by putting the S_a value in (4) we get:

$$F = \frac{\gamma_a \alpha S W\left[\frac{3}{2}\left(1+\frac{Z}{H}\right)-0.5\right]}{q_a} . \tag{7}$$

By making some comparisons we get the following formula that can be used to estimate Horizontal forces on mechanical equipment,

Proposed simplified formula for horizontal forces is

$$S_k = A k_0 k_1 Q_k^E \left[\frac{3}{2}\left(1+\frac{Z}{H}\right) - 0.5\right] \quad , \tag{8}$$

where:

A=0.4

For Soil class III, k_o=1.1

For frame and wall, k_1=0.4,

S_k=0.18 Q_k^E [1.5(1+z/H)-0.5]. (9)

As result we get following:

- when the mechanical equipment on the ground floor, Z=0 → S_k = 0.18 Q_k^E
- when the mechanical equipment on the top of building, Z=H → S_k = 0.18x2.5 Q_k^E = 0.44 Q_k^E.

3. Conclusion

- It is obvious that the current national regulation standards are insufficient for the design of mechanical systems that meet the requirements of seismic safety.
- It is possible to apply the best international practice to amend normative-technical documents in the RA
- The provisions contained in this Article may serve as a basis for the revision of national regulation standards.
- The proposed formula (8) is more convenient for calculations.
- According to (8) formula, it is obvious that the forces acting on the equipment during an earthquake depend on the level of installation of the equipment.

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THE PROBLEMS OF USING STRATEGIC MODELS FOR CONSTRUCTION DIVERSIFICATION

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Keywords: Diversification, strategic models, market of construction, economic benefits, resources

Abstract. One of the ways to increase the effectiveness of the activities of construction organizations and economic sustainability which is called diversification is presented. The results of study indicate that the desire to diversify the business can be conditioned by such factors as capital investment, risk reduction, increased production cost, the desire of more efficient use of distribution channels, management system improvements and etc. Offering a wider range of production and services, the construction company is able to increase its competitive capacity. In this regard; economic benefits in case of diversification have been studied, leading to increased business optimization and competitiveness. Based on the analysis, diversification strategy models for Armenia's construction sector have been proposed based on resources and construction market segments that enable them to reduce existing risks and ensure long-term sustainability of diversified business.

1. Introduction

Diversification in market economy is one of the most common business development strategies and the focus is always on the heads of large companies and corporations. The famous scientist I. Ansoff referred to the following general definition of this problem: "Diversification" is a term characterized by the redistribution process in the fields of activities that are substantially different from the previous ones" [1]. Basis of the diversification is first of all, the economic benefits of the enterprise, which in particular are caused by the reduction of the impact of crisis factors and mitigation of their consequences. One of such factors is the increased competition, globalization of the economy, declining profitability of the main business type, etc. Economic globalization has contributed to the formation of interconnected market, allowing companies to cross traditional and national boundaries to operate beyond them. International construction market companies often recognize diversification as a growth strategy, risk management, or both. Nevertheless, schemes of diversification of international construction companies are not clear. Most of them carry out diversification processes in a similar cultural or in institutional environment. The market requires companies to diversify in different geographical markets by studying new business segments [2]. The advantages of diversified production enable the company to achieve goals that are inaccessible to single-source issuers (Fig. 1) [3].

Armenia's construction sector is an essential component of the country's economy and contributes to the implementation of the state's social policy. In 2017 the volume of construction made about 415873.3 million AMD, and in 2018 422302.0 million AMD [4].

The disadvantages of diversification are based on studies. Indicating to Y. Yakovlev's diversification is a matter of action, which is time-consuming and requires serious investments, technical, professional resources and capacities [5]. The construction is also characterized by technical, economic, social and institutional risks that require special expertise. The analysis shows that the construction and all its fields should be viewed as a beneficial way of economic performance of diversification.

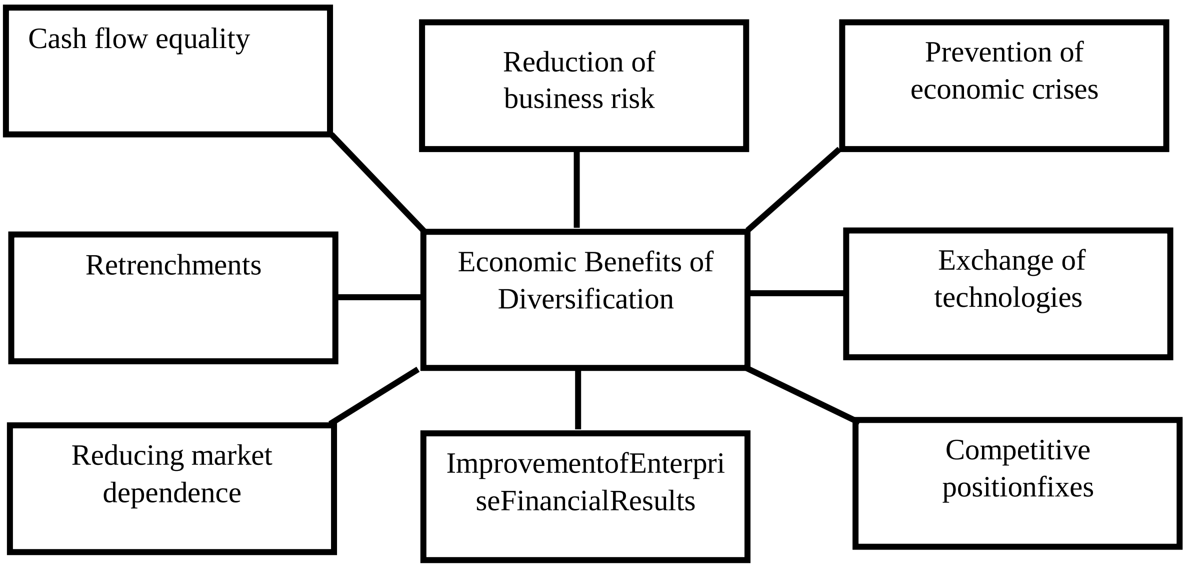


***Fig. 1. Economic advantages of diversification*.**

2. Method

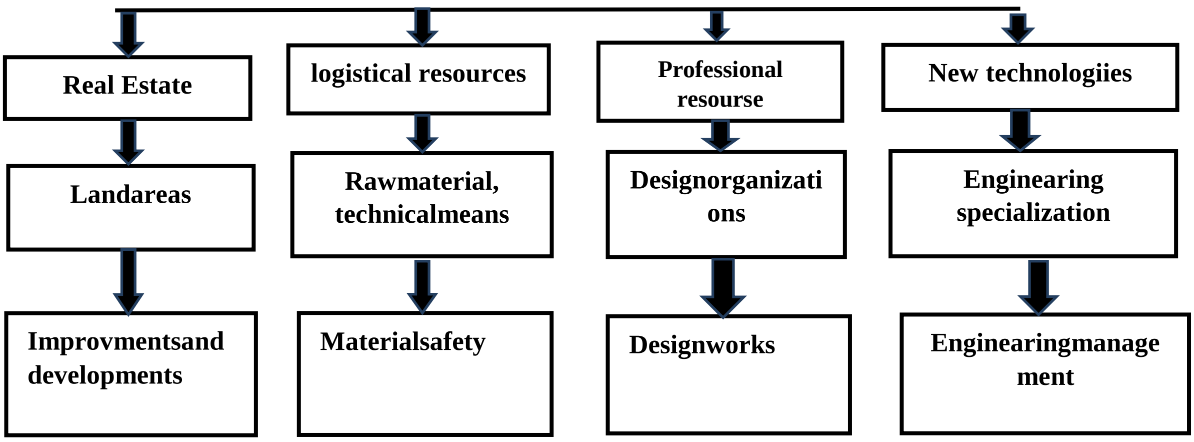
At present, the complexity of construction management is increasing objectively, which is conditioned by the reduction of the number of participants, the enhancement of the composition and content of the construction facilities, as well as the change in the process of preparation, financing and supply.Modern investment models are characterized by the unified nature of resources that are formed not only from different sources, but also under different circumstances. Construction diversification strategies can be built in two ways:

• based on available resources;

• Construction, based on market and product market research.

Generalization of the study and research in economics literature, product diversification strategy to become models of a construction company, based on available resources and markets (Fig. 2) [6].

3. Types of resources



Types of activities

Fig. 2.Strategic model of building diversification by resources.

In the first model, diversification in construction can have competitive advantages from the result of the use of the following resources: land areas, raw materials and technical means, professional resources, new technologies. At the same time, the use of structured and procedural approaches to the organization's diversification activities, as demonstrated by a practice, is necessary but not always sufficient (Fig.3).

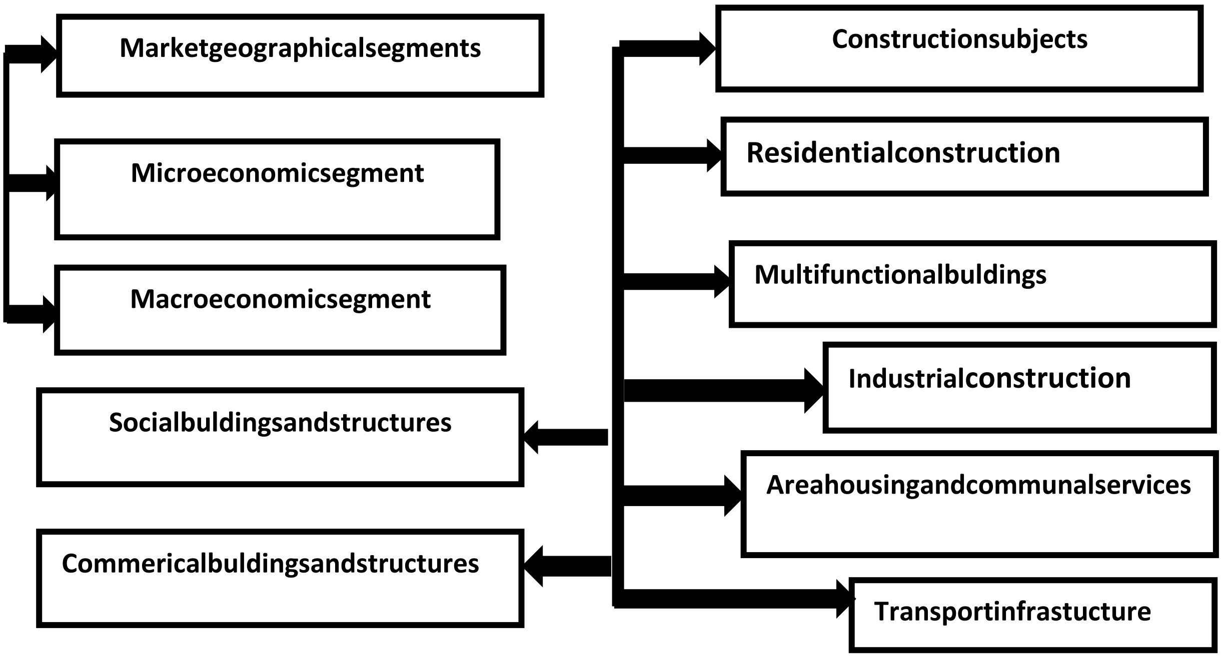


Fig. 3. Construction diversification strategy model according to construction market segments [7]

Second model of diversification strategy built on geographical criteria of Armenian construction market. It took into account all the sub-sectors related to the sector. Each sub-branch of the construction described in the model can be regarded as a separate, economically independent zone.

4. Results

The second variant of the diversification strategy is based on the criteria and legislative provisions in various construction-specific sectors [8]. As the analysis shows that the construction diversification in Armenia can be diversified, both in the construction and in the geographical area of the market segments. It should be noted that all of the constructional segments, being an autonomous strategic economic zones, may include appropriate sub-zones. Thus, diversification in construction can be effective if all possible risks and opportunities are taken into account. Studies have shown that diversification in construction can have a positive effect if all segments of the construction market are taken into consideration, which in turn will reduce risks and ensure long-term sustainability of diversified business. Studies have shown that, first of all, such a work organization contributes to a significant reduction in the overall design and construction time. As a rule, the use of diversification strategy models contributes to the reduction of construction costs by 10-15% and 20-30% of overall design and construction time, and helps equipment providers and construction companies better understand the requirements of the designer, and the designers, the local construction conditions (skilled professionals, local construction legislation, etc.) [9].

5. Conclusion

Based on the results of the research, these issues generally form a unified system and allow at the same time a basis for new research, innovation and implementation of the field. Studies have shown that diversified businesses are more stable in a changing economic environment and allow revenue from various sources that are not linked to each other, providing the company with an opportunity to expand the market segment. The analysis of current scientific and methodological approaches and current practice has allowed to formulate two strategic strategies for diversifying Armenia's construction, combining the strategic, tactical and operational level of the investigated processes in the context of sub-proprietary, business and operational diversification. The research carried out to date and can serve as a basis for the resolution of problems and improvements, as well as the results of the discussion and publication of materials related to these issues and make them transparent basis for future discussions and research.

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DANGER OF GENERATION OF HYDRAULIC JUMP IN THE PLASTIC GRAVITY PIPE AND ACTIONS TAKEN TO ELIMINATE IT

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Keywords: Plastic pipe, hydraulic jump, pressure movement, automatic check valve

Abstract. Cases of hydraulic mixed mode in a gravitational water supply system, accompanied by the phenomenon of a hydraulic jump is discussed. In the construction of compression pipelines, non-metallic pipes are currently in wide use, the permissible speed for which is significantly less than that of metal pipes. In the event of uncompressed movement in areas of a water supply system with a large slope, a shallow depth occurs. As with a shallow depth of the fluid flow, the bottom velocity is close to the average velocity of the living section, therefore, a large bottom velocity occurs, which can lead to rapid destruction of the bottom part of the aqueduct. The transition from the compression mode of motion to the non-compression one occurs through a hydraulic jump, which leads to the shaking of the aqueduct. A method for determining the length of the section of uncompressed movement of the aqueduct is given and an event has been developed to establish the compression motion throughout the aqueduct using an automatic check valve with a hydro-mechanical movement.

We have developed an event to establish a compression movement (and therefore, to reduce the speed of movement) throughout the pipeline using an automatic check valve with hydro-mechanical drive.

1. Introduction

Lines of gravity pressure pipelines in mountainous areas usually have many siphon sections and a number of pipe canal sections, which require special actions during the operation of the pipelines aimed at providing a calculated output [2]. For example, a series-connected mechanical pumping, and then regulation of the hydraulic system output by pressure and gravity methods, should be carried out in such a way that there is no mixed-mode movement with hydraulic differential in the water conduit and the output pumped mechanically is not less than the exit of the gravity section of the water conduit.

In order to exclude a mixed hydraulic regime in the water conduit and, especially, to eliminate it, it is necessary to establish the causes of its occurrence.

2. Results and discussion

For simplicity, let us consider a simple pipeline with a large slope and a constant diameter, at the end of which a valve is installed (Fig. 1).

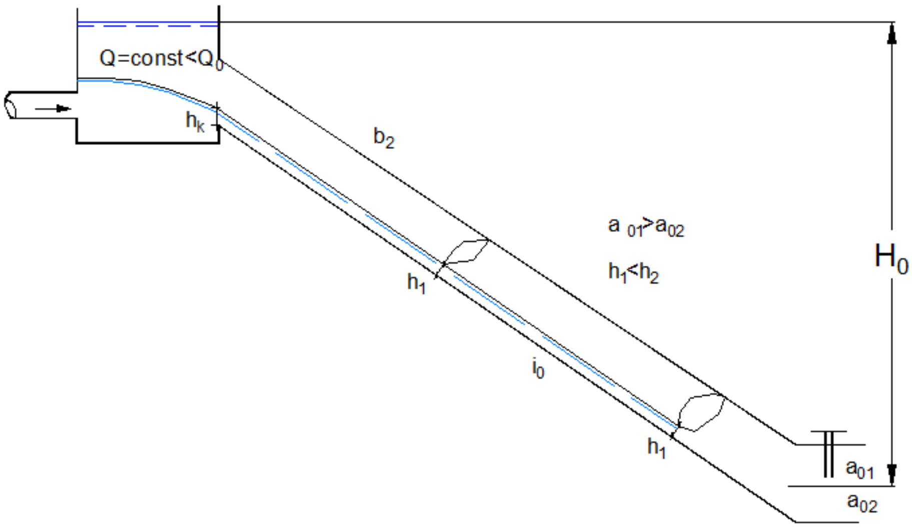

Fig.1. Scheme of hydraulic system

The output in such a system in pressure mode will be determined by the well-known Chez formula [2]:

$$Q_0 = \sqrt{\frac{H_0}{S_0}} \ , \tag{1}$$

where H_0 is the static pressure of the water conduit, S_0 is the total hydraulic resistance of the water conduit when the valve is fully open, installed on the lower section of the water conduit $a_0 = 1$.

To establish the pressure movement in the system, it is necessary that in the head of the conduit the output is no less, than Q_0. If the outlet of the head section is $Q < Q_0$, then non-pressure movement will occur throughout the conduit, a free surface curve of the type b_2 [4]. known in the special literature will be established in the pipe. In this case, the liquid level in the pool will drop and a critical depth of h_k corresponding to the outlet of Q will appear on the lower lip of the inlet pipe section, and along the length of the pipe, the flow depth will gradually decrease, tending to the depth of uniform movement of h_0.

It is known that at shallow depths of fluid flow, the bottom velocity begins to approach the average velocity of a live section. With large slopes of the pipeline, bottom speeds can be several times higher than the permissible maximum speed of the material of this pipe and lead to its rapid wear [7].

Now, if the degree of openness of the valve of a_0 is reduced, then a blockage of the fluid of H flow will appear in front of the valve and the movement will become pressure on a certain length in front of the valve, and the movement will be non-pressure on the rest of the pipeline length. A similar regime of fluid movement in a pipe is called mixed. In the mixed regime of fluid motion, there is a transition from non-pressure to pressure movement, which is called the hydraulic drop in a closed section. This phenomenon is dangerous for the pipe, as it is accompanied by rapid aeration of the fluid flow, as a result of which permanently acting hydraulic sections appear on the pipe wall. In the process of our experimental studies, it turned out that due to the phenomenon of a drop, the pipe is subjected to strong shaking. In addition, due to aeration, oxidation of the inner surface of the wall of the metal pipe also occurs.

If the degree of openness of the valve is reduced even further, the length of the section of pressure head movement will increase, and the place of the differential will move up the pipe. Since the output supplied to the pipe from the head remains unchanged, only a gradual transition of the fluid flow to the regime of pressure movement occurs [1]. Finally, depending on the magnitude of the supplied output, by establishing the degree of openness of the valve, a pressure movement will occur along the entire length of the pipeline, as a result of which the lowest speed corresponding to this output will appear in the pipe.

Therefore, to eliminate the non-pressure movement of the fluid flow in the pipe, it is necessary to throttle the valve installed on the lower end of the pipe in the closing direction.

The throttling value for a given output of Q is theoretically determined by the Chez formula [6] as follows:

$$Q = \sqrt{\frac{H_0}{S_0 + S_z}}, \quad (2)$$

where S_z is the hydraulic resistance of the valve.

In the occupational literature, depending on the type of the valve, the dependence of the local resistance, ξ , coefficient on the degree of opening of $\xi = f(a_0)$ [2] is given in the form of a table and a curve.

The relationship between the hydraulic resistance of $S_z = \varphi(\xi)$of the valve and the coefficient of local resistance has the following form:

$$S_Z = \frac{\xi}{2gA^2}, \quad (3),$$

where A is the pipe cut-off area.

Therefore, determining S_z using the formula (2), and ξ, using (3), and the degree of opening of the valve can be determined by the formula $\xi = f(a_0)$.

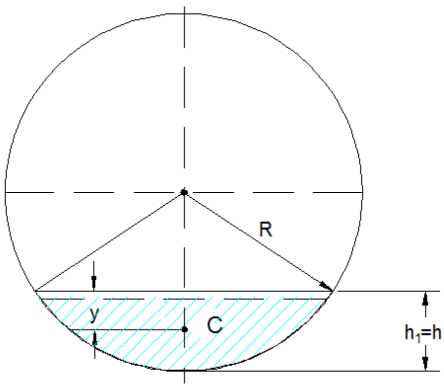

Fig.2. Cross section of the pipe

Thus, a decrease in the degree of opening of the valve leads to an increase in pressure in front of it, as a result of which the length of the section of the pressure movement increases. Therefore, the place of the difference is shifted towards the head of the pipeline[6].

Now let us turn to the question of the hydraulic differential of the closed channel, to clarify its features and, in particular, its forms. Since for exits of $Q < Q_0$ in the case of a pipe one of the drawn depths is necessarily equal to the diameter of the pipe of $h_2 = 2R$, the main task of the theory of the difference will be to determine its depth of $h_1 = h$.

The differential function for this output - Π(h2) will be constant and equal to

$$\Pi(h_2) = \frac{\alpha Q^2}{g\pi R^2} + \pi R^3, \tag{4}$$

and the differential function of the initial depth of the differential h, will have the following form:

$$\Pi(h) = \frac{\alpha Q^2}{gA} + yA, \tag{5}$$

where

$$A = R^2 \arccos\left(1 - \frac{h}{R}\right) - (R-h)\sqrt{h(2R-h)} \tag{6}$$

$$y = \frac{2h(2R-h)\sqrt{h(2R-h)}}{3\left(R^2 \arccos\left(1-\frac{h}{R}\right) - (R-h)\sqrt{h(2R-h)}\right)} + h - R. \tag{7}$$

Given the notations of (6) and (7), equating expressions (4) and (5), we determine the depth of the difference of h.

The definition of the form of the difference has theoretical and practical importance also.

With an open channel, the initial and final depths of the hydraulic differential are intertwined, that is, the functions of their differences are equal, while in the channel of a closed section they are for the most part not equal. This is precisely the feature of the hydraulic differential of the closed cut.

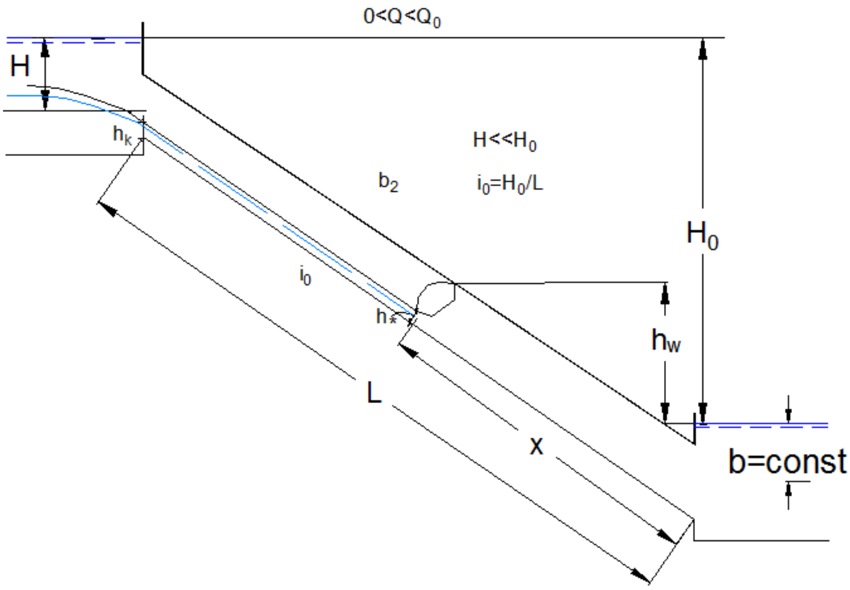

Fig. 3.Simple pipeline with stable backwater

To establish the place of the difference, let us use the hydraulic system shown in Fig. 3, at the bottom of which there is a backup of $b = const$. In this case, a pressure movement will appear along the x length of the pipe. Obviously, the place of the difference will be above the horizontal surface of the support in the amount of energy loss in the area of pressure movement, that is,

$$i_0\, x = b + \frac{x}{K^2} Q^2; \quad \Rightarrow \quad x = \frac{b}{i_0 - Q^2 / K^2}, \tag{8}$$

where i_0 and K, respectfully, are the slope and throughput of the pipe.

From (8) it follows that an increase in the output in the interval of $(0,\ Q_0)$ is accompanied by a shift in the difference point towards the pool.

Using the equation of stationary non-uniform motion of the prismatic channel [3], the depth of the live section of h_*, which is distant from the input section of the pipe of $L - x$ by the amount that will be the initial depth of the drop, is determined.

Now, comparing the drawn-in depth h with h*, we find out that
if $h_* <$ h or $P(h_*) > P(h)$, then we have a remote jumping,
if $h_* = h$ or $P(h_*) = P(h)$, then–we have the maximum jumping
if $h_* > h$ or $P(h_*) < P(h)$, then we have the muffled flight.

3. Conclusion

To switch from non-pressure to pressure movement, it is necessary to throttle the valve towards the closing direction, at which the output remains unchanged.
The conjugate depths of the closed slice may be conjugated and non-conjugate.

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COMPUTER SIMULATION OF WASTEWATER EUTROPHICATION POTENTIAL AS THE BASE FOR PROPER SELECTION OF TREATMENT TECHNOLOGIES

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Keywords: Eutrophication, wastewater, nutrients, computer simulation

Abstract. The anthropogenic eutrophication of surface waters presently is characterised by high intensity of development all over the world. The main cause of its intensification is the discharge of large loads of biogenic substances from anthropogenic sources. Wastewater plays the most important role in accelerating the development of eutrophication due to the high content of mineral forms of nutrients. Mineral nitrogen and phosphorus compounds are the bioavailable forms of nutrients, which are directly absorbed by aquatic vegetation and stimulate its development. The existing legal regulations regarding the content of nutrients in treated wastewater are very restrictive and can be reached only in very expensive advanced technologies. But they do not always provide effective protection against eutrophication, as evidenced by the unsatisfactory surface water state in different countries. Such situation can be explained, inter alia, by the fact, that the legal guidelines set the standards for total nutrients content without taking into account the share of their bioavailable forms in treated wastewaters which determine their eutrophication potential. The aim of the paper is to present the original approach based on application of computer simulation in order to select the proper wastewater treatment technologies, which ensure the minimum eutrophication potential of treated wastewater and are economically justified.

1. Introduction

1.1 Topicality of the Problem

Despite the huge financial investments, scientific and technical progress, the construction of expensive and energy-consuming wastewater treatment plants and development of rigorous legislation standards, the quality of natural waters continues to deteriorate all over the world. Already in 1989, the famous American ecologist E. Odum wrote: “All the largest cities in the world are located on large rivers, lakes, estuaries, which serve as free wastewater receivers. The people abuse the use of natural water resources so much that water can become a major limiting factor for a human as a biological species” [1].

The deterioration of surface water quality is associated not only with the direct pollution coming from different sources, but also with the disturbance of the ecological balance of aquatic ecosystems, leading to the appearance of secondary negative effects. The most obvious manifestation of ecological imbalance in surface waters is anthropogenic eutrophication (colloquially “water blooming”), which at the end of the 20th century became a global problem. Eutrophication leads to secondary pollution of water, degradation and loss of the resource value of freshwater and marine ecosystems. Practically all types of water use are violated and, most importantly, the shortage of fresh drinking water increases.

The most significant role in the development of eutrophication process play the municipal wastewater discharges, which contain the large amounts of nitrogen and phosphorus compounds.

Hence the main direction of eutrophication abatement is the reduction of biogenic loads discharged to water receivers from wastewater treatment plants. The basic tool for the implementation of this goal is the strict legal requirements concerning the quality standards developed practically in all countries for treated municipal wastewater discharged to water receivers. This forced the use of advanced technologies of enhanced biological nutrients removal (EBNR) which are characterized by high investment and operating costs. But these measures have not led to effective protection against anthropogenic eutrophication.

There are several reasons for such a failure: insufficient knowledge of intra-aquatic biological and biochemical processes and the inability to control them; the emergent properties of aquatic ecosystems; the dependence of eutrophication processes on many abiotic and biotic factors; the lack of appropriate environmental standards of nutrients (mineral forms of nitrogen and phosphorus), causing “water bloom"; the lack of consideration of the share of bioavailable nutrients forms in treated wastewaters which determine their eutrophication potential.

The aim of the paper is to present the original approach based on application of computer simulation in order to select the proper wastewater treatment technologies, which ensure the minimum eutrophication potential of treated wastewater and are economically justified.

1.2 Eutrophication Potential of Wastewaters

Biogenic substances are chemical elements and mineral salts needed for the development of the living organisms and essential for the growth and development of terrestrial and aquatic vegetation. In the aquatic environment, nitrogen and phosphorus compounds play a key role and are among the main limiting factors of water vegetation development. Biogenic substances occur in the aquatic environment in the form of dissolved inorganic and organic compounds and of organic and inorganic suspensions [2].

Table 1 presents the forms of biogenic substances in surface waters and biochemical processes in which their various forms take part [3,4].

Table 1 Nutrients forms occurring in aquatic ecosystems

Nutrients forms	Participation in biochemical processes
Dissolved inorganic	Photosynthesis, excretion, chemical changes, hydrolysis of dissolved organic matter, detritus decomposition, decomposition and release from sediments
Inorganic molecular	Creation of complex compounds, sorption
Dissolved organic	Hydrolysis, detritus decomposition, decomposition and release from bottom sediments, excretion
Organic molecular	Algae death, decomposition, deposition, zooplankton growth, molecular excretion
Biotic (in the composition of living matter)	Oxygen consumption and decay of vegetation, decomposition algae, development of zooplankton

Among the mentioned forms, only the dissolved inorganic forms of nutrients are directly available for aquatic vegetation, in rare cases these are some organic compounds. Nutrients are the most absorbable for aquatic vegetation when they are presented in water in the form of compounds analogous to cell protoplasts. For example, the nitrogen in the cell substance is contained in the reduced form (ammonium ions), while phosphorus - in its oxidized form (phosphoric acid). As a consequence, these forms will be the most available for assimilation by algae [5]. The forms of those chemical substances that are directly available for aquatic vegetation (so-called biogenic forms) are mineral compounds of nitrogen and phosphorus. It's just these forms determine the development of phytoplankton and higher aquatic vegetation [6]. The specificity of mineral nutrition of aquatic vegetation is not fully investigated due to the high degree of complexity of processes occurring in the aquatic environment [7].

On the basis of the analysis of knowledge on the bioavailability of various forms of biogenic compounds for aquatic vegetation, the definition of wastewater eutrophication potential was formulated. This term means the share of bioavailable (mineral) forms of nitrogen and phosphorus in treated wastewater discharged into the receiver, which intensifies the development of aquatic vegetation. In other words, it is the degree of influence of treated wastewater discharged to the receiver on the development of eutrophication processes, conditioned by the content of bioavailable forms of nutrients.

The share of bioavailable forms of nitrogen and phosphorus in wastewater is shown in Fig. 1 and 2.

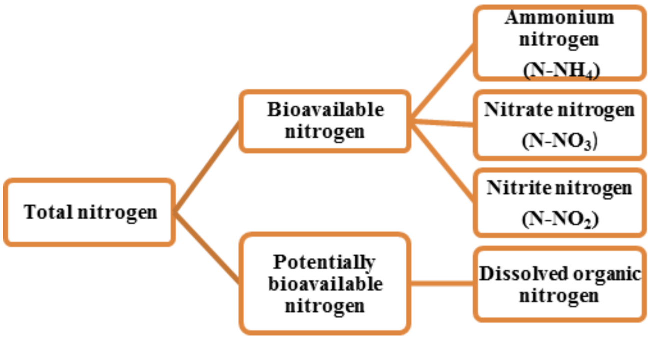

Fig. 1. The share of bioavailable forms of nitrogen compounds in municipal wastewater

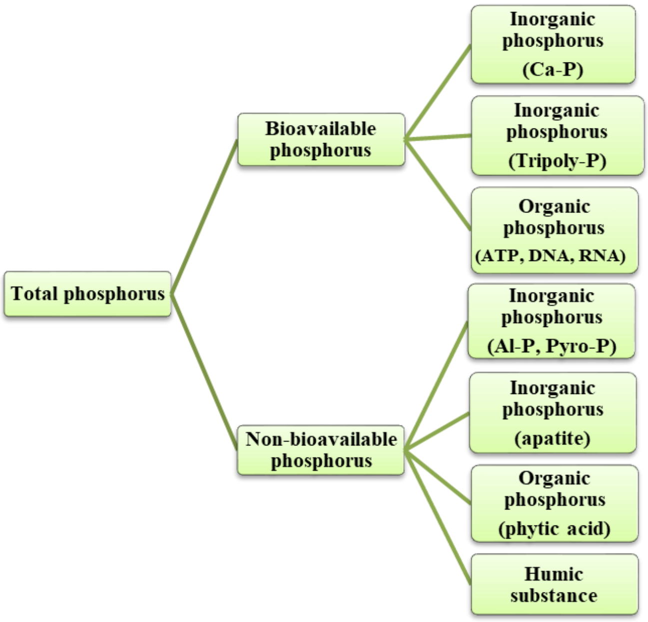

Fig.2. The share of bioavailable forms of phosphorous compounds in municipal wastewater

According to literature sources, the share of bioavailable nutrients loads in treated wastewater is varied and depends on applied treatment technologies. In most cases, more than 50% of phosphorus and 20-45% of nitrogen in treated wastewater is not available for aquatic vegetation [8-10].

Taking into account the above considerations, it may be pointed out that the impact of treated wastewater discharged into the aquatic environment depends not so much on the total loads of biogenic substances, but on the share of bioavailable forms of nitrogen and phosphorus, i.e. on the eutrophication potential of treated wastewater. In turn, the eutrophication potential of treated wastewater is highly dependent on the applied nutrients removal technology. In order to identify the technologies characterized by low eutrophication potential of treated wastewater the simulation studies were carried out.

2. Methodology

The approach for the selection of wastewater treatment technologies providing a minimum eutrophication potential of treated wastewater was realized on the base of computer simulation using software based on the ASM (Activated Sludge Model). The first edition of the ASM model (ASM1) was developed in 1987 by an international research group belonging to the International Association on Water Pollution Research and Control (IAWPRC). Later, within the cooperation of numerous research groups, new modelling concepts for wastewater treatment based on the activated sludge method were created [11]. In order to carry out the research, the Biowin model belonging to the group of ASM models was chosen. BioWin is a wastewater treatment process simulator that ties together biological, chemical, and physical process models. It is used world-wide to design, upgrade, and optimize wastewater treatment plants of all types. The input data for the simulation was wastewater quality monitoring data obtained from the Krakow-Kujawy wastewater treatment plant (Krakow, Poland). The requirements regarding the content of nutrients in treated wastewater have been adopted in accordance with legal requirements in force in Poland: Nog- below 10 mg/l and Pog - below 1 mg/l for agglomerations of over 100 000 PE (population equivalent) [12].

The aim of computer simulation was to determine the efficiency of removal of bioavailable forms of biogenic compounds in 10 most common treatment technologies of their elimination: traditional secondary treatment, Anoxic-Oxic technology (AO), Bardenpho technology (3-stage), modified Bardenpho technology (5-stage), University of Cape Town technology (UCT), modified University of Cape Town technology (MUCT), Anaerobic-Oxic technology (A/O), Oxic-Anoxic technology (OA), Johannesburg technology (JHB) and MJHB (modified JHB) technology [13-15].

The research concept was directed at identification of nutrients removal technology, which would provide the minimum eutrophication potential of treated municipal wastewater with the least complicated technological systems and optimal investment and operating costs.

3. Results of computer simulation

The results of simulation research presented in Table 2 show the content of total nitrogen (TN, mg/l), total phosphorus (TP, mg/l), dissolved inorganic nitrogen (DIN, mg/l), dissolved inorganic phosphorus (DIP, mg/l) and the percentage share of mineral nitrogen and phosphorus in their total content.

Table 2. Bioavailable nutrients content in treated wastewater

Technology	TN	TP	DIN	DIP	DIN%	DIP%
Traditional	58.15	2.76	54.66	2.61	94	95
AO	54.08	2.77	50.89	2.62	94	95
Bardenpho-3	53.26	2.24	49.85	2.07	94	92
Bardenpho-5	53.89	2.48	50.73	2.32	94	94
JHB	33.1	1.39	29.71	1.18	90	85
MJHB	33.09	1.39	29.71	1.19	90	85
UCT	39.16	1.93	35.83	1.74	91	90
MUCT	41.05	1.85	37.81	1.66	92	90
A/O	35.32	1.79	31.85	1.60	90	90
OA	56.59	2.83	53.18	2.68	94	95

Analysis of the results of simulation of the content of various forms of nitrogen and phosphorus in wastewater treated in different technologies shows that none of the 10 systems provides required quality standards for treated wastewater, and the content of bioavailable forms of nitrogen and phosphorus in total content of this nutrients oscillates between 90-94% and 85-95% respectively. The most effective elimination of nutrients was reached under wastewater treatment in JHB technology (1.39 mgTP /l and 33.10 mgTN/l) and in MJHB technology (1.39 mgNP /l and 33.09 mgTN/l). Simultaneously in the same technological systems, the lowest inorganic phosphor and inorganic nitrogen content was also reached: 1.18 mgDIP/l and 29.71 mgDIN/l in JHB technology and 1.19 mgDIP/l and 29.71 mgDIN/l in MJHB technology. Wherein, the lowest eutrophication potential has been achieved by wastewater treated in JHB and MJHB technologies (Fig. 3, 4).

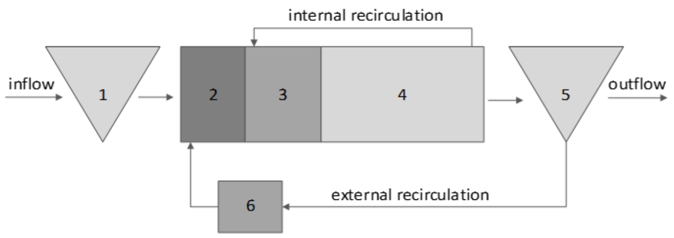

Fig.3. JHB technological train (1- primary sedimentation tank, 2- anaerobic chamber, 3 - anoxic chamber, 4- aerobic chamber, 5-secondarysedimentation tank, 6–pre-denitrification chamber)

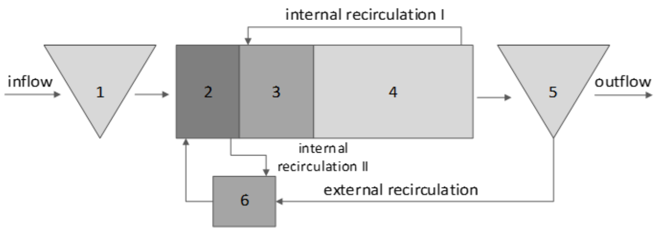

Fig. 4. MJHB technological train (1-primary sedimentation tank, 2-anaerobic chamber, 3-anoxic chamber, 4-aerobic chamber,5-secondary sedimentation tank, 6–pre-denitrification chamber)

The results of computer simulation presenting the content of bioavailable forms of nitrogen and phosphorus in wastewaters treated in different technologies are shown in Fig. 5.

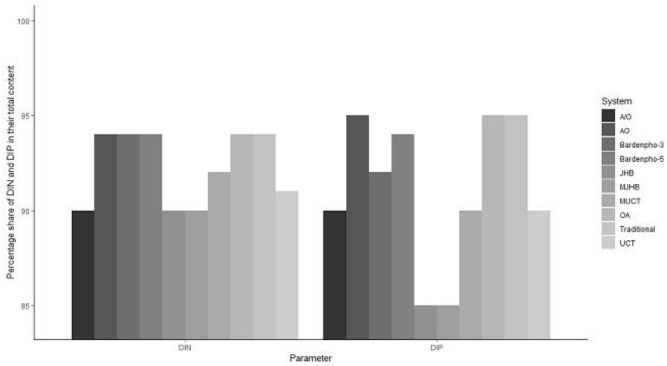

Fig. 5. The content of inorganic nitrogen and inorganic phosphorus in wastewaters treated in different technologies

4. Conclusion

Today the main direction in the prevention of surface water eutrophication is the reduction of nutrients loads introduced with wastewater to the receivers. The basic tool of water protection are the legal requirements applicable virtually in all countries concerning the treated wastewater quality discharged into the waters receivers. A common feature that characterizes the recent changes in water legislation in different countries are the tightening of the treated wastewater quality standards especially in terms of biogenic compounds. However, the permissible concentrations of nitrogen and phosphorus compounds in treated wastewater are determined mostly only for total phosphorus and total nitrogen, and only in some countries the permissible concentration are developed for some inorganic forms (phosphates, ammonium nitrogen or nitrates). Whereas, the influence of treated wastewater on eutrophication development depends on the content of mineral forms of biogenic substances, directly available for aquatic vegetation and conditioning the eutrophic potential of treated wastewater.

Considering the above consideration, the knowledge about the share of bioavailable forms of nitrogen and phosphorus in wastewater discharged to the receiver would allow the selection of efficient treatment technologies justified in ecological and economic terms. The suitable tool for the selection of optimal treatment technology can be a computer simulation, the result of which are presented in this paper. The simulation allowed the statement that none of 10 analysed technological systems provided the proper level of elimination of total nitrogen and total phosphorus from wastewater required by the Ordinance of the Minister of the Environment: below 1 mgP / l and 10 mgN/l [9]. The lowest inorganic phosphorus and inorganic nitrogen content was reached in JHB and MJHB technologies. This means that these technologies are characterized by the lowest eutrophication potential of treated wastewater and lowest contributing to the intensification of eutrophication processes in receivers, compared to the remaining 8 analysed technological schemes.

The research carried out proved that computer simulation can be an effective tool, that allows to making the decision when choosing an ecologically and economically efficient wastewater treatment technological systems, ensuring more effective protection of water receivers against eutrophication and its negative consequences.

5. Acknowledgements

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THE FEASIBILITY ANALYSIS OF CONSTRUCTION OF SOLAR PHOTOVOLTAIC STATION IN ARMENIA

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Keywords: Solar photovoltaics, solar power plant, availability, resources, sunshine duration, renewable energy

Abstract. Solar photovoltaic station is considered as one of the options for getting renewable energy. The aim of the article is to explore the experience of solar power stations in a number of European countries and the possible options for application of this experience in Armenia. The study was carried out through collection of geological archival materials on the case study area, as well as by studying the physical and mechanical properties of subsurface soils of the area. The preferred site for construction of the station should be an area non-usable by the population. The selected site has the best location with regard to solar resources, which will provide an opportunity to get the most of energy resources by using appropriate equipment.

1. Introduction

1.1. Background

For households in Armenia the day-to-day energy tariff is 44.98 drams per kWh and 34.98 drams per night. In case of socially insecure families, for one kilowatt-hour, 40 drams a day, 30 drams per night.[1] Taking into account that 766 thousand People are poor, this tariff can not be justified by itself.[2] Consequently, it is necessary to find an alternative option that will mitigate the problem at least in the frontier zones.

The best method is the installation of a photovoltaic station as the potential of solar energy in Armenia is good and the conditions for the implementation of the plant are also available, so the productivity is high, and access can reach half of the current price.

Reductions in costs driven by technological advances, economies of scale in manufacturing, and innovations in financing have brought solar power within reach of grid parity in an increasing number of markets. Continued advancements and further cost reductions will expand these opportunities, including in developing countries where favorable solar conditions exist. Policy environments for renewable energy in the developing world are being refined, drawing on the lessons learned from the successes and failures of policies adopted in first-mover markets. Solar is proving to be viable in more places and for more applications than many industry experts predicted even a few years ago. With this approach, the installation of a photovoltaic (PV) station in Masrik region was carried out in Armenia. This experience allows us to understand the prospects and expediency of such programs in Armenia.

[1] Electricity Tariffs for "Electric Networks of Armenia" CJSC for Consumers, www.energyagency.am

[2] "Social Image and Poverty in Armenia" report published by the National Statistical Committee of the Republic of Armenia, www.armstat.am

2. Theoretical Framework

2.1. Historical Overview

Large-scale photovoltaic power plants are an important driver for global PV growth. A growing number of large-scale projects are being implemented and connected to the grid around the world. In the dynamically expanding markets – especially the largest market, China – multi-megawatt power plants account for most of the deployment. Intersolar Europe, the world's leading exhibition for the solar industry and its partners, and the accompanying Intersolar Europe Conference are taking an in-depth look at large-scale power plants and the opportunities and challenges they bring, including operation and maintenance, financing and the impact of sinking prices on PV components. [3]

Thus developed countries, due to economic, environmental, security and social concerns, set new frameworks for energy policy. The primary goal of the countries was to promote renewable energy. Today, many countries register high rates of renewable energy growth thanks to past policies. Additionally, high rates of renewable energy growth are also a prerequisite for the decline in production costs of renewable energy, thanks to technological developments. Thus, the average cost of renewable energy has dropped 2.66 times compared to the 1990s. Moreover, the picture of the implementation of new investments in the renewable energy sector for 2004 and 2014 shows that in 2004 the volume of investments for developed countries composed 36 billion dollar, and for developing countries - 9 billion dollar, which has been progressively increased up until 2014 indicating 139 billion dollar for developed countries and 131 billion dollar for developing countries (Fig. 1). [4]

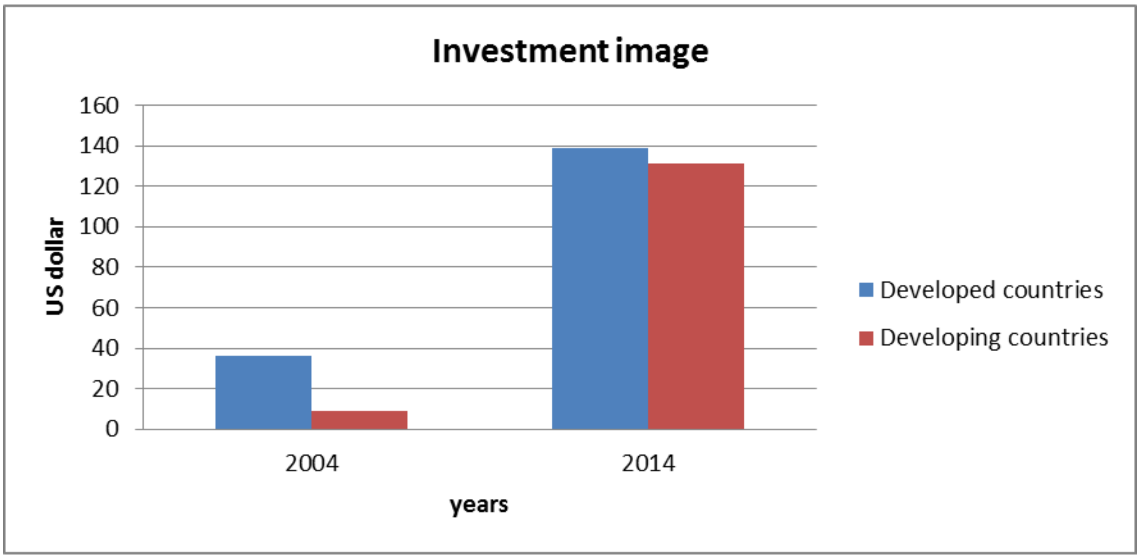

Fig. 1. Investment image from 2004 to 2014

Many European countries have implemented a plant installation that justified their expectations. And some developed countries have also promoted their development by appropriate mechanisms such as subsidies. These are Japan, Germany, and the United States.

[3] Inter Solar Europe, www.intersolar.de

[4] "National Centre for Legislative Regulation" FOUNDATION , www.regulations.am

Renewable energy today accounts for almost 20% of global electricity supply, while fossil fuels make up about 80%. Renewable energy, particularly solar and wind, are the fastest growing components in the energy system.

The nation has had a great impact on these indicators with different mechanisms, such as subsidizing. Subsidizing systems have been used by Japan, Germany and the United States as an important component of market transformation. Thus, for example, under the solar shining program of Japan, subsidies of capital were provided and the flows were provided for the installation of solar panels for roofs. From 1994 to 2000, the government invested $ 725 million, resulting in 58,000 new generating capacities totaling 220 MWh. Germany launched its "1000 Solar Thermal Stations" program in 1991, providing 60% subsidy for the purchase of solar cells. Later, the program was expanded and 100,000 new stations were deployed within 5 years. The initial reduction of capital expenditures is made for consumers through direct subsidy or discount systems. Direct investments are made to enable consumers to use more affordable prices than actual prices. In the United States, at least 19 states offer discount systems for the use of renewable energy technologies. All these discount systems are mainly offered by the state and are mainly referred to water heaters and solar power plants, but in some cases they also refer to geothermal, wind and biomass energy sources. Discount systems are provided primarily to households and companies. In some cases, discount systems are used in combination with low or non-interest bearing loans.

2.2. European Requirements for Photo Volunteers

Necessary conditions are: Assessment of the market opportunity takes into account broad issues at the national level, such as the regulatory environment, prevailing power prices, structure of the power market, the credit-worthiness of potential off-takers, and any specific financial incentives for developing solar PV power plants. The first tangible steps in the process are development of a concept and identification of a site. The project will then proceed through several development stages, including the prefeasibility study, a more detailed feasibility study, permitting and financing, and finally engineering (detailed design), construction, and commercial operation of the power plant. As the project developer initiates preparatory activities including securing a land lease agreement and permits, preliminary financing schemes are assessed. Energy resource assessment and activities related to project financing run in parallel with the project design (e.g., engineering, construction, etc.).

The key steps for developing a solar PV project are well established, and yet there is no definitive detailed “road map” a developer can follow. The approach taken in each project depends on site-specific parameters and the developer’s priorities, risk appetite, regulatory requirements, and the types of financing support mechanisms (i.e., above market rates/subsidies or tax credits) available in a given market. However, there is a sequence of actions that the International Finance Corporation presents in five stages:

1. Concept development and site identification.
2. Prefeasibility study.
3. Feasibility study.
4. Permitting, financing and contracts.
5. Engineering, construction and commercial operation.

STAGE 1 – CONCEPT DEVELOPMENT AND SITE IDENTIFICATION

The concept development stage includes identification of the investment opportunity at a specific site and the formulation of a strategy for project development. It is assumed at this stage that a target market has been identified and the project developer understands any special prerequisites for investing in that specific country and power sector. These market-level decisions require a detailed assessment that carefully considers the risk–reward appetite of the project developer and potential investors.

STAGE 2 – PREFEASIBILITY STUDY

The aim of a prefeasibility study is to develop a preliminary plant design and investment requirements, which allow further assessment of the financial viability of a project. This assessment involves more detail than the previous stage and determines whether to proceed further with the project and commit additional financial resources. The prefeasibility study can be carried out as a desktop study even though a site visit is desirable. Given the uncertainty of data available at this stage, viability will be determined in reference to a minimum financial hurdle rate, and will take into account a wide margin of error (e.g., +/-30%) to compensate for the lack of site-specific assessment data.

STAGE 3 – FEASIBILITY STUDY

The feasibility phase will build on the work undertaken at the prefeasibility stage by repeating the assessment in more detail using site-specific data, such as solar resource measurements, and should consider any previously identified constraints in more detail. If multiple sites are being assessed, then the preferred site needs to be selected. The objective of the feasibility study is to provide more detailed information on the potential project design, the investment requirements, and to plan for financing and implementation. If the results of the study are favourable, the developer should be prepared to invest more to advance the project to the financing stage.

STAGE 4 – PERMITTING, CONTRACTS AND FINANCING

After the feasibility stage and assuming that the project still seems to be financially viable, the project moves to the next stage. This includes obtaining final permits, securing project finance and pre-implementation activities (commercial contracts).

STAGE 5 – ENGINEERING, PROCUREMENT, CONSTRUCTION AND COMMERCIAL OPERATION

A single EPC contract is most commonly used for developing PV plants. In this case, one contractor is responsible for the complete project. The EPC contractor is required to confirm the solar energy resource, develop the detailed design of the PV plant, estimate its energy yield, procure the equipment according to specifications agreed upon with the developer, construct the PV plant, carry out the acceptance tests, and transfer the plant for commercial operation to its owner/operator.

There are two main sources of solar resource data: satellite-derived data and land-based measurement. Since both sources have particular merits, the choice will depend on the specific site. Land-based site measurement can be used to calibrate resource data from satellites in order to improve accuracy and certainty.

As solar resource is inherently intermittent, an understanding of inter-annual variability is important. Often ten years or more of data are desirable to calculate the variation with a reasonable degree of confidence, although many projects have been completed with less detailed levels of historical data.

In the northern hemisphere, a surface tilted at an angle towards the south receives a higher total annual global irradiation compared to a horizontal surface. This is because a surface tilted towards the south more directly faces the sun for a longer period of time. In the southern hemisphere a surface tilted towards the north receives a higher total annual global irradiation. Fig. 2 illustrates why the tilt angle is important for maximizing the energy incident on the collector plane.

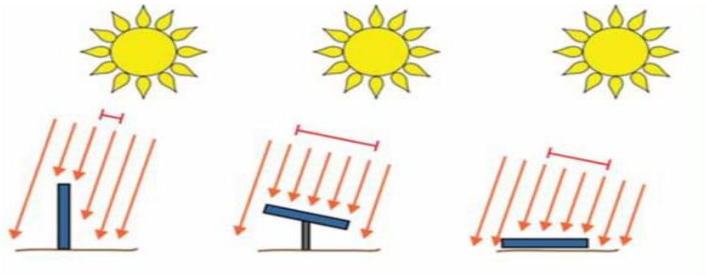

Fig. 2. Illustrates why the tilt angle is important for maximizing the energy incident on the collector plane

Ground-based solar resource measurement stations are very unevenly distributed throughout the world. Countries have different standards of calibration, maintenance procedures and historical measurement periods. In addition, as the distance from a solar measuring station increases, the uncertainty of interpolated irradiation values increases. On the other hand, the development of solar models using satellite data has advanced as the accuracy of such data increases. The precise distance at which satellite data become preferable over data interpolated from ground sensors depends on the individual case.[5]

The plant located in the Masrik region of Armenia corresponds to these conditions. There were serious studies and various calculations to predict the plant's efficiency. [6]

2.3. Solar pv Technology Overview

PV cell technologies are broadly categorized as either crystalline or thin-film. Crystalline silicon (c-Si) cells provide high efficiency modules. They are sub-divided into mono-crystalline silicon (mono-c-Si) or multi-crystalline silicon (multi-c-Si). Mono-c-Si cells are generally the most efficient, but are also more costly than multi-c-Si. The performance of a PV module will decrease over time due to a process known as degradation. The degradation rate depends on the environmental conditions and the technology of the module. Modules are either mounted on fixed-angle frames or on sun-tracking frames. Fixed frames are simpler to install, cheaper and require less maintenance. However, tracking systems can increase yield by up to 45 %. Tracking, particularly for areas with a high direct/diffuse irradiation ratio also enables a smoother power output. PV modules and inverters are all subject to certification, predominantly by the International Electrotechnical Commission (IEC). New standards are currently under development for evaluating PV module components and materials. The performance ratio (PR) of a well-designed PV power plant will typically be in the region of 77% to 86% (with an annual average PR of 82 %), degrading over the lifetime of the plant. In general, good quality PV modules may be expected to have a useful life of 25 to 30 years.

C-Si modules consist of PV cells connected together and encapsulated between a transparent front (usually glass) and a backing material (usually plastic or glass). Mono-c-Si wafers are sliced from a large single crystal ingot in a relatively expensive process. Cheaper, multi-c-Si wafers may be made by a variety of techniques. One of the technologies involves the carefully controlled casting of molten multi-silicon, which is then sliced into wafers. These can be much larger than mono-crystalline wafers. Multi-crystalline cells produced in this way are currently cheaper, but the

[5] International Finance Corporation, www.ifc.org

[6] Utility-scale solar PV plant, www.minenergy.am

end product is generally not as efficient as mono-crystalline technology. Both mono-crystalline and multi-crystalline module prices have decreased considerably in the last two years.

2.4. Countries of Case studies

Now, several major PV plants will be presented in compliance with European requirements with crystalline silicon technology.

1. Greece:

Athens Metro Mall

Basics-City/Location: Athens, Ag.Dimitrios

Latitude/Longitude: 37.941363 /23.739974

Type of application: BIPV

1st Year of operation: 2010

Description of the solution-Designed with the aim of saving resources and being environmental friendly, Athens Metro Mall combines various characteristics that make it a bioclimatic building with very low energy consumption. Solar panels cover 400 m^2 on the south side of the building achieving a reduction in energy consumption of up to 5%.

Site / building type: The BIPV consists of two façades and the south side of the commercial center “Athens Metro Mall”.

Duration of installation works: 20 days.

Technical description

Total installed power: 51 kWp

Area needed per kW: 7.72 m^2

PV technology used: Crystalline silicon

Economic aspects

Total cost: €142,000, (PV: 2.78 €/Wp)

Feed-in tariffs, subsidies, grants: The system feeds into the public grid and paid 0.394€/kWh by the Public Power Corporation (PPC). The system is estimated to produce approximately 39.9MWh/year which means that the total investment will be paid back in 9 years.

Results

Energy production: 39,900 kWp /year CO2 emissions savings: 23. 94 t/year

2. **Paros Island**

Basics

City/Location: Krotiri, Paros

Latitude/Longitude: 37.103483 / 25.149740

Type of application: ON-ROOF

1st Year of operation: 2012

Description of the solution

The PV system was installed in the framework of the program "Photovoltaic Systems on Buildings" with main aim the increase of the use of RE production and to reduce the distribution network loading and losses by localized energy production.

- Site / building type: The On-Roof system is installed on a wooden shading construction using slide-in mounting base in order to improve the aesthetic of the system

Duration of installation works: 2 days
Technical description
Total installed power: 4.8kWp
Area needed per kW: 6.87m²
PV technology used: Polycrystaline silicon with "Stay-Powerful" grid interconnection technology
Economic aspects
Total cost: €12,700, (PV: 2.65 €/Wp)
Feed-in tariffs, subsidies, grants: The system feeds into the public grid and paid 0.55€/kWh by the Public Power Corporation (PPC). The system is estimated to produce approximately 6.19MWh/year which means that the total investment will be paid back in 4 years.
Results
Energy production: 6.19 MWh /year CO2 emissions savings: 3.7 t/year[7]

3. Study of Territories in Armenia

3.1. Facilities for PV Plant Installation in Armenia

Let's now understand how far it is best to implement a PV station in Armenia. As an example we will take the area where we have already made the corresponding calculations and compare it with those areas where such a program has not been implemented. The selected site is located in the Gegharkunik region and is located in the Masrikh plain. The area under study is different in its physical-geographical, microclimatic conditions, which is conditioned by relief. Here, flat, weakly sandy, clayey flats, different expositions and slopes of mountain slopes are dominated. Valley is advantageously distinguished by the abundance of sun radiation, high intensity of direct radiation, the length of the comfort season, and so on. In such valleys, frosts are weaker than 2-30 in Sevan, which is lower (located on the plains). In the hot season of the year the slopes of the slopes are warmed by 3-40 times. These advantages, along with beautiful scenery, green slopes, lack of noise, and air cleanliness, speak of the availability of significant air and solar therapeutic resources. The area is not shadowed by high masses, as a result of which a large number of solar radiation sources are available, the duration of the sunshine is high. During the whole year, ultraviolet and infrared rays have the maximum values, from this point of view, the horizontal surface illumination is the highest. Radiation scattered due to considerable quantity of solar modes is low and straight to high. This belt is located in the "cold" climate zone and is characterized by very cold winters and cool summers.[8]

From hydro-geological point of view, Masrik plains represent a groundwater basin and pressure water basin. In the section of the lake-river sediments of the Masrikian valley, the following are the submerged hydrous horizons: Groundwater, Upper Low Pressure, Medium Pressure, Lower Pressure. Ground or weak pressure horizon is located at a depth of 1.5-2.7 m. The water is hydrocarbonate. It is fed mainly by the pressure of the pressure water, to a certain degree from the ground water formed by the winding rocks in the surrounding slopes. Most of the ground is fragile, which creates favorable conditions for atmospheric precipitation, penetrating deeper horizons. According to the seismic displacement map of the ANM II-6.02-2006, it is in the third seismic zone where the maximum seismic acceleration is 0.4g [9]. The area chosen as a photovoltaic station

[7] Intelligent Energy – Europe (IEE), ec.europa.eu
[8] According to the RAI-II-7.01-2011 "Construction Climatology" norms, www.arlis.am
[9] According to the displacement map of the ANM II-6.02-2006, www.irtek.am

corresponds to its good solar resource, good communication infrastructure, and there are no environmental barriers, trees or buildings that can shadow, reducing the efficiency of the photovoltaic modules.

Area geographical coordinates and altitude,

- Width: 40^0 to 13.564 North;
- Longitude – 45^0 43.565 East;
- Height above sea level - 1930 m (see Fig. 3).

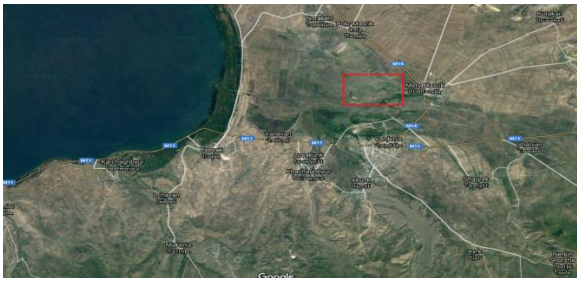

Fig. 3. Location of the premises[10]

The start of the competition for this program was launched in 2017. The Energy Week in Yerevan, in February, attended by representatives of more than 50 foreign companies. More than seven dozens of companies from Europe, the US, China, India, South Africa and other countries have received bids. Twenty companies presented applications, of which ten had overcome the pre-qualification threshold, had the right to participate in the main stage of the competition and present their advantageous tariff. The Department of Public Relations of the Ministry of Energy and Natural Resources informs that the minimum tariff proposal has been received from the Netherlands by Rennie Wendour BV (Fotowatio Renewable Ventures B.V) and Spanish Essell Solae et al. (FSL Solar S.L.) is a consortium of leading global companies. The offered tariff is 0.0419 US Dollars, without VAT (20.11 drams). At present, the tariffs for small hydropower stations on natural water supply systems in Armenia are 23.8 drams.

4. Conclusion and Recommendations

Solar Guiding Map allows you to visualize the available capabilities[11](Fig. 4.)

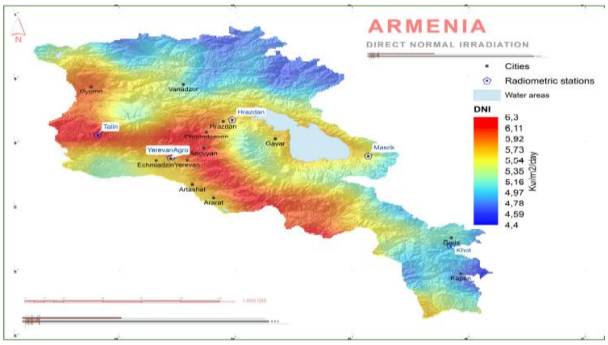

Fig. 4. Solar Guiding Map

Looking at the map, it appears that the Masrik part of the solar energy potential is at an average level and even by this data, it justifies itself, and in the frontier zones the potential of solar energy is

[10] Google Earth, earth.google.com

[11]Solar Guiding Map, minenergy.am

high, especially in Vayots Dzor, Aragatsotn and Shirak regions where weak winds, solid grounding, communication, lack of shade, good weather conditions, clean air, etc.

Vahan Hamazaspyan said there are 193 nuclear power plants in 30 countries of the world producing 400gigabits/h of energy. According to calculations, so many suns are going on in Armenian, enough to meet the world's energy demands 21 times. That is, our solar resources are more than the energy resources of the whole country.

It is important to concentrate on the deployment of the station in the border areas as there are free economic zones in the area, which will allow the company to operate in the most profitable way, and the lack of housing will allow the absence of the shadow. The communication will be provided with the help of neighboring villages. The cheap labor force will also be provided by residents of nearby villages. And what concerns the potential of the sun because it is stronger than the already existing PV panels, so the self-covering phase will end sooner.

Thus, European standards for the station are largely in line with the conditions of Armenia, so it is advisable to carry out such activities.

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WATER RESOURCES MANAGEMENT ISSUES IN ARMENIA

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Keywords: Underground water, addition, resource management, subboundary water

Abstract. Effective use of water resources has a strategic importance for the Republic of Armenia. However, today the use of this essential and irreplaceable resource is implemented to the highest degree inefficiently, moreover most of the rivers of Armenia flow throughout the country bringing no benefit to the socio-economic development. As a result of a situational analysis of different uses of water resources serious concerns have been revealed about the problems related to ineffective management of water resources. Technologic forecasts have shown many anticipated inevitable negative consequences if there will be no changes in the present water management policies. It is a real pressing issue in our country. Suggestions have been developed and made designed to conserve water resources formed in the Republic of Armenia by adding underground water resources. This will enable to get additional water volumes and in case of effective use of water to meet growing demand for irrigation, domestic supply, industry, etc.

1. Introduction

The main natural resource of the Republic of Armenia is water, the effective use and management of which can guarantee a free and prosperous life. However, the water resources of our Republic are currently almost totally or not used or are used in the most unsuccessful manner. As a result, irreversible losses are recorded in the area of environmental protection, destruction of the ecosystem, demolition of agricultural land, and reduction of forest cover. This sad picture of the situation requires immediate solutions. That is why large-scale investments in the management of water resources need to be substantiated with profound researches and meet modern technological requirements. It is necessary to develop a long-term plan for each river basin flow forecasting, efficient use and management, which should be justified by the maximum values of the minimum and expected outcome of the flow unit.

2. Methodology

Annual surface flows in the Republic of Armenia make about 7 billion cubic meters, from which, at best, the use of 1.5-1.7 billion cubic meters was used at best [1]. Today, the volumes of reservoir water are relatively small. It has two reasons: the first because of the global climate change, the number of atmospheric precipitations has dropped dramatically, and therefore the emerging surface flows, the second, which is most useless and illogical, deliberately deprived of them, used for personal gain, or does not use water meaning, in particular, they use small hydropower plants. As a result, we have non-cultivated agricultural land, almost completely demolished irrigation systems, deserted villages and desperate agricultural communities.

Large-scale construction of small hydropower plants has been totally disrupted by the natural equilibrium situation, which leads to a widespread desertification process in Armenia. The most dangerous phenomenon is that it is impossible to imagine the effects of mass desertification. It will lead to extreme poverty reduction, sharp rupture of demographic picture, irreversible loss of balanced ecological situation, etc.

A much worse situation has been set in the Ararat Valley's underground water resources, which, at the outset, had a strategic significance for the Republic of Armenia. This was the reason why the use of groundwater resources in the Ararat Valley was under strict surveillance. It, with severe restrictions, was used only for irrigation, drinking and household needs.

However, under the conditions of the corrupt system of governance established in the Republic of Armenia, the use of underground water resources of the Ararat Valley, mainly for fishery, annually brought about 1.7 - 2 billion cubic meters of freshwater volumes and operations to direct them to the Araks and Armenia. As a result, the groundwater resources dropped dramatically, and their levels dropped. The factor of global climate change was also added to it, under which conditions today a threatened situation has been established in the Ararat Valley.

The most difficult situation was also registered in Lake Sevan basin. In addition to the ecological hard conditions of the lake, discussions are also under way on the conservation of Lake Sevan's water resources. As the main source of climate and ecosystem regulation in the Republic of Armenia, Lake Sevan is subject to unavoidable waste of threats and accumulated water resources. There are many reasons but we should mention only a few:

• The streams of Lake Sevan have dropped sharply

1. With global climate change, due to which atmospheric precipitation has drastically diminished in our region,

2. As a result of the human factor, bypassing the flowing streams of Lake Sevan, the lake is directed toward the Arax River,

3. It does not work because of the unfounded delay of the Arpa-Sevan tunnel repairs,

4. Vorotan - after the completion of construction works of the Arpa tunnel, no any water has been transported to Lake Sevan.

• Wastewater filled with Lake Sevan changes the water quality drastically, making it non-strategic raw material.

Lake Sevan is a natural water reservoir that has a natural balanced state of preservation of biodiversity, development of agriculture, hydropower generation and many of the most invisible phenomena. However, it was interrupted by human intervention when the Sevan-Hrazdan energy system was built and large-scale irrigation systems, which are today the foundations of the agricultural industry. As a result, the water level in Lake Sevan fell by 18-20 meters, causing drastic changes in climatic, hydro-geological, environmental and other phenomena. Arpa-Sevan, later Vorotan-Arpa tunnels (Fig. 1) were built for the water level and the Lake Sevan elevation program was developed to be 1906 meters, which is lower than the natural horizon 10 meters.

Under these conditions, the management of Lake Sevan's water resources is carried out under extreme downturned infrastructure, without the use of water meters, often only for energy purposes.

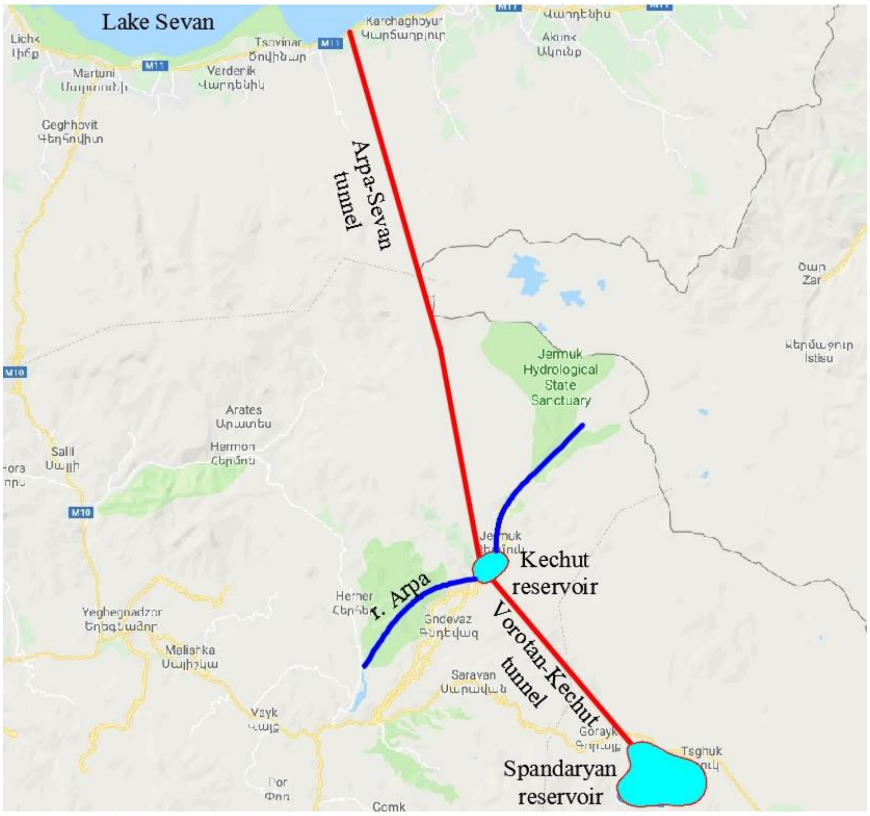

Fig. 1. Lake Sevan Infrastructure Chart

A crisis situation is anticipated in Akhuryan-Araks river basin zones, which include agricultural land in Shirak, Talin, Baghramyan and Armavir regions. The problem is that there is a great need for irrigation water in these regions as the Akhuryan reservoir is not completely filled and only half of the water is filled with the Republic of Armenia. According to the Hashiki contract, the total volume of Akhuryan reservoir (550 million cubic meters) is 350 million cubic meters. The meter would have to flow from the Kars River, flowing through Turkey, and the remaining 200 million cubic meters. meters from the Akhuryan River. For many years this agreement has been preserved. Today, the Turkish side built a 600-million-meter-long reservoir of water on the Kars River at the expense of the water reservoirs that had to be filled with Akhuryan reservoir, the only source of reservoir water flowing to the Akhuryan River. The point is that by filling our water reservoirs we will be obliged to divide the Akhuryan reservoir into two equal parts. As a result, we are experiencing a catastrophic situation, the consequences of which lead to the complete desertification of the region [2].

The vivid evidence of this is the policy pursued by Turkey in the transboundary water basin. Not satisfactorily with the purposeful dehydration of the Akhuryan reservoir, the Araz River is completely irrigated. At present, Araks River is being constructed with water reservoirs (800-1000) million cubic meters, in which the accumulated water should be transported to Igdir. Under these conditions, instead of the Arax River, the dry stream will remain and the Armavir main canal will be completely demolished. As a result, the irrigated lands of the Armavir province will turn into a desert that will lead to large-scale population emigration (Fig. 2).

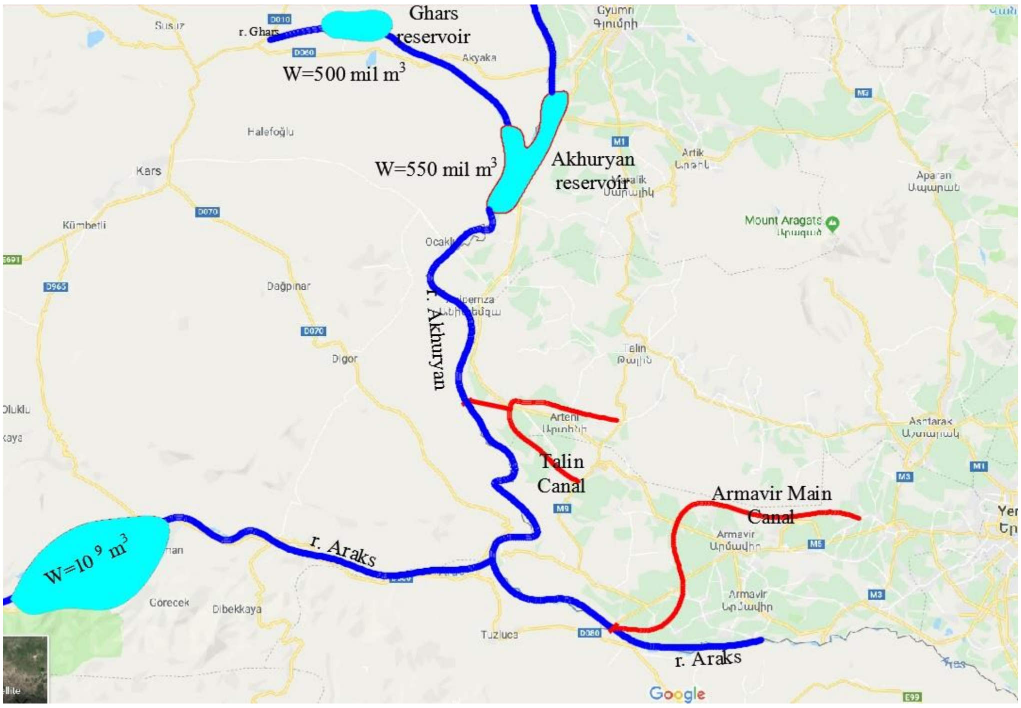

Fig. 2. Chart of supply of Talin and Armavir main canals

What Are Our Problems?

• To substantiate and elaborate a comprehensive program of efficient use of Akhuryan reservoir and Araks river flow from Armenia;

• strictly prohibit the use of underground waters in the Ararat valley for fishery purposes or to carry them in circulating water lakes;

• To stop the work of SHHPs operating in the Akhuryan-Arax River Basin,

• Development of prospective schemes for efficient use of the Hrazdan River flows,

• Develop flows of water flowing to Lake Sevan,

• Develop existing water infrastructure modernization programs;

• Introduce the latest technologies and equipment for water use;

• organize pumps, including deep pumps,

• Development of mechanical irrigation systems in them widely using modern equipment and automation systems,

• Implement fundamental changes in water utilization in agriculture, widely using modern methods, equipment and so on.

The underground water sources in Armenia are the source of atmospheric precipitations, mainly the coatings. Over the past decades, under the conditions of global climate change, the formation of snow cover has diminished, which negatively affects the accumulation of groundwater resources. Atmospheric precipitations are mainly in the form of rains which are mostly absorbed by other surface flows in the form of floods. They leave the territory freely, leaving only harmful consequences.

In order to mitigate or eliminate the harmful effects of surface flows and to change their character, we recommend building dams where the accumulated melt flows will penetrate the earth's crust and become groundwater (Fig. 3). The basics of construction of dams will require complex studies that will enable them to foresee structural efficiency and ground water reserve performance.

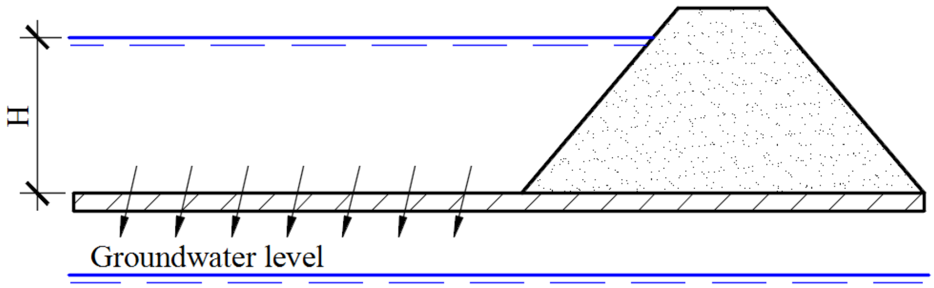

Fig. 3. Replenishment of groundwater resources

The construction of a protective dam can solve a number of economic issues:

• A significant part of the surface flows generated in the Republic of Armenia are accumulated in the form of groundwater and use it,

• Protect certain areas of the RA from hazardous mud flows,

• Increase the ecological safety of the RA territory and so on.

3. Conclusion

The next key issues in the use of water resources are related to the use of water and industrial uses and as a result of wastewater treatment. Notwithstanding the key issues of water use in Armenia, it should be noted that the quality of water used for water supply is largely consistent with drinking water standards and requires only disinfection and, in some cases, only mechanical cleaning is required. The problem is more complicated in household and industrial wastewater treatment as the required degree of cleaning is not implemented, at best it is carried out with inadequate mechanical cleaning. There are significant accumulated problems in this area that require urgent solutions.

Times have put forth imperatives to Armenia, and the decision-making delay may have sad consequences.

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DETERMINATION OF VEDY AND KHOSROV CONDUITS CONTROL VALVES OPENING DEGREE

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Keywords: Pipeline, control valve, opening, pressure regime

Abstract. Determination of installed control valves opening degree necessary to provide pressure regimes in water intake units at water lines junction of Vedi reservoir supply systems depending on inflow from water sources flow rates values is an engineering problem of great practical importance. To determine opening of control valves, depending on local resistance coefficients change, findings of experimental investigation have been used. In addition, energy losses occurring in the valve unit are conditioned by geometric parameters of the system, their special features and the hydraulic regime.

1. Introduction

Vedi reservoir feeding is performed by Vedi and Khosrov rivers flows which during a year have accented irregularity. To provide feeding of the Vedi reservoir it is required to transfer the maximum amount of these rivers flows. Toward this end several water receiving headworks have been built enabling implementation of surface water treatment to an admissible degree and its transfer through feed pipeline to the reservoir [1-4].

The conduit feeding the reservoir involves Vedi, Khosrov, and main conduits as shown in Fig.1.

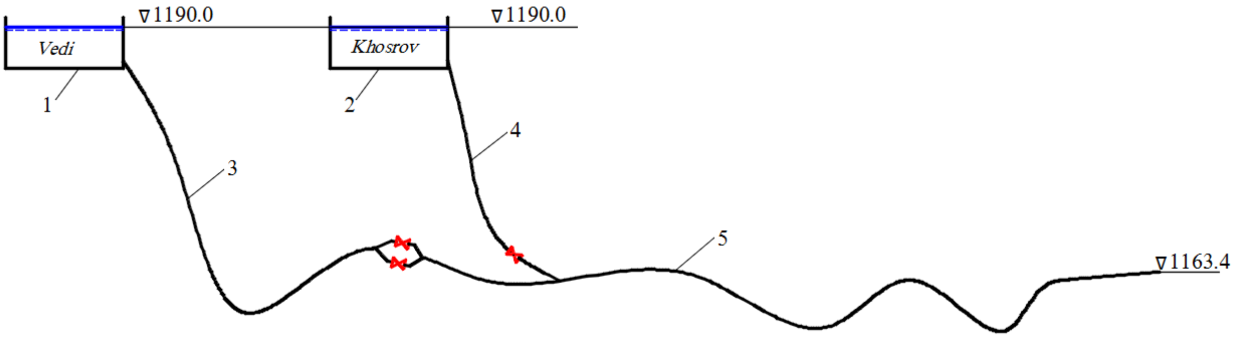

Fig.1. Vedi reservoir feeding system

1- Vedi conduit receiver, 2-Khosrov water line receiver, 3-Vedi conduit, 4-Khosrov conduit, 5-main conduit

2. Methodology

Vedi, Khosrov and main conduits are made of glass fiber composite pipes of 1800mm, 1000mm, and 1800mm diameters, respectively. The length of Vedi conduit is 1528m, which is connected to the water receiver structure at the 1186.5m mark. The length of Khosrov water line is 834m and it is connected to the water receiver at the 1187.1m mark.

Depending on flows of Vedi and Khosrov rivers flows feeding conduits are changed. In case of small flows in Vedi and Khosrov conduits fluid motion non-pressure regimes are developed and fluid motion velocities amount to 4.5-6m/s. Such velocities are inadmissible values for glass fiber composite pipes, for walls of glass fiber pipes under such velocities are failed most rapidly. Only in case of designed maximum flows that in Vedi and Khosrov conduits pressure regimes are settled and velocities become less than 2m/s which is within the admissible limits. To provide such limited conditions near Vedi and Khosrove conduits connection point regulating valves are installed as shown in Fig.2 and 3.

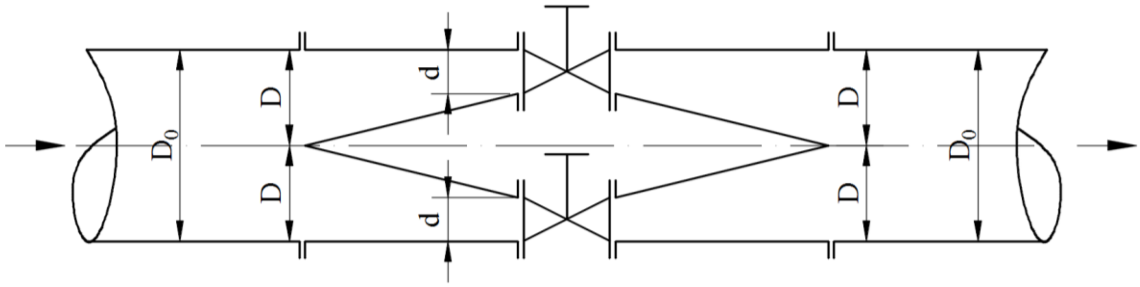

Fig.2. Vedi conduit regulating valve diagram

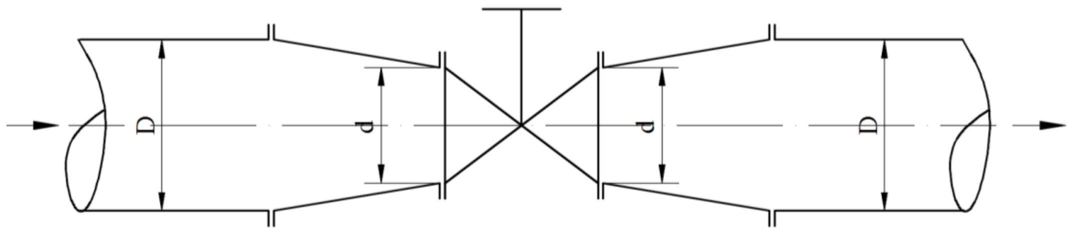

Fig.3. Khosrov conduit regulating valve diagram

By regulating valves, regardless of the flow running through them, in conduits regimes of pressurized motion should be provided. Depending on flows running through conduits it can be done by regulating openings of valves installed on them. The openings are choosed from the condition [3] of pressure regimes retaining in conduits

$$H_0 = h_{w1}\left(h_{w2}\right) + h_{vu} + h_w, \tag{1}$$

where H_0 is g ravitation pressure of the system

$$H_0 = \nabla_{sp} - \nabla_{ep} + \Delta h_s, \tag{2}$$

where ∇_{sp} are marks at initial points, $\nabla_{sp} = 1187.0$ m, ∇_{ep} is the mark of the main conduit end point, $\nabla_{ep} = 1863.6$ m, $\Delta h_s = 0.6$ m is the measure of pressure resource, that is $H_0 = 1187 - 1863.6 + 0.6 = 24$ m is the loss in Vedi conduit, h_{w2} is the loss in Khosrov conduit

$$h_{w1} = 1.1\frac{L_1}{K_1^2}Q_1^2 = 0.086 \cdot Q_1^2 \qquad h_{w2} = 1.1\frac{L_2}{K_2^2}Q_2^2 = 1.03 \cdot Q_2^2, \tag{3}$$

where K_1 is the carrying capacity of the Vedi conduit $K_1 = 140$ m^3/s, Q_1 is the flow of the Vedi conduit , K_2 is the carrying capacity of the Khosrov conduit $K_2 = 29.8$ m^3/s, Q_2 is the flow of the Khosrov conduit, h_w is the pressure loss in the main conduit`

$$h_w = 1.1\frac{L}{K^2}Q^2 = 1.1\frac{8210}{140^2}Q^2 = 0.461 \cdot Q^2, \tag{4}$$

where Q is the flow of the main conduit which is the sum of flows running through Vedi and Khosrov conduits

$$Q = Q_1 + Q_2 = 1.286 \cdot Q_1, \tag{5}$$

as far as $Q_2 = Q_1 \dfrac{K_2}{K_1}\sqrt{\dfrac{L_1}{L_2}} = 0.286 Q_1$.

The pressure loss in the Vedi valve unit h_{vu} is determined by (1). Substituting the numerical value in (1), we have

$$h_{vu} = 24 - \left(0.086 \cdot Q_1^2 + 0.461 \cdot 1.286^2 \cdot Q_1^2\right) = 24 - 0.851 \cdot Q_1^2 \tag{6}$$

Depending on the flow running through Vedi conduit the above equation enables to determine the pressure loss developed in the valve unit by which in the conduit a pressure regime is settled. Based on the required amount of the pressure loss in the valve unit the degree of the valve opening is determined

$$h_{vu} = \sum \xi_{vu} \cdot \frac{V^2}{2g} \tag{7}$$

where $\sum \xi_{vu} = \xi_{sc1} + \xi_{sc2} + \xi_v + \xi_{se1} + \xi_{se2}$ is the coefficient of the total local resistance of the valve unit (Fig.2), V is the average velocity of the fluid.

$$\xi_{sc1} = 0.5\left(1 - \frac{D^2}{D_0^2}\right) = 0.5\left(1 - \frac{1}{1.8^2}\right) = 0.35,$$

$$\xi_{sc2} = 0.5\left(1 - \frac{D^2}{D_0^2}\right) = 0.5\left(1 - \frac{0.8^2}{1}\right) = 0.18,$$

$$\xi_{se1} = \left(1 - \frac{D^2}{D_0^2}\right) = 0.5\left(1 - \frac{0.8^2}{1}\right) = 0.13,$$

$$\xi_{se2} = \left(1 - \frac{D^2}{D_0^2}\right) = \left(1 - \frac{0.8^2}{1}\right) = 0.48 .$$

Taking into account these values of local resistance coefficience from (7) we get

$$h_{vu} = \xi_{scv1}\frac{8Q_1^2}{g\pi^2 D^4} + \xi_{sc2}\frac{8Q_1^2}{g\pi^2 d^4} + \xi_v\frac{8Q_1^2}{g\pi^2 d^4} + \xi_{se1}\frac{8Q_1^2}{g\pi^2 D^4} + \xi_{se2}\frac{8Q_1^2}{g\pi^2 D_0^4} = 0.08Q_1^2 + \xi Q_1^2, \tag{8}$$

from which we have

$$\xi_v = \frac{4.95 h_{vu}}{Q_1^2} - 0.4 . \tag{9}$$

In accordance with the flow running in the Vedi conduit determining by (4) the necessary pressure loss in the valve unit is determined and by (8) coefficients of the valve local resistance are calculated. The regularity of the valve local resistance coefficient variation depending on the degree of the valve opening was obtained by analysis of carried out experimental research results [1,4].

$$\xi_v = 0.5\left(\frac{h}{d}\right)^{-2,7}. \qquad (10)$$

Then from (9) for the ξ_v value the degree of the valve opening degree is determined.

$$a_0 = \frac{h}{d}. \qquad (11)$$

For different values of the flow passing through the Vedi conduit by (4, 8) pressure losses developed in the valve units and coefficients of local resistance have been calculated. By (10) for the obtained values the degree of the valve opening degree $a_0 = \frac{h}{d}$ is determined. Carried out calculations are presented in Table .

For different values of the flow passing through the Vedi conduit by (4, 8) pressure losses developed in the valve units and coefficients of local resistance have been calculated. By (10) for the obtained values the degree of the valve opening degree $a_0 = \frac{h}{d}$ is determined. Carried out calculations are presented in Table 1.

Table 1

NN	Q, m^3/s	h/d	h, mm	NN	Q, m^3/s	h/d	h, mm	NN	Q, m^3/s	h/d	h, mm
1	0.1	0.019	15	17	1.7	0.2	160	33	3.3	0.410	328
2	0.2	0.033	27	18	1.8	0.211	169	34	3.4	0.429	343
3	0.3	0.047	37	19	1.9	0.222	178	35	3.5	0.448	359
4	0.4	0.059	47	20	2.0	0.223	187	36	3.6	0.469	375
5	0.5	0.071	57	21	2.1	0.245	196	37	3.7	0.492	393
6	0.6	0.082	66	22	2.2	0.256	205	38	3.8	0.516	413
7	0.7	0.093	75	23	2.3	0.268	214	39	3.9	0.543	434
8	0.8	0.104	83	24	2.4	0.280	224	40	4.0	0.572	458
9	0.9	0.115	92	25	2.5	0.293	234	41	4.1	0.606	485
10	1.0	0.126	101	26	2.6	0.305	244	42	4.2	0.644	515
11	1.1	0.136	109	27	2.7	0.319	255	43	4.3	0.688	550
12	1.2	0.147	118	28	2.8	0.332	266	44	4.4	0.740	592
13	1.3	0.158	126	29	2.9	0.347	277	45	4.5	0.804	643
14	1.4	0.168	134	30	3.0	0.361	289	46	4.6	0.885	708
15	1.5	0.179	143	31	3.1	0.377	302	47	4.7	0.995	796
16	1.6	0.189	152	32	3.2	0.393	315	48	4.75	1.067	800

Having obtained calculated in the above table data the flow running through the conduit – the degree of the valve opening relationship has been plotted (Fig.4). The diagram enables to determine the degree of the valve opening depending on the flow running through the conduit.

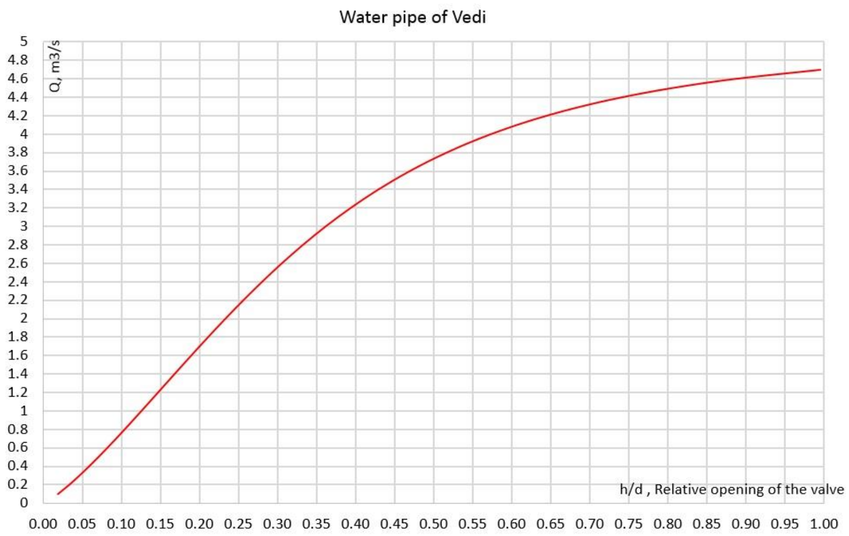

Fig.4. Change of the Vedi conduit flow depending on the valve relatively opening degree

In case of small flows one of the two parallel valves installed on the Vedi conduit should be kept closed and regulate the process only by one valve. In case when relatively large flows run in the Vedi conduit and one valve opening is not sufficient to let through such flows the second valve opens at that its half opens right away, and in case of very large flows it completely opens.

Pressure loss in Khosrov conduit valve unit according to (3, 6) will be

$$h_{vu} = 24 - \left(1.03Q_2^2 + 0.461 \cdot \left(4.5Q_2^2\right)\right) \tag{12}$$

where $Q = Q_1 + Q_2 = 3.5 \cdot Q_2 + Q_2 = 4.5 \cdot Q_2$.

The summary value of the local resistance coefficient of the Khosrov conduit valve unit can be calculated by the below formula

$$\xi_v = \frac{4.95h}{Q_2^2} - 0.23$$

In this case the necessary pressure loss h_{vu} developed in the valve unit is determined by (12), accordingly the local resistance coefficient of the valve - by (13), and the adequate degree of the valave opening – by (10). The results of calculations are given in Table 2.

Table 2

NN	Q, [m^3/s]	h/d	h, [mm]	NN	Q, [m^3/s]	h/d	h, [mm]
1	0.1	0.021	17	9	0.9	0.133	106
2	0.2	0.037	29	10	1.0	0.150	120
3	0.3	0.050	40	11	1.1	0.171	137
4	0.4	0.063	51	12	1.2	0.196	157
5	0.5	0.076	61	13	1.3	0.230	184
6	0.6	0.089	71	14	1.4	0.280	224
7	0.7	0.103	82	15	1.5	0.380	304
8	0.8	0.117	94	16	1.592	1.00	800

By data of the Table 2 the variation of the flow running through the Khosrov conduit depending on the valve opening degree the diagram in Fig.5 has been plotted which enables to implement regulation of the valve to provide pressure regime of the conduit.

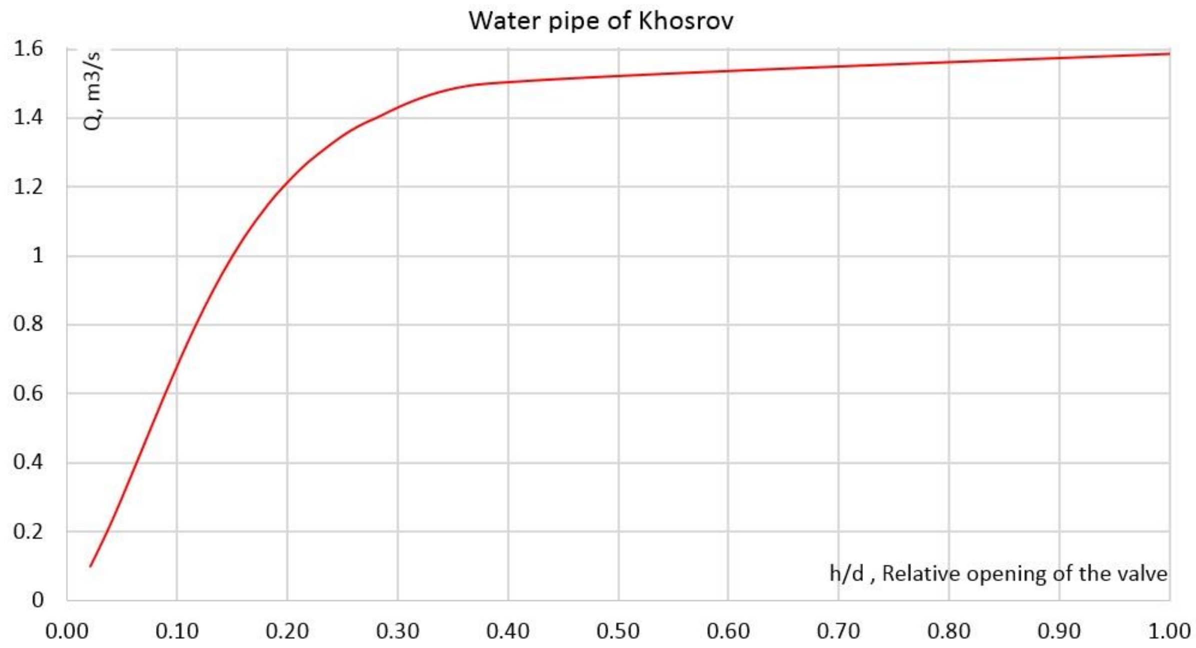

Fig.5. Change of the Khosrov conduit flow depending on the valve relatively opening degree

3. Conclusion

In order to provide pressure regimes in feeding sources of conduits feeding the Vedi reservoir conduit it was suggested a calculation method for determination of regulating valves openings installed on the conduits. Flow – relative valve opening diagrams have been plotted which enable to implement regulation of flows developed by feeding sources in such a way to obtain a pressure regime in branches of feeding sources which is the necessary technical condition for failure-free operation of glass fiber pipes.

Acknowledgements

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CRITICAL MASS OF SELF-SUSTAINABLE ECONOMY BASED ON SCIENCE AND TECHNOLOGY

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Keywords: Self-sustainable economy, science, technology, policy

Abstract. History has shown that the abundant wealth of the US economy was built on science and technology of the 1950s by automizatimg and manufacturing commercial products in general. The same has promoted China to an economy giant, growing continuously via the Belt-Road with MOU signed recently by Italy, France, Monaco and others to follow. To what extent the same could occur to benefit other countries would no doubt depend on the vision and wisdom of the policy makers to ward off those dictators destined to suppress the others. The ill-intended techniques are reflected by personalizing scientific development and other devious means. This presentation serves as a forum to discuss the conditions for establishing self-sustainable economy.

1. Introduction

Self-sustainable economy is no longer a single country proposition, particularly when the wealth of manpower, resource and scientist technology is also available among the countries. The trade war (TW) and wall barrier (WB), however, have hampered progress to prevent countries to establish self-sustainable economy. TW imposes tariffs to disrupt the well being of economy while the WB imposes restrictions on manpower. All countries have the right to have a better life through a stablized economy without suppression to control their lives. Healthy science and technology will not survive by the mal-intended forces of TW and WB. Heavy tariffs on imported consummer and key machinery goods could jack up the cost of manufacturing sky high. Similar actions apply to WB. Paraphrasing the 2019 warning of Pope Francis to leaders wanting to build walls to keep migrants out of their countries will end up becoming prisoners of the walls they build.

2. Double jeopardy

Wall creates two sides, separating the outside from the inside. The impasse prevents interaction and offers no benefit to neither side.The evil-minded aggressor of the trade war at present is determined to commit financial deficits at suicidal proportions with no winners. The madness is beyond civilized human comprehension. Such vengeance brings no peace to the world, less alone stablized economy. No countries should just standby and watch the world crumbles into rumbles. The aggressors should be dealt with to achieve a win-win proposition for those on both sides of the wall barrier instead of a lose-lose proposition to seal off interaction from both sides of the wall barrier. The recourse is to bypass the evil-mended science initiated from the early time of Newton [1,2].

3. Personalization of the privileged

One Newton [1] was hypothesized with the false notion of force, the correct derivation of which belongs to the Hookean force [1, 2] based on the energy. The reckless self-endorsed action of Issac Newton initiated an avalanche of personalized names for units [3] wiith Newton controlling the outcome as follows:

$$Newton\,(N) = Force : \frac{Kg \cdot m}{s^2} \tag{1}$$

The apparent inconsistency of Eq. (1) lies in mixing the personalized Newton with non-personalized kilogram for mass. The inconsistency led to the personalized Joule in Eq. (2) for energy or work.

$$Joule\,(J) = Energy\ or\ Work : \frac{Kg \cdot m^2}{s^2} \tag{2}$$

A Pascal and Watt were used, respectively in Eqs. (3) and (4):

$$Pascal\,(Pa) = Pressure\ or\ Stress : \frac{Kg}{s^2} \tag{3}$$

$$Watt\,(W) = Power : \frac{Kg \cdot m^2}{s^3} \tag{4}$$

The arbitray selection of the personalized manifests the intention to control the development of science for the self-serving and self-proclaimed privileged group.

4. Conclusions

Clearly demonstrated in [4, 5] are the conditions to avoid using the contrived science of Newton such that the essential components for achieving a sustainable economy could be used for constructive purpose. This includes the proportions of manpower, resource, scientific knowledge, administered by the decision maker for a win-win proposition. To be done away are the suicidal lose-lose propositions where the aggressor and retaliator both suffer.

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HYDROLOGICAL AND FINANCIAL MODEL OF RAINWATER HARVESTING SYSTEM

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Keywords: Rainwater harvesting systems, Life Cycle Cost analysis, calculation model

Abstract. Progressive climate change, surface waters pollution, improper use of water resources as well as increase of water requirements are the results of growing population of people in the world. These factors significantly affect the water deficiency in majority of countries in the world. Due to the water pollution advanced technologies for its treatment are in demand, what leads to increase of water price. In this connection, there are more often taken actions to reduce water consumption by using rainwater to flush toilets, wash cars, do laundry or irrigation of green areas.

1. Introduction

According to data published by the the United Nations Population Division, by 2030 urban population of the world will increase by 1,750,000,000 people [1], and by 2050 the total population of the world will increase to 9.3 billion [2]. Both the population growth and the progressing urbanization are the main driving factor causing both global changes and degradation of the natural environment. This contributes to rapid depletion of natural resources [3, 4] including water. Urbanization, which consequences include depletion of green areas, arable lands, and forests as well as decrease in the biological diversity of species, leads to considerable deterioration of the quality of air and water, not only locally but also at the regional and global level [5, 6]. Therefore, the natural environment's resources, including water, should be managed in sustainable manner.

The growing demand for potable water resulting from the increase in the world's population and due to the depletion of freshwater resources, most countries, including Poland, led to the deficit of water. According to the World Health Organization as many as 884 million people throughout the world do not have access to a safe source of drinking water [7], and each year over 5 million people die due to the lack of water or as a result of diseases caused by drinking unusable water [8]. Therefore, various measures are taken to reduce the depletion of the global water resources, e.g. by using recycled water [9-12], installing high-efficiency appliances [13] and using rainwater in toilet flushing, car washing, washing machines, irrigation of arable land or watering green areas [14-18].

Installation systems designed for collecting and reusing water have been used for years throughout the world. It is stated that depending on the climate conditions, country, type of building in which the system based on rainwater has been applied, savings in consumption of mains water may be as high as 100% [19]. It should be noted that systems of this type are also recommended by the European Commission for application in sanitary installations of civil engineering structures [20].

These systems have become an integral part of sustainable storm water management, for they can reduce the flow of rainwater into sewers, thereby impacting the related hydraulic load [21].

In recent years, researchers throughout the world have viewed rainwater harvesting (RWH) is one of the strategies allowing the sector of water management to adjust to the changing climate [22-24].

It is worth underlining that rainwater can be used for toilet flushing not only in residential buildings [25-28], but also in large sports facilities [29], university facilities [30], supermarkets [31] as well as office buildings [32].

2. Model of the System

Installation designed for domestic use of rainwater consists of the following components:

- roof draining system (roof gutters and drain pipes),
- appliances for rainwater treatment,
- lower storage tank with overflow system,
- upper storage tank,
- pumping system,
- water supply installation to supplement shortage of rainwater,
- installation distributing rainwater in the building,
- measurement and control instruments, anti-contamination equipment.

Fig. 1 presents the general layout of the system designed for utilizing rainwater in the residential building.

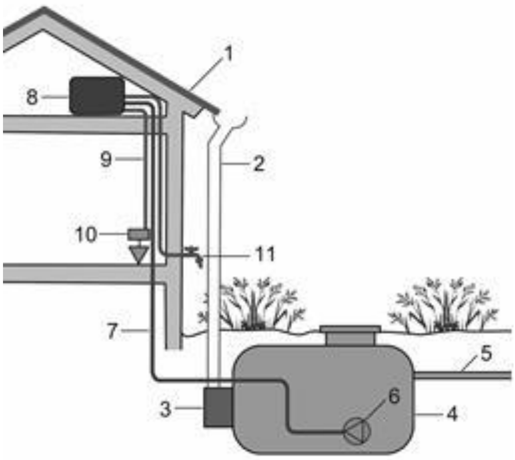

Fig. 1. Layout of the system designed for utilizing rainwater in the residential building (1 – roof surface, 2 – roof gutters and drain pipes, 3 – pre-treatment installation, 4 – lower storage tank, 5 – emergency overflow, 6 – pumping system, 7 – upper tank inlet installation, 8 – upper storage tank, 9 – installation carrying water to sanitary fittings, 10 – sanitary fittings, 11 – installation carrying water to other fittings)

Taking into account the connection between the roof draining system, both lower storage tank and emergency as well as the designed use of rainwater, the following configuration of the installation can be applied [19, 27, 33, 34, 36].

- installation system with a flow-through tank and duct releasing excess water to sewers,
- installation system with a flow-through tank and devices for excess water infiltration,
- installation system with distribution valve and duct releasing excess water to sewers,
- installation system with distribution valve and devices for excess water infiltration,
- installation system with storage tank for accumulating all rainwater.

3. Simulation Model

The computational model comprises the system of rainwater collection system, its storage and utilisation. Its operation is determined by such factors as: occurrence of precipitation, volume of water collected in the tank, size of retention tank, size of the roof surface as well as runoff coefficient and demand for water of lower quality. The model is presented schematically in Fig. 2.

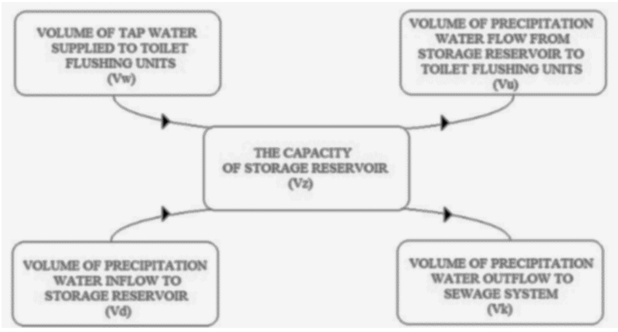

Fig. 2. Model of the system for utilization of rainwater (Vd – volume of precipitation water inflow to storage reservoir, Vk – volume of precipitation water outflow to sewage system, Vu – volume of precipitation water flow from storage reservoir to toilet flushing units, Vw – volume of tap water supplied to toilet flushing units, Vz – the capacity of storage reservoir)

The performance of the system is described with the following conditions which determine the processes of rainwater flow, its accumulation and release of water to sanitary installation and sewers. This templet is presented schematically in Figure 3.

FILLING IN AND ACCUMULATION OF RAINWATER IN THE RETENTION TANK:

If $Vrk_i + Vd_{i+1} > Vz$ to $V_{i+1} = Vz$, $i = 1, 2, \dots, n$

If $Vrk_i + Vd_{i+1} \leq Vz$ to $V_{i+1} = Vrk_i + Vd_{i+1}$, $i = 1, 2, \dots, n$

↓

RAINWATER INTAKE FROM THE RETENTION TANKS BY THE INSTALLATION:

If $Vrpi - Vs < 0$ to $Vrki = 0$ and $Vui = Vrpi$, $i = 1, 2, \dots, n$

If $Vrpi - Vs \geq 0$ to $Vrki = Vrpi - Vs$ and $Vui = Vs$, $i = 1, 2, \dots, n$

↓

FLOW OF MAINS TO THE TANK:

If $Vrpi > Vs$ to $Vwi = 0$, $i = 1, 2, \dots, n$

If $Vrpi \leq Vs$ to $Vwi = Vs - Vrpi$, $i = 1, 2, \dots, n$

↓

DISCHARGE OF RAINWATER FROM THE RETENTION TANK TO SEWERS:

If $Vrpi + Vdi \leq Vz$ to $Vki = 0$, $i = 1, 2, \dots, n$

If $Vrpi + Vdi > Vz$ to $Vki = Vrki + Vdi - Vz$, $i = 1, 2, \dots, n$

Fig. 3. Boundary conditions (V_i – volume of rainwater retained in the tank at the end of day i (no.), m^3; Vd_i – volume of rainwater inflowing on day i (no.), m^3; Vrk_i – volume of retained rainwater in the tank after intake by installation on day i (no.), m^3; Vrp_i – volume of rainwater retained in the tank before intake by installation on day i (no.), m^3; Vs – volume of water utilized by installation, m^3; Vu – volume of rainwater inflowing from retention tank to installation, m^3; Vwi – volume of mains water transported to installation on day i (no.), m^3)

4. Financial Model

Financial analysis calculated for water supply in the multi-family building was based on Life Cycle Cost methodology. The calculations were performed taking into account the complete life cycle of the building, including the initial investments designated for constructing the water supply system and the costs connected with its use. This is accordance with LCC methodology of calculations. LCC cost analysis is employed in various sectors of economy, e.g. power engineering, construction, infrastructure, pumping systems or transport. It is mainly used as a tool in decision-making and management processes [35, 37, 38]. Results of LCC analysis can provide valuable information and facilitate decisions in the process of assessing and comparing alternative solutions. Moreover, in many countries Life Cycle Cost methodology is required by the law in the case of new investments, particularly those projects which involve high initial expenditure and long exploitation.

Having regard to the usefulness of the calculation method described the present article delineates tests which make it possible to estimate the costs of building and operating RWH systems. For the multi-family building and for the assumed life of the building in question, the LLC costs were determined according to (1):

$$LCC = K_I + \left[\sum_{t=1}^{T} (1+r)^{-t}\right] \times K_E \qquad (1)$$

where: K_I – financial investment [PLN], K_E – operation costs [PLN], T – duration of LCC analysis, r – constant discount rate, t – successive year of using the building [-].

The analysed case took into account operation costs K_E connected with the purchase of mains water necessary for filling up the tank if the flow of rainwater from the roof does not cover the demand for water needed for flushing toilets. Also included the costs of discharging excess rainwater to sewers and the cost related to the transport of water from the tank, via pumps to water-closet bowls. The calculation of operation costs K_E was based on formula (2):

$$K_E = K_{ZWW} + K_{OWD} + K_{PW} \qquad (2)$$

where: K_E – operation costs water supply system in the building; K_{ZWW} – cost of purchasing water for flushing WCs; K_{OWD} – cost of discharging rainwater to sewers; K_{PW} – cost of transporting water from the tank, via pumps to water-closet bowls.

Subsequently, on the basis of formula (3) computed KPW operating costs connected with transporting water for flushing toilets via the pump system.

$$K_{PW} = c_{en} \frac{V_W \times \rho \times g \times H}{\eta_p \times 3{,}6 \times 10^6} \qquad (3)$$

where: c_{en} – unit price for electrical energy; V_W – annual volume of water transported from the tank via the pumping system to water-closet bowls; ρ – density of waste water; g – gravitational acceleration; H – pumping height; η_p – pumping system efficiency.

5. Conclusions

From the standpoint of sustainable development of cities, collecting and using the rainwater are very important. This proceeding is increasingly often recognized as a key measure in strategies design to reduce the shortage of water in urban areas. The LCC analysis can be successfully used to estimate the cost of the installation of rainwater collecting system in the multi-family buildings. The method works even for the installation of more complex and expensive systems. A system designed for the domestic use of rainwater in a building can be a valuable alternative for conventional water supply systems being a part of urban water supply systems. The implementation of systems for the collection, storage and use of rainwater is highly efficient from an environmental point of view.

Most importantly, this solution reduces the magnitude of transient stormwater runoffs from catchment areas and constitutes additional water reservoir. It additionally has beneficial impact on operation of combined sewers and wastewater treatment plants, and improves cost-effectiveness of urban drainage systems.

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ASSESSMENT OF QUALITY OF IRRIGATION WATER QUALITY AND SELECTED SOIL PHYSICOCHEMICAL PROPERTIES BY ELECTROCHEMICAL EXPRESS METHODS

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Keywords: Soil, irrigation water, quality assessment, electrochemical methods

Abstract. Assessment of the quality, physicochemical properties of artesian waters of the village of Yeghegnut in Ararat valley and soils under various crops (watermelon, eggplant, pepper, melon) irrigated by these waters has been carried out by the electrochemical express methods directly in the field as well as in laboratory conditions.

Numerous scientific research works are being carried out on quality control of water resources and cultivated soil around the world. New methods are being sought, new devices and equipment are being developed which enable the control of important parameters for plant normal growth: irrigation water mineralization, electrical conductivity, pH, soil salinity, moisture, nutrients, for assessment of which pH and activity of studied soils as well as pH, the specific electrical conductivity and salinity of water extracts of the studied soils and irrigation water has been determined.

Implemented researches, relevant analysis and actual results of the harvest showed that it is possible to assess quality of irrigation water and soil, as well as salinity, fertility, fertilization necessity and purposeful use of soil by the mentioned parameters and express methods.

Soil activity assessment has been carried out in field conditions for the first time in Armenia.

1. Introduction

In many countries, agriculture is one of the primary sectors of the economy. It is the largest water user. Water is widely used for different agricultural needs, especially for irrigation. The main sources of irrigation water are groundwater and surface water, as well as sufficient treated wastewater. Soil fertility depends largely on the irrigation water quality. Irrigation water can contain large quantities of hazardous chemicals, dissolved salts, and suspended materials which may reduce crop yields and soil fertility [1]. Evaluation of irrigation water suitability is one of the most urgent problems of irrigated agriculture as its quality affects the soil quality. For the evaluation of irrigation water quality, a number of indicators are taken into account, particularly, water temperature, pH, electrical conductivity (EC), mineralization, existence of suspended materials, dissolved salt content and so on. Thus, irrigated agriculture, compared with non-irrigated agriculture, can increase crop yield from 2 to 4 times.

Soil is the main source of food for humanity, which provides 95-97% of the country's foodstuffs [2]. Current situation of soil resources is of great concern. Soil fertility decline and ~~soil~~ degradation as a result of erosion, desertification, degradation, salinization, contamination with various chemicals are becoming apparent almost everywhere.

Various physical, chemical, and biological processes take place in the soil which are interrupted as a result of pollution. Changes the pH, degrades the soil absorptive complex, microbiological processes are being interrupted, the degradation of soil structure results in deterioration of the water-air regime, soil humus is exposed to degradation, and, ultimately, the soil quality decreases and it loses fertility [3].

Each plant needs elements in different quantities and this is the reason why each plant requires a particular range of pH (acid-alkaline balance) to optimize its growth, and therefore, pH is one of the most important indicators of soil fertility. Most plants prefer a pH range from 5.5 to 7.5; but some species prefer more acid or alkaline soils. Nevertheless, every plant requires a particular range of pH, for optimum growth [4].

The principle role for plant normal growth has soil salinity [5]. Soluble salts are indispensable for plant nutrition. However, extremely large doses can cause various anomalies as toxicity, alteration of the nutrient absorption equilibrium, water absorption problems, damage of soil structure and change in the pH level.

Some types of soils are naturally rich in salts. Apart from these, an excessive use of fertilizers must be avoided and particular attention must be paid to the use of water with high salt concentration. If high values are detected, there is need to use the appropriate techniques to reduce the presence of salts (washing away irrigation, reduction of fertilizer dosages, etc.).

Crop yield is largely depends on soil activity. Activity of a soil determines the content of dissolved salts directly in the soil and substrates, taking into account their main characteristics, such as moisture, temperature and density. Mobility or “activity” of salts and, accordingly, their availability to plants depends on these factors.

Soil total salinity is assessed by the specific electrical conductivity (SEC) of the studied soils and their water extracts as the EC is directly related to the concentrations of soluble salts [5]. Soil solution as the conductor determines the chemical composition of soluble materials and their concentration. The more soluble salts (movable forms) are, the greater the EC of the soil and water extract of the soil is, that is, this indicator gives some additional insight into soil pollution. Soil EC depends on a number of parameters: soluble material, content and concentration of soil moisture, hydrogen ion concentration, temperature and so on. Consequently, the EC combines a number of key factors and acts as a generalized expression of the whole range of soil conditions [6].

In agriculture, the soil EC is regarded as an indicator characterizing soil productivity [3,7].

Determination of non-saline soil EC allows to judge the relative yield of the soil as many ions (ammonia, nitrates and so on) in soil solution have a decisive effect on the EC, and are nutrients for plants. Results of EC assessment can be effectively used for developing fertilization program in such soils.

These methods are widely used in soil, agrochemical studies to assess the total soil salinity, soil salinity regimen, and control of pH, as a result of which it is possible to develop an effective fertilization plan and an irrigation schedule.

2. Material and method

Armenia is a mountainous country with scarce soil and water resources, so the rational use of irrigated lands is a priority. Soil and water conservation, and their purposeful use are extremely important for our country.

Ararat valley (Fig. 1) is located in the north-east of the Armenian Highland, in the Armavir region. Here is centralized major agricultural production of the country, as well as about 50% of usable groundwater resources. The Ararat Valley has a dry continental climate: it is hot in summer, and moderately cold in winter, the weather is mostly windless. The landscape is semi-desert with desert areas. It is more usable area of Armenia covered with grape and fruit gardens and vegetable crop fields.

During the last years the level of Artezian basin ground water of the Ararat Valley has been reduced by 15 m, which has led to a change in the qualitative composition of those waters. Naturally, during these years, the qualitative composition and salinity of the irrigated lands has changed and probability of secondary salinization of these lands has increased. The above mentioned circumstances make it necessary to carry out researches on the quality of artesian waters and irrigated lands of the region.

Fig. 1 Ararat valley

Yeghegnut is one of the villages of the Ararat valley, the lands of which are under threat of desertification, dusting and double salinization nowadays. The purpose of the work is to carry out both field and laboratory electrochemical express investigations on soil and irrigation water quality in four different irrigated areas of the Yeghegnut village, and to implement a comprehensive assessment of irrigation water and cultivated soil quality. Two large areas (about 1 hectare each) has been examined: two types of crops are grown on each of them (Fig. 2). Watermelon and eggplant are grown in the first area, on the other - pepper and melon. One sample at a time has been taken from each 2 large areas (Area 1 - watermelon, Area 2 - Eggplant, Area 3-pepper, Area 4 - Melon).

The main target was to identify the relationship between soil activity and fertility of soil under cultivated crops.

The research has been carried out by electrochemical express methods, both directly in the fields and in laboratory conditions. The measurements were made in 2018 before the harvest. After, harvest results were recorded.

The pH and SEC of the irrigation waters and pH and activity of soils has been measured in the field.

The measurements of soil activity were carried out at 3-5 different distances in each area, and then the arithmetic means of these indices were calculated. The soil was pre-wet with distilled water and after a while measurement was performed.

The soil was pre-cut into 3 to 5 mm particles, various organic residues visible to the eye were removed by a incl and dried at room temperature (without direct sun exposure) to the aerosol state, then crushed in a mortar, sieved with 2 mm sieve and transferred to a moisture container. Samples are stored in ammonia and acid vapors [8].

Fig. 2 Studied cultivated soils in the Yeghegnut village

SEC of soil samples water extracts have been determined through laboratory experiments.

The determination of SEC of soil:water extract is essential for periodic assessment of soil salinity in irrigated fields, determining its causes and evaluating the effectiveness of agricultural resource management in these regions [9].

Traditionally, salinized are considered to be the soil which water extract (soil paste filtrate) SEC is higher than 4 mS/cm, 4 to 8 mS/cm weakly saline, 8-15 mS/cm medium, 15 mS/cm very salty [10,11]. Recently, SEC index has been reduced to 2 mS/cm for soil salinity assessment.

Experiments have been made with HACH LANGE HQ 14d GMBH and Bench Top Incubator Shaker TOU-50N/120N.

In our laboratory researches, soil to water extractions have been made in 1:2 ratio and their pH and SEC have been measured [3,12,13].

3. Research results

Table 1 presents pH, SEC and mineralization values of irrigation waters of two large land areas (Area 1, 2 and Area 3, 4).

Table. 1 pH, SEC (mS/cm) and mineralization (g/l) of irrigation waters

Irrigation water quality parameters / Land area	pH	SEC, [mS/cm]	Mineralization, [g/l]
Area 1 and 2	7.6	0.89	0.56
Area 3 and 4	7.7	1.48	0.95

It is clear from the data that the irrigation water pH values in both areas are within the RA irrigation water quality proposed standards (pH = 6.5-8.5) [14].

SEC and total mineralization values of Area 1 and 2 irrigated by artesian waters are within the permissible limits for irrigation (SEC = 1 mS/cm, total mineralization - 1 g/l) [14].

SEC of irrigation water of Area 2 and 3 is above the norm for irrigation, and the mineralization value is at the permissible limit [14].

The pH values of the studied soils and their water extracts are presented in Table 2, which shows that the pH values of the soils under the crops and the bulk soils are from the neutral to low base range [4]. The pH values obtained as a result of the direct measurement of the studied soils are a little higher: slightly alkaline. This phenomenon is explained by the fact that the soil:water extract is diluted with water and the soil is not. It is a soil paste and is denser (measured in the field).

Table. 2 pH values of the studied samples and their water extracts

pH / **Studies soil**	**Soil pH**	**Water extract pH**
Area 1 (Watermelon)	7.92	7.4
Area 2 (Eggplant)	7.98	7.5
Bulk soil (Area 1 and Area 2)	7.99	7.5
Area 3 (Paper)	7.9	7.3
Area 4 (Melon)	7.72	7.0
Bulk soil (Area 3 and Area 4)	7.89	7.5

Table 3 presents the SEC values of soil sample water extracts. According to the data presented, the lowest is the SEC of the soil under the eggplant, and the highest is the SEC of soil under the melon.

Table 3 SEC values of soil sample water extracts (mS/cm)

SEC / **Soil sample**	**Soil sample water extract mS/cm**
Area 1 (Watermelon)	0.49
Area 2 (Eggplant)	0.11
Bulk soil (Area 1 and Area 2)	0.21
Area 3 (Paper)	0.39
Area 4 (Melon)	1.58
Bulk soil (Area 3 and Area 4)	0.27

It is interesting to note that ECs of water extracts of soils under the crops greatly differ from EC and of the bulk soil. The latter can be explained by the peculiarities of the crop types. It is known that there are crop types which roots disassemble the relevant substances (composite carriers, acids) to dissolve and absorb the unsolvable or unwanted elements in the soil that are needed for them [3]. As a result, the composition of water soluble salts in the soil is changed and consequently the ECs are changed.

Soil activity assessment has been carried out directly in field for the first time in Armenia. It has been revealed that in the lands where the soil activity under certain crops does not correspond to the range required for the crop normal growth, poor harvest has been obtained from that land (Fig.3.4).

Particularly, the soil activity should be 0.2-0.4g/l for rich harvest of watermelon, melon, pepper and eggplant. In the land, where the watermelon has been cultivated, the soil activity index was 0.59g/l and only 200 kg of yield was obtained from the land of 4000 m^2. In the land, where melon and pepper were cultivated, soil activity were respectively 0.76 g/l and 0.6 g/l, and 180-200 kg of melon and 210-230 kg of pepper were obtained from 4500 m^2.

In the land where an eggplant was cultivated, the soil activity index was 0.38 g/l and about 6 tons of yield was obtained from 5000 m^2 of land.

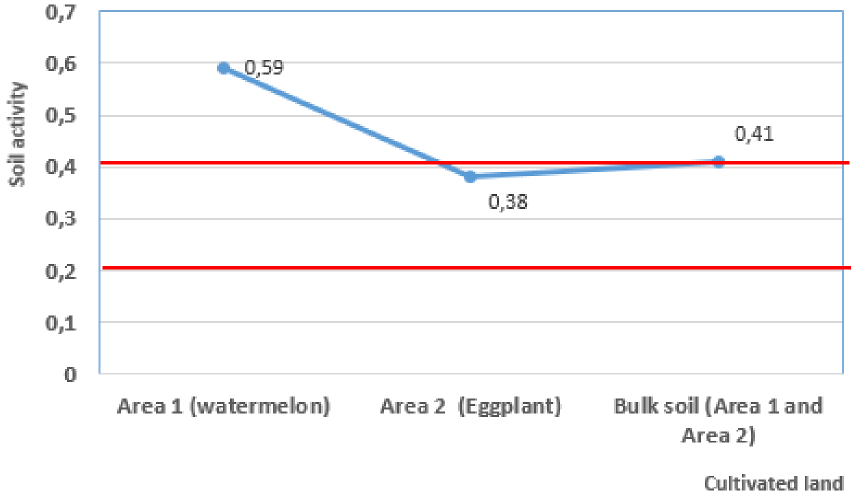

Fig. 3 Soil activity of bulk soil, Area 1 and Area 2 (g/l)

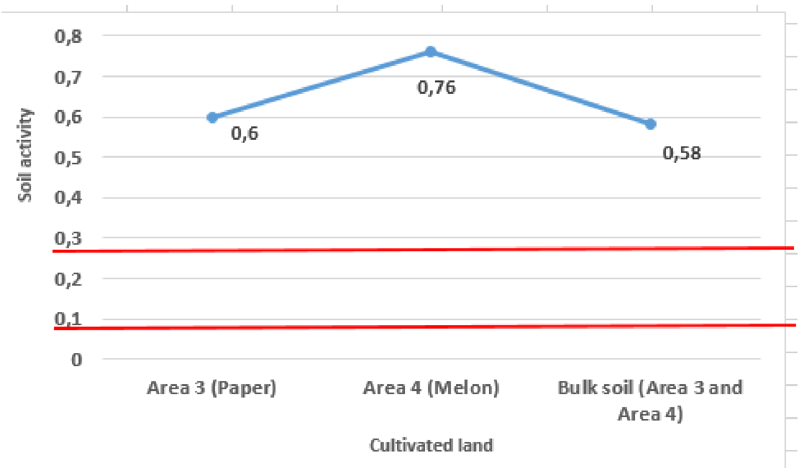

Fig. 4 Soil activity of bulk soil, Area 3 and Area 4 (g/l)

4. Conclusion

- The hydrogen ion concentration of irrigation waters are within the range of pH = 7.7: weakly alkaline waters. Irrigation water pH values in both areas are within the RA irrigation water quality standards.
- SEC of irrigation waters of Area 1 and 2 (0,89 mS / cm) and the total mineralization value (0,56 g / l) are within the permissible limits for irrigation.
- Irrigation water SEC of Area 2 and 3 is above the permissible limit for irrigation (1,48 mS / cm), and the mineralization value is at the permissible limit (0,95 g / l). Long-term irrigation with these waters may cause salinization.
- The pH values of the studied soils and their water extracts are from neutral to low alkaline range, so they correspond to the values set for the normal growth of most plants.

- According to SEC data of soil sample water extracts, the lowest value recorded in soils under the eggplant, and the highest in soils under melon.
- SEC (0.11 to 1.58 mS/cm) of soil sample water extracts show that studied soils are none saline.
- Assessment of soil activity directly in fields has been done for the first time in Armenia. It has been revealed that in the lands where the soil activity under certain crops does not correspond to the expected rate for the crop normal growth, poor harvest has been obtained from that land. Particularly, the soil activity should be 0.2-0.4g/l for high harvest of watermelon, melon, pepper and eggplant. In the land, where the watermelon has been cultivated, the soil activity index was only 0.59g/l and only 200 kg of yield was obtained from the land of 4000 m^2. In the land, where melons and peppers were cultivated, soil activity were respectively 0.76 g/l and 0.6 g/l, and 180-200 kg of melon and 210-230 kg of peppers were obtained from 4500 m^2. In the land where an eggplant was cultivated, the soil activity index was 0.38 g/l and about 6 tons of yield was obtained from 5000 m^2 of land. These indicators fully correspond to the indices of the SEC of those areas. Based on this analysis, necessity of fertilization of the lands can be determined.
- The quality of irrigation water and soil, as well as salt activity, fertility, fertilization necessity and purposeful use can be determined by the complex application of these electrochemical express methods.

Acknowledgements

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5. GEODESY (INCLUDING CARTOGRAPHY AND CADASTER)

DETECTING TRANSPORTATION MODES FROM GPS TRAJECTORIES USING RECURRENT NEURAL NETWORK

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Keywords: Transportation modes detection, GPS trajectories data, deep learning, gated recurrent unit, attention mechanism

Abstract. Transportation modes detection is an essential part of travel demand analysis, transport planning and traffic management. The trajectories data are collected by the Global Positioning System (GPS) devices. However, from GPS trajectories data, we can't directly get the transportation modes. It is necessary to mine these non-direct information points and extract meaningful information. Transportation modes detection from GPS trajectories usually relies on hand-crafted features and tradition machine learning algorithms. In recent years, deep learning has attracted considerable attention which has better feature representation capability and can deal with nonlinear and high complexity tasks. In this paper, we develop a deep learning model for detecting transportation modes from GPS trajectories data. The deep learning method can reduce the difficultly of designing the hand-crafted features and the interference of human experience to mine deeper hidden information and more accurately and efficiently identify the transportation modes. We extract the motion attributes of the trajectories as input rather than the original GPS points' attribute. We propose an approach based on Bidirectional Gated Recurrent Unit (Bi-GRU) recurrent neural networks that can learn state information for temporal sequences. Moreover, we exploit the attention mechanism to highlight important concepts, rather than focusing on all the information. The highest accuracy of 82.4% has been achieved through our optimal model on the GeoLife dataset. It is proved the feasibility and superiority of architecture we proposed.

1. Introduction

Transportation modes detection plays an important role in address the urban traffic problem [1]. Traditional approaches for getting transportation modes usually acquired researchers to collect information through diaries filled by participants or telephone surveys, which often depend on the memories of participants and resulted in incomplete and inaccurate data [2]. Furthermore, these methods are time-consuming and expensive. In recent years, the global positioning system (GPS) has grown substantially, which can inexpensive and straightforward acquires the trajectories data. The trajectories data consists of chronologically ordered GPS points. A GPS point is denoted as (latitude, longitude, timestamp). From these GPS points, we can't directly receive any explicit information, such as the transportation mode. So the important thing is how to use mining algorithms to extract hidden knowledge and then to detect transportation mode. Existing models on detecting transport modes include three steps: (i) data pre-processing; (ii) trajectory features extraction; (iii) the extracted features are fed into a learning algorithm to detect the transportation mode.

The classical machine learning algorithms' ultimate performance depends on the accuracy of the hand-crafted features extraction. However, the hand-crafted features may not necessarily distinguish between various transportation modes since they are vulnerable to traffic environmental conditions. Therefore, researchers often need certain professional knowledge to extract a large number of features. This leads to three problems: (i) It is difficult to determine whether there are missing features; (ii) The characteristics that depend on human experience may limit the ability of machine learning algorithms [3]; (iii) A large number of features may cause problems such as dimensionality disasters. In recent years, deep learning [4] has gained attention due to their success in tasks that involve complex input data like images [5] or temporal data, such as speech recognition [6] and automated machine translation [7-8]. These works show that deep learning algorithms can extract hidden information automatically without any human interference.

In this paper, we propose a model based on recurrent neural network architecture and add a self-attention mechanism for processing sequential GPS data to detect the transportation modes, in which modes are categorized into walk, bike, bus, car, and train. In our methodology, we use the labels classifies the transportation mode of GPS data into single-mode and extract four features including speed, acceleration, jerk, and bearing rate. Then we propose an effective architecture so as to attain the best accuracy on the GPS dataset collected by the Microsoft GeoLife project [9-10]. The behavior of the best network is then studied in detail, to gain some insights on what the network has learned and why.

2. Methodology

2.1 Pre-processing of GPS data

A GPS trajectory consists of chronologically ordered GPS points$\{\mathrm{p}_i\}_{i=1}^{n} = \{\mathrm{p}_1, \dots, \mathrm{p}_n\}$collected between two stationary states. First, we need to divide these GPS trajectories into different trips. In this paper, different trips are divided according to the stop points if the time interval between two consecutive GPS points exceeds a pre-defined time threshold. Second, trips are need further divided into single-mode segments according to the label given by the dataset (i.e., each segment contains only one transportation label). Because these segments have different lengths and the lengths' gap is very large. Each segment is sub-divided into instances that have the pre-defined number of GPS points. The whole process is as shown in Fig.1. After generating instances, we can compute the motion characteristics of each GPS point using the tuple (latitude, longitude, timestamp) of two consecutive points.

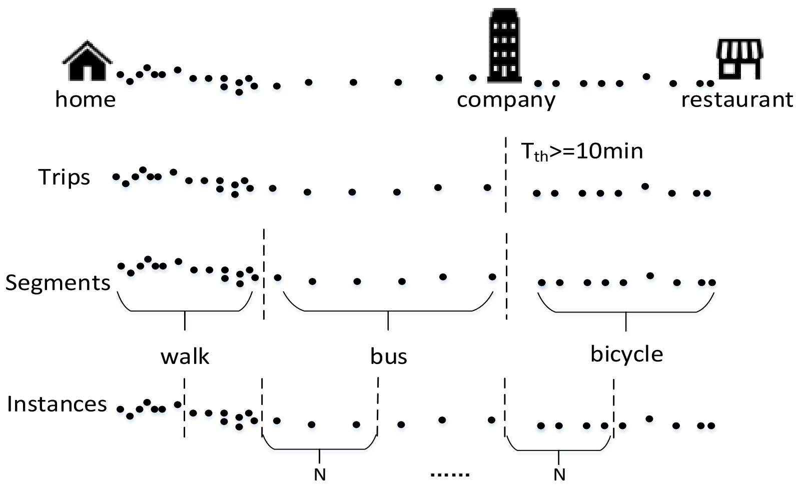

Fig. 1. The whole process of trajectories partition

2.2 Trajectory features extraction

We use the Haversine formula to compute the crow's flight distance between two succeeding GPS points P_1 and P_2. The interval between P_1 and P_2 is Δt. Let T_1 be the timestamp of P_1, E_1 is the longitude of P_1, N_1 is the latitude of P_1; T_2 is the timestamp of P_2, E_2 is the longitude of P_2, and N_2 is the latitude of P_2. The motion features are calculated as follows:

$$D_{1,2} = R \times \arccos\left(sin\frac{N1\cdot\pi}{180} \times sin\frac{N2\cdot\pi}{180} + cos\frac{N1\cdot\pi}{180} \times cos\frac{N2\cdot\pi}{180} \times cos\frac{(E2-E1)\cdot\pi}{180}\right) \quad (1)$$

$$\Delta\mathrm{T} = |T1 - T2| \quad (2)$$

$$V_{p1} = \frac{D_{1,2}}{\Delta t} \quad (3)$$

$$A_{p1} = \frac{V_{P2} - V_{p1}}{\Delta t} \quad (4)$$

$$J_{p1} = \frac{A_{p2} - A_{p1}}{\Delta t} \quad , \quad (5)$$

where V_{p1}, A_{p1}, J_{p1} represent the speed, acceleration, and jerk, respectively. The direction of different travel modes is varied. Cars and buses can only travel along the street while walking or cycling can change their direction more frequently [11]. In order to quantify the difference between the different modes, it is introduced as the fourth motion attribute. The bearing is expressed as the angle between the line which connected the two consecutive points and the reference line. The bearing rate is the absolute difference between the bearings of two consecutive points, which are calculated as follows:

$$\mathrm{y} = \sin\left(\frac{E2-E1}{180}\right) \times \cos\frac{N2\cdot\pi}{180} \quad (6)$$

$$\mathrm{x} = \cos\frac{N1\cdot\pi}{180} \times \sin\frac{N2\cdot\pi}{180} - \sin\frac{N1\cdot\pi}{180} \times \cos\frac{N2\cdot\pi}{180} \times \cos(\frac{E2-E1}{180}) \quad (7)$$

$$\mathrm{Bearing}_{(p1)} = \arctan(y, x) \quad (8)$$

$$\mathrm{BR}_{(p1)} = \left|Bearing_{(p2)} - Bearing_{(p1)}\right| \quad . \tag{9}$$

The computed motion features related to each instance then fed into GRU architectures. We use point feature to fully exploit the ability of recurrent neural networks to learn how to extract the hidden information, deriving higher-level features automatically.

2.3 Recurrent Neural Networks

Recurrent neural networks (RNN) are a popular neural network architecture that has been proven effective in many tasks on temporal sequences, while it faces the problem of vanishing and exploding gradients [12]. Thus, standard RNN cannot easily learn long-range dependencies. To solve this problem, many works have attempted to discover better optimization techniques, such as gradient clipping method [13] and more complex cell architectures, such as Long Short-Term Memory (LSTM) [14] and Gated Recurrent Unit (GRU) [15]. Gates are incorporated into a recurrent unit, which controls information flows in the net. They are computed at each time step from the current input and previous recurrent states. Therefore, the network automatically learns and remembers relevant information into recurrent states over time.

The GRU model is a variant of the LSTM model has only two gates, the update gate and the reset gate. The update gate is used to control the degree to which the status information of the previous moment is brought into the current state. The larger value of the update gate is, the more the status information is brought in at the previous moment. The reset gate is used to control the degree of ignoring the status information of the previous moment. The GRU model has fewer parameters and a simpler structure than LSTM. And GRU model has been shown to exhibit better performance on smaller datasets [7]. Fig. 2 displays a block diagram of the net, in which it represents the input at time t; h_{t-1} is the previously hidden state at time $t-1$; h_t can be seen as the typical hidden state at time t. z_t is the update gate and r_t is the reset gate. The operator $\circ$ denotes the Hadamard product in the following. At a time step t, the state is computed as:

$$z_t = \sigma(W_z x_t + U_z h_{t-1} + b_z) \tag{10}$$
$$r_t = \sigma(W_r x_t + U_r h_{t-1} + b_r) \tag{11}$$
$$h_t = (1 - z_t) \circ h_{t-1} + z_t \circ \tan(W_h x_t + U_h (r_t \circ h_{t-1}) + b_h \quad . \tag{12}$$

If stacking up more layers on the hidden layer yields deeper recurrent neural nets, it can learn more complex features from inputs, and may perform better.

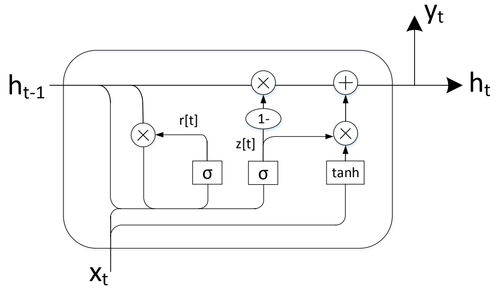

Fig.2. A block diagram of the gate recurrent unit

Bi-GRU has two GRU layers operating in parallel. The input to the first layer is provided as-is and the input to the second layer is a reversed copy of the input sequence. This helps to preserve information from both the past and the future by combining the hidden states of these two layers.

2.4 Attention mechanism

Attention mechanism for processing sequential data that focuses on the data itself to ignore invalid information and highlight effective information. Self-attention is also called internal attention. The calculation process is as follows:

$$h_{t,t'} = \tanh\left(x_t^T W_t + x_{t'}^T W_X + b_t\right) \tag{13}$$

$$e_{t,t'} = \sigma(W_a h_{t,t'} + b_a) \tag{14}$$

$$a_t = softmax(e_t) \tag{15}$$

$$l_t = \sum_{t'} a_{t,t'} x_{t'} \quad . \tag{16}$$

The element $\alpha_t, \alpha_{t'}$captures the similarity between the hidden state representations h_t and h_t at timesteps t and t' respectively. The self-attention mechanism can easier capture long-distance interdependent features. The GRU needs to be sequentially computed. For long-distance interdependent features, they need through several time steps can be linked then effective information captured little. However, self-attention is beneficial to these features. The output layer is connected to the last state by a softmax connection that computes the probabilities of modes.

3. Experiments

To evaluate the performance of the proposed architecture, experiments were carried out on the GeoLife GPS trajectory dataset. We only consider ground transportation modes. Therefore, our final list of transportations modes is: walk, bike, bus, driving, and train. To define the best architecture and parameters for the network, we started by assessing the performance of a shallow layer of different GRU neurons and incrementally add layers. Then adding attention mechanism allows the model to capture effective information.

The user's GPS trajectories are divided into different trips if the time interval between two consecutive GPS points exceeds twenty minutes as the interval threshold T_{th}=10min. Then according to each user's label file, each trip is divided into single-mode segments. Next, segments are converted into fixed-size instances when the number of GPS points for each instance is set to N. The determination of the number of N needs to satisfy two conditions: one is to ensure majority of the number of instance points are larger than N; the other is to ensure that the divided instances still have a certain length of time, which can be analyzed. We found that 80% of instances have more than 107 points. For simple calculation, we determine N=100. Now, the distribution modes are illustrated in Table1, with the total number of instances equal to 59123.

Table 1. The number of different mode instances

Transportation mode	Number of instances	Proportion, [%]
Walk	18420	30.2
Bike	10498	17.2
Bus	14125	23.2
Driving	8527	14.0
Train	9329	15.3

Several techniques may be used in order to speed up the training of neural networks and reduce over-fitting. We choose to add batch normalization layers before the non-linear activation function or recurrent layer as a regularization technique. As far as the optimization algorithm is concerned, we use Adam, which turns out to be quite robust to the input parameters such as learning rate, which is of great help in the parameter tuning phase. The training phase is performed with stratified mini batches of size 64. All data processing has been coded in the Python programming language. The architectures are implemented in Keras, using the TensorFlow as backend. We randomly sample 90% of the whole created segments as the training set while holding out the rest as the testing data. The final performance evaluation of a model needs to be done only on the test set.

4. Results and discussion

In the first round of our experiment, we only use Bi-GRU and seek for an optimal Bi-GRU configuration in terms of the number of units layers. In order to evaluate the superiority of the Bi-GRU, we also test GRU. So we test a different number of units with single GRU layer and Bi-GRU layer, the results are shown in Table 2. We found that all Bi-GRU layers perform better than GRU. And the 64 units of Bi-GRU perform slightly better than others and have similar performance to more neurons while being faster to train. Therefore, we settled on 64 units of Bi-GRU for these layers and subsequent ones we add.

Table 2. Results of different number of units with single GRU layer and single Bi-GRU layer

Accuracy		The number of units		
		32	64	128
The different layer	GRU	0.8062	0.8111	0.8087
	Bi-GRU	0.8094	0.8123	0.8104

Following on the idea that attention mechanism can learn useful information, we try to add attention mechanism, whose addition brought improvement. And consideration the deeper networks have better performance. we also try to increase the number of layers. As Table 3 reported, adding more layers does not appear to help, as shown by the experiment with 2 layers and no attention. Note that the network with several layers is significantly slower to train due to the increasing number of parameters and accuracy so we did not experiment with adding more layers. All results of 128 units not very well, which because these have 128 units' nets have too many parameters to train and result in bad accuracy. While in 32units and 64units, adding attention mechanism after a single Bi-GRU layer gives us a small but improvement, which has better accuracy than a single layer and deeper layer, which indicates the benefits of attention mechanism. And we found adding attention mechanism after two Bi-GRU layers which have a 64units model receives the best accuracy, which is the optimal model on detection transportation modes. Table 4 shows the optimal model architecture.

Table 3. Results of different Bi-GRU architectures

The number of units	The number of layer	Adding attention	No attention
32	1	0.8097	0.8097
	2	0.8033	0.8177
64	1	0.8123	0.8155
	2	0.8046	0.8238
128	1	0.8104	0.8108
	2	0.8079	0.8092

Table 4. The optimal model architecture (ignoring batch normalization and dropout layers)

Layer	No. of Units	Activation
Bi-GRU	64	
Bi-GRU	64	
Self-attention		sigmoid
Flatten		
Dense	8	softmax

Table 5 provides the details of our best architecture performance including the confusion matrix, recall, and precision pertaining to each transportation mode. All precision and recall values exceed 77%. As reported in Table 5, the walk mode results in achieving a perfect recall of 96%, whereas the driving mode with the lowest number of available segments obtains the lowest accuracy of 78%. It should be noted that the travelers' behavior in the driving mode is much more unpredictable since the driven environment are very complex. The bus and train adhere to pre-defined routes and schedules, which leads to more predictable behavior.

Table 5. Confusion matrix, recall, and precision of the optimal model

Ensemble of the optimal model		predicted						
		Walk	Bike	Bus	Driving	Train	Sum	Recall
Actual class	Walk	1689	48	13	4	1	1755	0.96
	Bike	172	850	30	5	1	1058	0.89
	Bus	159	40	1026	131	51	1407	0.85
	Driving	72	11	113	593	41	830	0.78
	Train	90	7	23	30	713	863	0.88
	Sum	2182	956	1205	763	807	5913	/
	Precision	0.77	0.89	0.85	0.78	0.88	/	/

Comparison with the previous studies to show the superiority of our model, we compare our results with the studies that have used the GeoLife GPS trajectory dataset in order to establish a fair comparison. We choose the study of Zheng [10], who used the classical machine learning method to make excellent results. Endo [16] turned the travel trajectories into the image of the earliest research using CNN to extract deep features. Because they didn't use any motion information and only used time information, the accuracy is lower than [10]. There are also research results by Dabiri [17] using several CNN models for identification before ensemble.

Table 6. Performance comparison with prevision related studies

Model	Accuracy [%]
Zheng et al.[10]	76.2
Endo et al.[16]	67.9
Dabiri et al.[17]	79.8
The optimal model	82.4

As can be seen in Table 6, our optimal model significantly outperforms the above related models by improving the accuracy more than 6.2%, 14.5%, and 2.6%, respectively. It is proved that the feasibility and superiority of architecture we proposed on mining the hidden information of the travel trajectories.

5. Conclusions

In this article, we deployed the architecture to combine Bi-GRU layers and the self-attention mechanism to detect transportation modes from GPS trajectories. We applied several data preprocessing steps to divide the GPS trajectories. We computed the motion attributes including speed, acceleration, jerk, and bearing rate from instances as the input data, then fed them into the model. We examined several Bi-GRU architectures with a different number of units and layers so as to identify the most efficient one. And then we add the self-attention mechanism after Bi-GRU layers to extract some useful information. Furthermore, the test accuracy of our optimal model exceeds the highest test accuracy reported by previous studies. It is proved that the feasibility and superiority of architecture we proposed on mining the hidden information of the travel trajectories.

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THE REFERENCE RANGEFINDER

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Abstract. The issues related to the construction of the reference rangefinder in order to create a basis of “0” class for the transmission of a unit of length to the working means are presented. The analysis of existing high-precision rangefinders is carried out and on the basis of this the basic requirements for reference rangefinders are determined. Taking into account the main advantages and disadvantages of the existing high-precision rangefinders, a functional scheme of the reference light rangefinder is proposed, which provides an error in determining the phase of linear measurements equal to m=0.02 - 0.025 mm..

1. Introduction

When solving many practical problems, the requirements for the measurement accuracy of electro-optical rangefinders continuously increase. In most cases, high-precision laser rangefinders provide the developers announced measurement accuracy. Currently, the accuracy of high-precision laser rangefinders reaches up to 0.08-0.1 mm and for such rangefinders it becomes relevant to conduct regular calibrations that allow to estimate the values of various instrumental errors, such as the error of determining the phase m_{φ}, the error of the constant correction the m_k, cyclic errors, etc. In international practice, calibration on baselines of both known and unknown lengths is used.

In this regard, the Nottingham Institute has developed and improved a method that uses segments of the basis of a known length, measured in all combinations, using the points of forced centering of instruments.

To assess the real state of the calibration problem of rangefinder equipment in England, the University of Surrey and the national Physical Laboratory (NPL) conducted a questionnaire survey. Out of a total of 160 surveys, it was found that about 20 organizations have at their disposal multi-line reference lines with a length of 100-300 m. Based on the interviews obtained information about the fact that most organizations noted the need for a special service for the calibration of distance measuring equipment not less than once a year.

The bases used for this purpose must be previously measured with an accuracy of not less $\pm(0.1\pm1\cdot10^{-6}D)$ mm and it is necessary to develop a new recommendation of requirements and methods for calibration of the very high precision distance measuring equipment. In particular, the frequency of calibration, reference lines and methods of their measurement, the nature of the corrections and the possibility of self-calibration of reference light rangefinders should be determined.

2. Discussion

Traditional methods for determining the correction and certification of high-precision phase rangefinders, by measuring their model linear basis, previously certified Invar wires, can no provide the necessary accuracy, because in the best case, Invar wires can obtain a relative error equal to

$8 \cdot 10^{-7}$ D, which is comparable to the error developed promising phase laser rangefinders [1]. Therefore, the baselines measured by interference method have been constructed in a number of countries. The relative measurement error is of the order of $3 \cdot 10^{-7}$. However, there are a number of significant shortcomings, which are identified in [2]. In other works, the expediency of the replacement of the interferometer Vaisala the rangefinder in two modes stable laser with optoelectronic heterodyning in the cathode chamber of the photomultiplier tube even with the use of additional laser [3,4]. Such an approach to solving a responsible problem is not desirable, because first, the phase delays of the reference and interference signals, even with the use of the optical delay line (ODL), are due to the processes occurring in the cathode chamber of photodetectors operating in the mode of two transformations, optical-when the intermediate frequency is allocated, and heterodyne - when the intermediate frequency is allocated, and secondly, all these processes are associated with the emission of photoelectrons, occurring at random moments of time. Therefore, it is impossible to assert the stability of the parameters of such light rangefinder.

In addition, numerous experiments have shown that such rangefinders are applicable in relative measurements, when the place of receipt of the receiving light on the photodetector is preserved.

It should also be taken that any complication of the construction scheme of the electronic part of the phase measurement of the light rangefinders always leads to the reference and interference signal circuits, not identical phase delays.

Thus, there are Comparators built in special conditions [5] and high-precision light rangefinders, but the problem of certification of basic lines remains open. In our opinion, first the possibility of building a reference rangefinder should be solved, what parameters such a rangefinder should have and how to carry out their certification.

The presence of really working world-famous phase light rangefinders on the compensation method ME-3000, ME-5000, Geomensor GR-204 and ДВСД-1200 [6-9] and the experience of their application to determine the sample lengths allow us to pre-formulate requirements for high-precision light rangefinders. The measurement accuracy of these rangefinders is almost the same, on the lines of 50-100 m is 0.25-0.3 mm. To determine the feasibility of certain solutions in the rangefinders of the Mekometer series, we are based on the fact that we worked with the ME-3000, the design features and the basic principle of operation are known, which are experimentally studied in the development and study of the ДВСД-1200 [10] and new light modulators [11,12].

In our opinion, among the high-precision compensation rangefinders, the base may be Me-3000, the main advantages of which are as follows. This is a high frequency of scale oscillations, about 500 MHz, the absence of systematic errors, the identity of the non-inertial processes of modulation-demodulation of light, the independence of the stability of the constant correction from the operating conditions of the light rangefinders and the use of the method of shifting the position of the light minimum. At the same time in Mekometer there are some disadvantages that need to be considered. The presence of depolarization in the receiving light caused by mirrors installed between the light modulator-demodulator, a large value of constant correction and the dependence of the equality of the recorded signals on the length of the measured distance reduce the potential possibilities of phase measurements.

Taking into account these main advantages and disadvantages, the light rangefinders ME-5000 was developed. At the same time, it was assumed that different modulation-demodulation crystals in the ME-3000 can be combined, the optical delay line (ODL) on the mirrors significantly increases the constant correction of the light rangefinder, for the efficiency of light modulation, the microwave generator lamp should be separated from the light modem and a laser light source should be used.

The construction of the light rangefinders ME-5000 with a single-mode laser and a single-crystal light modulator, without ODL and the quartz scale-frequency synthesizer showed that there was no expected increase in the measurement accuracy, which was compensated by other factors that were not taken into account. However, the presence of the ME-5000 showed that the identity of the processes of modulation-demodulation of light does not depend on the separation of transmit-receive channels and the replacement of the ODL by a smooth change of the modulation frequency.

All this formed the basis for the construction of the light rangefinders Geomensor GR-204, whose work once again convinces the developers of high-precision light rangefinders, that it is necessary to exclude all mirrors in the path of light between the channels of the light modulation and demodulation and increase the modulation frequency to at least 750-800 MHz, the crystals in the resonator of the light modulator should be installed at the same levels, increase the q-factor and coordinate the light modem with the microwave generator and apply a two-phase mode. This was implemented in the light rangefinder СД-1200 [13] without taking into account the following main factors.

1. No transmit-receive optics,
2. A large value of the constant correction of the order of 350 mm,
3. The absence of a symmetrical change in the modulation frequency relative to the Central value, which leads to some displacement of the light minimum point.
4. Insufficient microwave power to ensure 100% light modulation efficiency,
5. The transfer function of ODL on the movement of the light modem.

The influence of the above factors on the measurement accuracy of the light rangefinders short are as follows.

1. The medium in which the laser radiation passes is always optically inhomogeneous and there are fluctuations in the intensity of the receiving light, the modulation phase, the arrival angle and the polarization of light.

The correlation radius of fluctuations has the order of size of the first Frenel zone [14]

$$r = \sqrt{\lambda Д} \tag{1}$$

Where λ is the light wavelength, D is the measured distance.

For fluctuations not to be correlated with the receiver aperture, the diameter of the receiving part must be greater than the radius of correlation of the fluctuations. On lines with a length of 100 m at λ = 0.6328 μm have $r = \sqrt{0.6328 \cdot 10^8} = 8000\ \mu m = 8\ mm.$

In the light rangefinder СД-1200 the diameter of the receiving hole is only 2.5 mm, therefore all types of fluctuation are sources of errors. Experimental measurements show that the application of the reception optics of small diameter ∅ = 30-35 mm the variation of the modulation phase in the light receiving stream is reduced three times, i.e. instead of m_φ = 0.25 mm obtained m_φ = 0,08-0.09 mm. Therefore, regardless of the length of the measured lines, it is necessary to apply the receiving optical system.

2. The value of the constant correction of the compensation light rangefinders is dictated by the length of the ODL and the type of reflector and, if the correction is more than a quarter of the modulation wavelength, there may be systematic errors and temperature corrections. In the light rangefinders СД--1200, the constant correction has a value of about $3\lambda_m/2$, formed due to the mirror-lens reflector and the use of the light modulator as an ODL. It is necessary to install the light

modulator motionless, exclude the ODL, and transfer the ODL function to a smooth change of the modulation frequency. The reflector for the light rangefinders should be hollow triple prism of mutually perpendicular 3 mirrors with an outer enlightened coating.

3. The use of effective methods of modulation method of linear measurements leads to the implementation of the two-phase method, when two signals shifted in phase by 180° are formed in the receiving optical channel, which leads to an increase in the measurement accuracy by at least 3-5 times. The implementation of the two-phase method in the light rangefinder СД- 1200 [15] under all the same conditions made it possible to reduce the phase error to a value of m_{φ} = 0.03-0.04 mm.

For the reference rangefinder, the implementation of the two-phase method is possible on a two-phase light modulator [12] and is equivalent to an increase in the modulation efficiency and frequency by 2 times.

The use of the frequency deviation method to shift the position of the light minimum realized in the Geomensor 204 is not desirable, because it is possible to reduce the accuracy of the frequency measurement and the random transition to the second upper level of equality of the amplitudes of the receiving signals shifted in phase from the main to $\lambda_m/4$.

4. Increasing the efficiency of light modulation is associated with the coordination of the microwave generator with the modem and the choice of the light modem parameters.

Increasing the modulation frequency without maintaining the efficiency does not give anything. The modulation efficiency is maximum if the modulator and the oscillator are implemented separately and are connected in the form of a power-voltage transformer. A low-quality transistor generator is the best power source, and a high-quality modulator is an excellent power-to-voltage Converter.

5. Replacement move the modem as ODL on the smooth change of the modulation frequency solves the problem of uniqueness of the distance measurement. In this case, the light modem with transmitting and receiving optics without mirrors can be solved by building various modems of light. The first practical results open up new possibilities for solving this problem.

Thus, in the implementation of the above works, the phase error can be reduced to a value of m_{φ} = 0.02-0.025 mm. The layout is as follows: 2 times through the use of transmit-receive optics, 3 times through the use of a two-phase light modem, 1.6 times by increasing the efficiency of light modulation associated with a decrease in the modulation frequency by 1.5 times.

All this is individually confirmed by numerous measurements. Their joint implementation is a complex task that requires comprehensive research.

Turning to the possibility of using self-test laser rangefinder should say the following.

1. Published works related to the certification of the light rangefinders on crystal light modulators do not exclude the possibility of self-certification, but there is some concern in terms of the lack of sufficient experimental results.

2. The first numerous experimental measurements on self-determination of the constant correction of high-precision light rangefinders showed the best results. On different Comparators of 30-60 m length, the measurements made during 2 years by the light rangefinder СД-1200 on unknown segments were directed to the determination of the constant correction K. With minimal amounts of a segment of one line, the error in determining the constant correction of the light rangefinder СД-1200 was equal to the phase error $m_{\varphi} = m_{\kappa}$ =0,1 mm without other emissions and systematic errors. Similar results were obtained with the traditional methods of determining the constant correction K.

These first results of long-term measurements [16] indicate the possibility of self-testing of high-precision light rangefinders and presentation of the first requirements for the reference rangefinders, which can be previously represented as follows:

1. The rangefinder should not have systematic errors,

2. The light modulation-demodulation on the linear electro-optical effect for the reference rangefinder is advisable to carry out in the frequency range 750-800 MHz,

3. The relative error of the scale frequency should not be greater than $1 \cdot 10^{-7}$ -$5 \cdot 10^{-8}$,

4. The error of phase determination should be estimated by the value of $m_{\varphi} \leq 0, 02$ mm,

5. Constant correction is desirable to be within $\lambda_m/4$ and should not be related to the operating conditions of the light rangefinder,

6. Mirrors between the light modulation-demodulation channels should be excluded or strictly oriented in their application,

7. The range of the reference rangefinder can be limited to a length of 1 km.

A variant of the functional scheme of the reference rangefinder is shown in Fig.1, the principle of which is as follows.

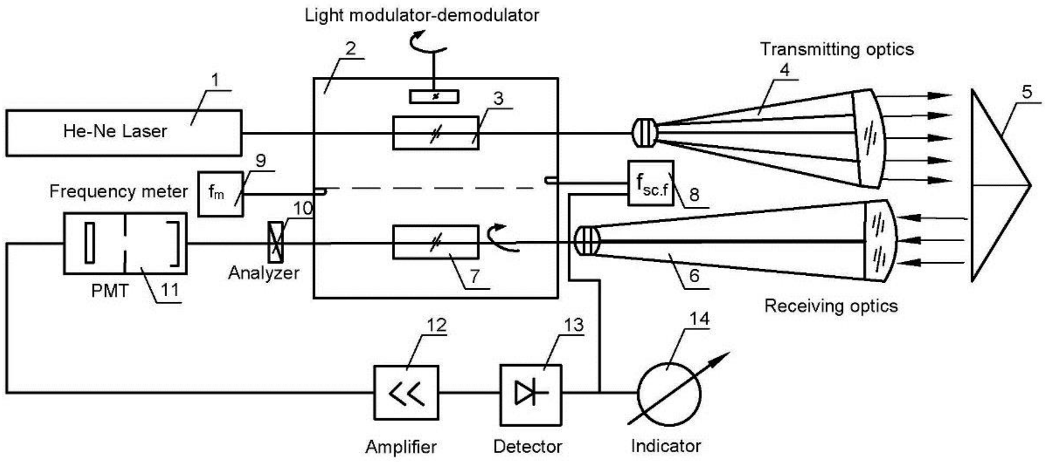

Fig.1 The functional diagram of the reference light rangefinder

The linearly polarized radiation of a single-mode He-Ne gas laser 1 is modulated in the volumetric resonator 2 in the electro-optical crystal KDP 3 and transmitted by the transmitting optics 4 to a distance, then received by the receiving optics 6 and demodulated in the crystal KDP 7. Crystals 3 and 7 are hidden in the antinode of the standing wave of TEM resonator 2 connected to the oscillator 8 of the scale frequency, the oscillations of which are measured by the frequency meter 9. The crystal 7 is rotated around the axis of the light passage synchronously with the pulses of the microwave power entering the resonator 2. As a result of the rotation of the crystal 7, light demodulation occurs in a two-phase mode, thereby the operation of the light rangefinder is carried out by a two-phase method. Demodulation light passes through the analyzer 10 and enters the photo detector 11. At the output of the photodetector there are two alternately incoming pulses, the amplitude of which depends on the modulation frequency.

The equality of the pulses amplitudes is achieved by smooth change of the modulation frequency for this distance. The output signal is amplified by the amplifier 12, detected by the synchronous detector 13 and observed by the indicator 14. Part of the detected signal is fed into the oscillator resonator to stabilize the oscillator frequency during the frequency measurement.

3. Conclusions

The schematic diagram of the reference light rangefinder can be based on both the use of ODL and a separate generator, and the combination of the modem and the oscillator.

In the first case, ODL should be on 2 mirrors moving in a small range, approximately 50 mm, and the oscillator on the switching of fixed frequencies, providing a small displacement of ODL.

In the second case, there are no mirrors in the path of the modulated light, and the modulation frequency is measured by a high-precision frequency meter.

In both cases, the light modem is used with separated channels of the light modulation-demodulation in two-phase mode.

By simplifying the scheme of construction of a rangefinder based on the natural property of electro-optical crystals, it is possible to achieve a solution to the problem of sample line calibration.

After the construction of the reference rangefinder, it will be possible to develop schemes for the construction of a Refractometer capable of measuring even short lines, since the determination of the parameters of the medium by individual measurements of temperature and pressure is not promising.

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THE RESULTS OF DURATION AND ACCURACY RELATION IN GNSS SYSTEMS USING IN TERRITORY OF REPUBLIC OF ARMENIA

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Abstract. Automation of implementation of various geodesic works is an important sectoral issue. Over the centuries, the Earth's information and its various parts have been collected by means of a long-term and step-by-step instrument equipment and methods.

The purpose of the research is to determine the dependence of observations made using GNSS signals in the territory of the Republic of Armenia (RA) from the duration of the monitoring. The results of such an outcome allow reviewing previously used methods, making the work efficiency and reducing costs. The observations will be the basis for introducing changes to the existing normative-technical documents, to reduce the measurement duration requirements and to increase the accuracy.

The observations were real-time (RTK) in pre-selected durations. The minimum duration was 3 seconds, maximum 1 minute. The frequency of reception of signals in the mobile station and base station is 1 second.

The scientific novelty of the work is that for the first time this kind of research was conducted for the territory of Armenia. Additionally, this is the first publication of a similar complex job. The other novelty is that previously conducted observations were mainly made with devices that received signals from only GPS satellites. In this study, the signals from the Glonass satellite system were also used. An attempt was made to receive signals from the European Galileo satellite system, but no observation was received from that satellite system. The observations revealed that the number and frequency of signals received from the satellites for the territory of the Republic of Armenia are sufficient to reduce the duration of the previously save observations.

1. Introduction

At the first stage of create the map people used visual method. That is the image of what they saw with their own eyes without the use of any equipment, taking into account certain scale factors. Then, in next the centuries, began to be used geodesic simpler tools, barrels, rulers and beams, which allowed them to get more accurate and identical data for the object measured. The next stage of development, after the discovery of the telescope in the 17th century, people had the opportunity to learn about the measurements by their surrounding planet and other celestial bodies. It was possible to accurately measure the radius of the Earth, the equator's length and so on.

As a result of the development of new technologies, many geodesic works were also automated. After the formation of satellite systems, satellite and immovable receiver observation methods appeared. Currently there are several operating completely global and regional satellite systems. They can be divided into two groups: *Worldwide*; American GPS, Russian Glonas, Chinese Beidou (Compas), European Galileo and *Regional*; Japanese QZSS, Indian IRNSS.

2. Methodology

Signals of GPS and GNSS are important in modern geodesic works. These signals come from satellite systems.

In the near of the Earth, Artificial Satellites of Earth (ASE) networks are equally covered the Earth's surface. The orbits of the ASE are calculated with great precision, so the coordinates of each satellite are known at any point in a time [1]. Satellite radio transmitters constantly transmit signals to Earth. This signal is received by GPS receivers located at a certain point on the Earth's surface, which coordinates need to be determined. The receiver determines the time of the signal transmitted from the ASE and calculates the "satellite - receiver" distance (as well as the radio signal spreads at the speed of light) [1,2]: Since determining the position of the point you need to know 3 coordinates (X,Y and H), the receiver must determine the distance from three satellites. Obviously, in the case of a radio navigation technique (called callout), a precise decision may be made only if the receiver and the satellite clock are synchronized [3]. For this reason, there are standard time for ASE receivers and the accuracy of the satellite standard time is extremely high (relative long-term stability of time measurement is ensured within 10-13-10-15 days.). All the ASE clocks are synchronized and are linked to the so-called "systematic timing". GPS receiver standard time has smaller accuracy and it has not expensive [4]. This standard should ensure only short-term stability at the time of the measurement session. In practice, there are always mistakes in the time dimensions due to differences between the ASE clock and the receiver clock. For this reason, the receiver calculates the length value or "fake distance". Calculating the distance from the ASE receiver with which is currently working with the receiver, carried out simultaneously. Therefore, the amount of time mismatch for all measurements can be considered stable. From a mathematical point of view, it is equivalent to not only the X, Y and H coordinates but also the receiver's time correction Dt. To determine this, it is necessary to make a false distance rather than the other 3 satellites so we need 4th satellite information. Thus, at least 4 satellites have to be visually impaired to make the necessary navigation decisions. Visibility of more than 4 satellites allows to increase the accuracy of the decisions.

Each signal in receiver per seconds is calculating with two navigation parameters fake distance and radial fake speed [4-6]. The fake distance from the receiver to the satellite is measured by the difference in the signal from the base signal received. The radial fake speed is determined by the same method. The satellite signal generated by the satellite is formed by quartz generators. Four satellites (k = 1, 2, 3, 4) required for the receiver's operation. The following formula is used for fake distance;

$$S_k(t)=R_k(t)+c\tau_o(t)+c\delta\tau_k(t)+\delta S_k(t), \tag{1}$$

Where; *Rk (t)* is the distance of the satellite and the receiver- *c*- speed of light- *τo (t)* - the deviation of the satellite clock sensor from the receiver's clock- *δτk (t)* - time-wave correction - *δSk (t)* is the accuracy of the receiver measurements.

The accuracy of determining the fake distance of the dual frequency receiver can be evaluated as follows:

$$\delta S0 = \frac{1}{1-m^2}\delta S_B - \frac{m^2}{1-m^2}\delta S_H = 2{,}53\delta S_B - 1{,}53\delta S_H \tag{2}$$

Satellite-transmitting equipment radiates a sinusoidal signal with two carrying frequencies; L1 = 1575.42 MHz and L2 = 1227.6 MHz. But before these signals are modulated in so-called random sequences (otherwise, this process is called phase manipulation). The L1 signal is modulated in two ways: C / A (Coarse Acquisition) code (open signal) and P (Protected) code (authorized access), and the L2 signal is only P code. Both signals receive additional navigation coding, which contains information about the orbits of ASE, atmosphere parameters and correction of system time (Figure 1) [6-8].

The radius of the transmitting satellite to the receiver when β = 90o is R = H = 19100 km, and β = 5o R = 24000.

P_0 capacity will be (Table 1):

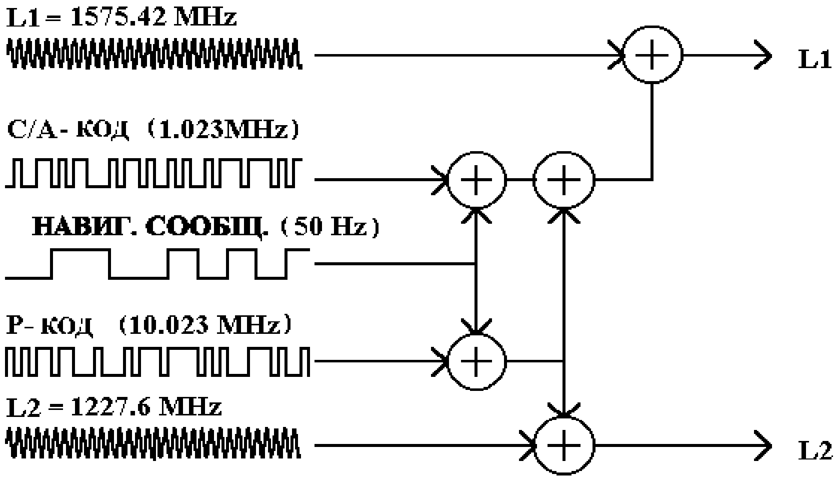


Fig. 1. Frequencies of satellite signals

Table 1

	1600 [MHz]		1250 [MHz]	
[B]	90o	5o	90o	5o
$[P_п]$	+15±1		+9±1	
[G(φ)]	+10	+12	+9	+11
$[\lambda^{2}/(4\pi R)^{2]}$	-182	-184	-180	-182
$[G_0(\beta)]$	0		0	
$[P_0]$	- 157±1	- 157±1	- 162±1	- 162±1

It turns out that the receiver's signal strength is the same as the satellite's zenith and horizon.

The following stations gather information about satellite constellation, processed by supercomputers and routinely transmitted to satellites for adjusting orbiting orbital information [7-9].

2.1 Sources of Errors: The correctness of the coordinate determination makes a great deal of errors that occur during the measurement phase. The sources of those errors are different:

Incorrect time determination. Despite the high accuracy of the ASE standard time, there are some errors in the satellites time. It leads to an approximately 0.6 m systematic error of the coordinate determination.

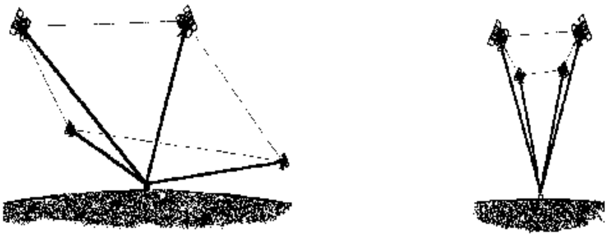
Error in determining orbits. This error is caused by the inaccurate prediction and calculation of satellites' efemerids in the receiver. This error also has a systematic nature and leads to a 0.6 m error of coordinate determination.

Receiver tool-hardware error. First of all it is conditioned by the noise of the receiver in electronic transit (on the way). The receiver signal / noise ratio determines the accuracy of the signal transmitted from the ASE and the base signal, which is the accuracy of the falsity detection. The noise generated σ (S) error can be evaluated as follows:

$$\sigma(S) = \frac{c}{2F_1}\sqrt{\frac{2g_{\text{ш}}k}{P_c T_0}} \qquad (3)$$

Where: c - speed of light, F1 - Frequency of random frequency, PC / gm - the navigation signal energy potential at the receiver, k - the quality of the navigation signal energy potential in the receiver (k ~ 1.5); T0 - interval of measurements (accumulation).

2.2 Geometrical position of the satellites: For determining the general error it is also necessary to take into account the position of the consumer and constellation satellites. For this reason, a new geometric reduction factor, PDOP (Position Dilution Of Precision) is introduced, by which to multiply all the above listed errors so that we get the result error. The PDOP coefficient depends on the satellite and the receiver configuration. It is counter-comparable to the size of the body that will be formed to hold unit vectors from the receiver to the satellite. The great value of PDOP speaks about the unsuccessful escape of the ASE and the great mistake. Figure 2 depicts the geometric success of the satellites (a) and unsuccessful (b) positions. The average PDOP range varies between 4-6.



a ***b***

Fig.3. Depicts the geometric success of the satellites (a) and unsuccessful (b) positions.

The most effective way to avoid errors is the DGPS (Differential GPS). Its essence is the measurement of the two receivers: one is deployed at a predetermined point, and the other is at the point coordinate point as a base station [10]. As the distance from the ASE receivers is considerably greater than the distance between the receivers, the two receivers are practically receiving signals in the same conditions. So the magnitude of the errors will be close. In DGPS mode, not the absolute coordinates of the first receiver, but its position relative to the base (base vector). The use of differential mode allows practically exclude distortions and accuracy in case of using a code method up to tens of centimeters and, in the case of a phase method, one or several millimeters. The best results show the phases, dual-frequency receivers.

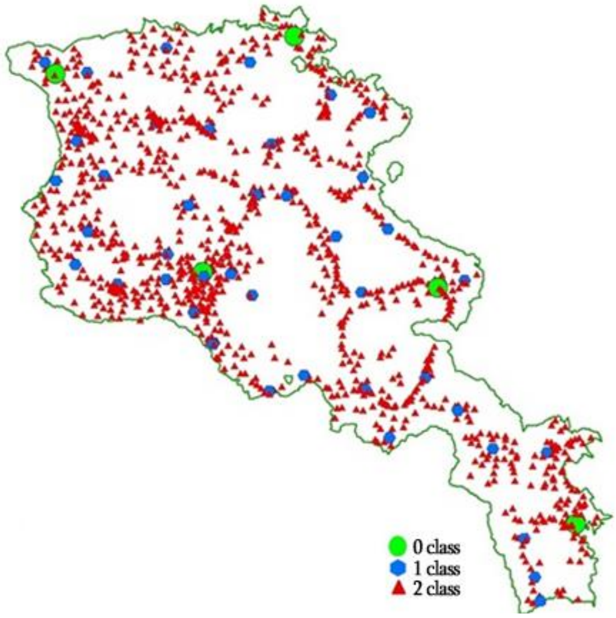


Fig. 2. Scheme of national geodesic network point location

2.3 Methods used: The method of multiple measurement was selected for the survey. The Leica firm GS 10/15, a portable GNSS station, was used for the monitoring, which received signals from GPS and Glonass satellite systems.

A base station was installed in Artashat city as a base station. The station's antenna is Leica AR 10, the receiver is GR 10.

The observations were made in real-time (RTK). Pre-selected durations. The minimum duration was 3 seconds, maximum 1 minute. The frequency of reception of signals in the mobile station and base station is 1 second. The observations were made on the second class point of the National Geodesy Network of Armenia network. These points were observed in 2007, with a duration of 12 hours and the coordinates were balanced up to 1 cm accurate. The items to be viewed are located in the city of Yerevan. Such a choice is due to financial means. It would be desirable to carry out similar periodical observations in RA provinces.

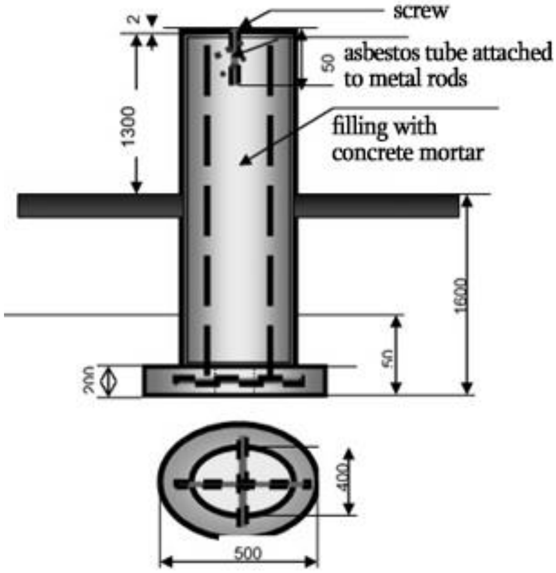


Fig. 4. Basis Position of Network Satellite

The RA Geodesy and Cartography Sector In accordance with the International Geodesy and Cartography Standards and joining the Central European Bureau of the European Coordination System (EUREF) in the territory of the Republic of Armenia in 2002-2007, 1115 points were made in the WGS-84 system, which 0 of each category is 5, 1st class is 41, 2nd class is 1069 points. The number of points covers the territory of the Republic of Armenia on average, with one point per 27 sq. km (Fig. 3) [11, 12].

The use of modern satellite technologies, in line with the effective concept chosen in our country, develops a geodesic network (Fig. 4), creating conditions for the use of existing networks, with the potential for existing networks.

3. Results

The scientific novelty of the work is that for the first time this kind of research was conducted for the territory of Armenia. Additionally, this is the first publication of a similar complex job. The other novelty is that previously conducted observations were mainly made with devices that received signals from only GPS satellites. In this study, the signals from the Glonass satellite system were also used. An attempt was made to receive signals from the European Galileo satellites, but during the observation no signals were received from that satellite system. The observations revealed that the number and frequency of signals received from the satellites for the territory of the Republic of Armenia are sufficient to reduce the duration of the previously observations. Thus, the observations

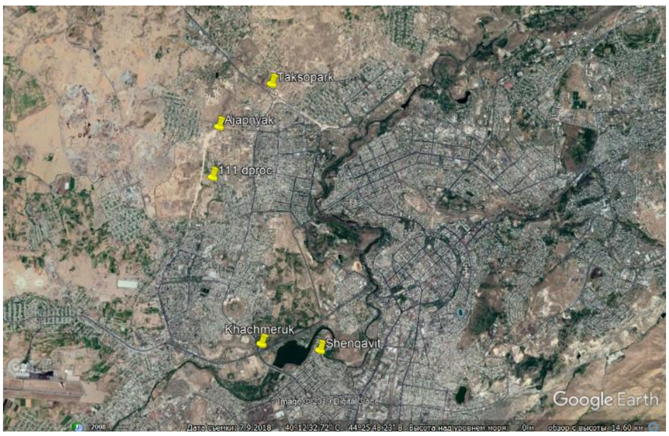


Fig. 5. Location of the observed bases on the map

Were implemented in the 5 basic point of the 2nd class of the Armenian National Academy of Sciences network in Yerevan, Tskopark, Ajapnyak, Khavhmeruk, 111 deproc and Shengavit (Fig. 5).

As a comparative standard value choose the coordinates and elevation of 2nd class points. The observations were made in RTK (Real Time Kinematic) mode. For correction of each database, 10 observations were made for 3, 5, 10, 30 and 60 seconds for data check. Each duration monitoring was performed in two modes using GPS satellites and GPS / GLONASS satellites.

A table 2 shows a section from the review results table. Three sessions per 10 seconds for each base point.

Table 2.

Taksopark	Northing	Easting	Ellip. Hgt.	**111dproc**	Northing	Easting	Ellip. Hgt.
1	-0.001	0.013	-0.019	**1**	0.005	-0.008	0.002
2	0.009	0.011	-0.017	**2**	0.011	0.017	-0.045
3	-0.004	0.012	0.010	**3**	-0.009	-0.021	0.044
Ajapnyak	Northing	Easting	Ellip. Hgt.	**Khachmeruk**	Northing	Easting	Ellip. Hgt.
1	-0.012	-0.003	-0.024	**1**	-0.015	0.039	-0.025
2	0.000	0.003	-0.012	**2**	-0.061	0.038	-0.044
3	-0.015	0.005	-0.025	**3**	0.046	0.020	-0.012
Shengavit	Northing	Easting	Ellip. Hgt.				
1	0.009	0.017	-0.012				
2	0.002	0.002	0.056				
3	0.026	0.014	0.005				

4. Conclusions

As a result of our observations, we came to the following conclusions:

- Since the difference in the duration of the observation does not exceed the accuracy of the measuring equipment, then even the minimum duration (in our case 3 seconds) can be obtained as a precise result.
- The use of satellite systems had no effect on the accuracy of observation data. The only difference was that during operation with only GPS systems, the instrument reached a limit of 30-60 seconds later.

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GEO INFORMATION SYSTEM (GIS) APPLICATION IN FIELD OF BRICKWORK AND STONE ARCHITECTURAL MONUMENT PRESERVATION AND PRESENTATION

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Keywords: Architectural historical buildings, building material, brickwork monuments, information database, geo information data

Abstract. The article studies the location of architectural monuments on the territory of the Republic of Armenia. The availability of accurate information on electronic maps and the impact of geo information GIS on the preservation of monuments. There have been numerous errors and omissions about location and information.

The article presents the results of the research conducted in 2018. Research has focus on the negative impact on the lack of geographical information bases for the planning, implementation and maintenance of architectural monuments. As well as to make these monuments accessible to tourists in the future.

During the research, study architectural monuments which the integrity of information about them and the fact that they were united in one place were studied. An initial database has been created for the brickwork structure in Republic of Armenia. Comparing the monuments which have geo information database and those monuments which does not have. We finding very important connection between monuments preservation and existing of geo information database.

It was suggested to create a new electronic map (ELMA), which will be multiple times correction data and will link to intelligence database. This base will provide accurate information about architectural monuments and will be able to find out their location and availability. Create a comprehensive full database of important and up to date information for the monument and make that database accessible to professional and public circles. Also, by refreshing this information minimum twice a year, we will always have p to date information about monuments. Any interference should be recorded and archived. At present there are some works done in this direction related to the brickwork structures of Armenia.

1. Introduction

In the territory of the Republic of Armenia there are many natural and architectural monuments. All the monuments are not familiar and well-known to everyone because there are shortcomings and omissions. There are few monuments explored in our region because they have little information about their location. Roads approaching monuments and their situation describing are also missing.

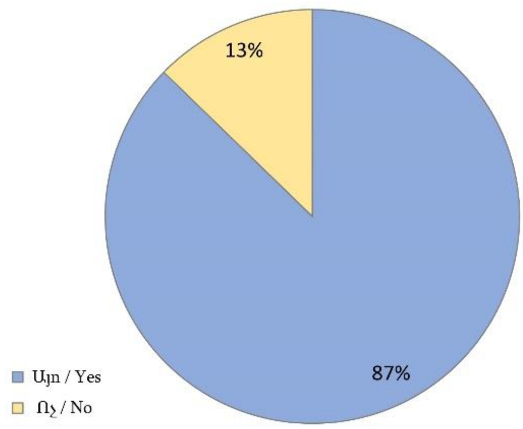


Fig. 1- Knowledge about the RA brickwork architecture

As a result of the statistical survey (fig.1), the public is informed that there are brickwork structures in Armenia but they are not known with their location. This is the fact that these structures are missing on the map. Because of this omissions, structures are ignored and appear on the edge of destruction.

As a result of the survey, the population was more aware of the existence of brickwork structures in Yerevan than in other provinces. It is also a great fact that the structures are neglected and unknown in the provinces (fig. 2) [1].

These problems will be solved a long time ago in Europe and the United States. It is clearly marked with coordinates and directions to the location of the majority of the monuments.

At different times, an attempt was made to create information databases by various governmental institutes. However, they were only one or two sectors. They were created incomplete and not in accordance with international standards.

Research has shown that there are no complete, applicable databases on the territory of the Republic of Armenia (also the Republic of Artsakh), existing infrastructures, sectoral facilities, which can be used to create new innovative resources. As a result of the study it turned out that there are separate small, narrow sectoral bases, which are not complete, and then they are mostly incompatible with each other. The problem of incompatibility has arisen because GIS technology is new to our country and there is no relevant normative documents. The problem of incompatibility has arisen because GIS technology is new to our country and there is no relevant normative documents. As a result, the existing bases have been created according to the knowledge, experience and of the specialists involved in these processes. An amount of independent and different saturation bases have been obtained.

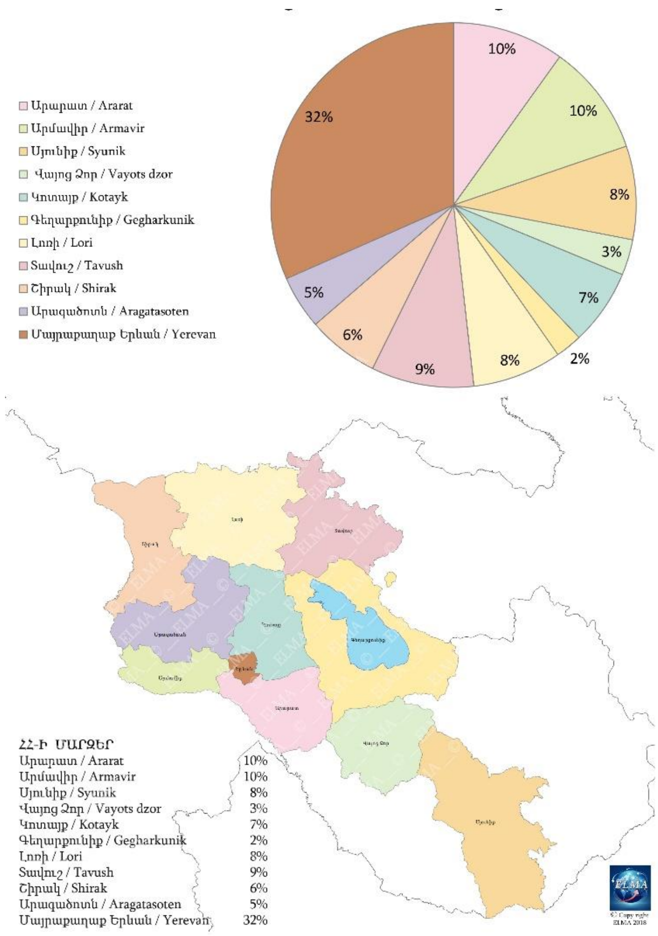


Fig. 2- The results of the public polls of our population is familiar with the brickwork structures.

To find out about such results we united the establishment of information bases and the development of digital tools. The research was launched in July 2017.

The arrangement of companies in the market is rather dense. They provide different services that meet some or all of the requirements of the user. Our calculations include about 120 different websites and apps where there are e- maps. However, each one has its own fault. For example, Google Maps provides a free map where many mistakes and inadequate offline mode, Yandex maps are more accurate but not available offline, OSM is generally volunteer initiatives and has a very low frequency of information updating, Navitel offline but the information is not accurate and have enough gaps in the necessary information.

Geo-information systems have been used a long time ago. However, as a full-fledged personal information system, the economy entered the second half of the 20th century. The leading GIS technology development country is the United States, followed by European countries.

GIS has a great toolbox for the ArcGIS software package [2]. Here are components that allow any specialist to see and analyze information in the form that is most appropriate for a specialist. For example, you can analyze visual and classification in same time. If comparisons are made to verify the data collected in the given precinct, you can analysis on map by giving the scale visualization and textual data transmitted by corresponding sorting and filtering [3].

The ultimate presentation of the mapping result is a map or plan. The map contains a lot of information that allows you to solve problems faced by GIS with the information collected. GIS provides modern tools that can be developed in many areas. Maps become 3D, complemented by graphs, videos, documents and more. GIS is closely linked to other information systems. The difference in GIS from other information systems is that it has the ability to analyze and modelling spatial data [4].

In the 19th century, geodetic methods were used to obtain a map of the area and building plans. Over time, these techniques have been improved and the opportunity has been created to the objects plan and the accurate facades, but also the human factor in that process, as well as man-made errors, to minimize [5,6].

Nowadays the geodetic survey of monuments can be divided into the following stages:

- Study of the monument and surrounding area, gathering information from different sources and choosing the most effective method of study,
- Field surveys, data collection,
- Collected data chamber development,
- Creation of Geographical Information Base.

The study of the monument and adjacent territory allows accurately evaluate the scope of the planned works and select a survey method which will be most effective for the performance of the given work. Additionally, before the start of the field work, collection of existing materials is done. The topographical and situational maps, text descriptions and photographs of this area are the most important.

In the next stage, a geodesic fieldwork is being carried out. It is very important topographical surveys, aerial surveys and scanning, photography with drones and photogrammetry.

The most popular modern methods of data collection are:

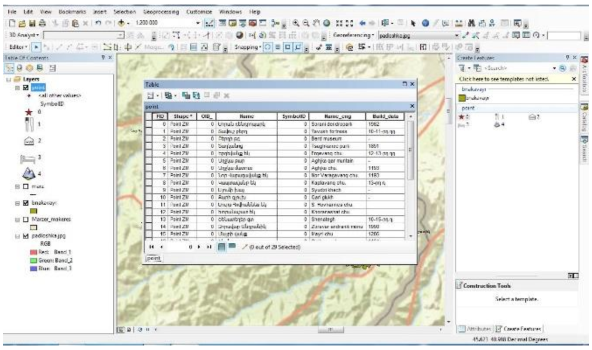
- Topographical surveys
- Aerial surveys
- Aerial scanning

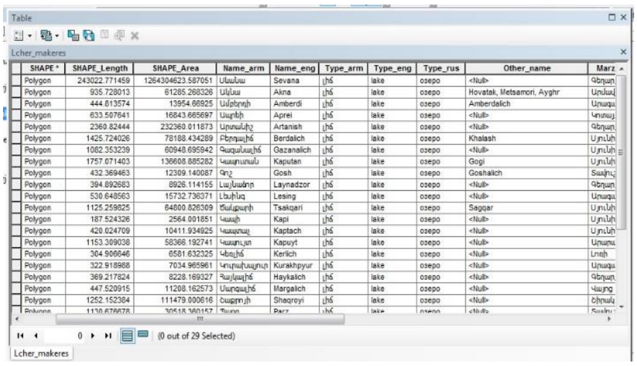
2. Methodology

The implementation methodology works as follows. Information gathered from the open source, provided by their authors, and obtained from an authorized or competent authority, under the relevant procurement or use contract, is collected as far as possible. The collected information is digitized, coordinated and brought to specified digital formats. After that, analysis of materials, elimination of repetitions, inaccuracies, conflicting or incompatible information is carried out. If necessary, discussions with other experts in the field. The materials available after the data reproduction are divided into two groups. The first group includes materials that are reliable. It is necessary to underline that the information to be considered valid at this stage should be obtained from three independent sources, except for state and international regulations. The second group includes the materials whose authenticity has not been confirmed by the relevant requirements.

The first group of materials is transferred to GIS professionals, based on their respective bases for receiving and layers. These activities are carried out in accordance with GIS software packages in which the type is not defined, it is important to maintain a set of standards and formats (Fig.3).

Subsequent separated first and second group data are transmitted to the field group. The transfer of the material of the first group is of advisory form so that in the event of inaccuracies in the works they will be directed. The materials of the second group are clarified in field conditions. Fieldwork data collection can be as GPS, GNSS equipment as well as through other means and methods.





Table

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SHAPE *	SHAPE_Length	SHAPE_Area	Name_arm	Name_eng	Type_arm	Type_eng	Type_rus	Other_name	Marz
Polygon	243022.771459	1264304623.587051	Սևանա	Sevana	լիճ	lake	озеро	<Null>	Գեղար
Polygon	935.728013	61285.268326	Ակնա	Akna	լիճ	lake	озеро	Hovatak, Metsamori, Ayghr	Արմավ
Polygon	444.813574	13954.66925	Ամբերդի	Amberdi	լիճ	lake	озеро	Amberdalich	Արագա
Polygon	633.507641	16843.665697	Ապրեի	Aprei	լիճ	lake	озеро	<Null>	Կոտայ
Polygon	2360.82444	232360.011873	Արտանիշ	Artanish	լիճ	lake	озеро	<Null>	Գեղար
Polygon	1425.724026	78188.434289	Բերդալիճ	Berdalich	լիճ	lake	озеро	Khalash	Սյունի
Polygon	1082.353239	60948.695942	Գազանալիճ	Gazanalich	լիճ	lake	озеро	<Null>	Սյունի
Polygon	1757.071403	136608.885282	Կապուտան	Kaputan	լիճ	lake	озеро	Gogi	Սյունի
Polygon	432.369463	12309.140087	Գոշ	Gosh	լիճ	lake	озеро	Goshalich	Տավուշ
Polygon	394.892683	8926.114155	Լայնաձոր	Laynadzor	լիճ	lake	озеро	<Null>	Գեղար
Polygon	530.648563	15732.736371	Լեսինգ	Lesing	լիճ	lake	озеро	<Null>	Արագա
Polygon	1125.259825	64800.826309	Ծակքարի	Tsakqari	լիճ	lake	озеро	Saggar	Սյունի
Polygon	187.524326	2564.001851	Կապի	Kapi	լիճ	lake	озеро	<Null>	Սյունի
Polygon	420.024709	10411.934925	Կապտաչ	Kaptach	լիճ	lake	озеро	<Null>	Սյունի
Polygon	1153.309038	58366.192741	Կապույտ	Kapuyt	լիճ	lake	озеро	<Null>	Արարա
Polygon	304.906646	6581.632325	Կերլիճ	Kerlich	լիճ	lake	озеро	<Null>	Լոռի
Polygon	322.918988	7034.965961	Կուրախպյուր	Kurakhpyur	լիճ	lake	озеро	<Null>	Արագա
Polygon	369.217824	8228.169327	Հայկալիճ	Haykalich	լիճ	lake	озеро	<Null>	Գեղար
Polygon	447.520915	11208.162573	Մարգալիճ	Margalich	լիճ	lake	озеро	<Null>	Վայոց
Polygon	1252.152384	111479.000616	Շաքրոյի	Shaqroyi	լիճ	lake	озеро	<Null>	Շիրակ
Polygon	1130.676678	30518.360157	Պարզ	Parz	լիճ	lake	озеро	<Null>	Տավու

(0 out of 29 Selected)

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Fig. 3- Data collection and classification using the GIS system

Architectural monuments and historical structures are measuring (survey) for more detailed. Analyzing the archival and historical documents. For geometrical survey we used laser scanning and other modern tools for measuring. Diagnostic studies are also being carried out for monuments, on this basis we can know the problem of degradation and suggestion the solutions ways [7].

Degradation causes can be divided into two main groups: natural; and anthropogenic. Natural degradation are result of weather condition and temperature changes, earthquakes, floods, landslides, erosion, fire, plant growth on structures, air pollution, and flood of underground waters [8-10].

Fig. 4- Panakhan residential house degradation map

Anthropogenic degradations are consequences of factors such as wars, urban development projects, demolishing buildings, inappropriate intervention, or simply abandoning the structure [8-10]. Degradations analysis based on ICOMOS Glossary [11]. This glossy describing all stone structures degradation forms and the reasons for their occurrence. As a result of analyzes and studies, we get a degradation map (Fig. 4), which clearly outlines the type and boundary of destruction.

This classification can be collected and grouped into the GIS system by the degradation reason or having similar problems and more.

3. Conclusions

It was suggested to create a new electronic map ELMA, which will be multiple times correction data and will link to intelligence database. Then, that e-map was made available to the public as an open platform. Since similar scientific work is being implemented in Armenia for the first time, it is also aimed publishing appropriate methodological guidelines.

The goal is very easy to imagine with the following concept, "Digital Armenia". The purpose of this goal is to have the maximum adjusted spatial data on the Republic of Armenia (also the Republic of Artsakh). In the event of achieving these goals, we can develop a variety of software, technologies and more in the framework of cooperation with IT professionals based on our research results.

All data is collected and classified in one database, all of data is visualised with an electronic map. The database is filled with different data associated with the monument (table 1). Each and every specialist studying these data can give an approximate idea of the structure. By examining the section of degradation and problems, they can suggestion for strengthening and restoration. After completing the data in the interventions section, you may find information about further steps or other issues.

Table 1

no	Name of monument	The number of monument in the State register list	Location	Type	Construction period	Significance		Current situation					Construction material	Archival documents		Buffer zone radiuses	description of degradation	Intervention description
						Governmental	Privet	Ruins	Distressed	Standing	Restored	Historical form		Drawing	Photo			

For the public is more visible and accessible by the presence of photographs and graphics, as well as a small introduction or a textual description. However, professionals and researchers need more professional information. In response to this question, ELMA also responded to a small sheet (Fig. 5) on the map, which would give the reader a little bit of information about monuments, but for the specialist would need more information that they could get on the elaborated mapping system.

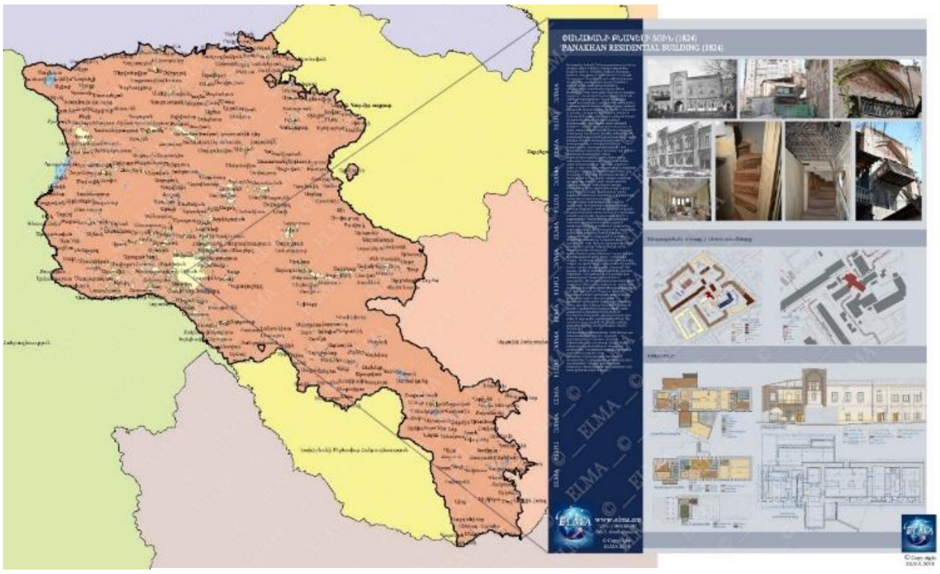

Fig. 5- Information table sample for each monument

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THE STUDY OF DOMESTIC AND INTERNATIONAL EXPERIENCE OF PASSPORTIZATION OF PUBLIC AND MULTIAPARTMENT HOUSING STOCK

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Abstract. The study of domestic and international experience of passportization of public and multiapartment housing stock is a part of the project on "Development of sample forms of passports for public and multi-apartment buildings, and development of Terms of Reference for implementation of software for buildings information" that has been implemented by the experts of Urban Foundation for sustainable development (UFSD) jointly with the "ArmProject" OJSC in November, 2018 - May, 2019 within the framework of the UNDP-GCF project on "De-risking and Scaling-up Investment in Energy Efficient Building Retrofits" upon the contract with the United Nations Development Program in Armenia.

The study allowed to identify the following points: a) practically various forms of passports for buildings (technical, energy, sanitation, environmental, fire safety, etc.) are used, including both the general data describing the building (e.g. building construction year, number of floors , number of flats and entrances, constructive solutions, type, etc.), and the data characterizing the functional features; b) the study of the available literature on the issue showed that in some of the near abroad countries (Russian Federation, Ukraine, Belarus, etc.) and in the far foreign countries (Germany, France, Flanders (Belgium), etc.) the unified passports are created in order to avoid the repetition of common data on the building (for instance, technical condition, energy indicators, data on management activity, etc.); c) the experience of European countries in the process of passportization of residential and public buildings is directly linked to the requirement for energy audit of buildings in EU member states.

1. Introduction

Methodological issues of passportization of residential and public buildings remain still relevant for Armenia. The presence of such factor as the interest of consumers in assessing the technical condition of a building in order to extend its safety and exploitation term, translates the problem from a theoretical one into a practical one. However, in essence, there is currently no definite methodological approach that allows institutionally conduct of a regular inventory of a country's residential and public fund in order to improve the quality of its operation. Adopted by the Government of the Republic of Armenia Strategy to improve the seismic resistance of buildings and structures for 2017-2025 provides a procedure for obtaining a passport for existing buildings and buildings under construction, including the development of a building sample passport, as well as a model of a unified information system based on the data contained in passports (in 2018-2019). For 2019-2021 it is planned to introduce a computer program based on the original passport data [1].

The entire study was wider than only analysis of domestic and international experience of passportization. One of the key aims was developing of sample forms of passports for public and multiapartment buildings. It was based on the review of the numerous available literature related to the theory and practice of using passports for residential and public buildings in Armenia, as well as in other countries of the near and far abroad, particularly in the largest cities of the Russian

Federation (Moscow, St. Petersburg), The Republic of Belarus, the countries of Baltic and Central Europe. Such a review allowed not only to formulate the definitions and content of a passport of a multiapartment and public building that will be acceptable for the conditions of Armenia, but also to determine which of the already developed and using successfully concepts can be adapted and applied in the conditions of multiapartment and public buildings of Armenia.

The developed passports were piloted for four buildings in Yerevan (2 residential multi apartment and 2 public buildings).

2. Methodology

The methodology for the study, particularly for the developing sample forms of passports for public and multi apartment buildings, included the following steps:

1. The study and analysis of domestic and international experience of passportization of public and multiapartment housing stock.
2. Study of buildings' passports types using in Armenia and other countries.
3. Drafting of the sample forms of passports for multi apartment and public buildings.
4. Distribution of the developed passports option to the relevant interested organizations (stakeholders).
5. Conducting a series of consultative meetings with key stakeholders.
6. Finalizing of the sample forms of passports.
7. Development of Guide for filling up a passport of a multiapartment and a public building.
8. Piloting of the developed sample forms of passports.
9. Collection and analysis of information on the application of the developed sample forms of passports.
10. Report on the work done.
11. Organization of a round table.

2.1 The study and analysis of domestic and international experience of passportization of public and multiapartment housing stock.

A review of the literature (list of references is attached) showed that the idea of multiapartment and public passportization buildings in Armenia is not new. Since soviet times, particularly in 1951, by Decree of the Council of Ministers of the USSR No. 431 dated by May 15, 1951 it was decided to include data on the building in its technical passport. This document was supposed to include such data as the address of the building, time of registration, plan of the land plot, plan of each floor, including basement floor, number of apartments, total area of apartments, living space, service area, plan of the building's facade, building profile, data on the basement floor, master plan and comprehensive data for all apartments.

Starting from 1993, data on the building should have been included in the technical passport on the basis of Government Decree No. 452 dated on September 8, 1993, as well as the RA Law "On the issuance of documents certifying the ownership of privatized apartments (houses) and the procedure for their registration". The technical passport should include the following data: the address of the building, the general plan of the entire building, the plans of individual floors, basement, semi-basement, the time when the building was registered, the area of the building and its parts, the total and auxiliary space of the building, which are common (shared), the technical conditions and the assessment of the building, the plan of the land on which the building is located, the access of the building to the utilities and their technical condition.

In 1997, in accordance with the Decree of the Government of the Republic of Armenia No. 466 dated by October 22, 1997 "On Approval of the form of the Certificate of unified state registration of property rights, real estate) in technical passport the following data has to be included: land data (land use purpose, land surface, type of right), construction data, purpose of use of the building, its space, type of right.

A number of other legislative acts and laws also played a significant role in the development of a legislative framework for the further implementation of the multiapartment and public buildings passportization. One of them was the Decision of the Ministry of Urban Development of the Republic of Armenia No. 168 dated November 26, 1998 on the "Methodological instructions for checking the technical condition of residential and public buildings". Based on Article 22 of the RA Civil Code dated 05.05.1998, homeowners in multi-apartment residential buildings also own certain shares in common property, including load-bearing structures, inter-floor overlapping, basement, attics, technical rooms, roofs, stairs, elevators, mechanical, electrical, sanitary and other equipment of residential buildings, land plots necessary for the maintenance and operation of the building.

The RA Law "On State Registration of Property Rights" (April 14, 1999) stipulates that when registering property rights of citizens, the certificate must include the name of the owner, the name of the real estate user, the coded number of the property, its state registration number, property rights, servitudes, purpose, size, master plan, as well as its share in total ownership in percent.

RA Government Decree No. 1161-N of October 4, 2007 "On determining mandatory standards for ensuring joint use of multi-apartment buildings" reinforced the need to use a technical passport of an multiapartment building, indicating the share (in percentage terms) of each homeowner in the ownership of common property of an multiapartment building, as the owners of residential premises in multi-apartment residential buildings became financially responsible for the status of the technical condition of the building [2].

In Armenia, as part of a number of energy-saving programs, surveys were carried out on residential buildings aimed at identifying the technical condition of buildings and the possibility of constructive and technical intervention in order to improve the energy-saving properties of buildings [3,4].

In a number of countries there is a fairly rich experience in passportization. In particular, in the Russian Federation (Moscow, St. Petersburg), in order to conduct a unified policy on the maintenance and safe operation of the housing stock, a targeted Integrated passportization program was approved. In the city of Moscow, housing stock passportization has been carried out based on this program since 1998. In order to create appropriate conditions for the passportization of the housing stock of Moscow the Center for assistance to the management of condominiums and passportization of the housing stock was created in 2002. Passportization in Moscow follows the path of improving the legislative base and creating technical passports for residential premises (apartments). Since 2001, over 54,000 passports for apartments in 295 houses have been manufactured [4]. In order to ensure the organization of technical maintenance and repair of housing facilities located on the territory of St. Petersburg, as well as obtaining reliable information about consumer properties of residential premises, the government of St. Petersburg has been certifying the housing stock of the city since 2003 [5, 6].

Within the framework of this study the international experience of passportization has been analyzed. Analysis showed that in a number of foreign countries there is a considerable experience of passportization. The study of international experience shows that practically various forms of passports of buildings (technical, energy, sanitary, environmental, fire safety, etc.) are used. The passport content includes as general data describing the building (e.g. date of starting of building exploitation, number of flats and entrances, constructive solutions, type, etc.), as well as data characterizing the functional significance. In order to avoid the repeated data in passports the common form with appropriate inserts (for example, technical status, energy indicators, governance activities, etc.) is used in the countries of near (Russian Federation, Ukraine, Belarus, etc.) and far (Germany, France, Flanders (Belgium), etc.) abroad. From our point of view this approach is also appropriate for Armenia's conditions.

2.2 Buildings’ passport types using currently in Armenia

Currently, there are two types of passports using in the Republic of Armenia: technical and energy passports. Resolution of the Minister of Urban Development of RA N 282-Ն dated 08.12.2009 has approved the "Methodological instructions for investigation of the technical condition of residential, public and industrial buildings and structures (hereinafter: buildings and structures)", which have an advisory nature and they are intended for the use for passportization of residential, public and some industrial buildings and structures. Annex 2-B of the above-mentioned methodological guidelines presents the form of the passport that is a subject to be completed as a result of the investigation of the technical condition of the building. It includes:

a) data relating to the physical location of the building in the nature (in particular, the marz, the residence, the location (address), the micro district, the district, the precinct),
b) general information on the building (name of the object, number of the master plan, scheme, number of building by map, structure type, capacity indicator - number of flats, work places, beds, students, productivity, number of employees in one shift, etc.);
c) the metric data of the building (height, length, width of building),
d) building value data (balance value, cost of equipment),
e) data on the on building constructive solution and characteristics of the construction structures,
f) data on seismicity status of the building,
g) other.

The methodological guidelines specify the composition and formulation of the investigation documents, namely: (1) The main characteristics that include the building and / or the structure certification sheet with the conclusion where seismic stability assessment and appropriate measures (reinforcement, functional alteration, demolition, etc.) are noted, (2) Supporting documentation, including photographs of the object and materials on seismic resistance of the building and (3) Supplementary inserts, including initial reference documents of the object, as well as engineering systems and infrastructures schemes.

The above-mentioned passport format was intended to confirm the evaluation of the building with the following parameters:

a) seismic stability (evaluation by three-stage scale: "seismically stabile", "does not meet seismic stability requirements", "does not meet seismic stability requirements due seismic variety of the site");
b) degree of damage;
c) level of deterioration.

The passport was intended to confirm the future exploitation of the building through the assessment by using 5-point scale, in particular:

a) the building may be exploited,
b) the exploitation of the building may be possible after its functional purpose change,

c) partial reinforcement is required,

d) full reinforcement is required

e) the building is subject to demolition.

The investigations of the technical condition of buildings and structures are carried out in accordance with the requirements of the RA legislation and normative-technical documents, by specialists licensed in the field, on contractual basis. As a result, a conclusion on the technical condition is given which, with the findings of other studies, in the form of an attachment, is included in the building or structure passport (certificate).

Starting from January 1, 2014 "Energy Saving: Building Energy Passport. Basic Provisions: Typical Form" (hereinafter referred to as "Energy Passport", AST 362-2013) was operated, which is designed to meet the requirements of the existing norms for conformity of the thermal energy efficiency index of the building, other specific indicators and the thermal protection indicators of the lined constructions. The energy passport is intended for designing of multi-apartment and public, new and reconstructed buildings, as well as for using during the exploitation of the existed buildings.

Building Energy Passport contains:

- the data of the responsible person/organization filling the energy passport,
- general information about the building,
- computational climatic conditions,
- geometric indicators,
- heat-technical and energy required calculation and operation indicators of the building,
- heat-transfer resistance of the external constructions;
- the specific heat energy consumption for heating and ventilation during the heating season,
- the energy efficiency class given to the building, etc.

The Energy Passport of the buildings in operation is filled out by the procedure established by the law by the certified person based on data of energy audit in the stages of design and building of the building by the certified person.

One of the disturbing factors in the effectiveness of the buildings' passportization process in Armenia is that there is no clear legal regulation that will ensure the accounting / registration of a building as a property object allocated in the nature environment, in particular the registration of common shared ownership rights (for its further exploitation and proper maintenance), with clear defining the relationship between the provision of primary information, their subsequent update, information transfer / exchange officers relationships, access to unified databases, the responsibility of users and managers of databases. Only then will it be possible to introduce a new model of building data system and its management to ensure its efficiency. At the same time, the passport of multi-apartment and public buildings is not imperative and there is no defined responsibility for not implementing it.

2.3 Drafting, discussing and finalizing the sample forms of multi apartment and public buildings’ passports

Within the framework of this project proposals on the structure of multi apartment and public buildings passports and their sample forms have been developed, including the following:

- general information about the building,
- information on building constructions,
- information on the engineering systems and equipment for the unified service that is the common shared property of the building,

- information on the characteristics of the main structural element of the common shared property of the building,

and Inserts regarding technical condition of the building, materials on the engineering-geographical investigation, building energy passport, technical condition of the seismic isolation system, building's fire safety condition, conclusion on the technical condition of the elevators in the building, building management information (not required for public buildings), information about the building's inhabitants (not required for public buildings), information on accessibility conditions for people with mobility difficulties, the construction and architectural plans, engineering infrastructure schemes, etc.

The sample forms and the structure of the multi apartment and public buildings' passports developed within the framework of the program have been considered and agreed with the stakeholders, particularly with the RA Urban Development Committee, Ministry of Education and Science of the Republic of Armenia, RA Statistical Committee, Committee of the Real Estate Cadaster of the Republic of Armenia, Ministry of Culture of the Republic of Armenia, Urban development, technical and fire safety inspection body, Ministry of Labor and Social Affairs of the Republic of Armenia, Ministry of Territorial Administration and Development of the Republic of Armenia, Ministry of Emergency Situations of the Republic of Armenia, Ministry of Health of the Republic of Armenia, Ministry of Energy Infrastructure and Natural Resources of the Republic of Armenia, Ministry of Nature Protection of the Republic of Armenia, Yerevan Municipality.

A guide to completing the sample forms of multi-apartment and public buildings passports has been developed in which detailed sources are described which will serve as a basis for obtaining necessary information to complete the passports.

2.4 Piloting of the developed sample forms of passports

Within the framework of the project, the working group of "ArmProject" OJSC implemented a pilot filling of passports' sample forms for 2 public and 2 multi-apartment buildings, proposed by the UNDP Armenia office, based on the results of the technical investigation and energy audit of the technical condition of these buildings. As a result, the passports of the following buildings were supplemented:

- newly-built multi-apartment building (address: Yerevan, Arabkir administrative district, Adonts street N6 / 1);
- existing multi-apartment building (address: Yerevan, Nor Nork, Jrvezh, Banavan, Building 42);
- Children's Creative Center N 3 (address: Yerevan, 0041, Erebuni, Erebuni 15);
- Kindergarten number 110 (address: Yerevan, Nor Nork, Mayak district, Building 6).

An analysis was made on the results of the pilot building passports filling, as a result of which the institutional, legal and financial impediments arising during the collection of data were revealed and possible solutions were given. A cost estimation of buildings' passportisation process has been accomplished with the enlarged indicators.

3. Results

Based on the study of domestic and foreign experience in passportization (applying passports), a version of a sample for passport was developed, respectively, for a multi apartment and public buildings.

4. Conclusions

The study of available literature on the issue allowed to make the following recommendations:

- to exclude repetitions in the building data collection, apply in the condition of Armenia the uniform format of building passport for residential and public buildings, respectively,
- the section of passport on “The general information on building” must be one of the mandatory duties of the head of Condominium (or authorized, or trustee manager), which will be reflected in the "Rules for management and maintenance of multi-apartment buildings",
- the collection of information required by the Inserts of the passport can, if possible, be carried out by the building management body and/or by involvement of specialized and accredited organizations / specialists based on an agreement/contract,
- it is necessary to elaborate a state support program for homeowners, which is aimed at providing technical expertise and energy audit loans (compensation),
- mechanisms for providing technical expertise and energy audit loans (compensation) should be developed.

The analysis of the legal framework and the current situation in Armenia related to the filed given the following suggestions:

- The political power and willingness of the Government of the Republic of Armenia is necessary to begin and finish the passportization process by using the developed form of passport agreed with the stakeholders.
- Oblige the owners of buildings and structures to legislate buildings and structures owned by the ownership right (inventory) according to the passport form approved by the RA Government and its supplementary guide.
- Establish the methodology for assembling the information required for the passports of buildings and structures, indicating sources of credible and reliable data, sources of funding required for their receipt, mechanisms for obtaining information on a free or paid basis, and the legal consequences of not providing them.
- Establish clear mechanisms, timelines and responsibilities for passportization of building and construction, by specifying possible forms of financial support that may include tax incentives (e.g. property tax exemptions), direct subsidy or co-financing of ownership, as well as licensed (private) subsidizing.
- Identify public support mechanisms, identify public-private partnership models and present them publicly to multi-apartment buildings’ residents.
- Develop a government support tool for infrastructural development and appropriate conditions for its using.
- Modify owner’s behavior by implementing relevant educational programs. It is necessary to inform the owners about the best examples of caring for their own property and motivate everyone to become the bearer of those changes.

Obviously, the effective organization and implementation of the passportization of buildings and structures will require adequate resources, which can be accessed through separate in-depth study and implementation of appropriate calculations.

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