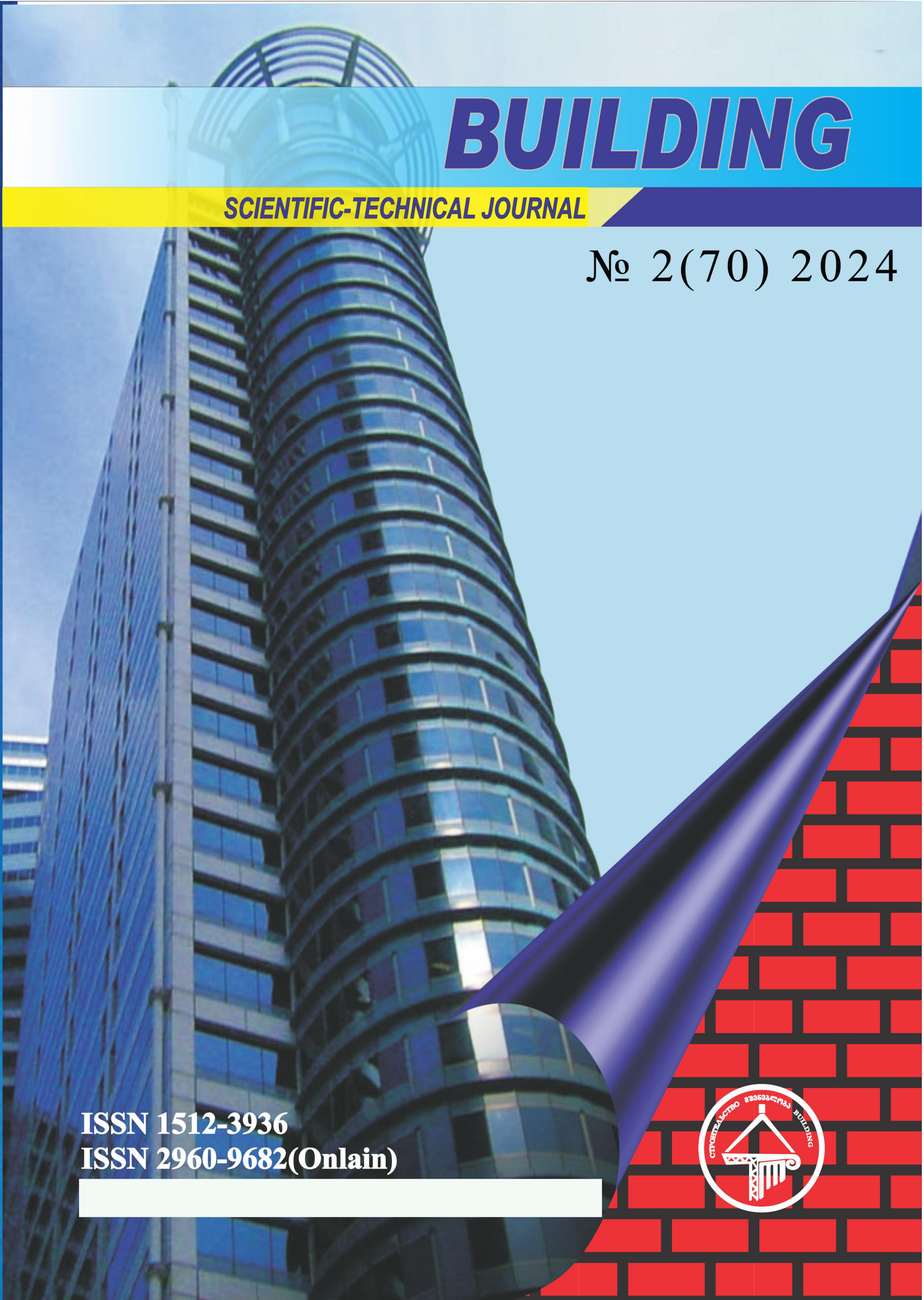

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Determination of the maximum suction height of the pumping unit (using the example of the pumping station in Dvin)

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Annotation. The Dvin pumping station is designed for subsidized supply of up to 180 liters/s from Artashat Canal to Dvin Canal for the purpose of irrigation of lands under the Dvin Canal.

The water supply from the channel to the receiving pool is carried out in a non-pressurized mode of movement through a concreted channel of rectangular cross-section of short length, the bottom of which is above the water level in the channel at a minimum depth of flow. The receiving pool communicates with the canal through a short pipe. Here the problem arises of determining the height of the maximum suction of the pumping unit. In this paper, it is solved using modern methods of mathematical measurements, which can be an exa

Keywords: channel, water movement, maximum suction height, pumping unit.

Introduction. A number of works by the author of this article are devoted to the issues of hydraulic calculations of pumping stations [1, 2, 3].

Armenia's water resources are formed mainly due to regional atmospheric precipitation and water flows of the Araks and Akhuryan border rivers. Although most researchers agree on the sources of formation of water resources in Armenia, however, various aspects are taken into account when assessing their reserves [4, pp. 45, 5, pp. 27 and 34, 6, 7, 8, pp. 84 and 278, 9, 10, pp. 63-67, 11]. According to some researchers, Armenia's water resources tend to decrease, steps are being taken to use them efficiently, and the construction of pumping stations is becoming relevant.

The Dvin pumping station is designed for subsidized supply of up to 180 liters/s from Canal of Artashat to Dvin for the purpose of irrigation of lands under the Canal of Dvin.

The outdoor pressure pool of the pumping station is located next to the right wall of the Canal of Dvin, which is connected to the canal by a rectangular opening. An outdoor swimming pool receiving a rectangular section of the pumping station, the floor mark of which is equal to the mark of the bottom of the channel, is located in the area between the engine room and the reinforced wall of the channel.

The main part

The water supply from the channel to the receiving pool is carried out in a non-pressurized mode of movement through a concreted channel of rectangular cross-section of short length, the bottom of which is above the water level in the channel at a minimum depth of flow. The receiving pool communicates with the canal through a short pipe.

Initial data

1. Static pressure	H_0 = 49-51.5 m
2. Maximum flow	Q_{max} =180 l/s
3. Minimum flow rate	Q_{min} =150 l/s
4. Design flow rate	Q_{max} =175 l/s
5. Pipeline length	L= 1476 m

Choosing the pipeline diameter

The steel pipeline of the pumping station is single-branched. The diameter of the pipe for supplying the calculated flow rate Q = 175 l/s is selected from the table of economically optimal diameters [12].

D=400 mm, or D=450 mm:

The water flow rate for the selected diameters, for the calculated flow rate will be:

V_{400}=4Q/3,14D^2=4 x 0.175/3,14 x 0.4^2=1.40 m/s.

V_{450}=4Q/3,14D^2=4 x 0.175/3,14x 0.45^2=1.10 m/s.

Since the liquid flow rate in the pumping pipeline is small, we will also discuss the issue of choosing a pipe with a diameter of d = 350 mm.

The water flow rate for a pipeline with a diameter of d =350 mm will be:

V_{350} =4 x 0.175/3.14 x 0.35^2=1.82 m/s.

Let's determine the pressure loss in the pipeline:

$$h'_W = 0.0827\frac{\lambda L}{d^5}Q^2$$

The table shows the calculation results:

L=1476, Q=175 l/s

The discharge pipeline has 10 clearly defined angles in the plan, which are the causes of pressure loss. Let's assume a local pressure loss of 7% of the longitudinal losses.

Since the maximum static pressure of the pumping station is 51.5 m, from the point of view of pressure losses, economically advantageous pipe diameters d_1 = 400 mm and d_2 = 350 mm are acceptable.

The total pressure loss in the discharge line will be:

$h_W = 1{,}07\, h'_W$:

d_1= 400 mm, $h_W =$ 8,40 m

d_2= 350 mm, $h_W =$ 17.0 m.

The required pressure H developed by the pump will be:

$H=H_0 + h_w$ (H_0=51,5 m)

d_1=400 mm, H=51,5+8,40 =59,90 m

d_2=350 mm, H=51,5+17,0 =68,5 m.

Now let's choose one of these two acceptable options from the point of view of the developing pump pressure:

The pressure developed by the pump:

D mm	λ	$0.0827\frac{\lambda L}{d^5}$	h'_W m
450	0,0209	150/138	6 /4,22
400	0,0216	256	8,5/7,85
350	0,0224	524/518	18/15,9

$H=H_0 + h_w$.

With a diameter of d_1=400 mm H=51.5+8.40=59.9 m,

With a diameter of d_2 =350 mm H=51.5+17.0=68.5 m.

Let's choose a pump according to the following pairs of parameters:

a. Q=175 l/s, H=60 m
b. Q=175 l/s, H=68 m.

From the pump catalog, option a. corresponds to the pump brand 12 D-9.

In the catalog for option b. the area is empty.

Therefore, a pumps of type 12D 9 with a diameter of the impaler D = 432 mm was selected for the pressure front of the Dvin pumping station[1].

Characteristics of the pumping unit:

The diameter of the impeller D=432 mm,

Revolutions – n = 1450 rpm,

The rated power of the electric motor is N_{electr} =170 kW,

Voltage - 400 V:

Pipeline Characteristics:

The results of calculating the coordinates of the characteristic curve of the pipeline are shown in the table.

d= 400 mm, H_0 =51.5 m, $S=L/K^2$=1470/4,85≈300 s^2/m^5 δ=6 mm.

[1] Centrifugal pumps account for 80% of all pumps and it is a known fact that most centrifugal pumps have an overcapacity of 20–30%. It has been calculated that the energy wasted by all the pumps operating at present in the EC is 46 TWh on a yearly basis [1]. Improving the efficiency and reliability of the regulation of centrifugal pumps installations of low and medium power is especially important in water supply systems with a variable component of the load, for example, in irrigation systems and in systems with a small static head. It has been established that sliding the operating point of pumps along the pressure-flow characteristic of the pipeline is the most effective method of controlling adjustable centrifugal pumps [13; 14; 15].

Q m³/s	0,030	0,060	0,090	0,120	0,150	0,180	0,200
SQ^2 m	0,27	1,1	2,45	4,35	6,75	9,72	12
$H=H_0+SQ^2$m	51,8	52,6	53,95	55,85	58,25	61,2	63,5

Hydraulic parameters of the operating mode point of the pumping unit

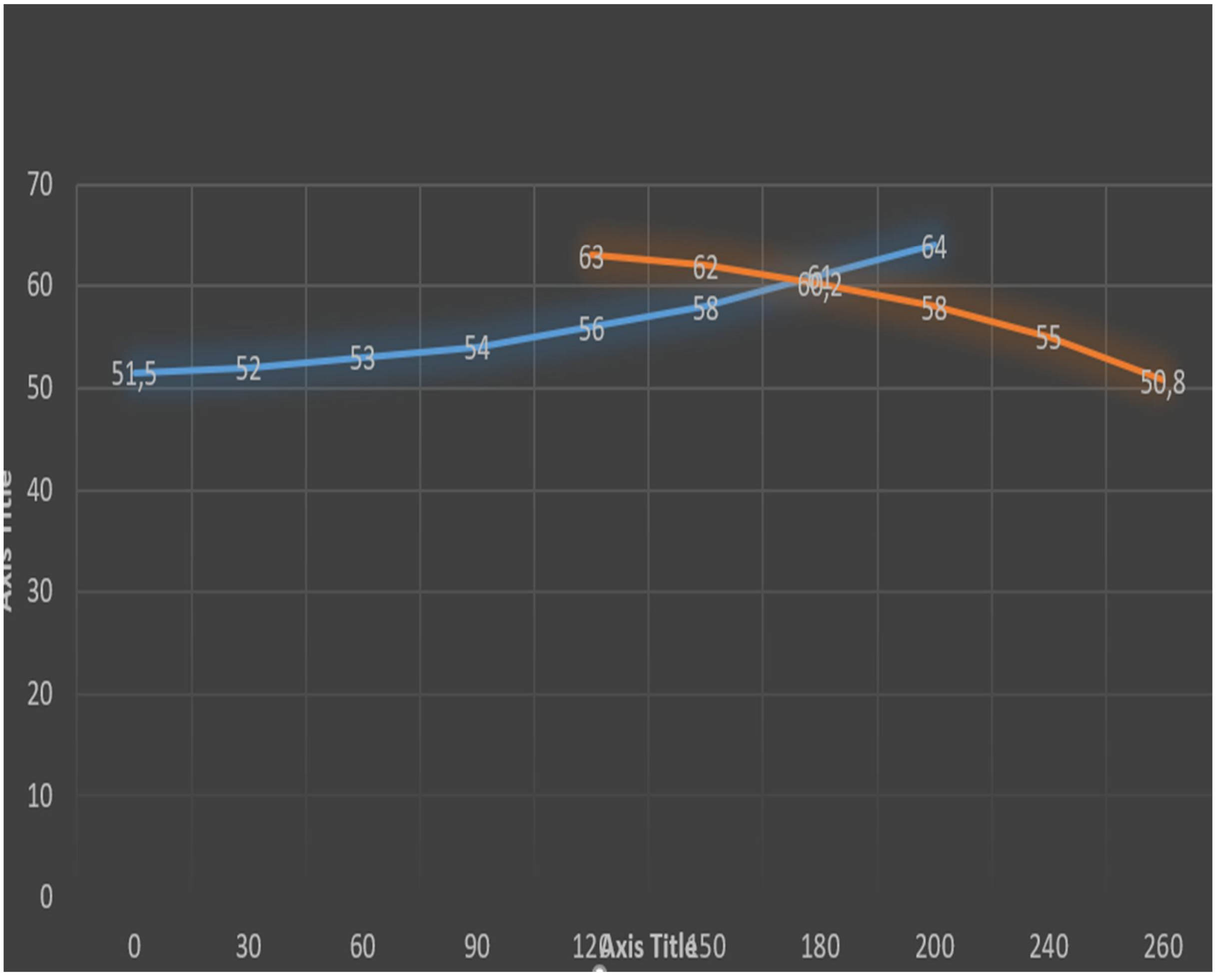

Fig. red: main characteristic of the pump 12D 9; blue: characteristic of the pipeline, the point of intersection of characteristics (Q=175 l/s; H=60 m).

The pump parameters in the operating mode (167 l/s, 61.5 m) will be:

power consumption: N_{cons} = 130 kW,

efficiency factor– 78%.

The permissible vacuum height is 6 m.

Pump Characteristics:

suction flange diameter D=300 mm,

discharge flange diameter d=250 mm,

pump weight 900 kg,

the weight of the electric motor is 1000 kg, the weight of the night together with the base plate is 3000 kg.

Determination of the maximum suction height:

At the pump installation mark (970 m) atmospheric pressure is:

P_{atm}= 9 m of water pillar.

The height of the maximum suction is determined at a maximum flow rate of

Q = 180 l/s = 0.18 m^3/s and a depth in the channel of at least h_1 = 1 m.

For a pump of the 12D9 brand, from the characteristics of the H_p^w-Q, we determined the maximum permissible vacuum value at sea level: H_p^w =6 m (*wp* – "water pressure").

The suction height of the pump will be:

$$h_s = H_p^w - h_w - \frac{v^2}{2g} = H_p^w - (\xi_{ent.} + \xi_{quant.} + 1)\frac{v^2}{2g}$$

The suction pipe has two sources of pressure loss: one at the entrance to the network and one at the 90° knee.

From the technical literature we have:

$$\varsigma_{enter.} = 5,\ \varsigma_{quant.} = 1{,}1.$$

The water flow rate in the suction pipe will be:

$$V = \frac{4Q}{\pi d^2} = \frac{4 \cdot 0{,}18}{3{,}14 \cdot 0{,}4^2} = 1{,}43 \text{ m/s.}$$

Neglecting the friction losses along the length of the suction pipe, we obtain:

$$h_S = 6 - (5 + 1{,}1 + 1)\frac{1{,}43^2}{2 \cdot 9{,}81} = 5{,}64 \text{ m.}$$

Since the atmospheric pressure at the height of 970 m of the pump installation mark is 9 meters of water jet, the maximum suction height will be:

$$H_S = h_S - 10 + H = 5{,}64 - 10 + 9 = 4{,}64 \text{ m.}$$

Conclusion:

The actual maximum suction height of the pump (at the current channel depth of 1 m) is 4.64 m, so the pump suction process is guaranteed.

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x-like biaxial voided concrete slab

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Abstract In the modern world, progress and development is a constant process. In order to build buildings with extraordinary and complex geometric shapes, existing building materials are improved and new materials are invented constantly, construction technologies are improved, as well as daily reporting programs are being refined, all this gives us new opportunities to design buildings with complex architectural shapes and come up with out of ordinary construction solutions.

One of the main structural elements of modern frame buildings is considered to be a slab, which is in a difficult stress-deformed state under the influence of static and dynamic loads. There are several types of slabs: conventional, flat, with a capital, waffle and voided slabs [1, 2]. The present paper discusses a certain type of voided slabs, more precisely, voided box-like biaxial slab. The structural elements of this type of slab create a unified rigid system. The structure is examined as a stand-alone structure as well as a part of the building. The study takes into account static and dynamic loads as well as seismic impacts in the form of an accelerogram. The paper emphasizes the advantages of using this type of rigid slabs in large span structures.

Key words: Large span reinforced concrete slabs, Voided slab, U-Boot, Cobiax, FEM Ansys APDL.

Introduction

Reinforced concrete box-like biaxial slab is a complex structure consisting of 3 load-bearing elements. These elements are: main and auxiliary vertical stiffness ribs, bottom and top binding slabs (Figure 1, Figure 2).

Reinforced vertical stiffness ribs are placed in the plan perpendicular to each other, the gaps between which are filled with a special lightweight, construction foam, or similar type of material. The lower and upper planes of the ribs are bonded with thin reinforced slabs. Reinforced slabs distribute the load on the supporting thin, vertical ribs, which in turn transfer the load to the main thick vertical ribs, while the main ribs are directly connected to the vertical load-bearing elements of the building - columns and pylons.

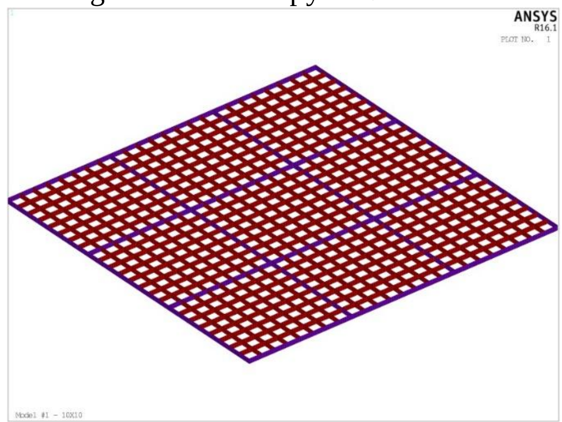

Fig. 1. Arrangement of main and auxiliary ribs

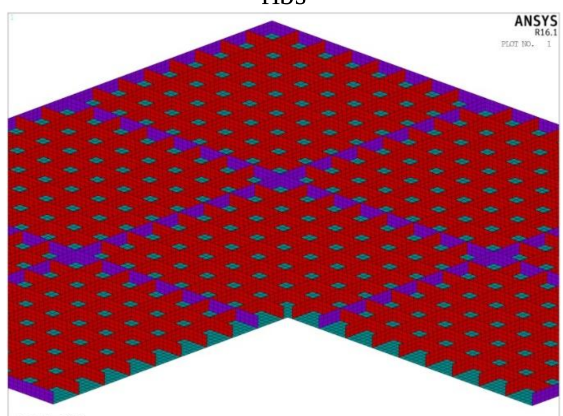

Fig. 2. Section of a box-like slab (only lower binding slab is visible)

The box-like structure allows us to get a rigid and light slab, as well as increase the size of the building span. The bottom surface of the box-like slab is also flat, giving architects and designers more opportunity for free planning.

In 2011, a patent was issued in Georgia for a similar type of slab, "Monolithic reinforced concrete skeleton" (patent number: U 2011 1651 Y) [3]. The author of the paper is also a co-author of the patent.

There are several systems of flat and light slabs in the world: U-BOOT BETON (Figure 3), U-BAHN BETON systems created by the Italian company DALIFORM GROUP [2, 4]

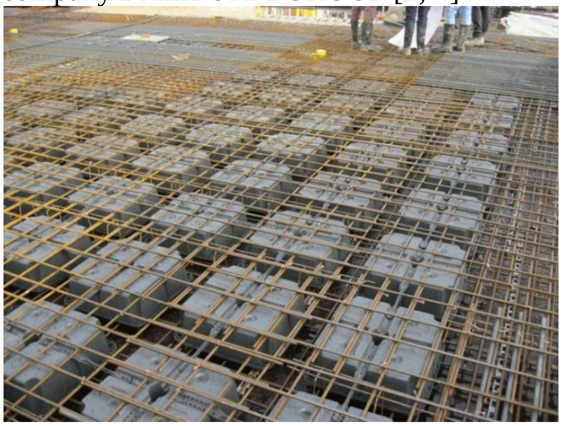

Fig. 3. U-BOOT BETON system

Also Cobiax SL (Figure 4), Cobiax EL systems created by the German company COBIAX. The main purpose of these systems is to lighten the structure of the slab [2, 5].

Fig. 4. Cobiax SL system

In the above-mentioned systems, the gaps are obtained from factory-made plastic products whose length and width or diameter do not exceed 52 cm, since these systems do not have an organized layout of load-bearing vertical ribs.

In contrast to these systems, our box-shaped slab ribs allow not only to alleviate the biaxial slab, but also to transfer the forces acting on them in an organized manner to the columns.

Main Part

Software complex Ansys Mechanical APDL. The Ansys finite element solvers enable a breadth and depth of capabilities unmatched by anyone in the world of computer-aided simulation. Thermal, Structural, Acoustic, Piezoelectric, Electrostatic and Circuit Coupled Electromagnetics are just an example of what can be simulated. Regardless of the type of simulation, each model is represented by a powerful scripting language the Ansys Parametric Design Language (APDL) [6, 7, 8].

APDL is like software; written on Fortran, in which we can enter thousands of commands of the analysis software Ansys (some commands represent an independent small algorithm). The software written using APDL allows us to calculate and investigate buildings of many shapes and sizes, where these types of slabs are used (different size and number of slabs, buildings of different heights and floors, different loads and their combination, different number of ribs in spans, different size of ribs, different materials, etc.). It is possible to obtain different types of solutions considering static, dynamic (including seismic) impacts, as well as to manage the inclusion of different methods in dynamics tasks (options for using spectral theory, different schemes of direct integration, use of different types of dimmers, etc.).

Using APDL we have created an analytical model of box-like biaxial slabs, therefore, with minimal intervention (modification) we can create and calculate models with different geometric shapes and sizes.

The structural elements of box-like biaxial slabs are approximated by the finite elements of the membrane represented in the program Ansys under the name Shell 181.

SHELL181 is suitable for analyzing thin to moderately-thick shell structures. It is a four-node element with six degrees of freedom at each node (Figure 5). SHELL181 is well-suited for linear, large rotation, and/or large strain nonlinear applications. Change in shell thickness is accounted for in nonlinear analyses. In the element domain, both full and reduced integration schemes are supported. SHELL181 accounts for follower (load stiffness) effects of distributed pressures. SHELL181 can be used for layered applications for modeling composite shells or sandwich construction. The accuracy in modeling composite shells is governed by the first-order shear-deformation theory (usually referred to as Mindlin-Reissner shell theory) [6, 7, 8, 9].

The element formulation is based on logarithmic strain and true stress measures. The element kinematics allow for finite membrane strains (stretching). However, the curvature changes within a time increment are assumed to be small.

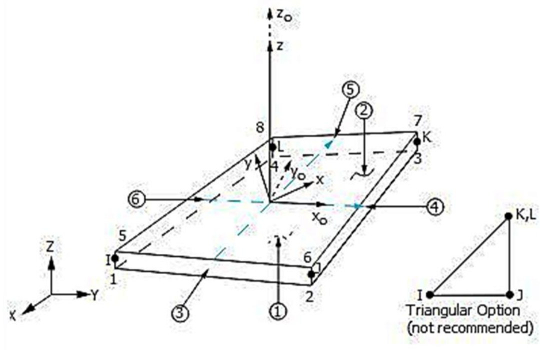

Fig. 5. Shell 181 Geometry

The element stress resultants (N11, M11, Q13, etc.) are parallel to the element coordinate system, as are the membrane strains and curvatures of the element. The program calculates moments (M11, M22, M12) with respect to the shell reference plane. By default, ANSYS adopts the shell midplane as the reference plane (Figure 6) [6, 7, 8].

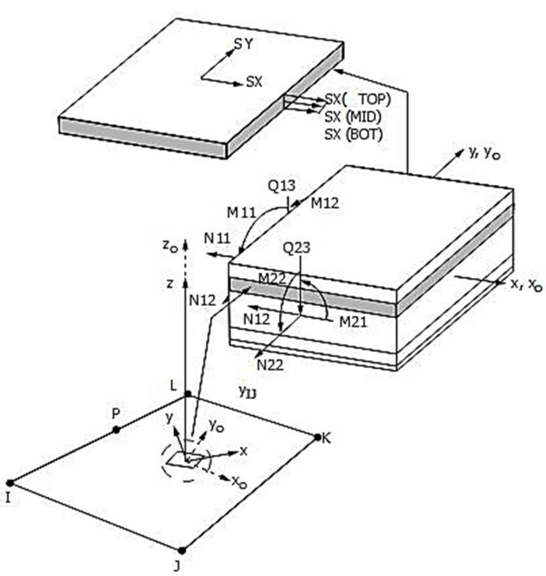

Fig. 6. Shell 181 Stress Output

The APDL model of box-like slab. Using APDL, we created an analytical model of box-like slabs. The model takes into account the geometric parameters of the structure (the size of the span, the number of ribs in both horizontal directions, the number of ribs, etc.), changing these parameters allows us to get a structure with various new geometric shapes.

The text file of the "software" written by us consists of more than 300 lines and dozens of different commands. Figure 7 shows a small fragment of a text file showing the initial variable parameters of the slab, the characteristics of the material used the creation of the joint's restraints and the modeling of an evenly distributed load on the surface of the box-like slab.

```
***GEOMETRY***

A=10.0       ! SPAN ON X DIRECTION (in meters)
B=10.0       ! SPAN ON Y DIRECTION (in meters)
NA=3         ! NUMBER OF SPANS ON X DIRECTION (quantity)
NB=3         ! NUMBER OF SPANS ON Y DIRECTION (quantity)
H=0.45       ! HEIGHT OF VOIDED SLAB (in meters)

NASWI=8      ! NUMBER OF AUXILARY RIBS ON X DIRECTION (quantity)
NBSWI=8      ! NUMBER OF AUXILARY RIBS ON Y DIRECTION (quantity)

NAS=5        ! RIBS MESHING NUMBER ON X DIRECTION (quantity)
NBS=5        ! RIBS MESHING NUMBER ON Y DIRECTION (quantity)
NHS=3        ! RIBS MESHING NUMBER ON Z DIRECTION (quantity)

FI=0.075     ! THICKNESS OF SLAB (in meters)
DZWS=0.4     ! WIDTH OF MAIN RIBS (in meters)
DAWS=0.2     ! WIDTH OF AUXILARY RIBS (in meters)

***LOAD***

Q=-1.0            ! DISTRIBUTED LOAD (T/M^2)

ACEL,0,0,9.81,    ! DEAD LOAD (self weight)
```

Fig. 7. Fragment from the APDL text file

We examined about 70 different models of box roofing. In this paper we discuss 3 models with different geometric shapes.

Model #1 is a 3-3 span box-like slab in the longitudinal and transverse directions, the length of each span is 10 meters, the height of the structure is 45 cm, the thicknesses of the main and auxiliary stiffness ribs are 40 and 20 cm, respectively, the thickness of the thin binding slabs is 7.5 cm. The pitch of the auxiliary stiffness ribs is 1.25 m. The material used is concrete grade B25, taking into account the model's own weight and evenly distributed static load on the surface – 1.0 t / m^2. The model rests freely on 16 supports.

Results obtained from the report: Maximum deformation of the structure - 8.5 mm in the edge spans of the structure (Figure 8); Figure 9 shows the distribution of the main tensile stresses ($\sigma 1$)

the maximum value was generated at the support, in the upper part of the rib – 9.274 MPa (945.7 t / m^2); Figure 10 shows the distribution of the main compressive stresses (σ3) of the main stiffness rib, the maximum value was generated at the support, in the lower areas of the rib – 16.266 MPa (1658.6 t / m^2); Figure 11 shows the distribution of the main tensile stresses (σ1) of the auxiliary stiffness rib, the maximum value was generated at the support, at the top of the rib – 6.591 MPa (672.1 t / m^2); Figure 12 shows the distribution of the main compressive stresses (σ3) of the auxiliary stiffness rib, the maximum value was generated at the support, in the lower areas of the rib – 6.324 MPa (644.9 t / m^2).

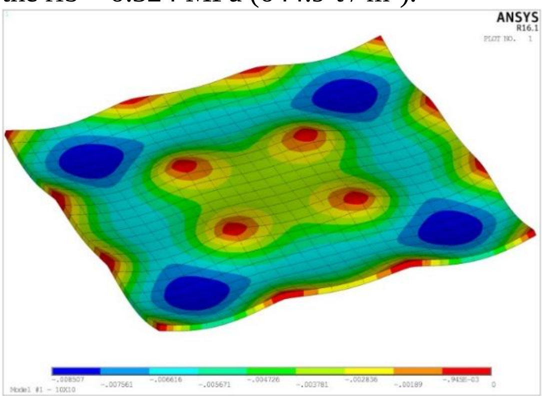

Fig. 8. Maximum deformation of the structure - 8.5 mm (scale is given in meters)

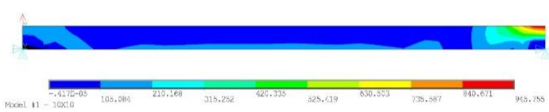

Fig. 9. Distribution of the main tensile stresses of the main stiffness rib (σ1 t / m^2). Maximum value – 9.274 MPa (945.7 t / m^2)

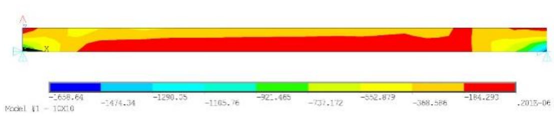

Fig. 10. Distribution of the main compressive stresses of the main stiffness rib (σ3 t / m^2). Maximum value – 16.266 MPa (1658.6 t / m^2)

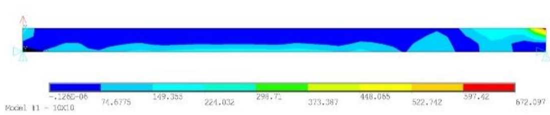

Fig. 11. Distribution of main tensile stresses of auxiliary stiffness rib (σ1 t / m^2). Maximum value – 6.591 MPa (672.1 t / m^2)

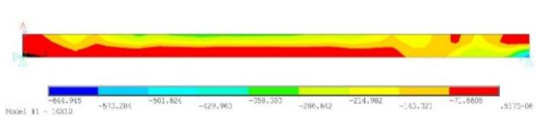

Fig. 12. Distribution of main compressive stresses of auxiliary stiffness rib (σ3 t / m^2). Maximum value – 6.324 MPa (644.9 t / m^2)

Forms and frequencies obtained by modal analysis of box-like slabs: Form I with a frequency of 9.15 Hz (Figure 13); II and III symmetric forms with frequencies – 9.479 Hz (Figure 13); Form IV with frequency – 9.553 Hz (Figure 14); Form V with frequency – 9.649 Hz (Figure 14).

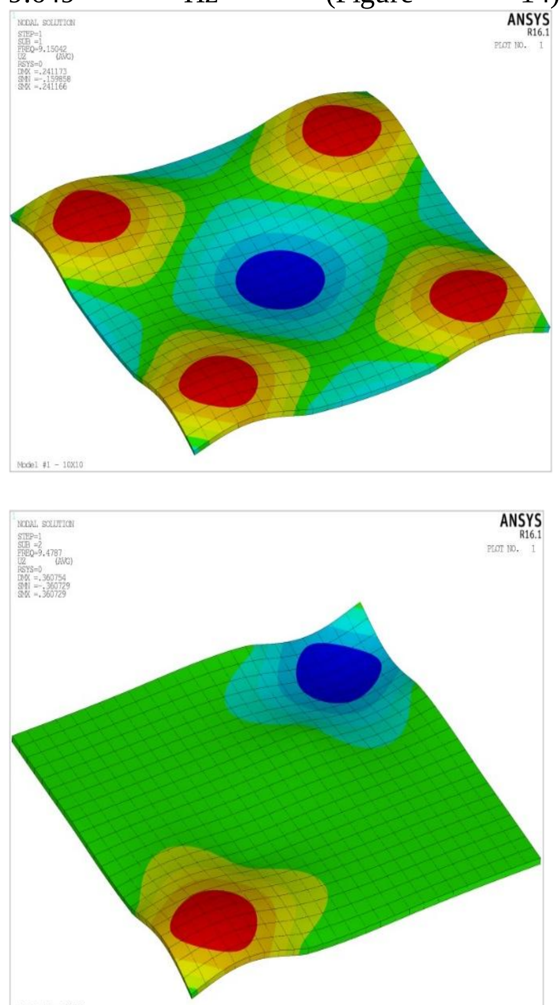

Fig. 13: I and II Forms and Frequencies of Model #1 slab (9.15 and 9.479 Hz)

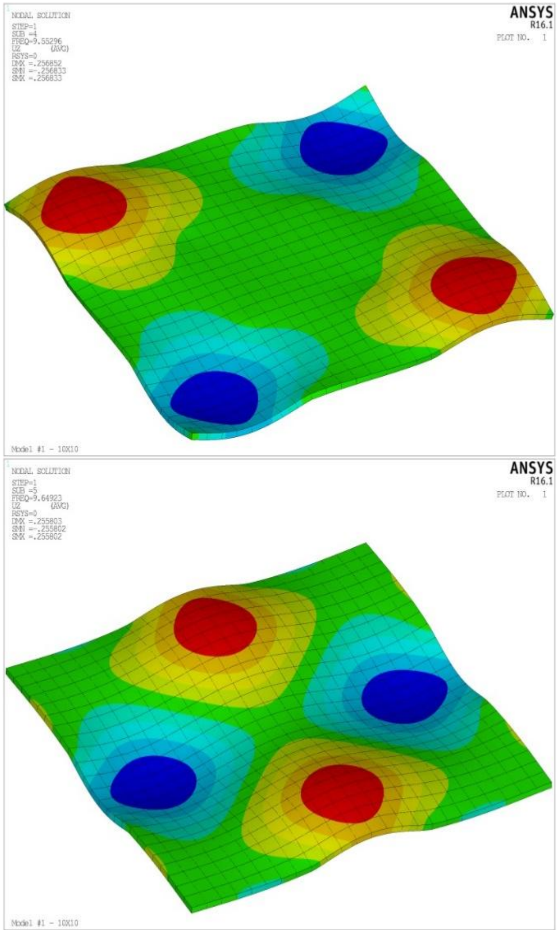

Fig. 14. IV and V Forms and frequencies of model #1 slab (9.553 and 9.649 Hz)

Model #2 is a 3-3 span box-like slab in the longitudinal and transverse directions, the length of each span is 12 meters, the height of the structure is 60 cm, the thicknesses of the main and auxiliary stiffness ribs are 40 and 20 cm, respectively, the thickness of the thin binding slabs is 7.5 cm. The pitch of the auxiliary stiffness ribs is 1.20 m. The material used is concrete grade B25, taking into account the model's own weight and evenly distributed static load on the surface – 1.0 t / m^2. The model rests freely on 16 supports.
Results obtained from the report: Maximum deformation of the structure – 10.2 mm in the edge spans of the structure. The distribution of the main tensile stresses (σ1) the maximum value was generated at the support, in the upper part of the rib – 10.116 MPa (1031.5 t / m^2); The distribution of the main compressive stresses (σ3) of the main stiffness rib, the maximum value was generated at the support, in the lower areas of the rib – 20.934 MPa (2134.7 t / m^2); The distribution of the main tensile stresses (σ1) of the auxiliary stiffness rib, the maximum value was generated at the support, at the top of the rib – 8.177 MPa (833.8 t / m^2); The distribution of the main compressive stresses (σ3) of the auxiliary stiffness rib, the maximum value was generated at the support, in the lower areas of the rib – 7.640 MPa (779.1 t / m^2).

Forms and frequencies obtained by modal analysis of box-like slabs: Form I with a frequency of 7.970 Hz; II and III symmetric forms with frequencies – 8.247 Hz; Form IV with frequency – 8.303 Hz; Form V with frequency – 8.340 Hz.

Model #3 is a 3-3 span box-like slab in the longitudinal and transverse directions, the length of each span is 14 meters, the height of the structure is 60 cm, the thicknesses of the main and auxiliary stiffness ribs are 40 and 20 cm, respectively, the thickness of the thin binding slabs is 7.5 cm. The pitch of the auxiliary stiffness ribs is 1.27 m. The material used is concrete grade B25, taking into account the model's own weight and evenly distributed static load on the surface – 1.0 t / m^2. The model rests freely on 16 supports.
Results obtained from the report: Maximum deformation of the structure – 18.5 mm in the edge spans of the structure. The distribution of the main tensile stresses (σ1) the maximum value was generated at the support, in the upper part of the rib – 14.342 MPa (1462.5 t / m^2); The distribution of the main compressive stresses (σ3) of the main stiffness rib, the maximum value was generated at the support, in the lower areas of the rib – 28.466 MPa (2902.7 t / m^2); The distribution of the main tensile stresses (σ1) of the auxiliary stiffness rib, the maximum value was generated at the support, at the top of the rib – 11.614 MPa (1184.3 t / m^2); The distribution of the main compressive stresses (σ3) of the auxiliary stiffness rib, the maximum value was generated at the support, in the lower areas of the rib – 10.769 MPa (1098.1 t / m^2).Forms and frequencies obtained by modal analysis of box-like slabs: Form I with a frequency of 5.938 Hz; II and III symmetric forms with frequencies – 6.162 Hz; Form IV with

frequency – 6.210 Hz; Form V with frequency – 6.266 Hz.

Conclusions

The ratio of the maximum deformations obtained to the size of the span is 1/1150 for Model # 1, 1/1150 for Model # 2, and 1/760 for Model # 3. Frequencies for all three models exceed 6 Hz. Consequently, the box-like slab is a rigid structure. By increasing the concrete grade, the height of the structure and the thickness of the ribs it is possible to balance the main stresses induced in the ribs. Based on the above-mentioned results, it is interesting to see how box-like slab works in multi-story buildings.

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Problems With Unfinished Buildings

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Abstract

There are unfinished construction sites in many cities around the world. Their existence not only creates problems for the purposeful development of urban planning, but also increases the danger of their constructions going out of order and the destruction of the buildings as a whole. In addition, the extremely unsanitary conditions created there have a negative impact on the natural environment. Unattended buildings are often visited by strangers to live there or to hold various events. This is associated with serious pollution of the area and great danger of accidents. Animals carrying va
rious infectious diseases, rodents, insects (dogs, cats, rats, mice, mosquitoes, flies and other living organisms) gather and reproduce on such neglected and abandoned objects.

Key words: building, construction, abandonment, dismantling, risk, annotation.

1. Introduction

There are a lot of abandoned construction sites in the cities of Georgia, which have been left unattended for several decades and represent a center of great risk. An example of this is an unfinished residential house on Tskneti Street in Tbilisi. In the most prestigious district of Tbilisi, it was built for its employees by one of the largest construction unions during the Soviet Union, Sakhidroenergomshen. In the early 1990s, Georgia's declaration of independence was followed by the cessation of centralized funding, and for 35 years since then, nothing has been done to finish the work started due to lack of funds. So far, the issue of dismantling the existing frame has not been resolved. In addition to the fact that people who have invaded the site are often forced out, due to the lack of a roof, the risk of damage to structural elements protected from natural precipitation and their junctions is increasing every year (Fig. 1).

Fig. 1. An unfinished house

At the same time, it has long prevented the development of infrastructure in the surrounding area and the full perception of the architectural solution of the new, modern-style buildings built near it.

In the same period, again due to lack of financial resources, the construction of a frame 16-story residential building in Borjomi resort was stopped on the 10th floor. In harsh climatic conditions, for many decades, the bearing capacity of the unsealed frame assembled with columns and coils has been reduced to such an extent that there is a danger of the building collapsing at any moment. Such a situation can have dire consequences. Especially since there are sports and recreation areas in its immediate vicinity. Dismantling of the emergency frame requires quite substantial funds, the allocation of which is very doubtful under the conditions of the district's meager budget. The only solution is to find an investor interested in this place, which has not yet appeared. A similar situation exists with regard to the unfinished frame of one of the educational buildings built in the late 80s of the last century, in front of the high-rise building of Tbilisi State University, near the road. Over time, the scraps of reinforcement of the structural elements of the reinforced concrete frame and their connecting nodes are so damaged by corrosion that they already fall apart by themselves. Fortunately, such facts have not led to an accident, but the frame definitely requires dismantling. Unfinished facilities include the conversion of the former Ministry of Agriculture building into the Tbilisi Hilton hotel in Tbilisi. which was supposed to be opened in 2019. Due to the mistakes made in the construction management, no work has been done on the object for 7-8 years, and if measures are not taken in time, it will definitely be subject to dismantling (Fig. 2).

Many more unfinished buildings can be listed throughout Georgia, which were started during the Soviet Union and stopped due to the change of the political system in the country. It should be noted that conservation work has not been carried out on almost any of them. Due to the restriction of the entry of strangers to the unfinished facilities and the lack of elementary conditions for safe movement there, many accidents occur, including many with fatal results. In various countries and cities of the world, there are unfinished buildings of greater cale and importance, the condition of some of which is described below.

Fig. 2. Tbilisi Hilton frame

2. Main part

As of June 2024, the tallest unfinished building in the world is Goldin Finance 117 (China 117) in one of the largest cities of China, Tianjin (Fig. 3). The construction of the super-tall, 597 m high skyscraper began in 2009 and was supposed to be completed in five years. Initially, it was intended for the rich, elite population, and the financiers spared no money for its realization. However, many doubted the viability of the project from the beginning. The owner of the building, Goldin Properties (Goldin Financial Holdings Ltd.), was implementing such a grand project for the first time and encountered many problems during the construction process. Difficulties appeared already in 2010 in connection with the world economic crisis, and the construction stopped for almost a year. In 2015, the construction of the building's frame was completely completed, but after the Chinese stock market crash in June 2015, construction was halted until today. One of the main problems of financing is the existing rule of receiving facilities in China. The owner has the right to start the sales process only after the inspection and acceptance of the object by the authorities. In addition, the Chinese government banned the construction of skyscrapers taller than 500 meters a few years ago, and when this building is completed, it will be the last skyscraper taller than 500 meters in China. Although this last ban does not apply to the mentioned facility, it has been almost ten years since it was not possible to mobilize funds to continue the works. At the same time, it turned out that the location of the building was chosen incorrectly from the beginning. It is located in an active industrial area, but for this very reason there were very few buyers. Instead, many are interested in climbing the top floor of the unfinished skyscraper and the cranes located there. Despite the increased protection of the object, such arbitrary ascents by representatives of different countries of the world take place almost every year. They usually videotape their unofficial visit and spread the footage of the extreme ride all over the world via the Internet.

Fig.3.Goldin Finance 117

The second tallest unfinished building in the world is Ryugyong Hotel, a 330 m high pyramid-shaped skyscraper in Pyongyang, the capital of North Korea (Fig. 4). Its construction began in 1987 and it was supposed to break the record of the Westin Stamfordis, the tallest hotel in the world built in 1986 by a South Korean company in Singapore. In 1992, the framework of the building was completed, but due to the collapse of the Soviet Union, the financing of the facility and the production of works were immediately stopped. The government managed to resume construction only in 2008. It was planned to open in 2012, but again due to financial problems it was postponed indefinitely.

Fig.4. Ryugyong Hotel

The hotel consists of three wings that meet at the highest point, and from the observation decks there, the whole city can be seen in the palm of your hand. Each wing is 100 m long and 18 m wide. In 2018, an LED display was installed on one wing of the building. It is used to show propaganda films and animations. The project of the building was also propagandistic from the beginning, and it is clear that no one paid much attention to its location and architectural solution. This was especially evident in modern conditions, but despite many efforts of the government, the hotel could not be completed. Worldwide, this building has long been the object of ridicule and ironic expressions. Some call it the worst building in the world, others consider it the embodiment of the current government, etc.

In 1990, the construction of a 60-story office skyscraper, the "Tower of David", began in Caracas, the capital of Venezuela. The construction was financed by millionaire David Bielenburg, and the facility received this name in his honor. In 1993, when 45 floors were built, due to the financial crisis in the country and the sudden death of the main investor, the descendants of the millionaire could not find the funds to continue the work, and the construction was stopped. After the revolutionary coup in the country and the arrival of a new government, in 2000 the building was arbitrarily invaded by the homeless of Caracas. The government did not take any measures to evict them, and the facility turned into the tallest "homeless skyscraper" in the world. There are still no windows, walls and railings. More than 3,000 people continue to live in the building, whose physical and sanitary condition is deteriorating, literally without observing any safety norms (Fig. 5).

Fig.5. "Tower of David" in Caracas

It should be noted that only the 28th floor of the building is equipped with electricity and water supply. Despite the lack of basic living conditions, the population pays utility bills to the government and arbitrarily continues to carry out various renovation works inside the unfinished building, which often makes life there even more dangerous. For example, playgrounds and children's playgrounds are arranged in open spaces without railings and without walls. In the conditions of such anarchy, accidents often happen, but no one cares to correct the situation, especially since there are still many homeless people living in the country and the political situation inside is very tense.

In Bangkok, the capital of Thailand, there is one of the world's tallest and most famous unfinished buildings "Satorna Tower" (Fig. 6). Construction of the 49-story, 185-meter-tall, 600-unit luxury residential building of reinforced concrete decorated with carved columns and balconies in the ancient Greek style began in 1990 in the Satorna district.

Fig.6. "Satorna Tower"in Bangkok

During this period, Thailand experienced the greatest economic progress. The unprecedented progress of the country was indicated by the numerous high-rise constructions going on there. In connection with the 1997 Asian financial crisis, money in Thailand devalued literally overnight. The financing company of the said object was the first to go bankrupt and soon it was completely liquidated, because they had already caused serious problems due to sales. The area in question was not considered prestigious, and only the distinctive architecture of the building, a tasteful fusion of old and new styles, was not enough to attract wealthy people. The work was stopped so suddenly that the 80% completed building is still in the same condition today. It should be noted that during the financial crisis, the construction of more than 300 high-rise buildings in Bangkok was suspended at the same time. As the economy recovered, most of them were completed, but Bangkok remains the city with the most unfinished high-rise buildings in the world. People's interest in the unfinished building was great from the beginning. Everyone wanted to go in there and have a look. Such arbitrariness led to many accidents. The number of suicides increased a lot (the number exceeded 40) and the authorities blocked all entrances and exits. The huge building, without which today's Bangkok is unimaginable, was called "bad" by the residents. It is only used to display advertising banners, and people believe that the reason for its incompleteness is that it should not have been built on the site of a cemetery. This disturbed the dead and only "evil spirits" can live there. The fate of the building is not clear at all. According to the current financial calculation, its renovation and completion will cost much more than the construction of a new similar building.It should be noted that due to the lack of fire protection systems in unfinished buildings, many cases end with serious damage. The best example of this is the Cathedral of New York, where in 2001, due to a strong fire, the entire building were so damaged that it took the next 7 years for restoration work. Its construction began on December 27, 1892 and is still unfinished. Because of this, he is ironically called "St. John the Unfinished".

Conclusion

1. Unfinished buildings, regardless of their purpose, create great difficulties in the development of cities. They prevent the production of new buildings and the development of infrastructure in the surrounding areas. Over time, in an unfinished, unroofed building, due to the impact of natural precipitations and climatic conditions, there is a risk of damage to its structural elements and the entire structure;
2. The main reason for the existence of unfinished buildings is the incorrect calculation of expected risks before the start of construction. These risks include: economic crises; inappropriate funding sources; lower than expected sales figures; unreliable investors, etc. The world construction practice has shown that this process is most affected by the change of political structure in the countries and revolutionary transformations;
3. Animals carrying infectious diseases, rodents, and insects usually gather on unfinished, neglected and abandoned facilities, and it gradually becomes a center of unsanitary conditions. In addition, it is impossible to protect such buildings from the entry of strangers, whose movement there often ends in accidents. The lack of fire protection is especially dangerous. comes with.

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Impact of climate change on Immovable Monuments of Cultural Heritage

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Abstract Climate change represents a significant threat to immovable cultural heritage sites globally, impacting buildings in diverse ways. This article delves into the complex effects of climate change on structures, emphasizing the direct risks posed by extreme weather events such as hurricanes, floods, and heat waves. These events can lead to structural damage, water intrusion, mold growth, and other forms of both tangible and intangible harm. Additionally, climate change can severely compromise and, in some instances, destroy building materials and foundations.

FIGURE 2. Average monthly temperature and rainfall in Georgia (1991-2020)[19]

Temperature extremes result in thermal expansion and contraction of building materials, causing cracks and structural weakening. Additionally, increased rainfall intensity or prolonged drought can lead to soil and foundation instability. Climate-induced erosion further destabilizes buildings situated on slopes or in landslide-prone areas. The concurrent vulnerability of various infrastructure components, including drainage and sewerage systems crucial to building sustainability, indirectly exacerbates these impacts.

Mitigating these challenges requires building climate-resilient buildings or adapting existing ones as much as possible, which is achieved by integrating robust materials and construction techniques that can withstand extreme weather, strengthening drainage infrastructure, and using energy-efficient designs to reduce environmental impact and reduce energy demand. By implementing proactive measures, buildings can better withstand the aggressive effects of climate change, ensuring the preservation and longevity of cultural heritage sites around the world.

Key words: climate change, cultural heritage sites, buildings, impacts, monument, temperature, precipitation, sea level rise, Vulnerability, map, immovable monument.

Introduction

Climate change presents a significant threat to immovable cultural heritage sites worldwide. The impacts on buildings are diverse and severe. Extreme weather events such as hurricanes, floods, and heat waves can inflict substantial damage. Hurricanes and storms can cause structural damage, floods can lead to water intrusion and mold growth, and heat waves can result in the deformation of building materials. Coastal buildings are particularly vulnerable to sea level rise, which can cause erosion, flooding, and saltwater intrusion, damaging both materials and foundations. Temperature extremes can cause thermal expansion and contraction of building materials, leading to cracks and structural weakening. Additionally, increased demand on cooling systems during high temperatures can significantly affect energy consumption.

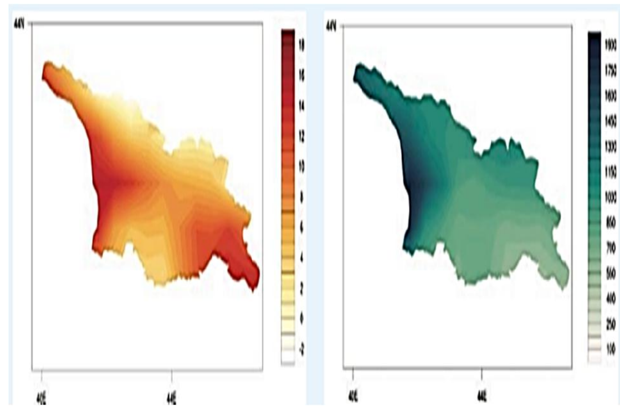

[2]

Changes in precipitation, such as increased rainfall intensity or longer periods of drought, can affect buildings. Drought can cause soil compaction and foundation compaction. Erosion and soil instability are also crucial factors. Climate change may increase erosion and soil instability, affecting the stability of buildings built on slopes or in landslide-prone regions and their structural sustainability.
Currently existing infrastructure is increasingly vulnerable to the effects of climate change induced by global warming. For instance, drainage and sewerage systems, which are crucial for the sustainability of buildings, are often not fully adapted to changing conditions, leading to indirect impacts on structural integrity. To mitigate these effects, buildings can be designed and constructed with climate resilience in mind. This includes using materials and construction techniques that withstand extreme weather, enhancing drainage systems, and adopting energy-efficient designs to minimize environmental impact buildings.

Main Part

Assessing the impact of climate change on immovable cultural heritage requires a multidisciplinary approach that combines scientific research, cultural heritage expertise and community engagement. Here are some research methods that are commonly used for this purpose:

1. Climate Modeling: Climate models can be used to predict future climate scenarios, including changes in temperature, precipitation patterns, sea level rise, and extreme weather events. These models help predict potential climate-related threats to cultural heritage sites.

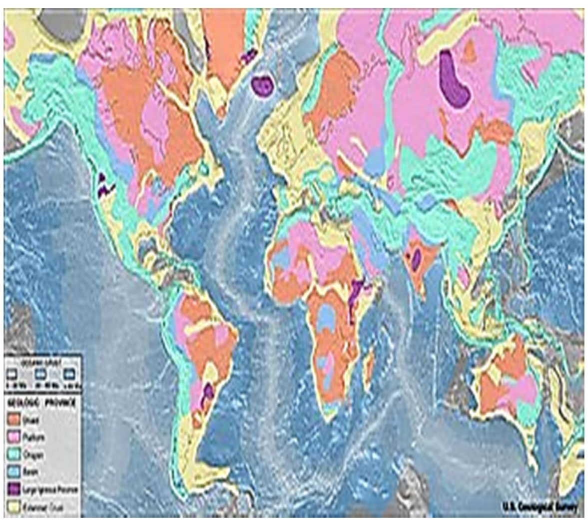


2. Historical Data Analysis: Examine historical climate data to determine trends in temperature, precipitation, storm frequency, and sea level rise. Historical records can provide information about past climate impacts on cultural heritage and predict future ones.
3. Site surveys and monitoring: Field surveys and monitoring programs should be carried out to assess the current condition of cultural heritage sites and to confirm any existing damage or vulnerability. Monitoring programs may include the use of sensors, remote sensing technologies, and visual inspections.
4. Risk assessment: Using all the factors at our disposal, we should conduct risk assessments to assess the sensitivity of cultural heritage sites to various climate-related hazards, such as floods, erosion, extreme temperatures and forest fires. Factors such as site location, building materials, structural

[2] NF P92-502 Building materials fire reaction tests https://www.laboratoar.com/ka/testler/urun-guvenligi-testleri/nf-p92-502-yapi-malzemeleri-yangin-reaksiyon-testleri/

integrity, and environmental conditions may be considered in the evaluation.

5. Vulnerability Mapping: This issue involves the creation of vulnerability maps in cultural heritage sites to identify high-risk areas and prioritize adaptation and mitigation efforts. Maps can include data on climate hazards, site characteristics, cultural significance, and causes of concern for stakeholders. Climate change vulnerability mapping involves assessing and understanding the factors that contribute to the vulnerability of a community or region to the impacts of climate change. Here are the basic steps and considerations for map security.



One of the primary issues is the identification of climate hazards. Specific climate hazards relevant to the study region need to be identified. Issues may include rising temperatures, changes in pre-existing precipitation patterns, rising sea levels, extreme weather events (hurricanes, floods, droughts), etc.

The next step in vulnerability mapping is exposure assessment, which involves determining how exposed a community or region is to these climate hazards. This involves mapping the geographic distribution and intensity of each hazard.

Depending on the content and purpose, they will distinguish:

specifically geological,
anthropogenic (Quaternary) sediments,
tectonic,
lithological,
formative,
paleogeographical,
metamorphic facies,
mineral,
hydrogeological,
Prognozuli et al. Maps.

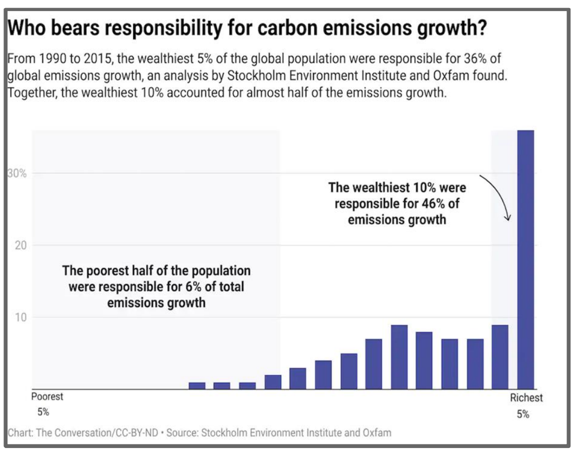
By analyzing which maps of Mokvladonbi are obtained.

U. A map drawn by Smith

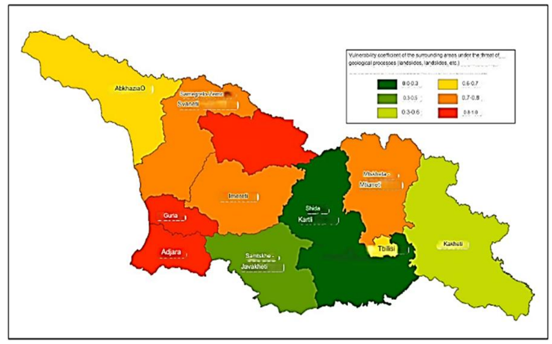
We are continuing our work with a sensitivity assessment report. It is necessary to assess the sensitivity of a community or region to identified climate hazards. This includes assessing how sensitive physical, social, economic and environmental factors are to climate change impacts. Factors such as infrastructure, ecosystems, health, economics and demographics need to be considered

Assessment of adaptive capacity, which refers to the adaptive capacity of a community or region, which refers to its ability to cope with

and respond to the impacts of climate change. Factors such as governance, institutions, financial resources, technology, education, social networks and community cohesion play a critical role in determining adaptive capacity.
Data collection and analysis Collect relevant data through field surveys, remote sensing, historical records, stakeholder interviews and other methods. Analyze data to identify patterns and trends related to vulnerabilities.
It is recommended that preliminary maps be created that integrate the collected information on exposure, sensitivity and adaptability. Geographic Information Systems (GIS) can be particularly useful for visualizing spatial data and identifying areas of high vulnerability.
Stakeholder Engagement Engage stakeholders throughout the process to ensure local knowledge and perspectives are integrated into the vulnerability assessment. This can help validate findings and ensure that adaptation strategies are contextually appropriate.



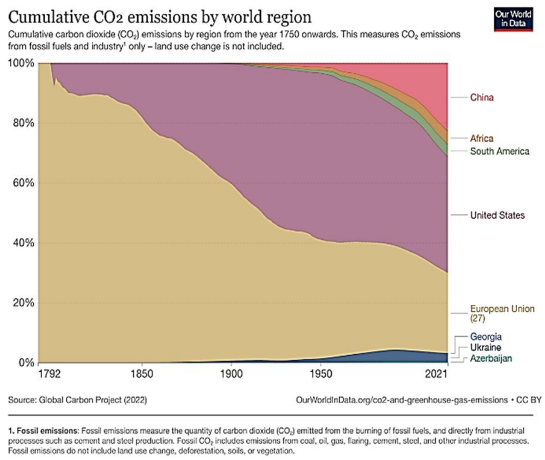
Risk assessment should be combined Vulnerability mapping with risk assessment to prioritize actions and interventions. Identify vulnerability hotspots where immediate action may be needed to reduce risks and improve resilience.
Scenario planning, which involves considering future climate scenarios to predict how vulnerability might evolve over time. It helps to plan adaptive strategies that are robust and flexible.
Integrating policy and planning Ensure that vulnerability mapping is integrated into local, regional and national policy and planning processes. This can help put climate adaptation on the development agenda and ensure coordinated action.



Map 4.9.3: Vulnerability of settlements to geological hazards by country

Mapping vulnerability to climate change is a dynamic process that requires constant monitoring and adaptation as new data become available and climate change continues. Effective vulnerability mapping can inform targeted interventions and policies that enhance resilience and reduce the impacts of climate change on vulnerable communities.
Hydrological and geotechnical studies: Conduct hydrological and geotechnical studies to assess the impact of climate change on soil stability, groundwater levels and drainage systems at cultural heritage sites. These studies help identify potential risks of erosion, landslides and water damage.
Cultural Landscape Analysis: Landscape analysis of cultural heritage sites to understand how climate change may alter their ecological, aesthetic and social value. Consider the interaction of natural and cultural elements within a landscape.
Community Engagement and Stakeholder Consultation: Local communities, subject matter experts, professionals, government agencies and other stakeholders should be involved in the research process from the outset. Their knowledge and experience are essential for understanding the cultural significance of heritage sites and for developing effective adaptation strategies.
Archaeological and Architectural Documentation: Conduct archaeological and architectural surveys to document the cultural heritage of vulnerable sites and assess the potential impacts of climate change on archaeological remains, historic buildings and

monuments.



Using a combination of these research methods, scientists, scholars and heritage practitioners can gain a comprehensive understanding of the impacts of climate change on immovable cultural heritage and develop strategies to protect and preserve these invaluable assets for future generations.

Conclusions

In conclusion, assessing the impact of climate change on cultural heritage requires a comprehensive and interdisciplinary approach that integrates scientific research, cultural knowledge, and community engagement. By utilizing climate modeling, historical data analysis, site monitoring, risk assessment, vulnerability mapping, hydrological and geological analysis, cultural landscape assessment, stakeholder consultation, and archaeological documentation, experts can effectively evaluate the vulnerability of cultural heritage sites. This multifaceted approach not only enhances our understanding of climate change effects but also provides adaptive strategies crucial for preserving our diverse cultural heritage amidst environmental challenges. Bringing together scientists, scholars, and heritage practitioners, this collaborative effort aims to safeguard our shared cultural heritage for future generations.

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Methodology for systematic analysis of buildings for reconstruction

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Abstract: The article considers the methodology of systematic analysis of the reconstruction buildings.

The article considers the methodology of systematic analysis of the reconstruction buildings. Based on the conducted research, the paper makes the following conclusions: in order to avoid subjective opinions of experts (especially at the first stages), the plan of the process of recommended building reconstruction provides the possibility to identify a number of formal methods and procedures as much as possible, which makes the process more efficient and allows to maximize the use of automation and computer technologies, which increases the efficiency of construction inspections, reduces production time, as well as cost and time.

Keywords: reconstruction, building, analysis, methodology, structural diagram**.**

1. Introduction

The system approach to the study of complex building structures in building reconstruction is of a comprehensive nature. The reconstruction building is considered as a complex system with all necessary attributes: the presence of subsystems (elements) united by links (physical, logical, mathematical), as well as the fulfillment of the condition of functional integrity. In the study of building structures of the reconstruction building the following basic logical elements are distinguished in the system analysis: goal (or goals); study of alternative means to achieve the goal (physical or mathematical modeling); resources for problem solving; systems of connection between goals, means and resources, criteria for selecting preferred alternatives.

2. Main body of the paper

With the system approach, the choice of methods of research of building structures of the building needing reconstruction or changing the functional purpose is made taking into account their role as a whole. Optimal characteristics of the system elements, physical non-mathematical models are considered as a single means of achieving the goal. Therefore, physical and numerical experiments should be coordinated with each other from the very beginning, should be oriented to the effective solution of the research problem and complement each other when considering the research process of the building construction as a separate system. Three main subsystems should be distinguished:

Experimental research on physical models of building renovation; computational research on mathematical models; linking the experiment with the report, which includes identifying some parameters of the computing model, checking its adequacy and correction. At the same time, the use of mathematical methods is still important due to the disproportion between and the high level of automation of the calculation process itself and the algorithms for the construction of calculation models of real buildings what allows obtaining the results depending on the subjective features of the study. Reliable results can be obtained experimentally. However, due to the complexity of the instructions and facilities, the labor intensity, cost and time of the research increase significantly. This is also true for physical modeling methods.

The reconstruction project should present principled approaches to optimize the process of research of complex structures on the basis of system analysis. In addition, physical and mathematical modeling of the buildings for reconstruction should be rationally coordinated in solving the presented problem. Mathematical methods are the main reference. Physical experiment is used only to refine and verify the reference model of the reconstructed building. This has prompted the use of focused physical models developed based on functional similarity, which simplifies the construction models of the building under reconstruction and reduces the cost of experiment supplies. In research the maximum possible distinction of formal methods allows to reduce the influence of subjective factors on the results. It is necessary to use automation. At the same time, it should be noted that the role of informal methods remains important in the study of complex structures of a reconstruction building, which makes the process of the research a combination of scientific methods and the experimenter's art.

When a building is reconstructed or its purpose is changed, it is increasingly necessary to develop mathematical and physical models for the study of building structures.

The principal approaches to optimize the process of studying complex building structures of buildings under reconstruction on the basis of system analysis are presented below. In addition, physical and mathematical modeling is rationally coordinated in solving the given problem. Mathematical methods are the main means. Physical experiment is used only to refine and verify the reference model of the reconstructed building. This has prompted the use of focused physical models developed based on functional similarity, which simplifies the construction models of the building under reconstruction and reduces the cost of experiment supplies.

The unity of physical and mathematical models leads to the uniformity of description of their characteristics and effects (input parameters), as well as to the uniformity of functional parameters of their state (output parameters), for which symbols and some basic definitions of the theory of algorithms and set are used. The features by which a reconstruction building differs from others form a set of parameters P. The change of external conditions affecting the state of a reconstruction building is characterized by a set of load effects N=$\{n_k\}$. It is clear that the sets P and N contain only properties and effects related to the studied building reconstruction tasks. As a rule, they are defined together with the reconstruction task before the research begins.

In the computational models of the reconstruction building, the set P is divided into two subsets: M=$\{m_2\}$ (building parameters known a priori) and X=$\{x_i\}$ (parameters to be determined during the building survey). Thus P =MUX. Thus, the result of the building survey is a set of stress-strain state parameters Y=$\{y_i\}$.

The sets P and Y should unambiguously characterize the state and behavior of the reconstructed building in the aspect of interest to the researcher both before and after the application of influences N. When solving the problems of a particular study building, it is necessary to pay attention to the correctness of their choice. We are guided by the fact that a functional correspondence is established between the sets N, P and Y of the reconstructed building, which is as follows:

For every $P_s \in$ P and $n_k \in$ N

corresponds to at least one element $y_i \in$Y

For every $y_{i\tau} \in$Y

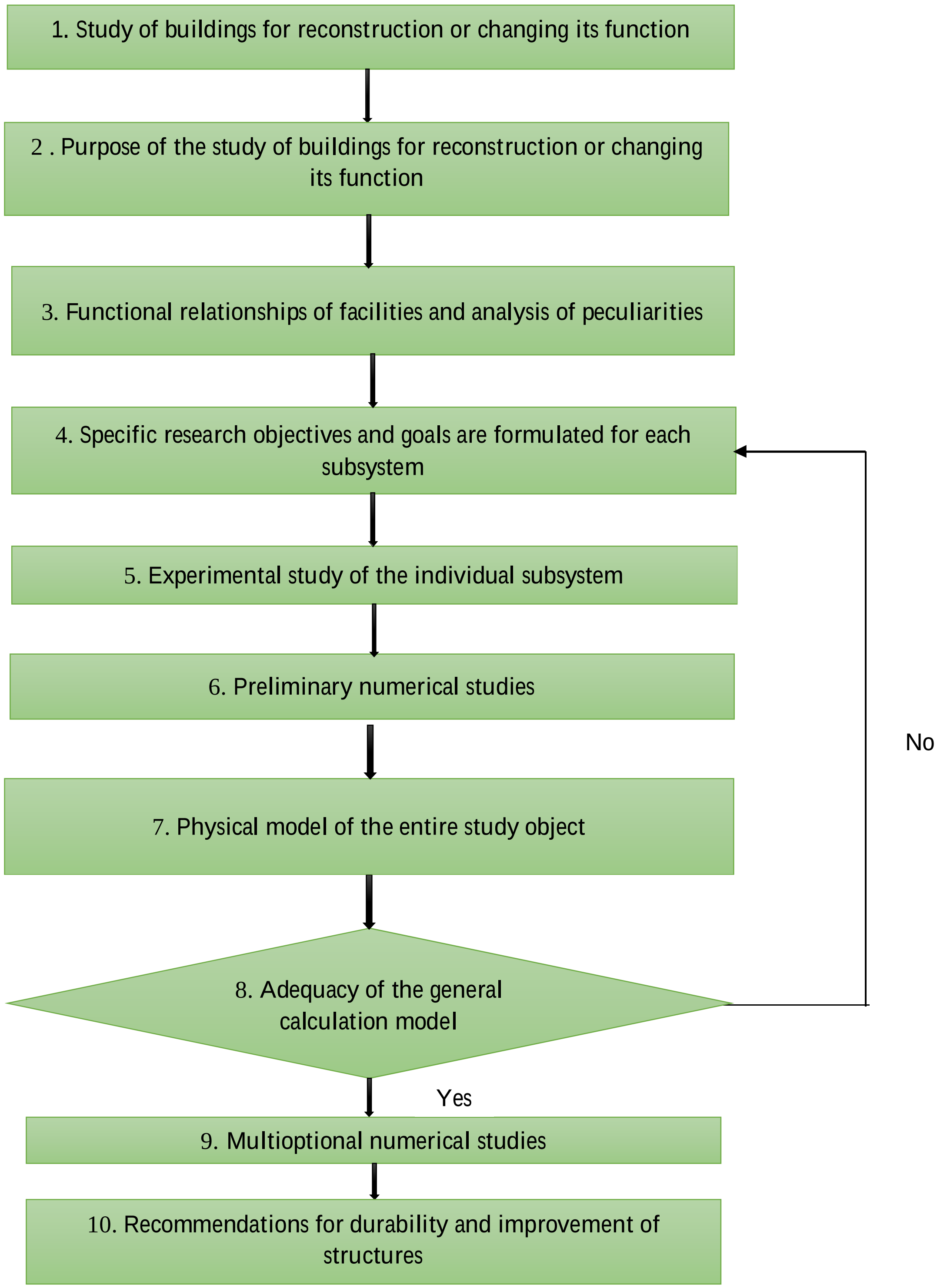
For every $y_{i\tau} \in Y$

corresponds to a single non-empty set $\vec{P}$< P and $\vec{N}$< N

In addition, the existence of some functions is likely

$$y_i = f_i, \vec{N}.$$

A block diagram of the building to reconstruct survey process is developed, which is shown in Fig. 5.


1. Study of buildings for reconstruction or changing its function
2 . Purpose of the study of buildings for reconstruction or changing its function
3. Functional relationships of facilities and analysis of peculiarities
4. Specific research objectives and goals are formulated for each subsystem
5. Experimental study of the individual subsystem
6. Preliminary numerical studies
No
7. Physical model of the entire study object
8. Adequacy of the general calculation model
Yes
9. Multioptional numerical studies
10. Recommendations for durability and improvement of structures

The considered system approach allows us to present the process of investigation of stress-strain state of complex structures of a building for reconstruction as a structural block diagram (Fig. 5), which will allow us to approach our goal more effectively.

Block 1. The study of complex building structures subject to reconstruction or change of functional purpose should begin with a detailed analysis of the object of research and a detailed analysis of the current issues on the problem:

- Study of the working drawings and other documentation of the study building;
- Analyzis of the functional purpose and working conditions of the building;
- Identification of distinctive features and peculiarities in comparison with previously studied similar buildings;
- Familiarization with the methods and results of previously conducted building research.

Based on the analysis, the importance and novelty of the problem will be assessed, the research task is specified taking into account the existing resources, their needs and possible policy constraints on them.

Block 2. After specifying the task, the objective(s) of the building investigation is formulated what is very important because the organization of the task solution, its strategy and tactics depend on the clarity of the objective. It is the correctly chosen goal allowing for rational allocation of resources. The researcher's work at this stage is characterized by the following principles:

- Breaking down the overall goal into more specific sub-goals;
- When defining the goal, setting the parameters that will allow us to do the following in a clear and specific way:
- To the extent posisble, formulating several options of the goal depending on the need for resources to achieve it, analyzing and evaluating the allocation of available resources. After setting the final goal, the master plan (program) of the building survey: the methods of organizing work and solving the presented tasks will be developed. Since there are practically no formal methods at the first stage of the building survey, they should be developed by a high-level performer.

Block 3. The functional relationships of the buildings being reconstructed and peculiarities of operation of individual elements for possible decomposition of complex systems into simpler subsystems are analyzed.

Block 4. After breaking down, the goals and objectives of the Shannon private study are formulated for each subsystem. Accordingly, for each i-subsystem a more appropriate a priori computational model is selected and Mi set of known values, Xi set of unknown values, Hi own systems of impacts and Yi parameters of the stress-strain state are determined.

Block 5. After breaking down, the goals and objectives of the Shannon private study are formulated for each subsystem. The parameters Yi of the stress-strain state, necessary for further determination of the unknown parameters Xi of the corresponding calculation models, are also determined experimentally.

Block 6. Preliminary numerical studies of the calculation models of subsystems of the building under reconstruction are performed. According to the experimental data, the unknown parameters Xi of the building calculation models are determined and the general calculation system of the study building is synthesized.

Block 7. Based on a similar functional method, a physical model of the whole reconstructed building will be developed and its experimental study will be performed.

Block 8. The adequacy of the general calculation model of the building to the statistical results of the experiment and numerical study of the functionally similar model is verified. If such verification gives a positive result, we proceed to the following procedures; Otherwise, the reasons for inadequacy are detected and the general calculation model is refined with new versions of calculation models of individual subsystems of the reconstructed building.

Block 9. After determining the adequacy of the calculation model, multivariate numerical studies are performed, the scope of which is necessary to answer the research questions posed to the researchers.

Block 10. The results of the reconstruction building survey are formed by recording the achievement of the set goal using the relevant procedure. As a rule, the research is completed with recommendations of the improvement of the reconstruction building design.

The block diagram presented during the studies is not the only one: depending on the type of study, some blocks may be ignored, or extra blocks may appear and their sequence may change as well. The strategy of selection and construction of the calculation model of the building to reconstruct or changing function adequate to the natural one reconstruction does not change.

3. Conclusion

As a result of the research conducted in the article it was established: in order to avoid subjective opinions of experts (especially in the first stages) in the plan defining the recommended process of reconstruction of the building makes it possible to identify a number of formal methods and procedures, which makes the process more efficient and allows to maximize the use of automation and computer technology what improves the efficiency of construction inspections and reduces labor capacity, cost and time of production.

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Research of practical methods of protection of urban space from traffic-induced moise and polluted air based on foreign experience

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Abstract

The purpose of this article is to discuss strategies and methods of urban space protection, which ensures the formation of a healthy environment based on sustainable urban planning principles. As it is known, as cities develop with time, the economic activities of the population and the number of industries increase, as a result of which traffic flows and traffic jams increase. Accordingly, air pollution and noise caused by transport increases, which has a negative impact on public health, social aspects and ecology. Therefore, the fight against air pollution and noise caused by transport in the urban environment is one of the most urgent problems for the world. The article discusses proven methods and their results. Research has shown that there are several effective methods of reducing transport emissions, but if they are implemented incorrectly, they not only can slow down the process of reducing pollution but stop the improvement process altogether. The developed methods are mainly related to greening, public transport, restrictions (policies), materials, pricing, urban furniture and activities that are carried out as an experiment in some cities. It should be considered that cities have their own characteristics (topography, relief, density, etc.) therefore every city may have developed its own specific and individual solution to overcome the problem. Regardless of the developed strategies and methods, it is still difficult to find a model that will solve the problem and adapt to the perpetrators.

Key words: urban health, tactical urbanism, transport, ecology, urban planning

Introduction

Cities grow and develop over time. Together with them, the number of population (residents), economic activities and industries increases, resulting an increase in the number of cars, traffic flows and traffic jams. All this leads to an increase of noise and air pollution caused by private and public transport. Polluted environment has a negative impact on human health and causes various diseases. Traffic noise is classified by the World Health Organization (WHO) as the second most important cause of ill health in Western Europe, after air pollution, according to the EEA, noise is associated with more than 12,000 premature deaths each year, and air pollution (PM2.5, NOx and O3) - more than 550220.

Therefore, the fight against air pollution and noise caused by transport in the urban environment is one of the most urgent problems for the world. Car-oriented urban environments also reduce an individual's daily physical activity and are strongly associated with rising rates of obesity. The design philosophy of car-oriented cities means wide roads and parking spaces. Such an approach has led to a number of complex issues affecting community cohesion, health and social aspects. According to the Environment Agency, road transport is responsible for one fifth of greenhouse gas emissions (EEA, 2016). Over the past 25 years, European directives on noise and air pollutant emissions have limited maximum levels of pollutants, set higher fuel quality standards, stricter policy and technology standards for vehicle emissions, and set air quality limits and noise thresholds (Fig.1 and. Fig.2). So there is a dichotomy, on the one hand, urban development and transport, which makes life easier and makes it possible to do various activities without wasting time, but on the other hand, it threatens the health of citizens, the environment and nature.

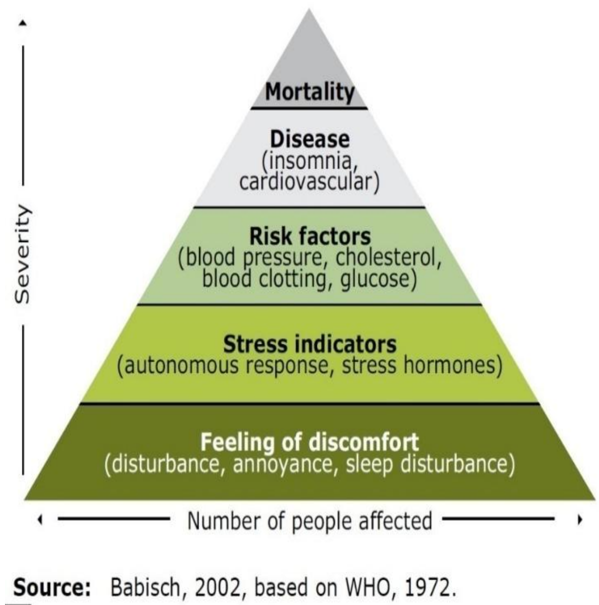

Figure 1 Pyramid of noise effects (European Commission, 2015)

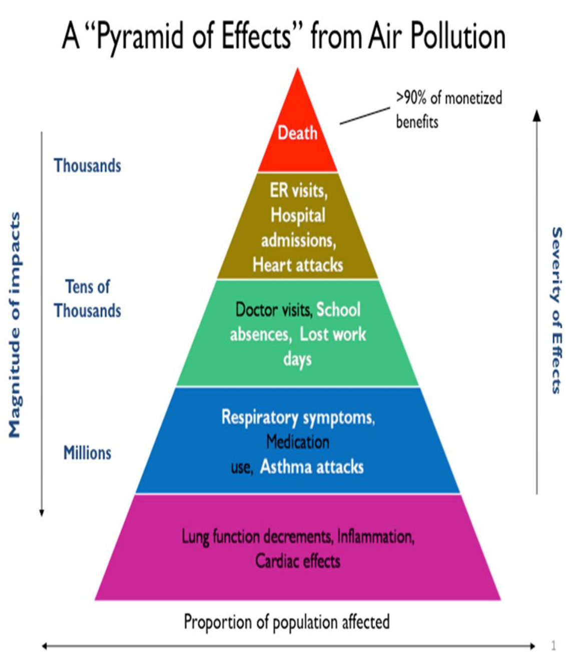

Figure 2 "Pyramid of Effects" from Air Pollution (EPA-US, 2015)

Main part

The purpose of this article is to discuss the existing practical methods and strategies that will reduce the negative impact of transportation on the population and promote the formation of a healthy environment based on the principles of sustainable urban planning. Dependence on the automobile and the focus of city architecture on it affect not only the health of society but also the ecology of the city.

The absence or lack of information makes it difficult to focus, manage and solve air pollution and noise related problems in the right way. Even when all the necessary data are available, it is still difficult to deal with air pollution and noise problems, especially within city center boundaries.

Everyone has the right to live in a good and healthy environment, which consists of a pleasant atmosphere combined with clean air, quiet streets, green spaces and other public places where the level of polluted air and noise does not harm people's health. But not only human health is at risk. Polluted air and vibrations caused by noise also damage buildings.

In many cities, the use of public transport is not widespread, because it does not provide enough or good connections between different areas of the city without losing a lot of time. Also nowadays, owning a private vehicle is no longer considered a luxury as it is available to people of different socio-economic status. Accordingly, the number of private cars increased significantly and traffic jams increased. This means that the problem is not only the loss of comfort and time, but also that the environment is increasingly damaged. Polluted air and noise are one of the main contributors to climate change.

Quality of life means "happiness and well-being of residents" which determines the success of cities in the future. (Eurostat, 2015). In a good urban environment, well-planned buildings and public spaces can create a safe, clean, peaceful and pleasant atmosphere. The well-being of citizens and the economy depend on the quality of the environment (EEA, 2009). Finally, the collected information was analyzed and divided into two main parts: ways to solve air pollution and acceptable measures to reduce noise. Their effectiveness depends on the characteristics, importance and scale of the city or individual area.

There are several effective ways to reduce transport emissions, whether in or around the city. However, if they are implemented incorrectly, they can not only slow down the process of reducing pollution, but stop improvement altogether.

For example, a method of taxation was introduced for the use of private transport, which was first used in Singapore in 1975. The method produced good results from the start, reducing congestion by 45% and traffic accidents by 25%. This method has helped increase the use of public transport and improved infrastructure, safety and air quality. Today, 65% of Singaporeans use public transport.

The next method has already been tested in various cities and is related to the pricing of parking spaces in the city center. Pricing parking spaces can make drivers decide whether to use a private car to get around and use public transportation. Paid parking is associated with economy and can be considered an important factor for citizens. This factor is accompanied by a lack of parking spaces in the city centers, which is mainly related to the loss of time when searching for a free space.

One method to reduce air and noise pollution in cities and increase physical activity of citizens is to close streets in central areas to vehicular traffic and leave these streets for pedestrians. For example: in some cities certain streets are closed to cars 24/7. In some places - on weekends and weekdays it opens only after 20:00. Often these are streets that are in the center of the city, historically important and popular with both tourists and locals. However, this method may cause another important problem, which is related to the absence of alternative ways, the so-called A detour through which citizens will be able to travel by car. Therefore, it is a rather difficult decision to accept, because it is related to changing the road structure.

While in some countries and cities the state is fighting the consumption of old cars, the tradition of car-free days is being established all over the world, September 22 is now officially known as the day when everyone is invited to leave their cars at home and use bicycles or simply walk. The main goal is to show "car dependent" people that in some cases it is faster to walk or bike.

Reducing the use of private cars automatically means providing better public transport that will work efficiently. The BRT system is an innovative, high-capacity and low-cost public transit solution designed to improve urban mobility. This system uses mostly specialized vehicles on the roads to provide fast and efficient transportation for passengers in different directions. (National BRT institute, n.d.). Another benefit of the BRT system is that it reduces traffic congestion, road and parking costs. In the short term, BRT can reduce pollutant emissions by 29% and in the long term by about 45% (Hossain & Kennedy, 2008).

As air and noise pollution is mainly caused by human activities, the European Environment Agency has produced a guide to how each person can individually help reduce pollution in their daily lives. These are daily tips for those who want to help reduce air pollution and protect the environment (EEA, How can I help reduce air pollution? 2014): The aim of the campaign is to raise awareness in the community. To help people better see the causes of the problem, threats, opportunities to avoid them and recommendations.

Some cities are actively moving towards a healthy urban model. For example, the cities of Amsterdam and Copenhagen are known for their bicycle-friendly infrastructure and extensive public transport network, where cycling is an integral part of urban culture. Such planning promotes healthy lifestyles, community relations and environmental sustainability.

Public involvement and initiatives will significantly contribute to solving the problem. One of the public initiatives is the so-called Citizen urbanism or tactical urbanism (Fig. 3).

A movement emerged to bring about changes in the traditional planning system that would solve urban problems at minimal cost and at the will of the people. The term is defined as: "a fast, low-cost, action-oriented approach to making significant civic changes in neighborhoods and cities" that involves returning critical areas of the city occupied by cars to pedestrians. Tactical urbanism is characterized by: flexibility, diversity, easily transformable based on requirements, temporality, aesthetics. It makes visible a specific problem and improves the quality of life in the context for which it was created, through community involvement. Thus, it is a strategy that promotes the sustainable development of cities, creating comfortable spaces for citizens on foot. Such urban interventions require support from the state to avoid urban conflicts. The so-called Triad: public space - transport - individual. Thus, tactical urbanism tries to restore small public spaces, although the strategy requires a much more future-oriented vision and has implications for improving the quality of life in the city. However, it cannot be considered a perfect model of urban development, because technical urbanism is a response to a specific intervention. The concept of tactical urbanism was published as a guide in 2011 by American architect Tony Garcia and urban planner Michael Lydon. They formulated five principles of tactical urbanism in the form of small-scale projects: art installations painted directly on the street or other public surfaces, traffic regulation solutions, small recreation areas, guerilla gardening and temporary bike lanes. Tactical urbanism interventions can take many forms, depending on the specific goals and context of the project. Its aim is to see the potential for positive transformation of roads and streets and to promote a do-it-yourself vision. The key is to identify specific needs or challenges and develop low-cost, temporary solutions that can be implemented quickly and easily.

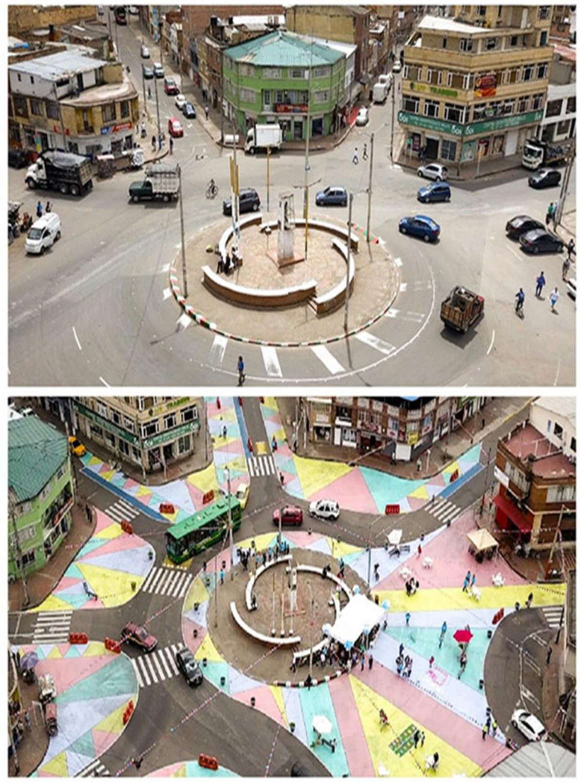

Fig. 3 Tactical Urbanism

Conclusion:

Thus, today's transport, accompanied by noise and air pollution, cannot be considered separately from the urban environment, so it is critically important to develop smart methods and strategies to overcome the problem. This is a process, the very management of which requires the joint involvement of society and the state.

The analysis showed that there are several effective ways to reduce transport emissions, but if they are implemented incorrectly, they can stop the improvement process altogether. The developed methods are mainly related to greening, public transport, restrictions (policies), materials, pricing, urban furniture and activities that are carried out as an experiment in some cities. It should be taken into account that cities have their own characteristics (topography, relief, density, etc.) therefore every city may have developed its own specific and individual solution to overcome the problem.

Regardless of the developed strategies and methods, it is still difficult to find a model that will solve the problem and adapt to the perpetrators.

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Energy Efficiency Analysis of Central Air Conditioning Systems

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Abstract. The article considers the ways of reducing heat and cold loads in air conditioning systems of public buildings both by air recirculation and by using these loads in recuperative ventilation systems. Energy efficiency is studied by analyzing thermody–namic processes of air treatment on the I-d diagram. The construction of thermodynamic air purification processes in recirculation and recuperative ventilation systems on the I-d diagram is considered.

Keywords: ventilation, air conditioning, recirculation, recuperation, utilization, thermo-dynamic treatment, heating and cooling loads, energy saving, energy efficiency.

Introduction

In modern society, more and more attention is paid to the economy of natural resources, among which energy resources are of particular importance. One of the largest con-sumers of energy resources is construction, which consumes 40-42% of the generated energy. Therefore, energy saving in const–ruction and increasing its energy efficiency is one of the current areas of modern construc–tion. Many countries around the world have a law on the energy efficiency of buildings, the main goal of which is to reduce the energy consumed by buildings to almost zero. Georgia also has such a law [ ], according to which all new buildings in Georgia must have almost zero energy consumption from 2030. For public buildings, this date is September 30, 2027. Increasing the energy efficiency of buildings and bringing them to a state of zero energy consumption is possible with the correct choice of thermophysical characteris–tics of enclosing structures and the installation of energy-efficient engineering systems for buildings. If it is relatively easy to achieve zero energy consumption in residential buildings with the correct selection of energy-efficient restrictive structures and recuperative venti-lation devices, then in public buildings (offic-es, theaters and cinemas, sports halls, etc.) achieving zero energy consumption is relatively simple. It is complicated by the thermodynamic processing of large quantities of air in the ventilation systems of these buildings (heating, cooling, drying, humidifi–cation, etc.). Air exchange rate in a number of public buildings n=5÷20, this means that in these buildings the amount of ventilation air must be $L=(5\div20)\cdot V$ m^3/hour(1) where V is the volume of the building in m^3.

Main part

Microclimate systems of buildings (heating, ventilation, air conditioning) must ensure the creation and maintenance of temperature and humidity conditions stipulated by standards in warehouse premises. For residential and public buildings, these standards are determined by the current standard [1], and for industrial buildings - according to the relevant industry standards. For atmospheric air, parameters A or B are taken into account depending on the construction area [2]. The climatic conditions of Georgia in summer are characterized by a conditional air temperature of up to +34ºC, relative air humidity $\varphi=(40\div60)\%$ within Humidity is relatively high in coastal and mountainous areas. At the specified humidity and high temperature, the humidity of the outside air reaches (18-30) g / kg of dry air, and in winter the outside air temperature is zero or lower, despite the high relative humidity ($\varphi = 60 \div 80\%$), the air is dry enough. At this time, the humidity of the outside air is (1 ÷ 3) g / kg of dry air. Thus, according to climatological data of the outside air, in summer the outside air is hot and humid, and in winter it is cold and dry. Neither in winter nor in summer are the parameters of the outside air satisfactory. For normal physiological functioning of a person. For this purpose, we carry out preliminary thermodynamic treatment of air in the central air conditioner and then supply it to the conditioned rooms so that the conditions of thermal comfort stipulated by the standards are established in these rooms [1]. These conditions are graphically presented in the so-called comfort diagram (Fig. 1).

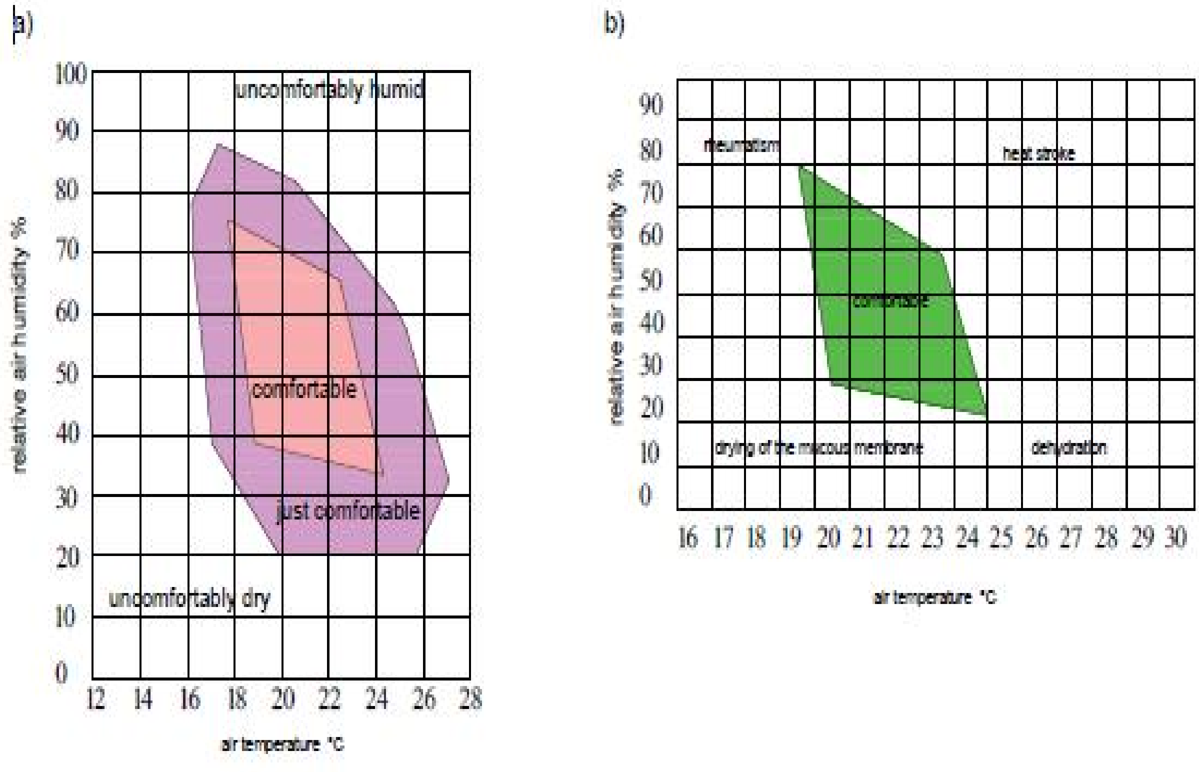


Fig. 1 comfort diagrams
a) values of temperatures and relative humidity of acceptable and comfortable microclimate zones.
b) harmful effects of uncomfortable zones on the human body.

The diagram a) shows the values of temperature and relative humidity that the air conditioning system must provide, and diagram b) shows what harmful effect the combined effect of temperature and relative humidity can have on the human body when these parameters remain outside at the comfort zone.

Fig. 2a shows the process of thermodynamic treatment of air in a central ventilation unit (air conditioner), depicted in the I-d diagram, for both summer and winter climatic conditions for the simplest direct diagram. This is a diagram where the outside air with parameter 1 (Fig. 2) is cooled and dried in summer, and heated and humidified to parameter 3 in winter. Thus, the purified air is supplied to the room to provide comfortable conditions in room 2. Section 2-3 is known in ventilation engineering as the process beam in the conditioned room and represents the ratio of the amount of heat released in the room and the released moisture.

$$\varepsilon=\pm(\Sigma Q/\Sigma W) \quad kJ/kg \qquad (2)$$

where ΣQ- The total amount of heat released in the storage is kJ/h

ΣW - The amount of moisture released in the storage kg/h.

The plus sign shows an excess of heat in the compartment, and the minus sign shows a deficit (lack of heat).

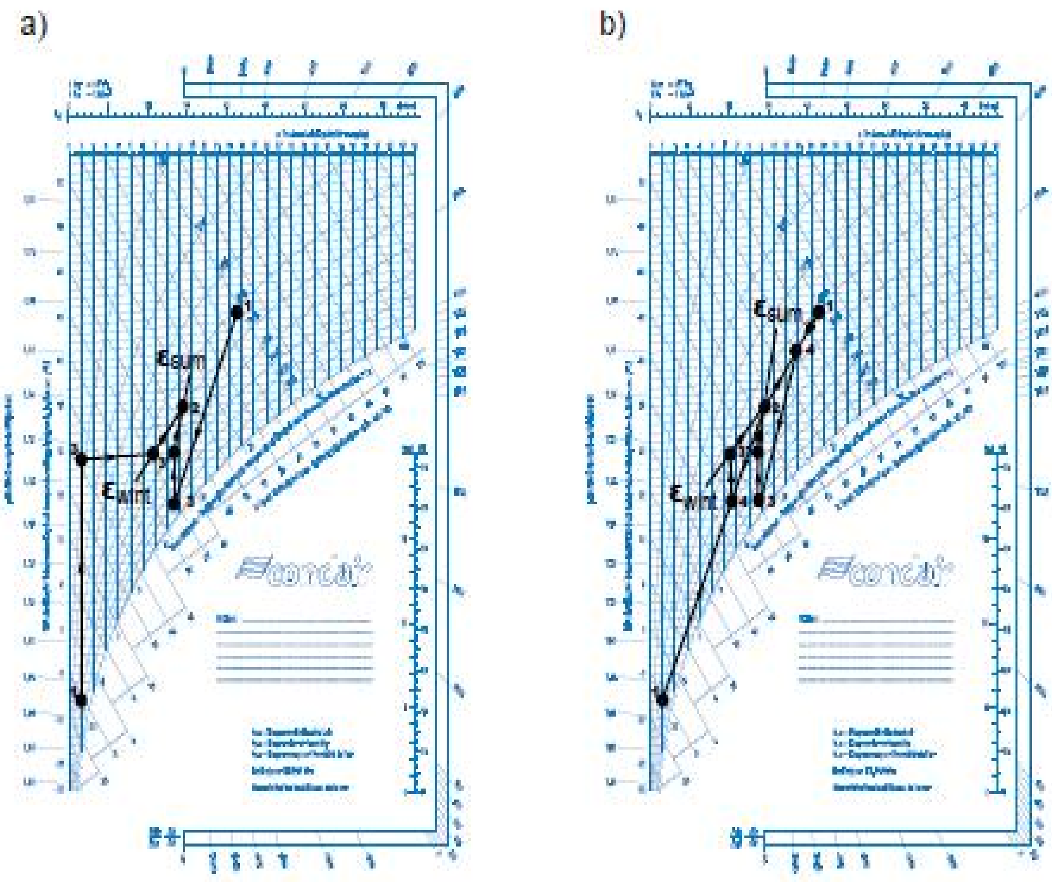


Fig. 2. Schemes of thermodynamic air treatment on the I-d diagram:
a) with a direct scheme, b) with air recirculation.

b) In Fig. 2a it is evident that in summer during the process of cooling and drying the air in the air conditioner its temperature is so low that it is necessary to additionally heat the air to an acceptable temperature of the supplied air (point 31). The temperature of the supplied air depends on the height to which we supply air to the compartment. If the air from the storage room is supplied to the working area, its temperature will be 5 degrees lower than the air temperature in the storage room. In winter, when the air in the air conditioner is heated, which occurs at a constant air humidity, the relative humidity of the air decreases to 10%, i.e. the air is almost completely dry. Therefore, before supplying the air to the storage room, it is necessary to humidify it to the required parameters of the supplied air (pos. 31). The presented I-d diagram displays the process of isothermal air humidification (t=const). With thermodynamic air treatment, it is possible to humidify it adiabatically (I=const). With such humidification, the air again becomes so cold that it is necessary to heat it. (d=const) so as to ensure that the required parameters of the supply air are achieved (pos. 31).

The scheme shown in Fig. 2a is the best from the point of view of hygiene, since at this time outside air, purified to the appropriate state, is supplied to the room, and the contaminated working air is discharged into the environment. From the point of view of energy efficiency, the scheme under consideration is unacceptable, since a large amount of air blown into the environment brings with it a large amount of heat in the winter and cold in the summer.

In order to save thermal energy, air recirculation is used in the air preparation process (Fig. 2b). In this case, only the amount of air stipulated by sanitary standards is supplied from the environment to the warehouse, which is mixed with recirculated air (returned from the exhaust air), again supplied to the warehouse.

Having depicted the processes of thermodynamic air treatment on the I-d diagram, we can already determine the cooling and heating loads of the air conditioning systems using the formulas:

$$Q=G_{del}\,(I_{St}-I_{sab})\ vt \qquad (3)$$

Where G_{del} - Air consumption supplied to the warehouse, kg/h;

I_{st} და I_{sab} Accordingly, in the air conditioner or air conditioner Initial and final enthalpies of the processed air (thermal changes) kJ/kg.

The parameters determining the cooling loads on the I-d diagram correspond to points 1 and 3 and 4 and 3 according to the corresponding direct and recirculation schemes, and the heating loads are determined according to the winter air preparation schemes, according to points 1 and 3 and 4 and 31.

The schemes considered above were widely used in a number of public buildings in the last century. Today, the use of these schemes is more appropriate in buildings whose microclimate parameters do not have strict requirements for comfort. These are: a number of industrial buildings, warehouses, wagon depots, garages and others, or those air-conditioned warehouses where people are less frequent.

In modern construction, recuperation systems of ventilation and air conditioning are widely used to improve energy efficiency. Recuperation systems allow heating the air supplied to the warehouse during the cold period of the year by extracting heat from the taken warm air, and cooling the hot air supplied from outside in the summer by cold air taken from the room. warehouse. Regenerative ventilation systems are used in all types of buildings and are a prerequisite for creating buildings with zero energy consumption. The main characteristic of ventilation recuperators is their efficiency.

$$\eta=t_{del}-t_g/t_{sh}-t_g \qquad (4)$$

where t_{del} supply air temperature in the compartment

After the recuperator ºC;

T_g - outside air temperature;

T_{sh} - room air temperature;

Today, ventilation recuperators have been created with an efficiency of up to 97%. Using a heat pump with a recuperator allows increasing the efficiency to 140%. In addition to heat recovery, some types of recuperators (especially rotary ones) provide the ability to utilize moisture. The efficiency values for different types of recuperators are:

Glycol recuperators----- 55%-მდე
plate-------------------------- 70%
rotor------------------------------ 85%
with resistance (including enthalpy) —92-94%
Two-stage (recuperator + heat pump) ---140%

The temperature of the ventilation air after the recuperator is calculated from condition (4) if its efficiency is known in advance.

$$T_{del}=t_g+(t_{sh}-t_g)\eta \qquad (5)$$

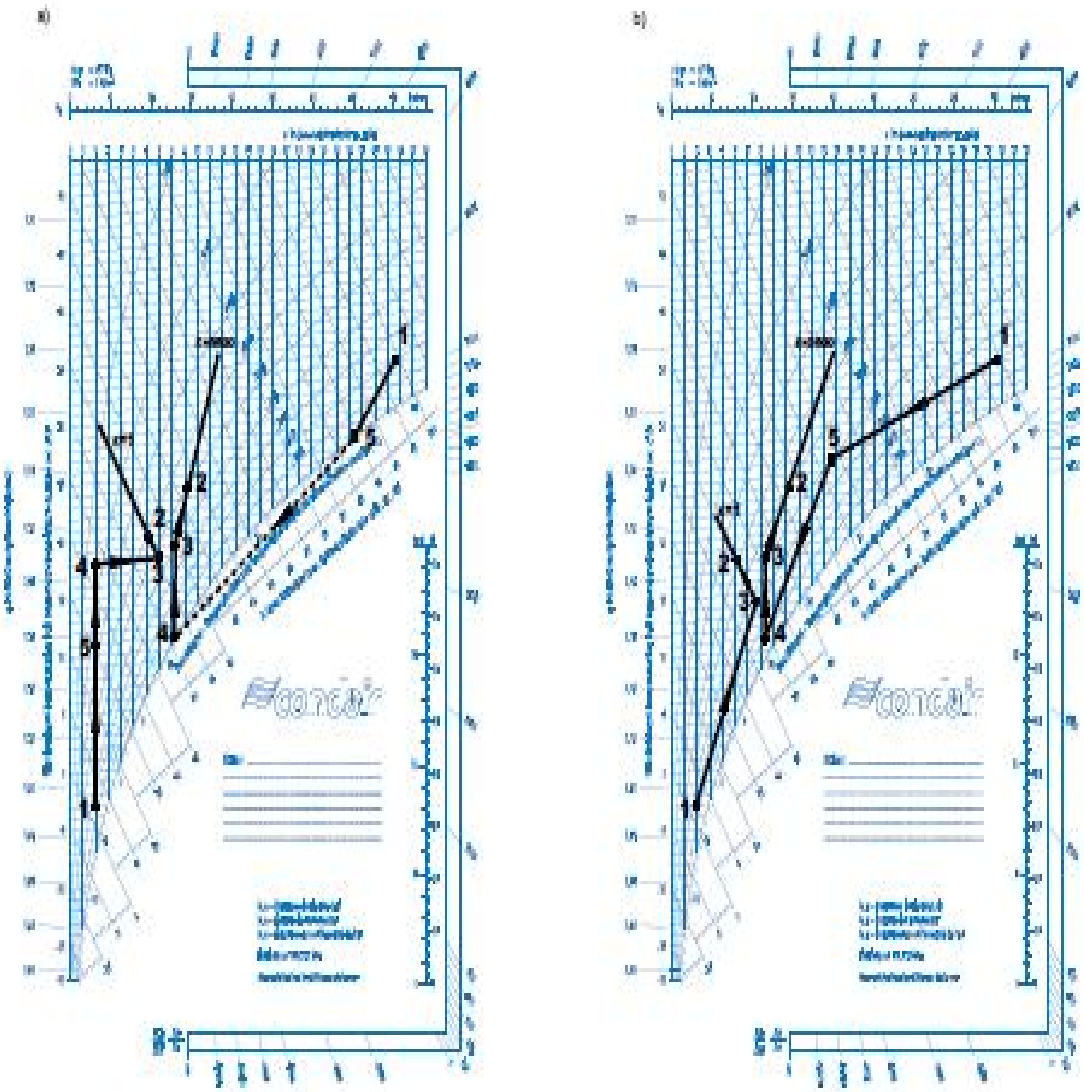
The heat transfer of air after the recuperator is calculated in the same way.

$$I_{del}=I_g+(I_{sh}-I_g)\eta \qquad (6)$$

T_{del} and I_{del} Based on the parameters, we determine whether additional thermodynamic processing processes are needed to bring the air up to the parameters.

The table below shows the values of supply air temperature (t) and relative humidity (φ) after the recuperator.

t_g	34	30	20	10	0	-5	-10
T_{del}	25	24,6	23,6	22,6	21,6	21,1	20,6
φ_g	40	50	60	70	80	%	
Φ_{del}	49	50	51	52	53	%	



1-outside air; 2-indoor air; 3-supply air;
4-air parameter after cooling (heating);
5-air parameter after the recuperator

Fig. 3. Schemes of thermodynamic air treatment on the I-d diagram in recuperative ventilation systems:

a) plate recuperators
b) in the case of rotary recuperators.

As we can see from this table, when the outside air temperature changes from 34ºC to -10ºC and the relative humidity values (40-80)% after the recuperator, the required parameters of air supplied to the warehouse are achieved, due to which there is no need for additional heating or cooling of air in the recuperator. Using a recuperator for buildings with low energy consumption (passive, active, zero houses, etc.), we can refuse expensive heating and cooling systems.

For public buildings in case of high excess heat and moisture or high heat losses, if the amount of heat and moisture utilized in the recuperator cannot provide the required parameters of air supplied to the warehouse, then additional measures must be taken. However, at this time, cooling and heating loads are reduced to a minimum.

The scheme of thermodynamic air treatment for public buildings, when additional cooling and dehumidification of air is required in summer, is presented in Fig. 3 for both plate and rotary recuperation.

The above diagram corresponds to the humid climate zone in Fig. 3, where the humidity of the outside air is high, the temperature (t_g=33ºC) and the relative humidity (φ=80%) d=26g/kg of dry air. At such high humidity, the heat extracted from the air sucked into the recuperator is mainly used for cooling and drying the outside air (beam 1-5), since after cooling in the recuperator, the air parameters (item 3) cannot react to the parameters of the supplied air (item 3), additional air cooling and drying (beam 5-4) and further heating (beam 4-3) are necessary. In winter, the recuperator alone is sufficient to provide the parameters of the supply air.

The air from the recuperator to the environment has a fairly high temperature throughout the year (t_{del}=5÷25ºC), which provides the best conditions for using a heat pump to provide the building with hot water. The temperature of the air removed from the building (after the recuperator) is calculated using the formula:

$$t_{\delta del}=t_{sh}+(t_g-t_{sh})\eta \quad (7)$$

When using a heat pump, the recovery efficiency increases to 140%.

conclusion

To reduce heat and cold loads in central air conditioning systems, replacing recirculation ventilation systems with recuperative ones significantly improves the sanitary parameters of indoor air, and due to the utilization of heat and moisture, it allows removing heat and cold supply sources from the premises. systems. In this way, high energy efficiency of a public building is achieved, which reduces the costs of heating and cooling buildings by 80-90 percent.

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Aspects of designing shelters in Georgia

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Abstract: In the article is considered the importance of protecting the population in possible emergency situations and during hostilities in Georgia using collective defense means. Necessary recommendations for the reconstruction of the existing shelters in Georgia and the construction of new ones based on the analysis of the current war in Ukraine and the study of the weapons used by Russia against the civilian infrastructure.

Keywords: shelter, civil defense, civil safety, collective protection of the population.

1. Introduction

Due to the geopolitical location of the country, the existence of civilian shelters is a critically important issue to ensure safety and protection of the population in case of possible foreign aggression. In this context, it is appropriate to focus on the comprehensive study and analysis of possible threats, which is an integral part of the shelter construction process. A detailed study of different types of weapons systems used in military conflicts, their destructive potential, impact radius and destructive factors is a necessary prerequisite for the design and construction of shelters that fully respond to protection and safety requirements.

Analyzing the current war in Ukraine and studying the weapons used by Russia against civilian infrastructure is very important for Georgia. This gives us the opportunity to study in detail and understand the radius of impact and the destructive potential of the weapons that Russia is using extensively against the civilian population and infrastructure. Russian occupation forces widely use missile weapons in their military operations against Ukraine.

Georgia's strategic location in the Caucasus region and its propensity for regional conflicts create the need to develop solid civil protection measures. By understanding and adapting to these threats, Georgia will be able to strengthen national safety and ensure the safety of its citizens.

In modern history, Georgia, depending on its geo-political location, faced various types of aggression several times. The last military conflict with the direct participation of Georgia took place in 2008, between Russia and Georgia. In this war, 412 Georgian citizens died, including 228 civilians, 170 military personnel and 14 policemen (Arabuli, 2023). The war exposed significant weaknesses in Georgia's civilian infrastructure, including the failure of the early warning and evacuation system. This historical context creates a good basis to prove the need for shelters in Georgia, which will protect citizens during conflicts.

A study of today's Russia-Ukraine conflict reveals the impact of modern wars on civilian populations and infrastructure. Analyzing this conflict allows us to identify specific weapons systems and tactics that could be used against Georgia and accordingly plan to design shelters that can withstand such threats. This chapter aims to identify the basic design parameters of shelters that will effectively deal with these hazards. This includes structural strength, capacity, accessibility, life support systems and communication infrastructure.

2. **Existing regulation frameworc**

According to the Law of Georgia on Civil Safety, a shelter is a building or structure that can be used to protect people from various damaging factors during an emergency or war. The shelter can be a dual-purpose, civil or industrial building and/or a special hermetic protective structure, which is designed taking into account damaging factors;

According to the same law, it is the duty of executive authorities, self-governments and organizations to provide in the areas assigned to their governance in the manner established by the legislation of Georgia:

- during an emergency situation, if necessary, creating a shelter for people, mobilizing collective protection means and other material resources;
- providing assistance in organizing the evacuation of people and, if necessary, placing

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- during an emergency situation, if necessary, creating a shelter for people, mobilizing collective protection means and other material resources;
- providing assistance in organizing the evacuation of people and, if necessary, placing

them in a shelter;
- maintaining the quality characteristics of the shelter in their use;

In accordance with the legislation, the main measures for the protection of Georgian citizens and other persons on the territory of Georgia from an emergency situation are: their evacuation and/or placement in shelters, implementation of fire, engineering, chemical, radiation, medical and biological protection measures and psychological assistance for them.

The personnel of the facility of vital importance should be protected in the shelter from the emergency situation.

A metropolitan underground structure, cave, bunker and tunnel, as well as the underground floor and storage of a building suitable for shelter (including dual purpose) can be used as a shelter.

The maintenance and intended use of the shelter is ensured by the persons authorized to own, dispose of and/or use the property.

It is possible to change the intended purpose of the shelter and the building and storage suitable for shelter based on the prior written consent of the Emergency Situations Management Service and the Ministry of Defense of Georgia. Alienation of the state-owned shelter is not allowed without the prior written consent of the Emergency Situations Management Service and the Ministry of Defense of Georgia.

According to the law of Georgia "Georgian Code of Spatial Planning, Architectural and Construction Activities", which refers to safety protection during the operation of the building, "during the design and construction of the building, civil safety engineering and technical measures should also be taken into account, the purpose of which is to protect the population from emergency situations, expected losses and reduction of destruction, creation of necessary conditions for promotion of rescue and other emergency works." (Parliament of Georgia, 2018)

Based on the above, according to the Resolution No. 51 of the Government of Georgia of January 14, 2014, regarding the approval of the technical regulations - "Civil Safety Engineering-Technical Measures", the following basic requirements for the design of shelters are defined: the total number of sheltered persons in civil defense protective structures in enterprises is determined by the maximum number of workers per shift. Shelters should provide protection of sheltered people from shock wave, penetrating radiation, radioactive contamination and light radiation of explosion, high temperatures and combustion products during fire, as well as poisonous and bacterial agents. Shelters must provide protection for the sheltered persons for two continuous days and nights.

In an emergency situation, in order to protect the population and ensure the stable functioning of economic objects, priority is given to the utilization and use of underground spaces of cities for the design and construction (placement) of protective structures of civil defense. For the same purposes, it is advisable to transform the ground (semi-recessed) and underground floors of existing and new buildings under construction.

The construction of shelters to be used as a shelter should be considered on the underground floors of industrial and auxiliary buildings under construction, public, residential and other buildings, as well as semi-recessed separate standing buildings. Shelters should be used for household, auxiliary and storage warehouses located in the underground space of the city (except for flammable, explosive, toxic, poisonous and undervalued loose materials warehouses), trade and public catering facilities, cultural-household and sports warehouses, underground parking lots, tunnels, underground passages. and other buildings.

Shelters to be used as shelters should have emergency exits outside the zones of possible explosions as a result of the collapse of nearby buildings and structures.

Protective structures of civil defense (shelters and anti-radiation shelters), which are used in peacetime in the national economy and for population services, should be brought into readiness to shelter people for no more than 12 hours.

In processed underground mines and caves, where it is possible and appropriate, provision of shelters and anti-radiation shields should be provided for the protection of the population.

For the protection of seriously ill patients, whose evacuation is impossible due to their health condition (non-transportable patients), as well as for their service personnel, shelters should be provided in the basements of newly designed buildings of medical profile institutions (hospitals, clinics) located in the zones of possible strong destruction of categorized cities and objects, which are used in peacetime. will be as needed by the treatment facility.

The number of patients to be accommodated in the shelters of medical institutions is determined to be 10% of the total design capacity of the medical institution in peacetime.

The use of metropolitan areas for the protection of the population is recommended not only in times of war, but also in peacetime emergency situations.

Metropolitan lines and districts should be used as shelters during wartime.

Planning of shelter of people is allowed both on station platforms and in transfer tunnels, alleys, connecting branches, depots and other structures. The number of sheltered people in the metropolitan area is determined by the norm of the area per person: in deep tunnels and stations, it is 1 sq.m., and in tunnels of small depth - 1.5 sq.m.

Employees working in the largest shift of institutions, who do not stop working during the war, and who are within a radius of no more than 500 m from the station, as well as the population, who are in the metropolitan area and within a radius of no more than 500 m from the station, take refuge in the metropolitan area. The filling time of the metro station intended for shelter should not exceed 10 minutes. In some cases, this time can be increased to 13 minutes.

When designing metro lines, connecting metro and railway stations should be taken into account in accordance with the expansion of all types of urban transport and railways.

Metropolitan building constructions and protective devices are calculated for the impact of excess pressure in the front of the probable explosion shock wave, its value is taken equal to 3kHz/sq.cm for deep laying lines, and 1kHz/sq.cm for lines of small depth. Backup power and air supply are provided by a decentralized scheme from diesel power plants and autonomous ventilation units, respectively.

Metropolitan lines and areas that have won special protection orders for shelters should be divided into plots. Those areas of the metropolitan area, which are located under the bed of rivers, in unstable aquifers and will be used as evacuation routes, should be separated by protective walls from the buildings designed as shelters of the metropolitan area.

The amount of special protective electrical, air and water supply, control, notification, communication, sanitary-technical and medical provision means is determined according to the number of the population sheltering in the metropolitan area and the duration of their stay in the shelter (no more than 2 days and nights). Air collection and air extraction channels of ventilation systems, gas-air tracts of special ventilation, which exit to the surface of the ground, must have a protective device against penetration of the shock wave into the shelter.

Safety guards placed at the entrances of the stations should ensure that the entrances are locked in a minimum time (2 minutes).

In the normal mode, the power supply of the metropolitan lines and areas should be provided from the source of the external power system, and in the shelter mode - from the protected diesel power plants.

In metropolitan areas, shelters should be supplied with air from both a decentralized and a centralized system, from the existing and to be designed air collectors by means of filter-ventilation devices. The operation of the ventilation system of shelters located in metropolitan areas should be considered in the mode of clean ventilation and filter-ventilation.

Protective devices of ventilation systems, in technologically necessary places, should be equipped with remote control and control signaling devices.

According to the technical regulations "Building Safety Rules" adopted by the Resolution No. 41 of the Government of Georgia on January 28, 2016:

- In the buildings, the area of shelter should be considered, that is, the area where people who are unable to use the road-stairs can temporarily stop before receiving proper instructions or evacuation.

- According to paragraph 307.7 of the mentioned rules, a group containing a large risk, i.e., enterprise buildings and relevant research areas, where hazardous production substances and substances are used, the total amount of which exceeds the values given in the tables 307.1(1) and 307.1(2) of the same rules, should be classified as CIS-5 group. Accordingly, according to paragraph 307.9 of these rules, at the facilities belonging to the DSS-5 group, for the management group, for the total number of personnel working in shifts, a shelter with easy access should be provided, which should be planned with the provision of airtightness and taking into account special effects and use (operational) requirements.

Analysis of weapon systems used in the Russia-Ukraine war

Analyzing the current war in Ukraine and studying the weapons used by Russia against civilian infrastructure is very important for Georgia. This gives us the opportunity to study in detail and understand the radius of impact and the destructive potential of the weapons that Russia is using extensively against the civilian population and infrastructure.

Russian occupation forces widely use missile weapons in their military operations against Ukraine. At least 12 missile tactical groups equipped with operational-tactical and tactical missile systems are involved in the war. Tactical missile groups mainly use 9K720 "Iskander-M" operational-tactical missile systems equipped with 9M723 quasi-ballistic or cruise missiles. The range of the mentioned 9M728 and 9M729 missiles is mainly up to 500 km, although for the winged version it is possible to have a range of up to 2100-2300 km (Missilethreat, 2024). Russia also uses modern missile variants such as the Kh-101 and 3M-14 (Conflict Armament Research, 2022). In addition, the use of surface-to-air missiles has been reported several times. These weapons are smaller than cruise missiles and are used at a shorter range (about 300 km radius). Tactical "Tochka-U" type missile system 9K79 belongs to a similar type of missile.

The depth of damage of Iskander (9K720) missiles depends on several factors, including the type of charge used, the hardness and specifications of the target. However, in general, Iskander missiles are known for their high penetration and damage capability, especially when using concrete-destroying charges. Concrete shattering charges were designed specifically to damage reinforced structures, such as reinforced concrete shelters and bunkers. A charge of such strength can damage several meters of reinforced concrete (usually 2-4 meters). The depth of specific damage depends on a number of factors, such as the hardness of the target, the type of charge, the angle of impact (if the missile hits the target correctly, the depth of damage will be greater than if it is hit at an angle), the type of surrounding soil, etc. (Cranny-Evans & Kaushal, 2022).

The Tochka-U (SS-21 Scarab) missile, especially in its improved variants, has some capability to damage reinforced concrete structures, although it is less advanced than systems like the Iskander. The Tochka-U can be equipped with a high-explosive (HE) fragmentation warhead or a penetrating warhead. The HE warhead is designed to cause significant burst and fragmentation damage, but is less effective at deep penetration. Penetration warheads designed to fracture reinforced concrete can penetrate approximately 1 to 1.5 meters of reinforced concrete, depending on the specific warhead design and impact conditions.

As for the Kh-101, this missile also has the ability to be equipped with various types of warheads, including high-explosive (HE) and penetration/penetrating warheads. A penetrating warhead is specifically designed to penetrate hardened targets (for example, reinforced concrete bunkers) (Army Recognition Group, 2024). Although the specific penetration depth for the Kh-101 penetration warhead is not officially known, based on similar systems and typical warhead designs, we can conclude that the missile can penetrate approximately 2 to 3 meters of reinforced concrete.

An overview of the main parameters of shelters

In order to ensure the structural integrity of shelters against such weapons, it is necessary to use safe construction materials. As a rule, in the construction of shelters, reinforced concrete and steel materials are used, which can withstand the strong pressure caused by the explosion and the impact of debris. Reinforced concrete is one of the main materials used in the construction of blast shelters due to its strength and durability. The use of iron mesh (reinforcement) in concrete increases its strength and makes the wall more resistant to the impact of high blast pressure. Steel helps distribute the load evenly on the concrete and increases the overall durability of the structure. It acts as an additional barrier that can absorb and dissipate energy from impact, thereby reducing the depth of penetration. The armature is made of high strength steel and is available in different types. In the US, carbon steel rebar (ASTM A615) and low alloy steel rebar ASTM A706 are most common (iRebar, 2020). In addition to traditional reinforcement, steel mesh and steel fibers can be used to reinforce concrete. These materials increase the concrete's strength, impact resistance, and energy absorption capacity by distributing the reinforcement/strength uniformly throughout the concrete (Sanytsky M., 2023).

Reinforced concrete is effective in reducing both penetration and blast damage. Considering the damage potential of the tools discussed above, several layers of reinforced concrete, at least 2-3 meters thick, should be used in the process of construction of shelters in Georgia. Reinforcement should be located in such a way as to ensure an even distribution of the load. This involves the placement of reinforcement in both horizontal and vertical directions by placing grid-like structures in the concrete. This helps to absorb and dissipate the energy caused by the impact of the penetrating warhead. In addition to reinforced concrete, high-strength steel is used in the construction of shelters. This material is mainly intended for the construction of explosion-proof doors and critical structural components. Blast-resistant doors are designed to protect the interior of the shelter from extreme pressure and blast-related debris. Such doors must be made of steel several inches thick and tested to withstand various levels of blast force (several thousand pounds of pressure per square inch). Also, it must be sealed with a strong seal to prevent blast waves, toxic gases and debris from entering the shelter.

Another important component to consider when designing shelters is the location and depth of the shelter. It is best to build a shelter underground, as the ground has the ability to absorb and dissipate the energy of an explosion and provides good protection against a variety of threats, including missile strikes, conventional explosives, and even nuclear explosions. Based on the missile data described above, it is recommended that the underground shelter be placed at least 5-7 meters deep. In terms of location, shelters are best located near elevated terrain (mountains/hills) as using natural geological features can provide additional protection and avoid the need to dig deep into the ground. Shelters should be located away from primary targets (military bases, industrial facilities, etc.) to reduce the likelihood of a direct hit.

The capacity of shelters is an important issue that affects their efficiency and safety. FEMA recommends that shelters be at least 5 square feet per person for short stays (less than 24 hours) and 10 square feet per person for stays longer than 24 hours. The capacity must also correspond to the capacity of the ventilation system. As a rule of thumb, 10-20 cubic meters of air per hour should be calculated per person (FEMA, 2006).

Support systems in shelters are necessary to maintain living conditions in crisis situations. These systems include basic necessities such as ventilation, clean water, food, medical first aid kits, temperature control and waste management.

As mentioned, in the event of a conflict, the primary threat to Georgia from the potential adversary is expected to be the use of such weapons systems, which are more focused on the destruction of infrastructure and buildings, and not on attacks carried out with chemical, biological or radiation weapons. Therefore, when designing a ventilation system, the focus should be on ensuring air cleanliness and protection against overpressure and debris. Ventilation systems must be equipped with filters for dust, smoke and other harmful particles. It is advisable to have a double ventilation system so that in case of failure of one of the systems, the supply of fresh air continues without interruption. Pressure and debris protection shall be controlled by means of blow-off valves. These valves are automatically closed during the explosion and protect the shelter from the blast wave and debris. After stabilization of pressure, they are opened and ventilation is resumed. The air intake/exhaust system must be installed in an area protected from direct impact or debris. To catch large particles/debris, there should be a so-called Pre-filters, while filtering of fine particles should be done by means of high efficiency air particle filters. In addition, the shelter must have overpressure relief vents that will automatically open to relieve excess pressure to protect the structural integrity of the shelter and ventilation system.

For water supply, large and solid reservoirs should be used, which should be regularly checked for contamination. Filters should be used for water purification and, if necessary, it should be chemically treated. For waste recycling systems, it is better to use secondary water in order to make efficient and long-term use of water resources.

The shelter should have a proper ventilation system to ensure temperature and humidity control. Main and reserve energy sources - generators are used for energy supply. Backup systems provide short-term power supply for critical systems such as lighting, communications, and medical equipment.

The shelter should also have long-term food supplies. Also, medical supplies and equipment, including first aid kits, medicines and basic medical equipment.

It is important for shelters to have good communication infrastructure, which should be used for internal and external communication in emergency situations. For internal communication, fixed and mobile telephone systems are used, which provide fast and reliable communication inside the shelter. Shelters should be equipped with emergency call systems that allow residents to quickly contact the appropriate persons or medical personnel if necessary. External communication in shelters is carried out through radio, Internet, satellite connection. For communication, communication lines protected from cyber-attacks and information leakage should be used, which ensure a secure and confidential connection. Uninterruptible power supply is necessary for communication systems, for which generators and other types of power sources (eg UPS) must be used.

Conclusion

The importance of asylum in Georgia is determined by many factors and is closely related to the country's safety, geopolitical situation and the need to protect the population. The country's geographical location and historical experience determine the importance of the civilian shelter system. The country is located in a strategically sensitive region, where geopolitical tensions often arise. The 2008 Russia-Georgia war and the ongoing occupation underscore the need for civil defense infrastructure.

In this paper, the main parameters of designing shelters in the context of Georgia are discussed. The aim of the paper was to study the military weapons that can be expected to be used by a potential adversary and, based on the analysis of these weapons, to offer recommendations that should be considered in the process of construction/reconstruction of civilian shelters to protect against weapons. As a result of the research, several important aspects were identified, which must be taken into account when creating an effective and safe shelter system in the country.

First, an analysis of the weapons systems used in the Russia-Ukraine war highlights the need for shelters that can withstand the threats of modern warfare, including high-velocity missiles and artillery. The analysis also showed that it is unlikely that nuclear and chemical weapons will be used against Georgia, and therefore shelters should not be counted on such a threat (as was the case in the Soviet Union). In the process of building shelters, emphasis should be placed on the construction of solid underground structures, which will be designed for rockets capable of damaging 3-5 meters of reinforced concrete. Along with sustainability, it is important for shelters to be capacious and have a convenient location. In this regard, Georgia can benefit from its mountainous terrain. In the case of building shelters under elevated ground, the ground becomes a natural shield against blast waves.

Along with the construction of new shelters, it is necessary to survey the existing shelters, determine their sustainability, reconstruct and put them into operation. It will be less expensive than building new shelters. Such an approach ensures not only the construction of new shelters, but also the effective use and improvement of the existing infrastructure. In this way, it will be possible to ensure maximum safety of the population and optimal use of state resources.

The analysis of international experience has made it clear that for the development of civilian shelters, it is necessary to have a solid legal base that will regulate in detail the issues of construction and operation of shelters. In this regard, Georgian legislation needs to be refined and harmonized with international standards.

By integrating these elements, Georgia can create a comprehensive civil defense strategy that will protect its population from both natural and man-made disasters. The creation of such a system will not only strengthen national safety, but also contribute to the overall sustainability and stability of the country.

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Sustainable Urban Development Model (Example of Resort Akhtala)

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Abstract The article presents the results of dissertation research on anthropogenic processes within the natural-territorial complex of Akhtala resort. This interdisciplinary study employed remote sensing methods to assess the extent of environment changes occurring within the framework of urban development.

By synthesizing research methods from various disciplines and adapting them to the specific context of Akhtala, we developed essential documentation, a geodatabase, a comprehensive planning guide, development strategies, and monitoring mechanisms.

The findings from this approach can be applied to similar complexes. The integration of advanced technologies facilitated the acquisition of detailed information about the research area.

Depending on the researcher's objectives, these methods can be utilized to create strategic development plans, implement action plans, or ongoing monitoring processes.

The research aimed to analyze the dynamics of natural and anthropogenic changes in the Akhtala resort area, by applying sustainable urban development principles. The goal was to mitigate or limit factors contributing to global challenges.

The anthropogenic landscape has intensified due to rapid urbanization over the past decade. The research focused on developing strategies to counteract the negative impacts of urbanization, driven by population growth. This issue has emerged as a significant obstacle to sustainable urban development.

Key words: Anthropogenic, Urbanization, Green space, Land use, Resort Akhtala, Natural-territorial complex, Satellite photos, Information digitization, Buffer, Environment, Degradation, Erosion, Territorial planning, Creative planning, Rational land use.

Introduction

The research was conducted to fulfill the requirements for a Ph.D. at Georgia Technical University. A dissertation titled "Urban Green Spaces Dynamics (Example of Gurjaani City)" was produced within the scope of this study. The primary objective was to analyze the dynamics of anthropogenic factor changes within the natural-territorial complex and evaluate the growing environment challenges posed by anthropogenic impacts in the context of urban development.

Given the varied conditions and small scale of similar complexes, acquiring and processing suitable information presents challenges. To address this, satellite imagery and maps should be digitized and integrated into an electronic database for easy interpretation and accessibility.

Emerging challenges in sustainable urban development highlight the critical need for rational and purposeful land use as a fundamental problem-solving tool. Rational land use is a key strategy for mitigating the negative consequences of urbanization. Effective urban planning, including the arrangement of green spaces, is essential for optimizing the use of natural resources. The creation of green spaces is identified as both a tool and outcome of sustainable urban development, presents as a buffer against environmental degradation.

The research incorporated the global sustainable development strategy, which aims to create ecologically clean, socially just, and economically viable urban spaces. Integrating green spaces into urban areas, protecting natural spaces and resources, and effectively planning land use are crucial elements for achieving this goal.

Main Part

Natural Green Space and Data Analysis

The Akhtala resort complex exemplifies a natural green space. Research information was integrated into a comprehensive database. This data was then deciphered and analyzed. The dynamics of urban and anthropogenic processes were documented through step-by-step observations.

Spatial Overview and Boundaries

While nature lacks defined boundaries, a separate object or transitional state can be represented as a limit. Accordingly, the Akhtala resort complex, borders presenting not only natural areas, but also anthropogenic ones. Therefore, its volume and distribution area can be determined.

Classification System and Object Identification

A classification system was developed during the research. Using the NDVI index, the complex was divided into nine distinct objects (see image 1).

These categories include:

1. Water (swamp) surfaces;
2. Pseudo-volcanic craters;
3. Low vegetation;
4. Parking/Ground surface;
5. Path;
6. Building;
7. Road;
8. Evergreen vegetation;
9. Mixed vegetation.

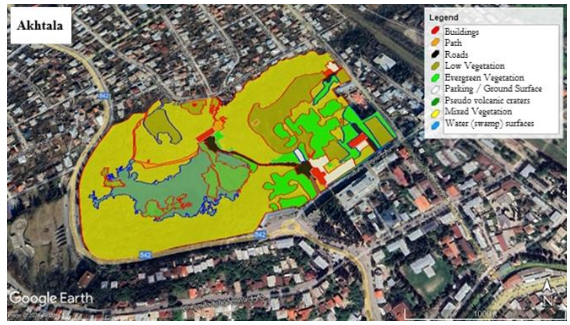


Image 1. Akhtala Resort's Clusters according to the Classification Table.

Buffer Zone and Anthropogenic Impact

The clusters within the Akhtala complex, based on their distribution area and location, warrant particular attention. These clusters function as a natural buffer zone, mitigating anthropogenic impact within the complex and its surrounding areas. Anthropogenic factors are most prominent along the road leading into the complex; their influence diminishes towards the central areas but remains visible.

Plant Health Assessment and NDVI[3] Index

Remote sensing methods were employed to assess plant health using a dedicated information base. The NDVI index was used to categorize plant zones, and their areas were calculated based on the classification table. Objects with varying NDVI indexes were identified (see image 2). Lighter red colors represent areas with sparse vegetation cover or water surfaces.

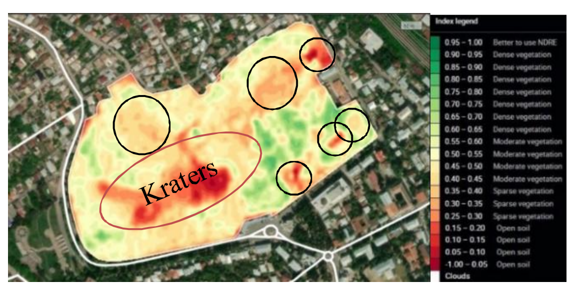


Photo. 2. *The resort of Akhtala clasters, according to the NDVI index of the vegetation cover.*

Long-Term Monitoring: For to the discovery

[3] NDVI is a widely used index in remote sensing to estimate vegetation health and density. It's calculated from the difference between near-infrared (NIR) and red (R) reflectance values of a surface.

of dynamics for anthropogenic factors, To fully understand how human activities change this area over time, we need to keep observing the Akhtala complex. This means studying it not only in different places but also over many years.

Localized object in time (chronological overview)

A Brief Historical Excursion

Akhtala is a mud-healing resort located in Gurjaani city, 122 kilometers from Tbilisi, at an elevation of 392 meters. The region has a moderate continental climate characterized by hot summers, warm winters, and an annual precipitation of 700 millimeters. The resort's primary asset is its healing mud. Pseudo-volcanic mud has been used for baths, applications, and tampons since the 18th century, as mentioned by historical figures such as Vakhushti Batonishvili, P. Yoseliyan, and Doctor A. Meskhisvili.

Thorough scientific research into the healing properties of Akhtala mud began in 1928 at the D. Javakhishvili Institute of Spa Therapy and Physiotherapy. Historically, Akhtala was a separate village where mud ore was extracted. In 1785, a significant robbery occurred, resulting in the theft of large quantities of money, silver, and copper. Mud ore production resumed in 1786, and in 1934, Akhtala was incorporated into the newly formed city of Gurjaani.

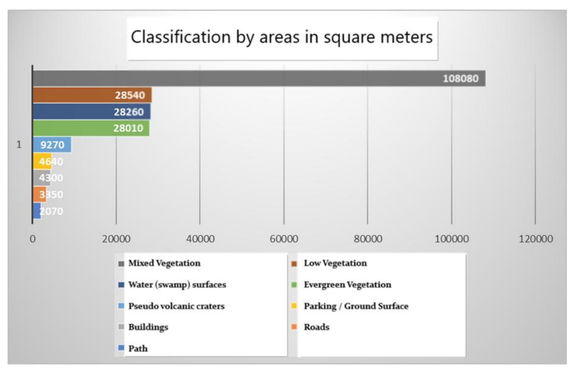
While historical sources, video, and photo archives from 1960 provide valuable information, this research relied primarily on spectral data analysis due to the challenging terrain. Remote sensing methods and various satellite platforms we used it to overcome the difficulties of physical access to this dangerous environment.

Despite the low resolution of early satellite images, it was possible to identify the general location and extent of the large-scale object. However, accurate evaluation based solely on this data was limited. Although the 1985 image lacks detail, it reveals a uniform green space. you can see (Image 3).

Image. 3. *Akhtala resort satellite photo Google Earth 1984 - 2023 year.*

Akhtala, a natural territorial complex, consists of:

The territory bordered by the roads encompasses a total area of 246,600 square meters.



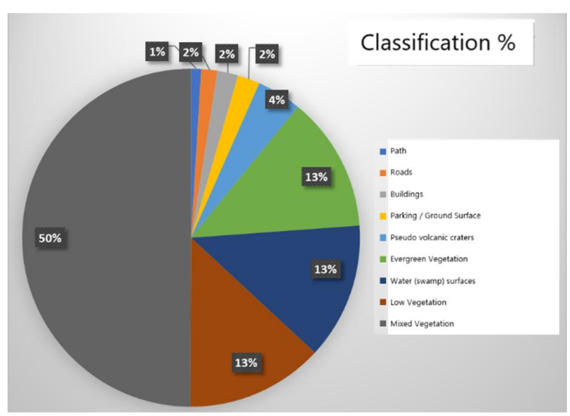


Image. 4. *resort Akhtala clasters, area by %.*

According to the classification system, it is crucial that the largest area within the entire complex be covered by vegetation (Image 4). However, the most critical focus is on areas with low vegetation cover. These surfaces are threatened by desertification, often caused by human activities. In addition to human impact, erosion and soil washing-out processes are also progressing.

Therefore, without in-depth research, determining the exact causes is impossible. Our objective is to assess the extent of the current situation rather than seeking its origins.

For accurate calculations, we considered that low vegetation cover has a low self-recovery capacity and proportionally produces minimal oxygen. Consequently, we focused solely on mixed and evergreen vegetation. After that, we removed marked objects (with varying NDVI indices) from the electronic base and the entire territory-complex system, and we used modern technologies in order to calculate the oxygen produced by the mentioned area in one day. This Volume is sufficient for 8,180 people.

Possible Factors of Complex Formation: Organic Systems in Urban Design

Example: The Natural Territorial Complex of Akhtala

Time and Development: Organic systems evolve gradually under various influences. Akhtala exemplifies a complex where natural and human-made processes have concurrently shaped a unique landscape.

Interconnection: System elements are connected and interdependent. Consequently, complex development should be harmonious and interconnected.

Structure without a Central Plan: Natural complexes often exhibit distinct zones that function as an integrated whole. Akhtala demonstrates this by revealing definable functional zones that interact with the surrounding territory.

Examples of Natural Organic Systems: - The Akhtala Natural-Territorial Complex’s River Systems. Rivers in the complex dynamically change over time, creating channels, floodplains, and diverse ecosystems. The main river in the complex is a Vedziruli river potentially at risk of diffuse pollution. It is in the listed among 25 water bodies under threat (European Union Water Initiative Plus East Partnership for Countries - Vedziruli (Ved302) - Image 5).

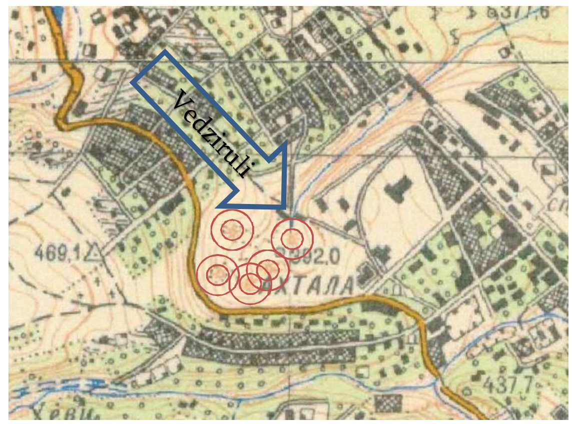


Image. 5. *topographic map from Napr.gov.ge map base.*

Forests: Forests are complex ecosystems where trees compete for sunlight, water, and nutrients. Diverse species create intricate habitats. Notably, desertification and slope collapse are evident within the complex, requiring further investigation to identify underlying causes.

Canyons and Craters: These geological features result from natural processes like erosion and volcanic activity, which have shaped the landscape over vast periods. Satellite images from 2000 show five crater’s cones, while only four remain in 2007. (Image 6) Determining the cause of this disappearance, such as erosion or human intervention, requires detailed study. A topographic map also confirms the presence of five crater cones. The complex represent a dynamic natural system continually influenced by human activities and inversely proportionally. Additionally, a river's origin cannot be in a depression unless it's a specific pseudo-volcanic water source. The complex's internal structure is constantly evolving, affecting its current state.

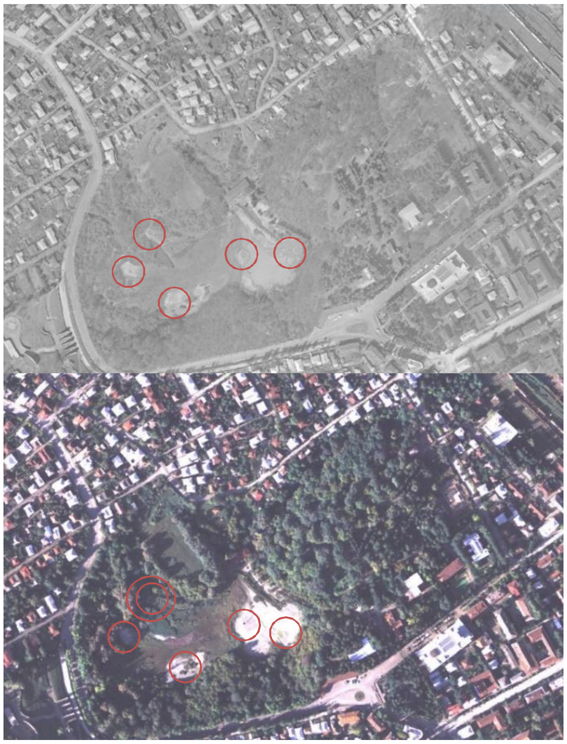


Image. 6. *Akhtala resort 2000-2007; disappearance of the 5th crater.*

Natural Organic System's Formation Factors

Volcanic Activity: Volcanic activity is crucial in shaping the complex's landscape characteristics. However, naturally formed landscapes typically lack the infrastructure necessary for urban development.

Natural Erosion: Natural erosion also significantly contributes to the complex's formation but does not create a suitable environment for an urban network.

Anthropogenic Activity: While human influence cannot be disregarded due to the presence of resources, it is important to note that volcanic activity and natural erosion are the primary factors in shaping the Akhtala complex.

Sustainable Urban Development Criteria: The Akhtala Complex

Sustainability encompasses social, economic, and environmental impact. The Akhtala complex should align with sustainable urban development principles, creating healthy and vibrant spaces while minimizing environmental harm. It's essential to consider the local population's needs and integrate them into spaces planning, ensuring ecological and economic stability.

Land Use Planning: This involves categorizing land for specific purposes like residential, commercial, industrial, and green spaces. For Akhtala, determining the functional purpose of different territories is crucial. Prioritizing green spaces, recreational zones, and scientific research areas is essential to avoid expanding unwanted marked areas (Image 7, based on Image 1 & 2).

Image 7. *Akhtala resort 2007-2024; disappearance of the objects.*

Infrastructure - While infrastructure development falls outside the scope of this research, it's essential to note that over the years, the number and size of infrastructural facilities in the complex have been changed, in the future residential and other structures should adhere to sustainability standards. Geological, water supply, and energy systems require in-depth investigation, especially if considering the region's earthquake activity.

Society Participation - Public involvement is crucial for successful development. Residents should contribute through public consultations, hearings, and feedback mechanisms.

Economic Development - Economic development strategies should prioritize job creation and economic opportunities. The resort should be developed to maximize benefits for the local population.

Aesthetics and Design - Urban spaces should be visually appealing and enhance the community's well-being. To preserve the complex's natural beauty, many objects and materials should be removed from the territory.

Processes to Ensure Compliance with Criteria

Planning: This stage involves analyzing existing conditions, setting goals, and developing a comprehensive plan. Detailed research is crucial, especially given the area's seismic activity and pseudo-volcanic terrain. Satellite imagery, orthophotos, and topographic maps are essential tools.

Zoning: Determining appropriate land use for different zones is critical. Local regulations must be considered. A classification table can be used, or new micro-zones can be identified based on territory-oriented and sustainable urban planning principles (refer to Photo 1, based on Photos 2 & 7).

Construction, Financing, Management, and Care: These responsibilities primarily lie with the resort owner and local authorities. Successful implementation depends on the preceding planning and zoning stages.

Conclusions

Natural attractions like the Akhtala Complex often embody principles of organic systems. Their unplanned evolution, characterized by interconnected elements and emergent order, creates unique and dynamic environments. Traditional urban planning systems may not be suitable for such complexes, highlighting their distinct nature. Sustainable urban development, a model that fosters a partnership with nature, could be particularly relevant for Akhtala. Balancing environmental and economic interests is crucial. The means to achieve this are explored in the part of the article, section: "Criteria for Sustainable Urban Development: The Akhtala Complex."

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Modification of concrete with superplasticizers

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Abstract The use of a chemical additive (superplasticizer) is the most universal and accessible means of managing concrete technology, regulating properties, and saving cement. A chemical additive, which is introdu-ced into concrete in small quantities (0.1...2.0% of the cement mass), changes the properties of the concrete mixture and concrete in the desired direction.

Keywords
Concrete, admixture, superplasticizer, cone setting, water-holding capacity, strength, water-cement ratio, technology.

Fig. 1. Composition of concrete prepared in the first experiment

Introduction

In recent years, the composition and technology of effective chemical additives have been developed, which have a significant plasticizing effect (superplasticizer). When using this additive, the workability of the concrete mixture increases, the water requirement decreases, the strength of the concrete increases, the obtaining of a thin, plastic concrete mixture allows us to use the molding technology of laying, dramatically reduce the labor intensity, due to good ease of placement, the vibration time and heat treatment mode are sharply reduced. Plastic concrete mixture is easy to transport, pump and store. The molded concrete mixture does not crumble and retains its bond.

Main part

The superplasticizer was first used in the world in Germany and Japan. Currently, it is used in all developed countries. It is effective in thin-walled, densely reinforced, complex-configuration structures. In monolithic structures, concreting should be carried out by adding a plastic mixture.

However, when using a superplasticizer, it is important to take into account the duration of the liquefying effect, which varies within 1...1.5 hours. Therefore, the plasticizer is added to the readymade mixture. Before transporting the mixture, the amount of plasticizer is calculated at the factory, which is converted into the volume of the concrete truck. The plasticizer is added to the concrete mixture immediately before unloading. The concrete mixture is completely mixed with the plasticizer within 5 minutes. The plasticizer is stored in a closed container. Many of them need to be protected from sunlight and frost.

How does a superplasticizer "work"? It consists of watersoluble polymer molecules. When mixed with concrete, these molecules adhere to the surface of the cement grains and help create an ionic group. As a result, part of the cement becomes negatively charged, which causes mutual repulsion and hysteretic hindrance (restriction of intra or inter-molecular interactions caused by the spatial structure of the molecules).

Superplasticizers can be divided into four different groups: melamine formaldehyde sulfide condensate (SMF); naphthalene formaldehyde sulfide condensate (SNF); modified lignosulfonate (MLS), sulfuric acid ester, polyacrylate, polytyrol sulfonate, etc.

The most effective superplasticizers are:

Superplasticizers derived from modified lingosulfonate: Acosal fluid and NT, Ozsan S, VN liguidaat WS, Botokem LP, Plastiment BV40, Pozzolitr 300N, Pozzolitr8 and others.

Sulfidated melamine formaldehyde water-soluble superplasticizer Melment L10 and F10, Complast M1, Sealoplaz super and others.

Sulfidated naphthalene formaldehyde water-soluble superplasticizer: Agilplast, Cozmix Spi, Blankol N, Tamol N, Lomaz D, Rheobild, Crysofluid and others.

Let's give data on several superplasticizers: BEVETOL-RDG type, used for slow-setting concrete. (ASTMC-494; Type A, D and G, ELOTEN934-2; T 11.1 and T11.2). Color dark brown, dosage 0.2…0.8% (of cement mass)

BEVETOL-SPL G type, used for slow-setting concrete (ASTM C-494; Type A, D and G, ELOTEN934-2; T 11.1 and T11.2). Color - dark brown, dosage - 0.6...0.8 %.
ADJUM 110, liquid with polycarbonate effect, based on standard EN 934_2: T 3.1 and T 3.2. Reduces water consumption by 20%. Color - light brown. Dosage - 0.6...1.40%.

ADJUM 130, liquid with polycarbonate effect, based on the standard EN 934_2: T 3.1 and T 3.2. Reduces water consumption by 20%. The concrete mixture retains its plasticity for a long time. Color: dark brown. Dosage - 0.35 ... 0.70 % (of cement mass).

Let's consider one of them - Sika VisconCrete Hi-tech 4127, it can be used for any concrete mix. It maintains workability for a long time and meets the requirements of the standard:

- Workability retention time of about 240 minutes;
- High water reduction (up to 40%);
- Reduction of exotherm

Application:

- Production of high-quality ready-mixed concrete;
- Concreting at high temperatures;
- Concreting of massive structures;
- Long transportation time of concrete mix;
- Production of high-strength, waterproof, frost-resistant, crack-resistant and wear-resistant concrete:

Advantages:
• Maintaining workability (plasticity) for a long time (=240 min);
• High water reduction (up to 40%);
• Reduction of concrete exotherm;
• Production of massive, crackresistant structures;
• Obtaining concrete with low deformation shrinkage and creep;
• Obtaining concrete with adequate strength and water tightness;
• Obtaining concrete with high chemical resistance;
• Does not contain chlorides that cause corrosion of reinforcement.

It is known that the concrete mixture, before the hydration process takes place, is a multi-component polydisperse system, in which we can distinguish a twocomponent structure: macrostructure (gravel-cement mortar); Mesostructure (sand-cement dou-gh), microstructure (cement mass, consisting of cement and additives dissolved in the source). Within the framework of the study, we changed the microstructure of the standard concrete mixture in order to improve its physical and mechanical properties, as well as to increase the workability of the mixture in comparison with the standard mixture in order to conduct the technological process of concreting in accordance with the standards.

In the first experiment, we prepared concrete without additives, with a w/c ratio of 0.6. The cone settlement was 15 cm. Concrete samples were tested at the age of 7 and 28 days. At the age of 7 days, the strength was 12.69 MPa, and at the age of 28 days, it was 19.45 MPa.

Table 1. Composition of concrete prepared in the first experiment

Experiment I	Density	kg
w/c	0.6	
Cement	3.05	350
Water	1	210
Sand	2.58	1060
Gravel	2.62	710

Sum		2350

In the second experiment, we prepared admixed concrete with a w/c ratio of 0.4. We reduced the water content in the mixture using Sikament MR 50-S, adding 1% of the cement mass. The cone diameter was 16 cm. Concrete samples were tested at 7 and 28 days of age. The average data of the tested samples at the age of 7 days was 14.4 MPa, and at the age of 28 days it was 23.4 MPa.

Table 2. Composition of concrete prepared in the second experiment

Experiment II	Density	kg
w/c	0.4	
Cement	3.05	350
Water	1	140
Sand	2.58	1065
Gravel	2.62	795
Sikament	1.1	3.5
Sum		2353.5

In the third experiment, we also prepared admixed concrete with a w/c ratio of 0.36. We added SikaVisconcrete Hi-tech 4127, in an amount of 1.5% of the cement mass. The cone settlement was 19 cm. The average data obtained as a result of testing concrete samples at the age of 7 days was 20.1 MPa, and at the age of 28 days it was 34.41 MPa.

Table 3. Composition of concrete prepared in the third experiment

Experiment III	Density	kg
w/c	0.36	
Cement	3.05	350
Water	1	126
Sand	2.58	1090
Gravel	2.62	784
Visconcrete	1.07	5,25
Sum		2355,25

As expected, samples with a low W/C ratio showed higher data. In particular, a 33% reduction in the amount of water gave a 17% increase in the strength of concrete samples at the age of 28 days, while in the second case a 40% reduction resulted in a 77% increase.

Table 4. Data obtained as a result of testing the samples

	W/C	Additive	Additive % from cement mass	Strength of concrete 7 days (MPa)	Strength of concrete 28 days (MPa)	Concrete Slump cm
I	0.6	-	0	12,69	19,45	15 (S3)
II	0.4	Sikament MR 50-S	1	14,4	23,4	16 (S3)
III	0.36	Sika Visco-ncrete Hi-tech 4127	1.5	20,1	34,41	19 (S4)

Conclusion

To predict the expected effect of an admixture in concrete, it is necessary to conduct a technical and economic calculation. In addition, we must take into account the additional costs of its use: cost, warehouse, transport highway, preparation unit, dispenser. Therefore, the admixture should be used where it will give us the greatest technical and economic effect.

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Study of permissible deviations from the project of buildings acceptable for use

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Abstract The article discusses the determination of allowable deviations from the project of buildings acceptable for operation and from the current construction norms, both from the architectural and construction point of view. They are also analysed taking into account all the risks of errors. Unique results have been obtained, which are as follows: as a result of the research, new permissible threshold values from the current regulations for buildings acceptable for use, which differ from the numbers proposed by the current rules, have been determined. The results of the study are based on the deviations of the buildings commissioned under the amnesty law and the sustainability findings presented by the accredited inspection organization as the main argument.

Keywords: exploitation, operation, buildings, deviations from the project, permissible deviations.

1. Introduction

The note aims to determine the permissible limit values of deviations from the approved project and valid norms of the buildings that can be put into operation.

The research objects are the buildings in Tbilisi, according to the respective classes (II, III and IV).

The theoretical and practical basis of the research is the following methods and examples: analysis of applicable laws and regulations, within the amnesty law, analysis of commissioned buildings, architectural analysis of buildings, structural analysis, analysis of installation works, analysis of the arrangement of engineering networks, analysis of national accessibility standards, arrangement of fire systems Analysis.

The research is based on the study of the buildings in operation in Tbilisi. As part of the research, about three thousand buildings were inspected.

2. Main part

As you know, the commissioning of the completed construction means the final determination of the compliance of the completed construction with the permit conditions. There are several basic documents that the completed construction must comply with for the building to be put into operation.
These documents are:
- Law of Georgia - Code of Spatial Planning, Architectural and Construction Activities of Georgia
- Resolution of the Government of Georgia No. 255 (2019) - on the procedure and conditions for issuing a construction permit and putting the building into operation
- Resolution of the Government of Georgia No. 57 (2009) - on the procedure for issuing construction permits and permit conditions
- Regulations approved by the Resolution of the Government of Georgia No. 41- - Building safety rules

A change in the construction document does not require a new construction permit or notice when the implemented change meets the requirements of the detailed construction plan of the technical regulations or the conditions of using the land for construction; An expert opinion on compliance must be submitted.

Going through the mentioned procedure is not mandatory, in case of the following changes to the construction documentation:
a) Slight change of the main dimensions of the load-bearing structural elements of buildings, but not more than 0.1 meters (except for the horizontal section of the columns, the width of the supporting wall.
changes in the heights of the vertical section, the cross-section of inter-floor roofing tiles and consoles), which should not lead to the

weakening of the stability of the construction system defined by the building regulations according to the building construction implementation documents;

b) Changing the development area of each floor on objects belonging to classes I and II with an accuracy of 1.0 m 2 for every 100 m 2 of area, changing the area of development of each floor on objects belonging to classes III and IV with an accuracy of 1.0 m 2 for every 200 m 2 of area, which does not should lead to the weakening of the stability of the structural system determined by the construction documentation of the buildings according to the construction regulations;

c) change of floor height by a maximum of 0.2 meters (by a maximum of 0.3 meters for individual residential houses belonging to the II class), which should not lead to weakening of the stability of the structural system defined by the construction documentation according to the construction regulations, turning the maintenance floor into an incomplete floor and turning an incomplete floor into a full floor;

d) the change of the dimensions of the exterior no more than 0.4 meters, and the change of the dimensions of the building no more than 0.3 meters, if the cadastral boundaries and border zone are not violated and there are no changes that are not considered in the permissible changes;

e) moving/changing and/or adding/subtracting non-loading and self-loading structural elements of the interior;

f) Changing, adding or shortening the separate local engineering and communication network of buildings;

g) replacement of construction materials and products with other construction materials and products with appropriate technical and aesthetic characteristics;

h) moving/changing such parts of buildings that do not require a construction permit by this rule;

i) horizontal displacement of the ground edge and/or underground part of the building structure about the ground surface no more than 1.0 meters, provided that the borders of the cadastral unit are protected;

j) vertical change of the zero mark of the building about the absolute zero of no more than 0.4 meters (including any kind of change caused by this change), which should not lead to the transformation of the underground floor into a ground or above-ground floor;

k) depending on the properties of the soil, the additional charge of the foundation of the building (in the case of point, ribbon and monolithic slab) of no more than 0.5 meters;

m) Depending on the properties of the ground, additional or less deepening of the building's girder foundation to the solid part of the ground.

Allowed changes in the construction documentation should not violate other permit conditions, or requirements of technical regulations and should not violate the rights of third parties.

It is forbidden to build one or more floors on the agreed object, to change the development area of the object by more than 20%, and to change the defined function of this object. In such a case, the procedure for obtaining a construction permit starts again by the applicable legislation.

Permissible deviations during construction-installation work Quality control of construction-installation works (CEM) is carried out to determine and ensure compliance of the performed works and used materials, products and structures with the requirements of the project, building rules and other applicable regulatory documents.

This goal is achieved by solving the following tasks:

- timely detection, elimination and prevention of defects, grievances and violations of work rules, as well as their causes;
- by establishing the compliance of the quality indicators of construction materials and the performed construction-installation works with the established requirements;
- by improving the quality of construction and installation works, reducing non-productive costs of processing defective materials;
- By increasing production and technological discipline, workers are responsible for ensuring the quality of construction and installation works.

Quality control of construction materials, products, constructions and the work performed is carried out by their continuous or selective inspection, if necessary, by opening previously completed hidden works and constructions, as well as by testing existing constructions (by non-destructive methods, loads and other methods) for strength and stability, settlement, impermeability of sediment, sound and for thermal insulation and to compare other physical, mechanical and technical properties with the requirements of the project and regulatory documents.

Quality control is carried out by:

- Representatives of state control and supervision bodies (state architectural and construction supervision, technical supervision, energy supervision, state sanitary and epidemiological supervision, fire supervision, etc.);
- Representatives of the customer's superior organizations and the contractor, who inspect the construction;
- representatives of project organizations (author supervision);
- complex commissions consisting of representatives of the customer and contractors;
- Customer representatives (technical supervision of construction);
- Personnel of contractor construction organizations (engineering and technical workers who directly carry out work production, foremen and ring leaders, construction laboratory, geodetic service), as well as internal control commissions appointed by the head of the contractor organization.

Quality control of construction projects is carried out in the following terms:

- by the personnel of the contractor construction organizations and representatives of the customer - daily;
- representatives of design organizations - within the terms specified by the designer's supervision agreement;
- State supervision bodies - periodically.

Construction sites must have:

- general log of works, special logs for certain types of works (log of installation of construction structures, log of welding works, log of anti-corrosion protection of welded seams, log of installation edges and joints, etc.), the list of which is drawn up by the user in agreement with the general contractor and subcontractors, Journal of copyright supervision of project organizations (if any);
- inspection reports of hidden works, interim acceptance of load-bearing structures, testing of equipment, systems, networks and devices;
- Other production documentation for certain types of works provided for by construction norms, SNDTS and as executive documentation - working drawings with a note on the compliance of the work performed with these drawings or included in them
- With changes. Agreement with the design organization, concluded by the persons responsible for the production of construction and installation works.

During control and acceptance of work, the following are checked:

- Conformity of the used materials, products and structures with the requirements of the project;
- compliance with the composition and scope of the work performed with the project;
- compliance with controlled physical-mechanical, geometric and other indicators with project requirements;
- Timely execution and correctness of production documentation;
- Eliminating the deficiencies mentioned in the work logs during the control and supervision of the construction and installation works.

3. Conclusion

As a result of the research, new permissible threshold values were determined from the valid norms of buildings acceptable for operation, which differ from the numbers proposed by the current regulations. The results of the study are based on the deviations of the buildings commissioned under the amnesty law and the sustainability findings presented by the accredited inspection organization as the main argument.

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Calculation of horseshoe-shaped lining in elastic environment

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Abstract The horseshoe-shaped lining in an elastic medium is deformed both from the inside and from the outside. From the outside, the lining receives elastic resistance from the soil, which changes along a square parabola and helps the lining work. Taking into account the influence of elastic resistance of the rock on the work of the tunnel lining is of qualitative importance. The paper considers the calculation of a horseshoe-shaped lining in an elastic medium, taking into account the influence of elastic resistance of the rock. The system under consideration is statically indeterminate, the calculation is carried out using the method of forces in matrix form. Examples of calculation are given.

Key Word: Horseshoe-shaped lining; elastic medium; soil resistance; method of forces in matrix form

Introduction

Calculation of the vault taking into account elastic resistance is a relatively complex task. Experiments have established that the law of distribution of the resistance diagram can be approximated by a square parabola. The vault is a static indefinite system, the calculation of which can be made by the method of forces in matrix form.

Calculation of tunnel lining

This calculation takes into account the influence of elastic rock resistance [1]. When calculating, the following are specified: the shape of the resistance diagram and its zone of action, and the greatest value q^1_{max} the resistance intensity is determined under the assumption that the rock is an elastic Winkler base. In addition to the rock resistance, the influence of friction forces is also taken into account, the intensity of which at each point of the outer surface of the lining is equal to the rock resistance intensity at this point, multiplied by the friction coefficient f (t^1=f· q^1). The selection forces are directed along the normal, and the friction forces are tangential to the outer surface of the lining.

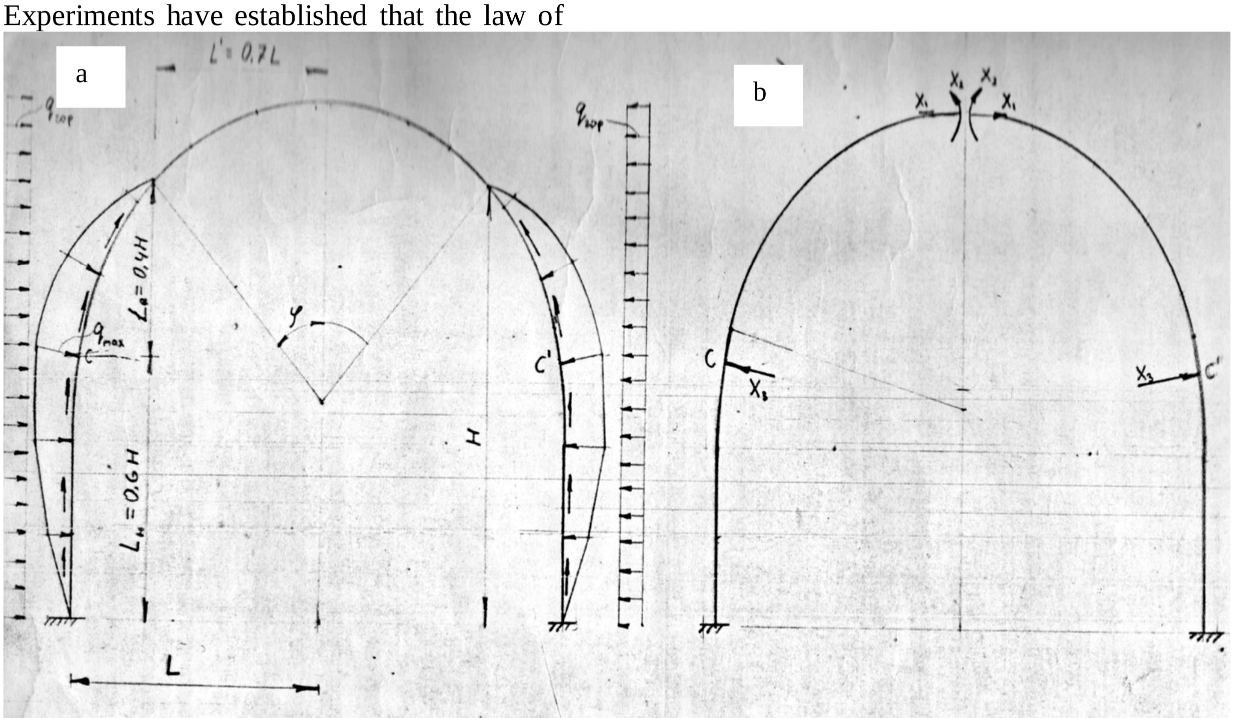

Figure (1a) shows the load diagram, and Figure (1b) shows the design diagram of the arch

The unknowns are the efforts X_i and the magnitude of the intensity q^1_{max}. They are found from the canonical equations of the force method and the equation

$$q^1_{max} = k_c \cdot V^1_{max} \qquad (1.1)$$

where k_c is the coefficient of rock bedding on the sides of the arch (т/м³), V^1_{max} – displacement of that point of the lining at which the resistance of the rock has the greatest value ordinate of the diagram q_{max}. The largest ordinate of the resistance diagram q^1_{max} is accepted as being located at the level (0.33-0.4)H, where H defines the zone of action of elastic selection and is established graphically from Fig. 1. The distribution law q^1 are set as follows:

$$q^1 = q^1_{max}\left(1 - \frac{Z^2}{L^2}\right), \qquad (1.2)$$

where Z is the vertical distance from point C at which $q^1 = q_{max}$. It is assumed that point C is removed from zero point A by a distance of 0.4 H. When constructing the diagram q^1 for the section of the arch located above point C, instead of L,

$$L_B = 0.4\ \text{H},$$

And below this point $-\text{L} = L_н = 0.6\text{H}$.

The canonical equations of the force method are:

$$\delta_{11}X_1 + \delta_{12}X_1 + \delta_{1q^1} + \Delta_{1P} = 0$$
$$\delta_{21}X_1 + \delta_{22}X_1 + \delta_{2q^1} + \Delta_{2P} = 0 \qquad (1.3)$$

In these equations the coefficients δ_{11}, δ_{12}, δ_{21}, δ_{22} and free members Δ_{1P}, Δ_{2P} have the usual meaning, as for the coefficients δ_{1q^1} и δ_{2q^1}, then they represent a movement in the direction of unknowns X_1 и X_2, caused by the action of a single rock rebuff q^1_{max}=1 and the corresponding friction forces $t^1 = q^1 \cdot f$. Let's apply at point C and C[1] forces directed along the normal to the geometric axis of the arch X_3. Let us denote by δ_{31}, δ_{32} and δ_{3q^1} displacement in the direction of force X_3 from single impacts: $X_2 = 1$, X_2 =1 and single selection of the breed, and through , Δ_{3P} – from a given external load. Then the total displacement in the direction of the dash from a given external load. Then the total displacement in the direction of the dash X_3 equals:

$$\Delta_3 = V^1_{max} = \delta_{31}X_1 + \delta_{32}X_1 + \delta_{3q^1} + \Delta_{3P}$$

Based on the formula (1.1), $V^1_{max} = \frac{1}{K_C} q^1_{max}$. Taking the latter into account, we have:

$$\delta_{31}X_1 + \delta_{32}X_1 + \left(\delta_{3q^1} - \frac{1}{K_C}\right) q^1_{max} + \Delta_{3P} = 0 \qquad (1.4)$$

Equations (1.3) and (1.4) can be represented in matrix form

$$\delta \cdot X + \Delta = 0 \qquad (1.5)$$

where $\delta = \begin{Vmatrix} \delta_{11} & \delta_{12} & \delta_{1q^1} \\ \delta_{21} & \delta_{22} & \delta_{2q^1} \\ \delta_{31} & \delta_{32} & \left(\delta_{3q^1} - \frac{1}{K_C}\right) \end{Vmatrix}$;

$$X = \begin{Vmatrix} X_1 \\ X_2 \\ X_3 \end{Vmatrix}; \qquad \Delta = \begin{Vmatrix} \Delta_{1P} \\ \Delta_{2P} \\ \Delta_{3P} \end{Vmatrix}; \qquad (1.6)$$

The matrix can be obtained by the formula:

$$\delta = \overline{S^T}\,F\,\overline{S_1} + K$$

Where $\bar{S}$ - matrix of unit efforts. In the first column of the matrix $\bar{S}$ located efforts in the main system from the force: X_1 =1, in the second column from X_2 =1 and in the third from - X_3 =1. S_1 - is also a matrix of unit efforts. It differs from the matrix $\bar{S}$ the fact that in its third column there is no effort in the main system, from a single resistance of the rock, that in its third column there is no effort in the main system, from X_3 =1, and from a single resistance of the rock (при q^1_{max} =1).

$$K = \begin{Vmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & -\frac{1}{K_C} \end{Vmatrix} \qquad (1.8)$$

The matrix Δ can be obtained by the formula:

$$\overline{S^T}\,F\,S_P \qquad (1.9)$$

Here S_P - effort matrix.
The final forces in the static indeterminate tunnel lining are determined by the formula

$$S = (\overline{S_1^1}\,X + S_P^1)P = (-\overline{S_1^1}\cdot\delta^{-1} + S_P^1)P \qquad (1.10)$$

Whereδ и Δ matrices are determined by the formula (1.7) и (1.9). $\overline{S_1^1}$ − unit effort matrix. It is different from the Matrix $\overline{S_1}$ in that it includes efforts, the value of which is determined by q^1_{max} =1.

Example 1
Based on the above method, the arch is calculated. The vertical and horizontal loads are respectively equal to: $q_{верт.}$=25 $\frac{т}{м^2}$, $q_{гор.}$ =1.5 $\frac{т}{м^2}$.
The coefficient of rock bedding on the sides of the arch is equal to $K_П =$ 16 $\frac{т}{см^3} = 16\cdot 10^3 \frac{т}{м^3}$.

All geometric dimensions of the arch are given in Table No. 1. We begin the calculation by determining the internal forces in the main rock support system. ($q_{верт.}$=1 $\frac{т}{м^2}$) и от external specified load (see table No. 1).

$$S = \begin{vmatrix} 0 & 1 & 0 \\ 0.23 & 1 & 0 \\ 0.89 & 1 & 0 \\ 1.93 & 1 & 0 \\ 3.27 & 1 & 0 \\ 4.70 & 1 & 0 \\ 6.30 & 1 & 1.63 \\ 7.03 & 1 & 3.29 \\ 9.55 & 1 & 4.94 \\ 0 & 0 & -0.19 \\ 9.55 & 1 & 4.94 \end{vmatrix}$$

$$S_1 = \begin{vmatrix} 0 & 1 & 0 \\ 0.23 & 1 & 0 \\ 0.89 & 1 & 0 \\ 1.93 & 1 & -0 \\ 3.27 & 1 & -1\ \ .02 \\ 4.70 & 1 & -4.16 \\ 6.30 & 1 & -9.69 \\ 7.03 & 1 & -17.65 \\ 9.55 & 1 & -26.89 \\ 0 & 0 & -26.89 \\ 9.55 & 1 & -26.89 \end{vmatrix}$$

$$S_P = \begin{vmatrix} 0 \\ -32.19 \\ -119.17 \\ -236.07 \\ -349.43 \\ -428.41 \\ -463.42 \\ -465.09 \\ -502.05 \\ 147.25 \\ -502.05 \end{vmatrix}$$

$$\overline{S}_1^{1} = \begin{vmatrix} 0 & 1 & 0 \\ 0.23 & 1 & 0 \\ 0.89 & 1 & 0 \\ 1.93 & 1 & -0.02 \\ 3.27 & 1 & -1.02 \\ 4.70 & 1 & -4.16 \\ 6.30 & 1 & -9.69 \\ 7.03 & 1 & -17.65 \\ 9.55 & 1 & 26.89 \\ 1 & 0 & 0 \\ 0.96 & 0 & 0 \\ 0.89 & 0 & 0 \\ 0.67 & 0 & -0.023 \\ 0.44 & 0 & -0.15 \\ 0.19 & 0 & -0.12 \\ 0 & 0 & 0.06 \\ 0 & 0 & -0.29 \\ 0 & 0 & -0.43 \end{vmatrix};$$

#	corner			Coordinates in m			Section thickness	Efforts in the main system			
								From resistance and friction forces q^1_{max}=1		From the specified load	
	φ	sin φ	cos φ	X	Y	Y_1	h	$M_{T.M.}$	N_T	$M_{T.M.}$	N_T
0	0	0	1	0	0	0.23	0.70	0	0	0	0
1	0.27	0.27	0.96	1.60	0.23	0.89	0.75	0	0	-32.19	10.74
2	0.56	0.53	0.84	3.08	0.89	1.93	0.775	0	0	-119.17	-39.73
3	0.83	0.74	0.66	4.323	1.93	3.27	0.825	-0.02	-0.023	-236.07	78.42
4	1.12	0.89	0.43	5.23	3.27	3.27	0.875	-1.02	-0.154	-349.93	115.48
5	1.38	0.98	0.19	5.74	4.70	4.70	0.95	-4.16	-0.124	-428.41	139.45
6	1.57	1	0	5.89	6.30	6.30	1.00	-9.69	-0.055	-463.42	147.25
7	1.57	1	0	5.89	7.93	7.93	1.20	-17.65	-0.294	-465.09	147.25
8	1.57	1	0	5.89	9.55	9.55	1.26	-26.89	-0.428	-502.05	147.25

$$S_P^1=\begin{vmatrix} 0 \\ -32.19 \\ -119.17 \\ -236.07 \\ -349.93 \\ -428.41 \\ -463.42 \\ -465.09 \\ -502.05 \\ 0 \\ 10.74 \\ 39.73 \\ 78.42 \\ 115.48 \\ 139.55 \\ 147.25 \\ 147.25 \\ 147.25 \end{vmatrix}$$

F=
|28.43; 46.22; 41.09; 34.10; 28.61; 22.74; 19.50; 11.28; 9.74; 17.14; 119.05|

$$\overline{S_1^1}=\begin{vmatrix} 0 & 10.63 & 36.57 & 65.81 & 93.55 & 106.88 & 122.85 & 89.45 & 93.02 & 0 & 1336.93 \\ 28.43 & 46.22 & 41.09 & 34.10 & 28.61 & 22.74 & 19.5 & 11.28 & 9.74 & 0 & 119.05 \\ 0 & 0 & 0 & 0 & 0 & 0 & 31.79 & 37.11 & 48.12 & -3.26 & 588.11 \end{vmatrix}$$

$$(\bar{S}^T\cdot F)\cdot\bar{S_1}=\begin{vmatrix} 141.39 & 1745.11 & -30572.05 \\ 1745.11 & 360.76 & -3975.67 \\ 6570.46 & 705.13 & -18219.87 \end{vmatrix};$$

$$\delta=(\bar{S}^T\cdot F)\cdot\bar{S_1}+K=\begin{vmatrix} 141.39 & 1745.11 & -30572.05 \\ 1745.11 & 360.76 & -3975.67 \\ 6570.46 & 705.13 & -18219.87 \end{vmatrix}+\begin{vmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & -\frac{24.103}{16\cdot 10^3} \end{vmatrix};$$

$$K=\begin{vmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & -\frac{24.103}{16\cdot 10^3} \end{vmatrix};$$

$$\Delta = (\bar{S}^T \cdot F) S_P = \begin{vmatrix} -814790.25 \\ -113129.97 \\ -351890.92 \end{vmatrix}; \quad X = \begin{vmatrix} 53.94 \\ 94.49 \\ 3.79 \end{vmatrix}; \quad S_1^1 \cdot X = \begin{vmatrix} 94.49 \\ 106.89 \\ 142.99 \\ 198.51 \\ 267.00 \\ 332.21 \\ 397.53 \\ 455.25 \\ 507.5 \\ 53.94 \\ 51.78 \\ 36.04 \\ 23.16 \\ 9.79 \\ 0.23 \\ -1.10 \\ -1.63 \end{vmatrix}; \quad S = \begin{vmatrix} 94.49 \\ 74.70 \\ 23.32 \\ -37.56 \\ 82.93 \\ -96.20 \\ -65.89 \\ -9.84 \\ 5.52 \\ 53.94 \\ 62.52 \\ 85.58 \\ 114.47 \\ 138.64 \\ 149.34 \\ 146.15 \\ 145.62 \end{vmatrix}$$

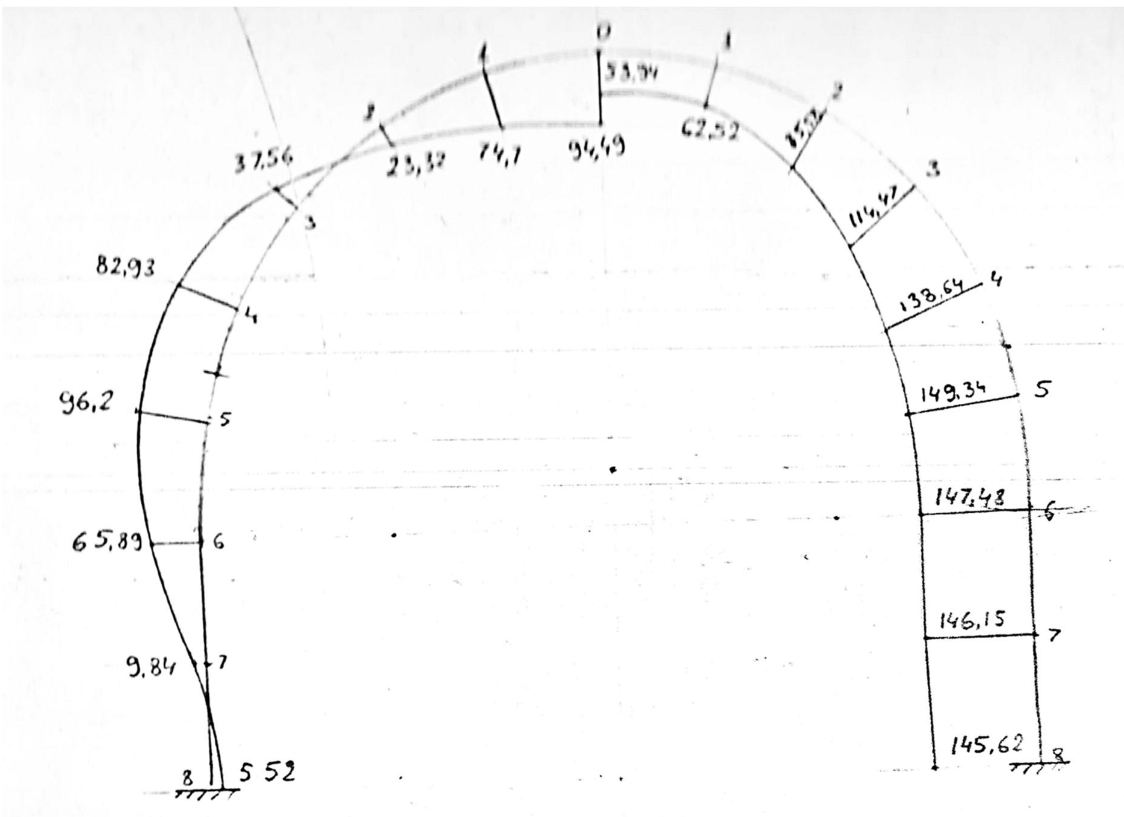

Figure 2.

The arch is calculated on the vertical – $q_{верт}$=25 $\frac{Т}{М^2}$ and on the horizontal $q_{гор}$=1.5 $\frac{Т}{М^2}$ loads. The coefficient of rock bedding on the sides of the arch is equal to $K_П$=1.10^3 $\frac{Т}{М^2}$. loads. The coefficient of rock bedding on the sides of the arch is equal to

$$K = \begin{vmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & -\frac{24.103}{16 \cdot 10^3} \end{vmatrix};$$

$$\delta=(\bar{S}^T\cdot F)\cdot\bar{S_1}+K=\begin{vmatrix}14199.57 & 1745.11 & -30572.05\\ 1745.11 & 360.76 & -3975.67\\ 6570.46 & 705.13 & -20469.87\end{vmatrix};$$

$$\Delta=(\bar{S}^T\cdot F)S_P=\begin{vmatrix}-814790.25\\ -113129.97\\ -351890.92\end{vmatrix};\quad X=\begin{vmatrix}51.34\\ 92.52\\ 2.48\end{vmatrix};$$

$$S=\begin{vmatrix}92.52\\ 72.14\\ 19.04\\ -44.51\\ -92.05\\ -104.88\\ -71.44\\ -9.13\\ 14.20\\ 51.34\\ 60.03\\ 83.37\\ 111.74\\ 137.70\\ 149.00\\ 147.40\\ 146.53\\ 146.19\end{vmatrix}$$

The diagrams of the bending moment and longitudinal force are shown in Fig. 3.

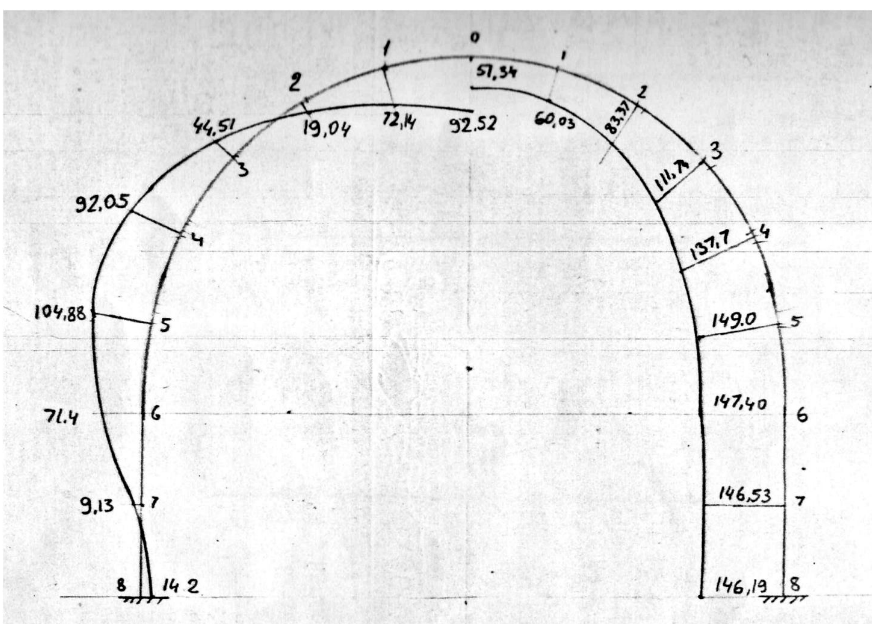

Figure 3.

The arch is calculated for the same loads and geometry without taking into account the influence of the elastic foundation. The corresponding matrices in this case have the form:

$X=\begin{vmatrix}46.47\\88.82\end{vmatrix}$; $\delta=(\bar{S}^{T}\cdot F)\cdot\bar{S_1}=\begin{vmatrix}14199.57 & 1745.11\\1745.11 & 360.76\end{vmatrix}$; $\bar{S_1}=\begin{vmatrix}-814790.25\\-113129.97\end{vmatrix}$;

$$S=\begin{vmatrix}88.52\\67.32\\11.00\\-57.57\\-92.05\\-109.17\\-121.20\\-81.87\\-7.80\\30.52\\57.21\\55.34\\79.23\\109.55\\135.92\\148.38\\147.25\\147.25\end{vmatrix};$$

The plots are shown in Fig. 4.

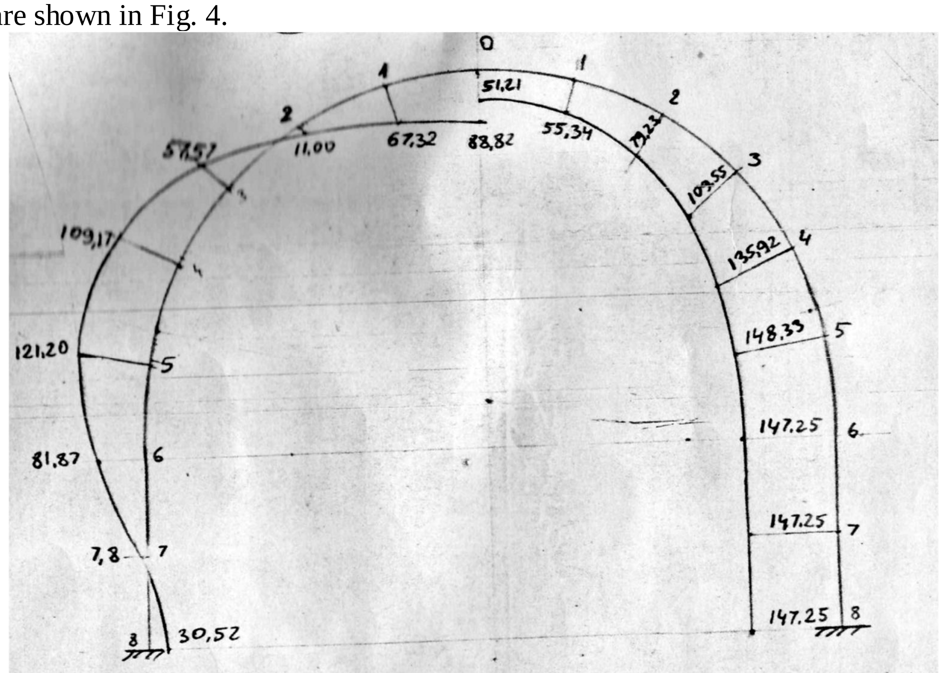

Figure 4

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Reuse of greywastewater in multi-story buildings: a sustainable solution to save water

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Abstract

Gray water makes up 60-70% of a home's water requirement and thus can be an alternative source of water for flushing toilets. However, although it is intended to be quite "clean", it can be contaminated and thus pose potential health and aesthetic risks. This article describes the quantity and quality of different sources of domestic gray water and their relative contribution with respect to reuse for toilet flushing. The dishwasher was found to be a major source of organic matter and nutrients, while baths and showers were identified as major sources of fecal coliforms. Six different scenarios were studied, in each of which a different greywater source was xcluded from the 'mainstream' greywater stream and the impact on the quality and quantity of the raw 'mainstream' was examined. The potential for water savings in the domestic sector was then assessed, with Israel serving as a case study, representing a semi-arid country suffering from water shortages. Reusing greywater for toilet flushing in the domestic sector will increase the sustainable use of water in the urban environment.

Key words: greywater reuse, water conservation, alternative water resources, sustainable water use, urban water reuse

1 Introduction

Water storage, typical for Georgia, is the main reason for the introduction of a national desalination scheme in the country with a capacity of hundreds of millions of cubic meters per year (MCM/y) in 2008. However, this "non-traditional" water source entails high production costs as well as negative environmental impacts such as increased emissions (CO_2 and other pollutants), environmental degradation, etc. Therefore, in parallel with the development of desalination capacities, a review of domestic water consumption is required in order to reduce the overall demand and thus minimize the use in desalination. The total specific urban water demand is about 300 liters per capita per day (l/c/d), while domestic demand (excluding horticulture and other external uses) is 100-150 l/c/d, which in total amounts to 240-360 million cubic meters per year worldwide - the second largest water consuming sector after agriculture. Except for small amounts, most domestic water consumption is converted into domestic wastewater, which can be divided into two main categories:

1. Gray water: generated from all household "water-generating" appliances, with the exception of toilets, and accounts for 60–70% of domestic water consumption.
2. Black water: formed from toilets, and accounts for 30-40% of domestic water consumption.

Since the quantity of greywater is substantially higher than that of blackwater, direct in-house reuse of greywater for toilet flushing is possible. This would result in a potential saving of around 40 l/h/d (15 m^3/h/year) of specific domestic water demand - a significant reduction in urban water demand if significant implementation were to be achieved. The concept of in-house greywater reuse has been explored in recent years, particularly in the EU and Japan, where conservation of natural resources is a major motivation for this initiative. However, since it is a relatively new concept, full-scale systems are not common (UK Environment Agency, 2000). Most studies to date have focused on the single-house scale, with little coverage of the high-rise/neighbourhood scale.

- There is no uniform approach to greywater reuse in the EU, for example in Denmark internal greywater recycling is not permitted, in Austria, Germany and Sweden it is permitted, while in the UK there is no legislation or clear guidelines. In Austria and Germany pilot systems have been installed in housing estates. In 2000 the UK Environment Agency (2000) completed a two-year trial in 10 single-family homes.
- The United States has long experimented with greywater reuse, primarily because about 60% of homes in the country are not connected to sewer systems and rely on on-site treatment. Despite this, on-site greywater recycling has not been well established. In 1989, Santa Barbara County in the United States became the first region to legalize greywater reuse. In 1992, Los Angeles completed a pilot project to reuse greywater for gardening (toilet flushing was not an option due to health concerns). Although drought-prone western states reuse greywater for irrigation, there is little evidence of household recycling of non-potable greywater.
- Water reuse in Japan is strongly focused on urban reuse, unlike other countries where water reuse is mainly used for agricultural irrigation. Greywater treatment and reuse systems in Japan range from simple ones in residential areas to advanced recycling systems in high-rise areas. For example, in Tokyo, greywater recycling is mandatory for all new buildings over 3,000–5,000 m^2 (Ogoshi et al., 2001).

Greywater, although considered to be fairly unpolluted, can be highly polluted and thus pose a potential health risk and aesthetic nuisance (Almeida et al., 1999; Diaper et al., 2001; Dixon et al., 1999; Rose et al., 1991 and others). Greywater also exhibits internal variability which is reflected in high variations in discharge volumes and pollutant loads, for example: shower discharge volumes range from 2 to 120 L/use and its COD loads range from 8000 to 36000 mg/use (Friedler and Butler, 1996). As a result of the above, direct indoor reuse requires highly efficient and reliable transport, storage and treatment systems to prevent the use of water that may pose a health risk and have negative aesthetic effects such as odour and colour.

Various treatment processes are proposed in the literature. However, because domestic gray water recycling is in its infancy, only a few off-the-shelf systems are available for commercial use, and even fewer have been tested at full scale over extended periods of time (UK Environment Agency, 2000; Diaper et al., 2001). Initially, preference was given to physical processes. Today, a combination of physical, biological and chemical treatment processes are reported. These are usually followed by a disinfection plant. Due to space limitations, processes with a small footprint have been selected. The main ones are listed below (Hills et al., 2001; Jefferson et al., 2001; Ogoshi et al., 2001; Shin et al., 1998):

- Physical: filtration, microfiltration (MF), ultrafiltration (UF), nanofiltration (NF) & reverse osmosis (RO);
- Biological: membrane bioreactors (MBR), biological aerated filters (BAF) and SBR bioreactor;
- Disinfection: chlorination, ozonation & UV irradiation;

A study was conducted to investigate the feasibility of greywater reuse in an urban setting. The conditions differ from those in most countries where indoor greywater reuse has been investigated, as higher ambient temperatures may increase the rate of organic matter decomposition and enhance pathogen regrowth. This may result in higher health risks and negative aesthetic effects, and thus require more stringent treatment. The study is divided into four phases: characterization of different sources of indoor greywater; assessment of realistic water savings potential on a national scale; a pilot study of treatment and reuse; and a feasibility study.

This article describes the results of a sampling campaign conducted to characterize greywater produced by different water-generating devices, compares the results with literature data, and discusses the implications of the results for treatment and reuse options. The final part of this article analyzes the potential for water savings in the domestic sector, serving as a case study representing a semi-arid country suffering from water resource depletion.

2 Methods and materials

A sampling campaign was performed in order to characterise the quantity and quality of greywater generated from individual household appliances. Details about samples distribution is presented in Table 1. Each time a sample was taken the discharge volume of the event was measured. 20 parameters were analysed in the laboratory in accordance with the methods of Standard Methods (APHA et al., 1998): pH, electrical conductivity (EC), chlorides, sodium, boron, ammonia, phosphate, total solids, volatile total solids, suspended solids (total & volatile), COD (total & dissolved), BOD (total & dissolved), TOC (total & dissolved), total oil, MBAS and faecal coliforms (FC).

Table 1. Greywater samples distribution

All information was stored in a database containing over 2,000 data records. We can see the average values obtained for each parameter-device combination. They show that the kitchen sink and the first two stages of the washing machine and dishwasher cycle are the main sources of contamination, as described below:

Appliance	**No. of samples**
Wash basin (WB)	33
Shower (SH)	19
Bath (BT)	10
Kitchen sink (KS)	19
Dishwasher (DW)	(6*4)24
Washing machine (WM)	(7*5)35
TOTAL	**140**

- Boron – The highest concentrations and loads were found in stage 2 of the dishwasher: 7.5 mg/L and 58 mg/use, respectively. Unlike other countries, washing machine wastewater in Israel does not contain high concentrations of boron, since all washing powders in Israel are required to have a low boron
- pH – Generally in the range of 7 to 8, except for the last stages of dishwashers (~8.5).
- Organics – The highest COD and BOD values were found in greywater from the first stages of washing machine and dishwashers, while the highest load was found in greywater from the first stage of washing machine operation: over 70 and 20 g/use COD and BOD respectively.
- Phosphates – The highest concentrations were found in greywater from dishwashers (second stage): concentration close to 1300 mg/L and load 10 g/use. Washing machine produces 524 mg/L and about 9 g/use.
- Ammonia - The most important source was the washing machine with concentrations of 7.0-13 mg/L and 137-222 mg/L in the first two cycles. The dishwasher contributed 10 and 7.9 mg/L in the first two cycles, but the load was much smaller. · Sodium - The highest concentrations were found in the first cycles: 1205 mg/L with an average load of over 20 g/use. In the second cycle, the dishwasher greywater contained 1108 mg/L and a load of 8.5 g/use.
- Chloride – The highest concentrations were found in the first two stages of the dishwasher: 777 and 1261 mg/L. The highest chloride load was found in stage 4 of the washing machine (over 12 g). Relatively high chloride loads were found in the greywater generated in the shower, bathtub and all other stages of the washing machine and dishwasher.
  content (Israel Ministry of the Environment, 1999).

3 Research object

As a preliminary step in developing an appropriate greywater treatment and reuse scheme, all municipal greywater sources should be assessed in terms of their daily discharge volume and pollutant load. The product of the average pollutant concentration and the average daily use volume of the relevant device yields the specific daily load (load/hour/day) of each pollutant-device combination. The overall specific daily load of a municipal greywater with a discharge volume of 104 l/hour/day, a TSS load of 27 g/hour/day and a BOD load of 36 g/hour/day, the last two representing 50-60% of the "typical" specific load of a municipal wastewater. The relative contribution of each device has been calculated and the variability between devices is very high. For example:

- The dishwasher and washing machine were identified as the major contributors to most pollutants, with 24% and 16% of the daily discharge volume, 49% and 12% of TSS, 36% and 25% of CODt, 49% and 22% of BODt, 51% and 19% of total oil, respectively.
- The sink, on the other hand, was found to be the least polluting appliance, contributing less than 10% of the total pollutant load.

Since the daily water consumption used to flush household toilets is significantly less than greywater consumption (about 50% or less), it is possible to avoid treating and recycling all greywater streams, and instead select those streams that are less polluted and therefore require less treatment and have fewer potential negative health and aesthetic impacts.

This approach is particularly strengthened by the results presented in Figure 1. To examine the potential effects of such measures, six baseline scenarios were studied, each with one greywater generating device excluded, and the total daily discharge and pollutant loads were recalculated. The results are presented as a residual percentage of the baseline (all devices included). As expected, the most significant improvement occurred when the dishwasher discharge stream was excluded, reducing the load of most pollutants to 50-60% of their baseline levels, with a milder impact on the total daily flow (a reduction of only about 25%). Thus, eliminating this stream from the greywater to be treated and reused will reduce the size of the treatment device. This is true for organic matter and nutrients, however, when it comes to pathogens (as indicated by faecal coliforms), the dishwasher is a minor contributor, while the bath and shower are major contributors, with reductions of up to 65% of the original FC concentration when either is removed from the total greywater stream. This creates a dilemma, as high concentrations of organic matter and nutrients can lead to negative aesthetic effects and a greater potential for pathogen regrowth on the one hand, while potentially high concentrations of pathogens (as indicated by high FC concentrations) pose a higher health risk on the other. A slightly different treatment setup may be required to combat each of the two types of contaminants mentioned above.

4 Results and analysis

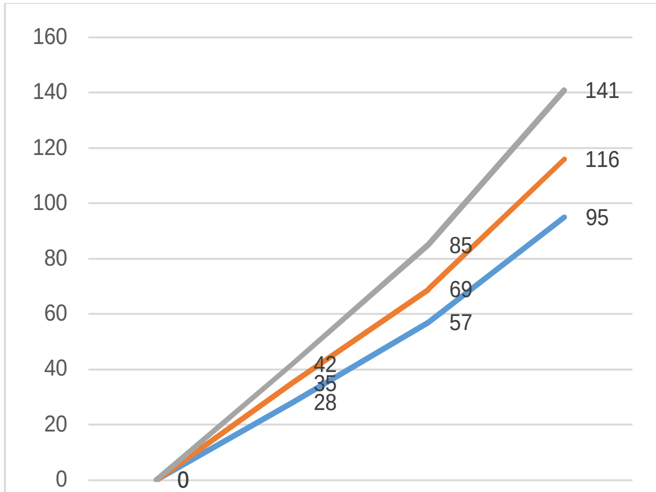
The discussion so far has focused on the quantitative and qualitative characteristics of the different greywater sources and their impact on treatment and reuse. As stated in the introduction, most greywater reuse schemes to date have focused on single-household to small-scale systems, which have their own merits but do not have an impact on the regional/national water budget. This section analyses the water saving potential of large-scale implementation of greywater reuse schemes in the urban sector and their impact on the water budget of urban centres. An effect that could lead to a more intelligent approach to greywater use that takes into account not only human needs but also broader environmental aspects, thus improving the sustainable use of water in the urban environment.

To assess the likelihood of achieving the penetration rate and, consequently, the water saving potential in the urban sector in Israel, the following assumptions were made:

- The lower limit for installing a greywater recycling system is a 3-story building with 12 apartments. This is the smallest building that can finance the operation and maintenance of a greywater recycling system by a professional, certified firm. Over the past 20 years, about 55% of new apartments have been built in buildings at least 3 stories high. It was assumed that this ratio would continue in the future.
- The average “core” family size is 3.36 people. It was assumed that each

apartment is occupied by one "core" family, and the size of the "core" family would not change in the future.

A realistic penetration rate was estimated using two independent methods: the design life of buildings and data on new residential buildings in Israel. The penetration rate for 2021, estimated using the results of the above analyses, was between 20% and 35%, corresponding to water savings of 25-50 million m3/year on a national scale.



5 Conclusions

Domestic greywater, although considered fairly 'clean', can be highly contaminated and thus pose a potential health risk and aesthetic nuisance. It also exhibits high variability between appliances. This led to the investigation of 6 different scenarios, in each of which a single greywater generating appliance was removed from the 'main stream' for treatment and reuse, and the effects on the quality and quantity of the 'main stream' were examined. This analysis revealed that the dishwasher was the main source of organic matter and nutrients, while the bath and shower were identified as the main sources of faecal coliforms. This creates a dilemma where treatment and reuse are seen as high concentrations of organic matter and nutrients, which may lead to negative aesthetic effects and a greater potential for pathogen regrowth, on the one hand, while on the other hand, potentially high concentrations of pathogens (as indicated by high FC concentrations) pose a higher health risk. Slightly different treatment conditions may be required to combat each of the two abovementioned types of contaminants.

Reusing greywater for toilet flushing in the domestic sector can save significant amounts of freshwater. Around 25-50 million m3/year of freshwater could easily be saved in the domestic sector alone over 20 years (nationally). Reusing greywater for toilet flushing in the domestic sector will lead to a smarter approach to household water use that takes into account not only human needs but also broader environmental aspects, thereby increasing the sustainable use of water in the urban environment.

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Quantitative and qualitative assessment criteria of load-bearing structures technical state

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Abstract: In the article are stated the quantitative and qualitative assessment criteria of load-bearing structures technical state that determination is achieved by visible defects and visual and instrumental examinations damages, as well as laboratory tests and testing based on calculations.

Keywords: load-bearing structures, buildings, criteria, technical state.

1. Introduction

The structureal evaluating the technical state depends on the functional purpose of the buildings and construction solutions, the type of building structures and the used construction materials, the working conditions, of structuresand other similar factors.

2. Basic part

According to the Law of Georgia on Civil Safety, a shelter is a building or structure that can be used to protect people from various damaging factors during an emergency or war. The shelter can be a dual-purpose, civil or industrial building and/or a special hermetic protective structure, which is designed taking into account damaging factors;

The maximum allowable values of the criteria for assessing the technical state of buildings are obtained with the following values:

• Design schemes, loads and impacts - from the project documentation, including explanatory notes for calculation of structures;

• Strength and physical-mechanical characteristics of materials and structures - according to projects, technical passports, Eurocodes, technical regulations and resolutions currently in force in the territory of Georgia, etc. according to;

• Geometric dimensions of buildings and structures - working drawings, technical passports, etc. according to;

• Deviations in linear dimensions and height marks - according to executive schemes, Eurocodes, technical regulations and resolutions currently in force on the territory of Georgia for the production and acceptance of the relevant types of construction and installation works;

• Operating characteristics - calculations of project documentation, Eurocodes, technical regulations and resolutions currently in force in the territory of Georgia, etc. according to

The actual values of the criteria for assessing the technical state of load-bearing structures are obtained on the basis of visual and instrumental examinations, as well as laboratory tests and verification calculations.

The criteria for assessing the technical state of load-bearing structures would be divided into two groups:

1. Characteristic criteria of carrying capacity, stability and deformability of construction structures (first and second group of limit states);

2. Characteristic criteria of operational suitability of buildings and their structures.

Normative documents (Eurocodes, technical regulations and decrees currently in force on the territory of Georgia, etc.) establish the marginally permissible values of the criteria for assessing the technical state of construction structures of buildings.

The technical state of the building structures must be determined based on the evaluation of the joint impact of the defects and injuries identified as a result of preliminary and detailed investigations, as well as on the basis of verification calculations of their carrying capacity, stability and operational suitability.

In the event that one of the criteria of the technical state of the buildings does not meet the requirements of the normative documents, the building structures are subject to repair, strengthening or replacement.

On the basis of many observations, we develop the criteria for evaluating the categories of the technical state of individual load-bearing structures of the building.

Structure	Defect	Over stress, %	Relative reliab-ility, $y = \gamma / \gamma_0$	Defect size at down state
1	2	3	4	5
1. reinforced concrete slab	Reducing the protective layer thickness from 3.5 cm to 1.5 cm	38	0,72	3,3 cm
2. reinforced concrete column	Reduction of concrete strength by one class (reduction of strength by 24%)	17	0,85	27%
3. Steel column	Profile thickness up to 20% is metal corrosion	28	0,78	21%
4. Roofing steel beam	Profile thickness up to 20% is metal corrosion Profile thickness up to 20% is metal corrosion	15	0,87	23%
5. Beams support on brickwall	Absence of support pads (support area is reduced by 52%)	110	0,47	32%
6. 5-story frame building's flooring and roof structures	Exceeding the loads by 15% on individual areas of roofing and covering due to the growth of crusts from slabs and beams	15% of slabs and beams	0.87 of slabs and beams	25% of slabs and beams
		35	0,85	30%

Using this criterion, the impact of defects and injuries in structures on reducing their strength and stability can be evaluated on specific examples of calculations taken from practice.

Example 1. During the manufacture of a 100 mm in thickness reinforced concrete roofing slab, the protective layer was reduced from the bottom side of the slab, the protective layer of the working reinforcement of the lower layer of the reinforcing mesh was reduced to 15 mm, instead of 35 mm provided by the project. It is necessary to determine how this will affect the strength of the structure (Figure 1).

The reinforcement of the slab is obtained from 5 rods of diameter Ø10 mm, diameter 20 cm, reinforcement class A500c,

A_S = 3.93 cm², R_S = 375 MPa = 3750 kgf/cm².
Concrete B25 class,
R_{bt} = 10.7 MPa = 107 kgf/cm².

Determine the bearing capacity of the slab taking into account the defect obtained during the pouring of the existing slab (by reducing the protective layer)

The working height of the slab is equal to

$$h_0 = 10 – 1,5 – 0,5 = 8 \text{ cm.}$$

Let's determine the height of the compressed concrete zone

$$x = R_s A_s / R_{bt} b = 3750 \cdot 3,93/107 \cdot 100 = =1,38 \text{ cm.}$$

Let's determine the load-bearing capacity of slab

$$[M]_0 = R_s A_s (h_0 – x/2) = 3750 \cdot 3,93 (8-1.38/2) = 3750 \cdot 3,93 \cdot 7.31=107\ 731 \text{ kg/sm.}$$

Let's determine the design load-bearing capacity on bending:

$h0 = 10 – 3,5 – 0,5 = 6$ cm.

Let's determine the height of the compressed concrete zone

$x = R_S A_S / R_{bt}\, b = 3750 \cdot 3{,}93/107 \cdot 100 = {=}1{,}38$cm

Let's determine the load-bearing capacity of slab

$[M] = R_s A_s (h_0 – x/2) = 3750 \cdot 3{,}93 (6-1.38/2) = 3750 \cdot 3{,}93 \cdot 5.31=77\,659$ kg/sm.

The overstress of the structure is equal to (107 731 – 77 659) 100/77 659 = 38.7%.

Relative reliability of the structure compared to the design one

$y=\gamma/ \gamma_0 =[M] / [M]_0= 77\,659 / 107\,731 = 0{,}72 < 1$, or the technical state is unworkable, or the load-bearing capacity is reduced (up to 38.7%).

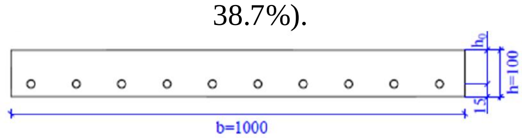

Fig. 1. Cross-section of monolithic concrete slab

Example 2. During the manufacture of a centrally compressed reinforced concrete column of a multi-storey building, the strength of concrete was reduced by one class compared to the design one, i.e. concrete of class B25 with calculated compressive strength $R_b = 14.5$ MPa = 145 kgf/cm² was obtained instead of concrete of class B20 R_b = 11.5 MPa = 115 kgf/cm² (the strength was reduced by 22%). It is necessary to determine how this affects the technical state of the structure (Figure 2).

Floor height (desugn length of the column) l0l= 4.8 m. Column section A = 40x40 = 1600 cm2. Working longitudinal reinforcement 4 Ø25 mm in diameter, A500c class, A_S = 19.63 cm², R_{SC} = 3750 kgf/cm².

Determine the flexibility of the column

$l0/ h = 480/40 =12$, $\varphi = 0{,}96$.

Design load-bearing capacity of the column

$[N]0 = \varphi\, (Rb\, A + R_{SC}\, A_S) = 0{,}96(145 \cdot 1600 + 3750 \cdot 19{,}63) = 293\,388$ kgf.

Actual load-bearing capacity of the column taking into account the defect

$[N] = 0{,}96(115 \cdot 1600 + 3750 \cdot 19{,}63) = 247\,308$ kgf.

The structure has been overstressed

(293 388 – 247 308) 100/247 308 = 18.6%

Relative reliability of the column

$y=\gamma/ \gamma0 =[N] / [N]0 = 247\,308 / 293\,388 = 0{,}84< 1$, or the technical state is limited operable.

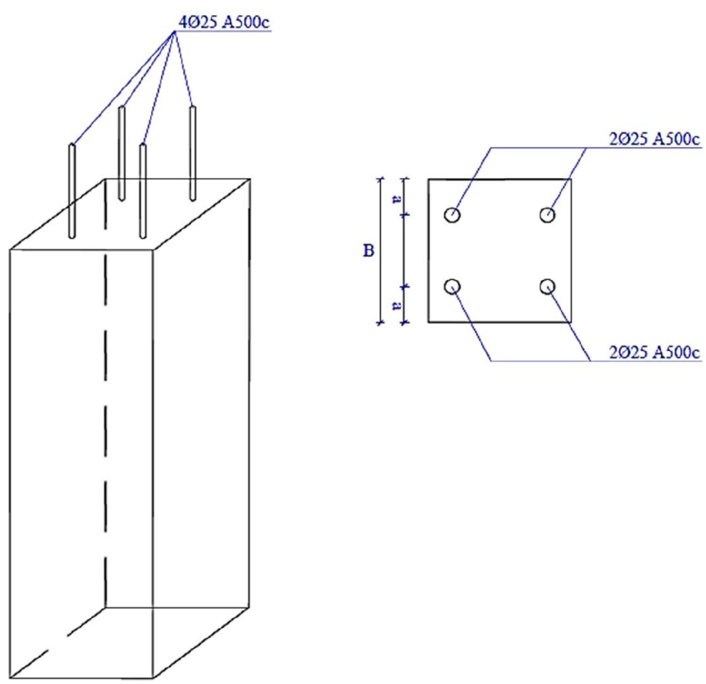

Fig. 2. Section of a monolithic reinforced concrete column

Example 3. A steel column that represents I beam 26K2, with a wall thickness of *d*=7 mm, flange thickness of *t* =11 mm, received corrosion at 1 mm, which is 19.5% of the full thickness. Determine the reduction of the carrying capacity of the column as a result of corrosion (Fig. 3).

The cross-sectional area of the column is A0 =75.5 cm², the thickness of the corroded metal on both sides of the profile thickness - $\delta = 2 \cdot 1 = 2$ mm = 0.2 cm, the reference resistance of steel

R_y = 245 MPa = 2450 kgf/cm².

Let's determine the attenuation coefficient

$k_{sa} = \delta / 0{,}5(t + d) = 0{,}2/0{,}5(1{,}1 + 0{,}7) = 0{,}22$.

Reduced cross-sectional area

$A = A_0 (1 - ksa) = 75{,}5(1-0{,}22) = 59$ cm².

The load-bearing capacity by project

[N]0 = Ry A0 = 2450 · 75,5 = 184 975 kgf.

The load-bearing capacity with taking into account the defect

[N] = Ry A = 2450 ·59 = 144 550 kgf.

Overloading of the column from the design loads

(184 795 – 144 550) 100% / 144 550 = 27,9%.

Relative reliability

$y=\gamma/\gamma_0$ = [N] /[N]0 = 144 550/184 795 = 0,78<1.

The technical state is inoperable.

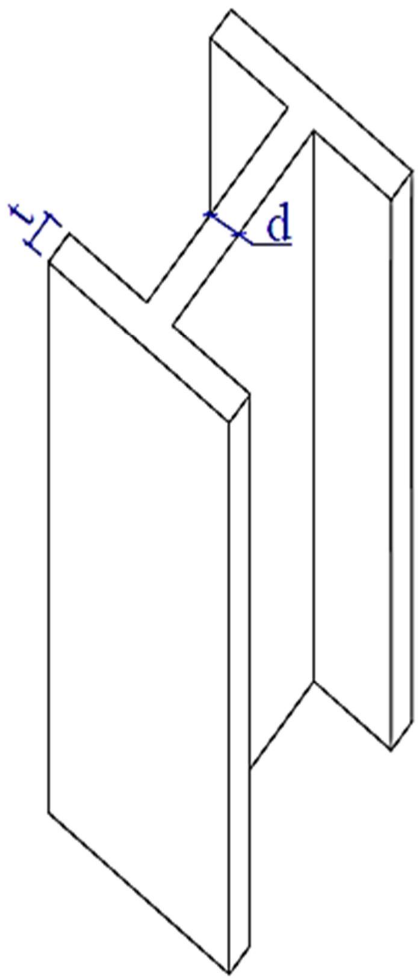

Fig. 3. Cross section of metal beam 26K2

Conclusion

The actual values of the criteria for assessing the technical state of load-bearing structures are obtained on the basis of visual and instrumental examinations, as well as laboratory tests and verification calculations. The criteria for assessing the technical state of load-bearing structures can be divided into two groups: criteria for load-bearing capacity, stability and deformability of building structures (the first and second group of limit states); Characteristic criteria of operational suitability of buildings and their structures. In the event that one of the criteria of the technical state of the buildings does not meet the requirements of the normative documents, the building structures are subject to repair, strengthening or replacement.

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Frame-panel houses with reinforcement tension in construction conditions and its prospects for seismically active regions

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Abstract The article will consider frame-panel multi-story residential buildings, which are much more convenient to build on a construction site by tensioning reinforcement than ordinary monolithic multi-story buildings. Modern building materials created in the construction industry and the active use of chemical additives in concrete have opened up new ways to save building materials by 20-25%, reducing labor costs and construction time. As a result, we have much stronger and more durable load-bearing structural elements (prestressed floor slabs), and as a result, the whole building responds to increased seismic resistance.

Key words: frame-panel, reinforcement tension in construction conditions pressed sleeve, seismic ball.

Introduction.

The use of prestressing in multi-story frame buildings is a progressive method. It allows the use of high-strength steel to reduce its cost. At the same time, cracks in prestressed reinforced concrete are less likely than in ordinary reinforced concrete, which ensures its durability and hardness.

This system has significantly reduced the types of typical elements in buildings and reduced them to a minimum number, although it has not limited the distribution of space in it, on the contrary, the system has given architects amazing opportunities for distributing space: the foundations of the building, the number of stories, unlimited free distribution of living space. A frame system that, from a statics point of view, has not at all rejected the basic principles of construction of this type of building with reinforced concrete structures.

Main part

The so-called frame-panel system. Building system IMS is a square or rectangular cell. Such a cell consists of four prefabricated columns and one hollow roof plate. On the one hand, these are the main elements of the building frame that perceive vertical and horizontal loads.

The column and the roof panel are connected by pre-stressing the armature passing through the sections of the column and in both directions of the roof plate. After tensioning the armature, the tensioned armature, placed between the roof plates, is covered with monolithic concrete, protecting it from corrosion, thus creating a hidden rod (anvil) from pre-stressed reinforced concrete. First, the armature was stretched only in a straight line, later, due to the increase in the height of the building, the armature was stretched by twisting, т. e. by the epiuric forces (pic. 1).

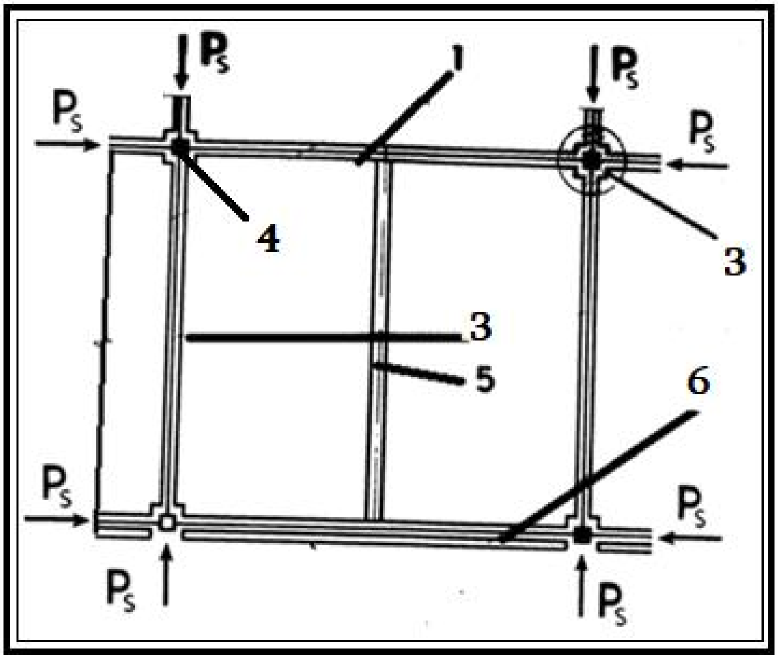

Fig. 1. Frame-panel system with tension reinforcement
Under construction conditions, general view; 1-roofing slab;
2-columns; 3-monolithic section prestressed reinforcement;
5-central seam between roofing slabs; 6-side element.

The frame carries horizontal wind and seismic loads, although the bulk of the loads fall on the stiffness diaphragm. The diaphragms are located between the columns and connected to them at the overlap level by pre-stressed reinforcement.

The main function of the columns is to resist the forces caused by vertical and horizontal loads, especially after concreting, when the stiffness diaphragm and columns are combined.

The frame-panel system is based on the implementation of strict provisions for the connection of individual load-bearing structures to each other in construction conditions with tension reinforcement. The high strength of the nodes determines the reliability of the entire system.

The monolithicity of the frame system is achieved by pre-tensioning. The connection of the column and the roof slab is carried out by pre-tensioning the reinforcement and the generation of large friction forces on the contact surfaces.

The magnitude of the pre-tensioning depends on the span of the building, vertical loads, and the straightness of the reinforcement. Straight-stretched reinforcement is permissible for beams with a span of 5 m. The number of tensioned reinforcement varies from 2 to 4 c. ropes.

As mentioned above, the ropes pass through the holes in the columns between the roof slabs along the entire length of the building and are then concreted with monolithic concrete by vibration, as a result of which the reinforcement is completely protected from corrosion and mechanical damage. In addition, such protection of the reinforcement provides less loss of pre-tensioning, and the frame system is further pre-tensioned.

The structural elements of the frame-panel system are manufactured in a factory-made manner from high-grade B30 fine-grained concrete.

The proposed building is a prestressed spatial structure of columns and beams, the rigidity of which is ensured by concrete diaphragms for seismic resistance. The system is calculated for the following loads: vertical and gravitational, wind, and seismic forces, with a total load on a typical 4.8 m span roofing slab of 600 kg/m².

The reliability of the system, which

immediately raised doubts among many of its specialists, was the rejection of the slab support as a fundamentally established principle, the danger that the slab would slip under operating conditions due to the drop in prestressing, was and remains a doubt for specialists, for which purpose experimental and computer studies were conducted. The selected strength characteristics were taken from two unfinished residential buildings on Guramishvili Avenue in Tbilisi, one up to 7 floors and the other up to three floors (Fig. 1). A computer model was created, where two options were considered:

Fig. 2 . Residential buildings in operation and unfinished

The solution of the set tasks became possible by monitoring 10 completed and 2 unfinished 16-story buildings located in different districts of Tbilisi and then recalculating the model created based on the computer engineering program.

During the inspection and study of ten 16-story buildings, it was found that the buildings do not have any defects, which are not permissible by the norms and would raise doubts about their reliability. The load-bearing elements of the completed and operational residential buildings: columns, roofing slabs, and monolithic seams, where prestressed reinforcement is located, are completely suitable for normal operation.

Conclusion.

Monitoring of buildings constructed and operated with the IMS structural system in Tbilisi showed that changes in the strength of prestressed cables and monolithic concrete have not decreased, on the contrary, after 30–35 years, the strength characteristics of reinforced concrete elements have increased by 25–30%, the stresses in monolithic concrete joints and reinforcement, roofing slabs and columns are equal to the design value, and the changes have not worsened, which proves that the system is reliable for future operation.

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Cultural roots in contemporary grounds: intangible heritage and sustainable urban landscape

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Abstract

This article explores the integration of intangible cultural heritage into sustainable urban design, using the Meskhetian Terraces in Georgia as a case study. These terraces, which represents centuries-old agricultural practices, are highlighted as both historical sites potential designs for addressing current sustainability challenges, such as climate change adaptation and ecological preservation (Deng et al., 2021; Tarolli et al., 2014). The study shows how traditional knowledge systems, such as the sustainable agricultural methods represented by the terraces, can inform modern urban planning and architectural innovation (Geografski inštitut Antona Melika ZRC SAZU, 2017).

Key words: Cultural heritage, Sustainable architecture,Sustainable tourism development,Georgia's intangible cultural heritage, Resililent urban landscapes.

The research points up the role of cultural heritage in fostering community identity, social cohesion, and resilience within urban landscapes, drawing parallels with global examples of integrating heritage into urban planning (Pietryk-Kaszyńska et al., 2016). Additionally, the article examines how elements of Georgia's intangible heritage, such as Qvevri winemaking and the Tone bread oven, have been integrated into contemporary architectural practices to promote sustainable tourism development (UNESCO, 2013; Tsilosani, 2023b). By combining historical practices with innovative design, this research provides a framework for exploited cultural heritage as a foundation of sustainable urban development, promoting cultural diversity, environmental direction, and cultural flow (Soini & Birkeland, 2014; Richards, 2018).

Introduction

In the dynamically evolving discourse on sustainable development and urban planning, the integration of intangible cultural heritage is emerging as an important, yet often neglected, component (Soini & Birkeland, 2014). The richness of traditions, practices, knowledge systems, and rituals collectively define the cultural fabric of societies, shaping identity, values, and connections to place (Richards, 2018). The challenge of maintaining sustainability in the process of growth and transformation of urban landscapes is closely linked to the maintenance of cultural progression, which connects societies to their history and to each other (UNESCO Urban Heritage Atlas, 2023).

The importance of integrating intangible cultural heritage in a sustainable urban landscape is various. First, it recognizes that cultural practices, expressions, and knowledge are as important components of a society's identity as the physical environment (Pietryk-Kaszyńska et al., 2016). By integrating intangible aspects of heritage into the urban fabric, cities can create a sense of belonging and progression for their residents. This integration not only enriches the urban experience but also counteracts the integration process of globalization, preserving the uniqueness and diversity of urban environments (Richards, 2018).

On the other hand, intangible cultural heritage provides invaluable knowledge about sustainable living practices developed over generations. Traditional knowledge, such as agricultural techniques, water management, and ecological protection, reflects a deep understanding of the local environment and a sustainable coexistence with nature (Deng et al., 2021; Tarolli et al., 2014). Using this wisdom, urban planners and architects can create innovative and time-tested solutions that increase the sustainability and resilience of urban environments (Geografski inštitut Antona Melika ZRC SAZU, 2017).

Furthermore, the promotion of intangible cultural heritage in urban environments escalates social cohesion and public engagement (Pietryk-Kaszyńska et al., 2016). Cultural expressions and practices create a platform for community engagement, which strengthens the connection between individuals and between a community and its environment. This engagement is critical for the success of sustainable urban development initiatives, ensuring that they are inclusive and responsive to the needs and values of society (Soini & Birkeland, 2014).

Studies on the Meskhetian Terraces and the integration of Georgian intangible cultural heritage into wider architectural practices highlight the potential of cultural heritage as a foundation of sustainable urban development (Tsilosani, 2023a). The analysis of these cases clearly demonstrates the importance of preserving and integrating intangible cultural heritage in shaping sustainable, resilient, and vibrant urban landscapes. This integration not only protects cultural diversity and heritage but also sends the urban environment towards a sustainable and inclusive future, where the cultural and environmental dimensions of sustainability are inseparable (Tsilosani, 2023b).

In the process of the evolution of urban landscapes, the integration of intangible cultural heritage into sustainable development strategies offers a path that respects the past while creating a sustainable future. It challenges urban planners, architects, and policymakers to rethink the role of culture in shaping the cities of tomorrow, ensuring that the spirit of community is preserved and celebrated in every brick that is laid and in every policy that is implemented (UNESCO Urban Heritage Atlas, 2023).

Methodology

The methodology adopted in researching the integration of intangible cultural heritage within sustainable urban landscapes, as illustrated in the studies on Meskhetian terraces and sustainable architectural practices in Georgia, employs a multi-disciplinary approach. This methodology is designed to comprehensively address the complexities of preserving intangible cultural heritage within the context of modern urban development and sustainability. It surrounds a combination of qualitative and quantitative research methods, fieldwork, comparative analysis, and collaborative approaches to ensure a holistic understanding and actionable insights.

A great review of existing literature forms the basis of the research, shutting in academic journals, UNESCO reports, architectural and urban planning texts, and documentation of intangible cultural heritage practices. This review establishes a theoretical framework that guides the exploration of sustainable urban development, architectural innovation, and the significance of intangible cultural heritage. It also aids in identifying gaps in current practices and knowledge, setting the stage for further investigation.

Fieldwork in Georgia, focusing on the Meskhetian terraces and other relevant sites, plays a crucial role in the methodology. This includes direct observation, photographic documentation, and soil and biodiversity analysis where applicable. Engaging with local communities, practitioners, and experts through interviews and collective workshops ensures an in-depth understanding of the intangible cultural practices, their significance, and the challenges faced in preserving them among urban development pressures.

Drawing on global examples of sustainable urban planning and architectural practices that have successfully integrated intangible cultural heritage, the research employs a comparative analysis. This method highlights effective strategies, innovative solutions, and potential risks, offering a broader perspective on the challenges and opportunities in integrating cultural heritage within sustainable urban landscapes.

Incorporating cooperative design and planning processes is essential to ensure the research is grounded in the needs, values, and aspirations of the communities involved. Workshops, community meetings, and stakeholder consultations facilitate the co-creation of design and planning solutions that are culturally sensitive, sustainable, and reflective of community identities.

The collected data, both qualitative and quantitative, undergoes exact analysis to identify patterns, insights, and correlations between the preservation of intangible cultural heritage and sustainable urban development outcomes. This analysis informs the development of guidelines, best practices, and policy recommendations tailored to the integration of these elements in urban landscapes.

Building on the insights gained, the research aims to develop conceptual and practical models for integrating intangible cultural heritage into sustainable urban planning and architectural design. These models serve as a design for practitioners and policymakers, illustrating how to support cultural heritage for increasing urban sustainability, resilience, and community well-being.

Main part

Set in the historic heart of Meskheti, Georgia, the Meskhetian Terraces are a breathtaking example of human innovation and a example to the hard work spirit of the Georgian people. These ancient agricultural landscapes, carefully cut into the mountainous landscapes of the region, not only show the innovative agricultural practices of past civilizations but also represent the rich cultural heritage and identity of Georgia. However, the winds of change, marked by fast urbanization and the shift towards modern agricultural techniques, pose significant risks to the preservation of these terraced landscapes. This article explores the cultural, ecological, and architectural importance of the Meskhetian Terraces and presents a persuasive case for their preservation and integration into contemporary society.

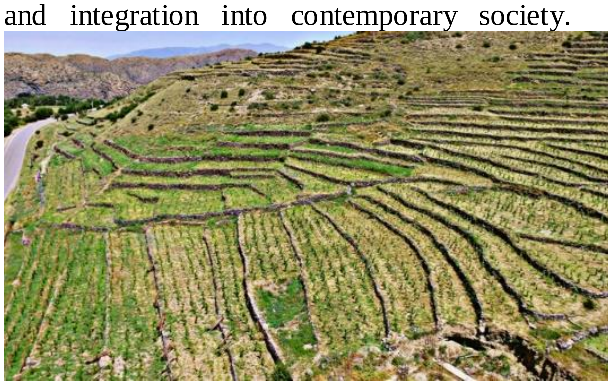

Fig. 1 Meskhetian Terraces

The Meskhetian Terraces are more than just agricultural landscapes; they are a living museum of Georgia's past, presenting centuries of traditional farming practices, community life, and resilience in the face of natural suffering (Tsilosani, 2023a). These terraces are the example to the deep connection between the Georgian people and their land, a relationship further through generations of careful direction and respect for the natural world (Nikolaishvili et al., 2019). However, the survival of these terraces is under risk from modern challenges, including climate change, urban sprawl, and the dropping of traditional farming methods (Deng et al., 2021; Tarolli et al., 2014). This research shows to highlight the urgency of preserving these landscapes, not just as objects of the past, but as pointers for sustainable living and cultural flow (Geografski inštitut Antona Melika ZRC SAZU, 2017).

One of this study's key objectives is to explore the integration of ancient terracing techniques into modern architectural practices. The Meskhetian Terraces offer invaluable insights into sustainable construction, water management, and landscape design that can inform contemporary building practices (Tsilosani, 2023b). By studying these ancient systems, architects and urban planners can develop innovative solutions that address today's environmental challenges, such as soil erosion, biodiversity loss, and water shortage (Deng et al., 2021; Tarolli et al., 2014). Moreover, the terraces' ability to harmonize with the natural landscape serves as a model for eco-friendly construction, promoting a balance between human habitation and nature conservation (Slamova & Belcakova, 2019).

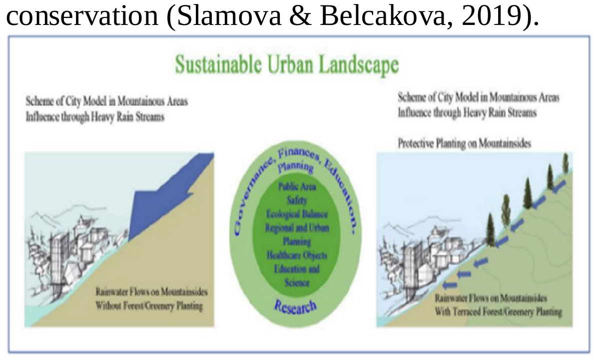

Fig.2 Sustainable Urban Landscape

The potential of the Meskhetian Terraces to increase Georgia's hospitality industry is another important point of this research. As travelers increasingly seek authentic and impressive experiences, the terraces can serve as a unique attraction that connects visitors with Georgia's rich cultural heritage and breathtaking natural beauty (Richards, 2018). This study explores how the hospitality sector can support these ancient landscapes to offer sustainable tourism experiences that celebrate Georgia's history and support local communities (Landorf, 2009).

In Georgia's beautiful landscapes, where echoes of the past connect perfectly with the heart of contemporary, cultural heritage preservation and architectural innovation go hand in hand. The research paper *"Preservation and Innovation: Integrating Sustainable Practices and Historical Georgia's Intangible Cultural Heritage in Architecture"* presents a comprehensive look into this beneficial relationship, with a special focus on the Meskhetian terraces—a landmark to Georgia's lasting history of sustainable agricultural and architectural practices (Tsilosani, 2023b).

At the heart of this study lies the Meskhetian terraces, symbolic of Georgia's commitment to sustainability long before the term entered the global dictionary. These terraced landscapes, formed with correct care and profound understanding of ecological balance, serve not only as agricultural sites but as guardians of cultural narratives, connecting the tangible with the intangible heritage of the Georgian people (Nikolaishvili et al., 2019). By examining these terraces in conjunction with global examples, the research illuminates their significance not only as historical artifacts but also as designs for future sustainable architectural efforts (Geografski inštitut Antona Melika ZRC SAZU, 2017).

Fig.3 Meskhetian Terraces

Georgia's storied history as a wine-producing country, coupled with its recognition by UNESCO for its intangible cultural heritage, provides a rich tapestry for analysis (UNESCO, 2013). This dual heritage, both tangible in its landscapes and intangible in its winemaking traditions, offers unique insights into the integration of cultural elements into architectural innovation (Richards, 2018). The research explores into how these linking heritages can inspire contemporary architectural designs that are both sustainable and culturally meaningful (Tsilosani, 2023a).

The combination of sustainable architectural practices with Georgia's intangible cultural heritage offers a unique pathway toward preserving the nation's rich historical tapestry while fostering innovation within its contemporary architectural landscape. This chapter seeks into two specific elements of Georgia's intangible cultural heritage—Qvevri winemaking and the traditional Georgian bread oven, Tone—as pivotal components in promoting sustainable tourism development through architectural innovation (Nikolaishvili et al., 2019; Timothy, 2016).

Qvevri, large clay pots used for the fermentation, storage, and aging of traditional Georgian wine, represent a method dating back over 8,000 years (Tsilosani, 2023b). In 2013, the UNESCO recognition of the Qvevri winemaking method as an Intangible Cultural Heritage of Humanity underscored its global cultural significance (UNESCO, 2013). This ancient practice is not only an example to Georgia's historical depth as a wine country but also highlights a sustainable approach to wine production that harmonizes with nature rather than seeks to dominate it (Landorf, 2009).

The architectural integration of Qvevri into modern designs offers an innovative approach for preserving this ancient tradition. By integrating Qvevri within the structures of contemporary wineries and visitor centers, architects can create spaces that are deeply rooted in Georgian culture while meeting modern sustainability standards (Ragheb et al., 2016). Such designs encourage the use of local materials and traditional techniques, reducing the environmental footprint and strengthening the connection between the built environment and the landscape (Deng et al., 2021).

Similarly, Tone, the traditional Georgian bread oven, is an symbol of Georgia's culinary heritage. The process of making bread in a Tone is a ritual that has been passed down through generations, a symbol of the Georgian way of life (Timothy, 2016). Integrating the concept of Tone into the design of restaurants, bakeries, and cultural centers can offer a unique dining experience that elevates the architectural space to more than just a place for eating but a venue for cultural immersion (Richards, 2018).

By designing spaces that accommodate the Tone, architects can contribute to the preservation of Georgian culinary traditions and offer visitors a tangible connection to Georgian culture. This approach not only upgrade the architectural landscape with cultural base but also supports the improvement and continuation of traditional baking methods, fostering a sustainable link between culture and contemporary practices (Pietryk-Kaszyńska et al., 2016).

The integration of Qvevri and Tone into Georgia's architectural and tourism landscapes serves as a catalyst for sustainable tourism development. These practices offer a unique selling point for Georgia's tourism industry, attracting visitors interested in authentic cultural experiences and sustainable practices (Slamova & Belcakova, 2019). By promoting an impressive experience into Georgia's intangible cultural heritage, the country can differentiate itself in the global tourism market, encouraging responsible travel and deeper cultural engagement (Landorf, 2009).

Moreover, the architectural preservation and innovation that Qvevri and Tone contribute to the broader goals of sustainable development by promoting environmental sustainability, cultural diversity, and economic benefits for local communities. These initiatives can inspire the development of educational programs, workshops, and cultural events that further upgrade the tourism experience and foster a sustainable relationship between visitors and the host community (Geografski inštitut Antona Melika ZRC SAZU, 2017).

A significant dimension of this study is the exploration of how Georgia's UNESCO recognitions and its vibrant tourism industry can benefit from the integration of intangible cultural heritage. The inclusion of cultural elements not only strengthens the architectural landscape but also improves the tourism experience, promoting a deeper connection between visitors and the local culture (UNESCO, 2013). This approach not only promotes sustainable tourism development but also ensures the preservation of cultural heritage for future generations (Tsilosani, 2023b).

The paper shows a future where architectural practices are represent the heart of Georgia's cultural heritage, combining preservation with innovation. It argues for a comprehensive approach to architecture, one that respects and improves historical practices while containing modern sustainability principles. Through detailed analysis and case studies, the research offers a model for architects and planners worldwide to incorporate cultural heritage into their projects in meaningful and sustainable ways (Soini & Birkeland, 2014).

Conclusion:

The study of the integration of intangible cultural heritage into the framework of sustainable urban development and architecture, drawing on the examples of Meskheti terraces and sustainable practices in Georgia, makes an important discovery: intangible cultural heritage is not only a object of the past, but also a living and important element in the creation of sustainable, resilient and significantly developed urban environments. This study highlights the profound importance of intangible cultural heritage, which expresses, improves and contributes to the sustainability and socio-cultural vulnerability of contemporary urban and architectural practices.

Intangible cultural heritage, which includes traditions, practices, knowledge and skills that are passed down from generation to generation, offers us valuable and important knowledge about sustainable living, social sustainability and environmental protection. The Meskhetian Terraces, as an ancient agricultural wisdom, are an example of how traditional knowledge systems can help address contemporary sustainable development challenges such as biodiversity conservation, soil erosion control and climate change management. Also, the integration of Georgia's rich winemaking traditions into contemporary architecture not only preserves cultural identity, but also promotes sustainable tourism and the economic development of the community.

The importance of intangible cultural heritage in sustainable urban landscapes and architecture goes beyond environmental sustainability and considers social cohesion, identity and continuity. It acts as a conduit for community engagement, ensuring that urban development is not only physically sustainable, but also culturally resonant and inclusive. By integrating cultural heritage into urban networks, cities help a sense of belonging, pride and ownership among their citizens and boost social sustainability and well-being.

Integrating intangible cultural heritage into urban planning and architectural design also challenges the integration of urban spaces and promotes diversity and innovation. It encourages architects and planners to reevaluate design paradigms to use traditional knowledge and practices to create unique, context-specific solutions that reflect the importance of local cultural narratives. This approach not only increases the rich architectural and functional qualities of urban environments, but also contributes to the global discourse on sustainable development, the topic of intangible traditions and problems, and alternative visions.

As a result, the preservation and integration of intangible cultural heritage into sustainable urban landscapes and architecture is essential for creating environments that are environmentally sustainable, socially cohesive and culturally rich. This study highlights the need for a paradigm shift in urban development and architectural practices that recognizes the natural value of cultural heritage as a foundation for sustainability. As cities continue to evolve, embracing intangible cultural heritage as an important part of urban planning and design will be essential to ensure that future generations have urban landscapes that are not only usable but also reflect the diverse works of cultures.

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Methods of obtaining screen views through AutoCAD Introduction

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Abstract: It became possible to receive screen views in **AutoCAD** versions of the last year, which is a kind of novelty for users interested in this program. Screenshots are one of the best ways to describe an object, which is a good way to visualize it.

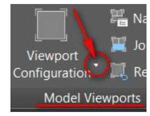
Keywords: Viewports screen views; Named Viewports named view; DVIEWBLOCK Dynamic views block.

Introduction

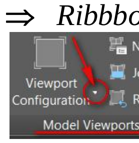
AutoCAD is one of the most popular engineering software packages, it allows solving a wide range of engineering tasks faced by the designer quite easily. It allows the creation of drawings and models, as well as the ability to test them.

AutoCAD is a powerful tool for drawing, it has the ability to make the necessary changes in the drawing and gives an accurate final drawing. It has a powerful editing tool that makes it easy to adjust the drawing at any stage of execution.

Main part

AutoCAD has many methods of viewing objects. One of the quick and easy methods is the drop-down menu. To do this, point **Tabs** to **Visualize**, and then to the **Ribbo** 

left-click on the thumbnail On the **Viewport Configurations** page, click the triangle icon located on the Model **Viewports** panel and select **Four: Equal** from the drop-down menu (Figure 1).

abs ⇒ **Visualize** ⇒ *Ribbbon* ⇒ **Model Viewports** ⇒ 

Viewport Configurations ⇒ **Four: Equal** (Figure 1)

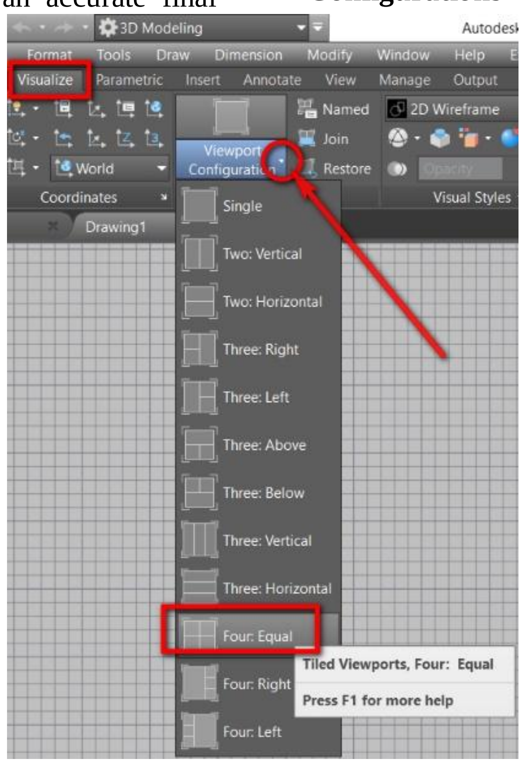


fig. 1

As can be seen from the **Viewport Configurations** menu, it is possible to display on the monitor both a **Single** screen view and, as needed, any number of screen views at the same time with one to four desired layouts. Figure 2 shows the classic (standard) layout of four screen views. It is generally preferable to work on one view, and if necessary, use the keyboard **ALT+V** for quick recall. In the context menu (Fig. 3) indicate the option we want. Here it is possible to indicate **New Viewports** (Fig. 4), where it is possible to select different parameters, both for **2D** and **3D**. Select **Four: Equal.** If we specify the appropriate properties, we get the screen view shown in Figure 2. Any viewport can be saved by giving it a new unique name in **New Name**, and can later be called via **Named Viewports.**

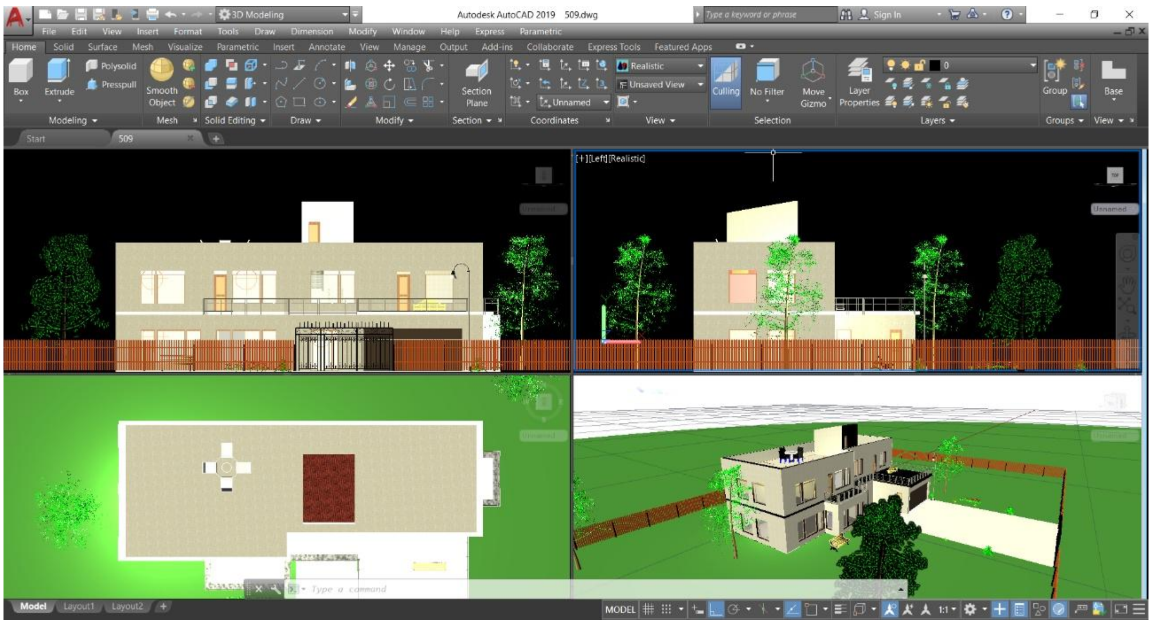
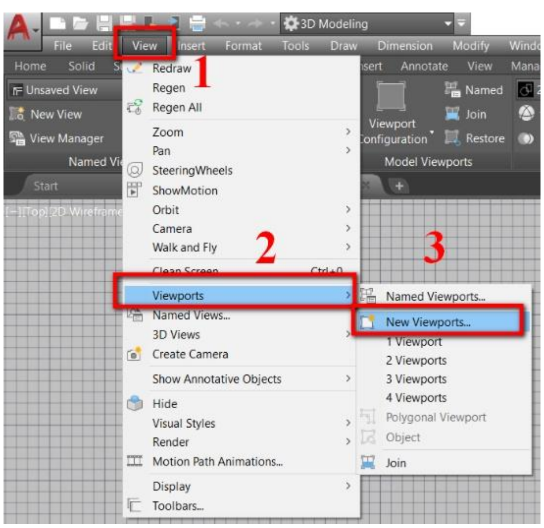


fig. 2



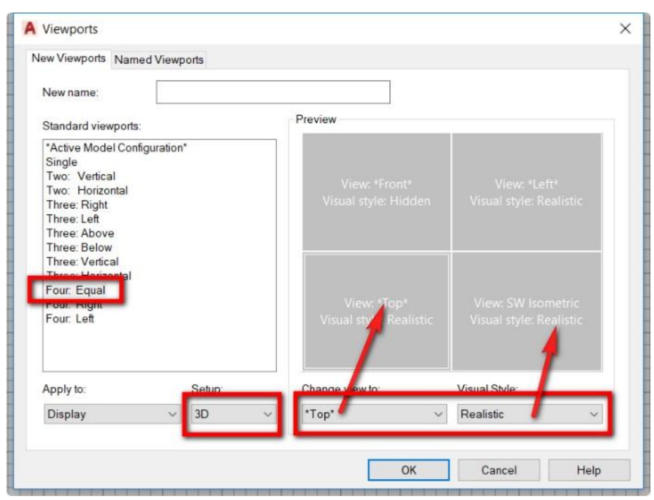


fig. 3 fig. 4

In addition to the method discussed above, there is also another method, which is possible through the command **DVIEW (DYNAMIC VIEW),** which allows more control of object views. This method also allows to individually select the point of view. When choosing a point of view, the main thing is to choose a virtual camera and a target, in the same way as when taking a photograph. In this case, it is necessary to optimally select the location of the camera and the shooting object.

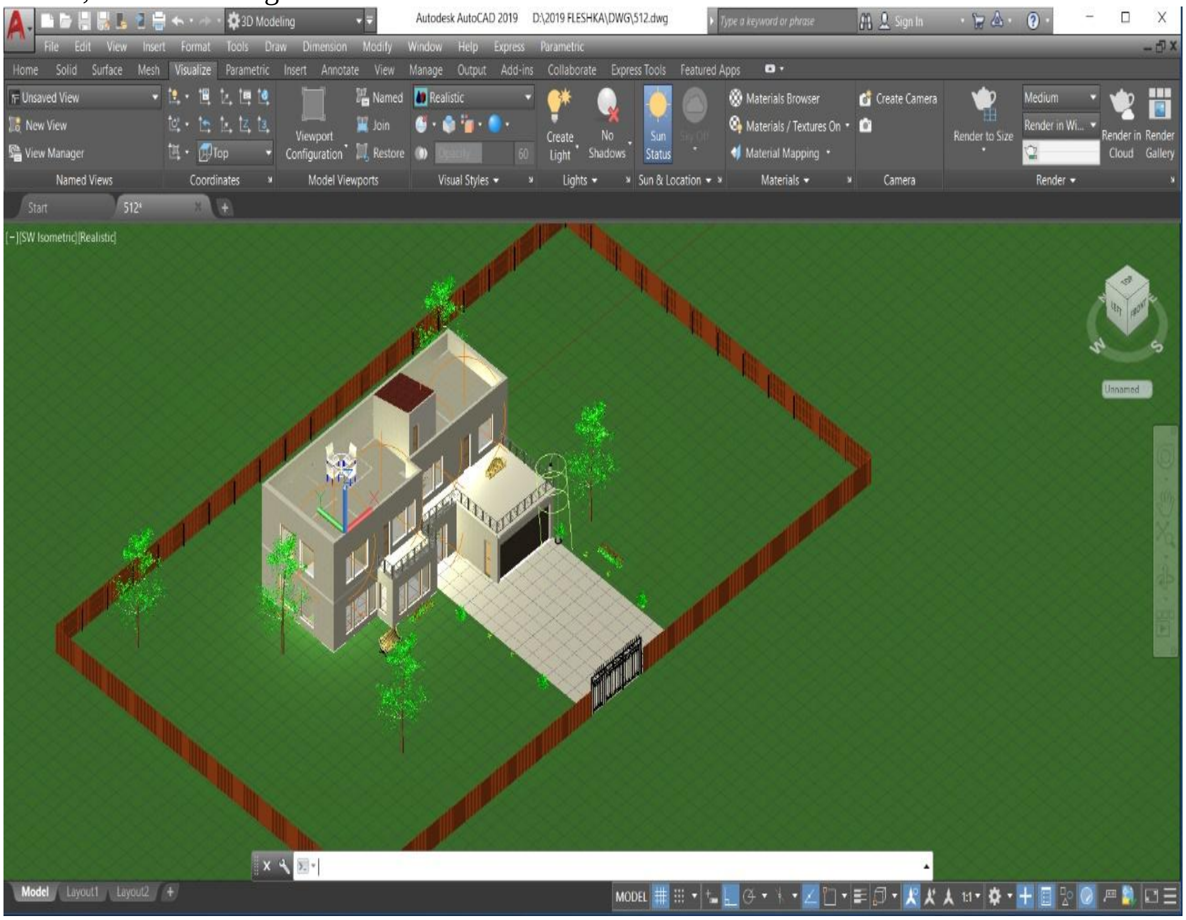
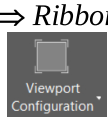


fig. 5

Through **Viewports**, let's go to **Single** unit screen view and through **Views** specify **SW Isometric** (Fig. 5)

Tabs ⇒ **View** ⇒ *Ribbon* ⇒ **Model Viewports** ⇒ 

Viewport Configurations ⇒ **Single** And then *Tabs* ⇒ **View** ⇒ *Ribbon* ⇒ **Views** ⇒ **SW Isometric**

In the **Command Line**, type the command **DVIEW** and **Enter**, after which **AutoCAD** will give us the following instruction **Select objects or <use DVIEWBLOCK>:** To select an object, you can select all or the desired object and press the **Enter** key, the following instruction will be **[Camera Target Distance Points Pan Zoom Twist Clip Hide Off Undo]:** ([Camera Aim Distance Points Pan Zoom Twist Crop Hide Disable Cancel]:) Here you can select and specify any of the options. Let's consider each of them:

CAmera - type **CA** ⇒ **Enter** or click on this option.

or [Toggle (Anglein)] <30>: (or [Lever (Angle)] Any angle from -900 to +900 can be specified. It is also possible to freely rotate the object using the cursor.

TArget - type **TA** ⇒ **Enter** or click on this option.This command works in the same way as the previous command.

Distance - type **D** ⇒ **Enter** or click am opciaze

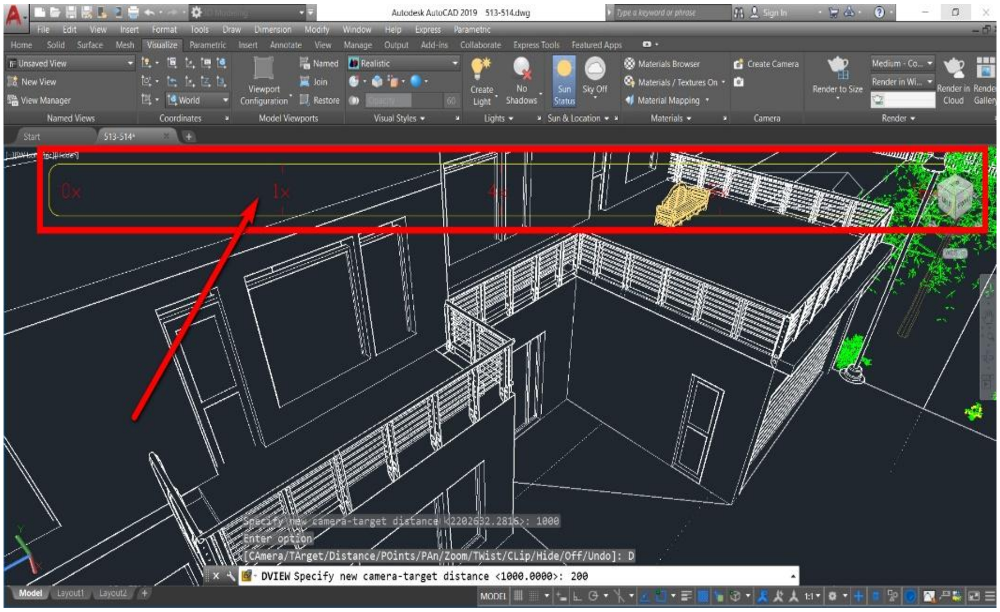


fig. 6

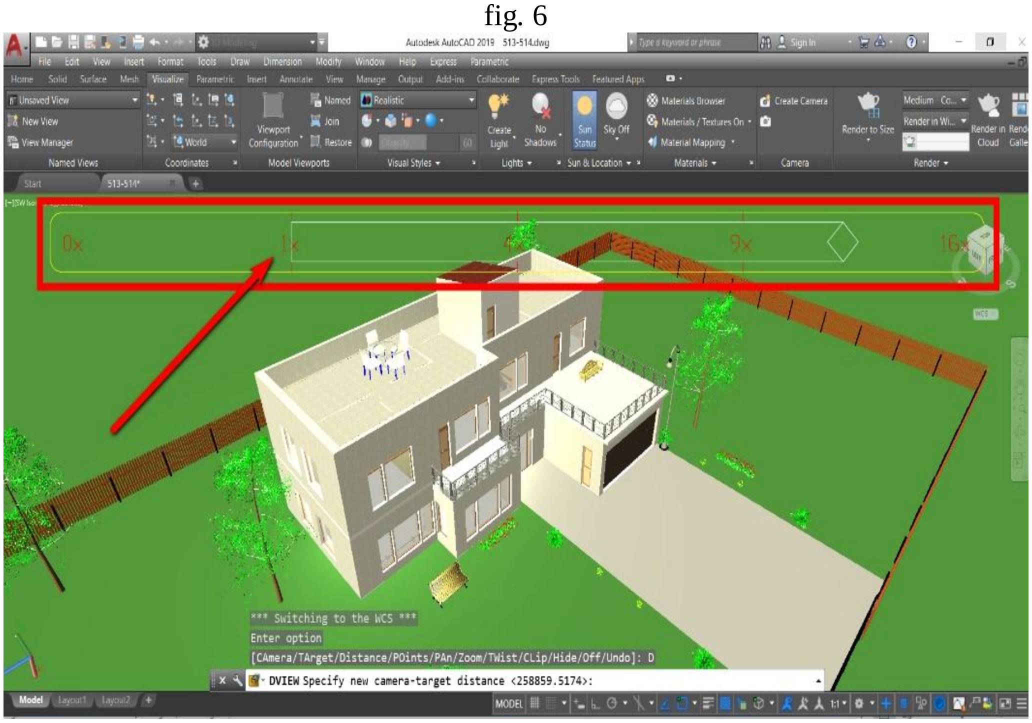


fig. 7

Specify new camera-target distance <100>: (select the distance to the new camera-target) in this case it is possible to specify the distance directly using the keyboard or to specify the desired scale using the slider placed on top of the graphic area. The slide is marked in the picture (Fig. 6, Fig. 7).

POints - type **PO** ⇒ **Enter** or click on this option **Specify target point <100, 100, 100.>:**. In this case, it is possible to specify the starting point where the target will be located, using the keyboard, then ⇒ **Enter** The next instruction will be **Specify camera point <700, 700, 700.>:** Specify the camera location point using the keyboard and ⇒ **Enter**, after which the operation will be completed. In this case, it is also possible to specify the target and camera points using the cursor.

Figure 8 shows how we pre-selected the target and camera locations, and then used the POints command to get the view shown in

Figure 9.

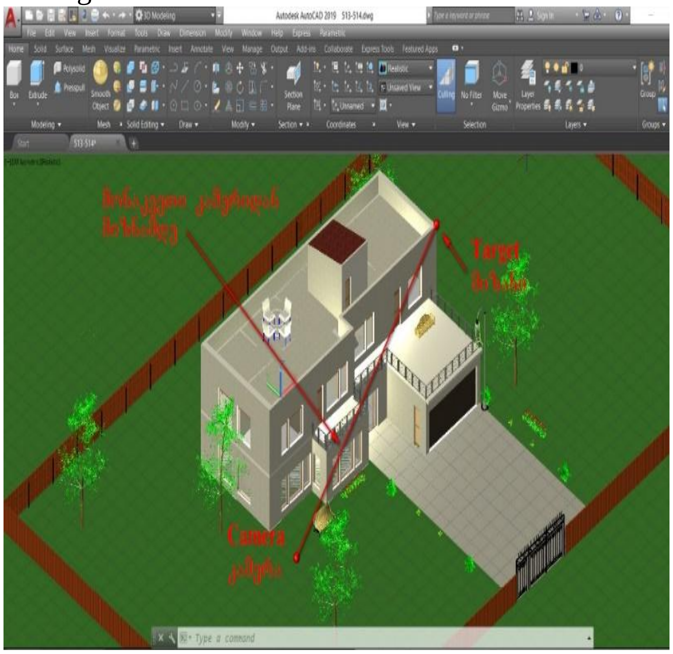


fig. 8

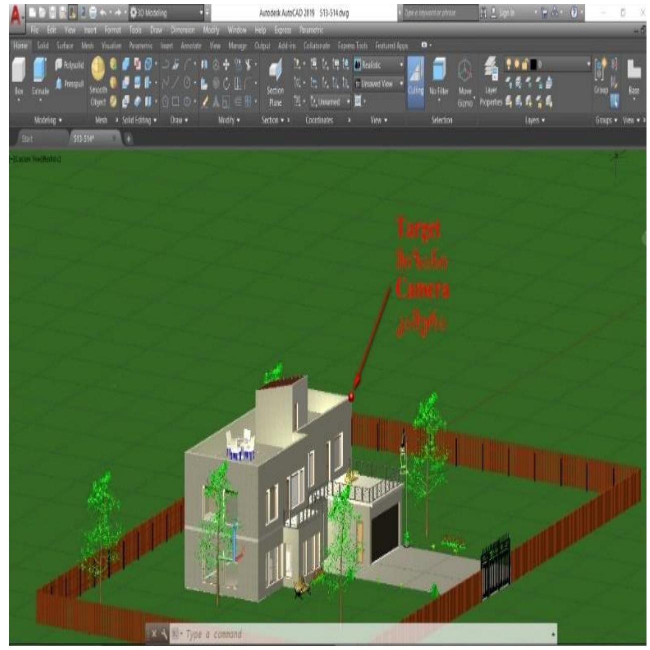


fig. 9

DVIEW ⇒Enter ⇒Select objects or <use DVIEWBLOCK>: Select the section from the camera to the target ⇒ **Enter** ⇒ The following instruction will appear in the command line: **[Camera Target Distance Points Pan Zoom Twist Clip Hide Off Undo]:** Specify P**O** ⇒ **PO** ⇒ **Enter⇒Specify target point <-36.800790, -28.437726, 32.543399>:** Select the point labeled **Target** as the target point and click on it ⇒The following instruction will be: **Specify camera point <-246.405836, -238.042772, 242.148445>: (Select camera point <-246.405836, -238.042772, 242.148445>:)** Click on the point **Camera** ⇒ the following instruction will be: **[Camera Target Distance Points Pan Zoom Twist Clip Hide Off Undo]:** After that, any operation can be performed again, and this command can be exited with the **ESC** key.

The rest of the options of the **DVIEW** command work similarly to the examples described above.

In order to save any work we have just done, it is enough to type **V (View Manager)** ⇒ **Enter** in the command line (Fig. 10). Then in the dialog box, point to **New**, and in the window that appears (Fig. 11) **View name:** give a new unique name. In addition, other properties can also be specified here. If we need to call the saved view, it is enough to type **V** ⇒ **Enter** in the command line using the keyboard and in the dialog box, which will be similar to the dialog box shown in Figure 10. On the left side of the dialog box, in the **Model Views** field, all memorized nominal views will be displayed. Select the desired one and press the **OK** button, and the selected nominal view will appear in the graphic area.

The same **View Manager** dialog box can also be called using the **Ribbon** (Fig. 12).

Tabs ⇒ **Visualize** ⇒ *Ribbon* ⇒ **Views** ⇒ **View Manager**.

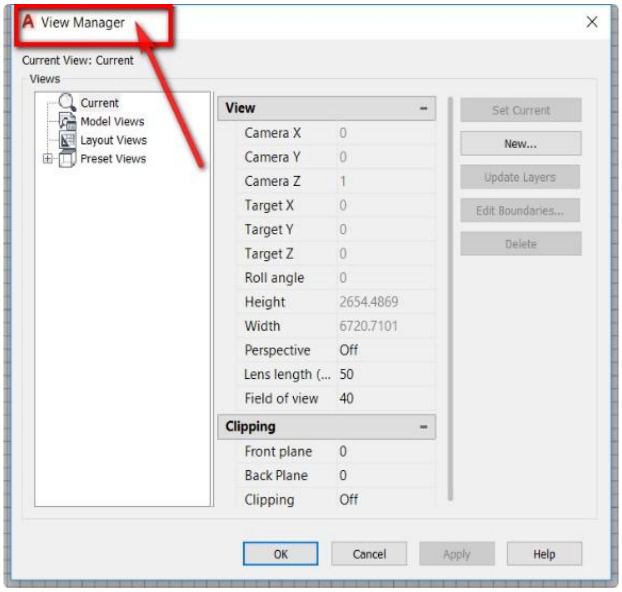


fig. 10

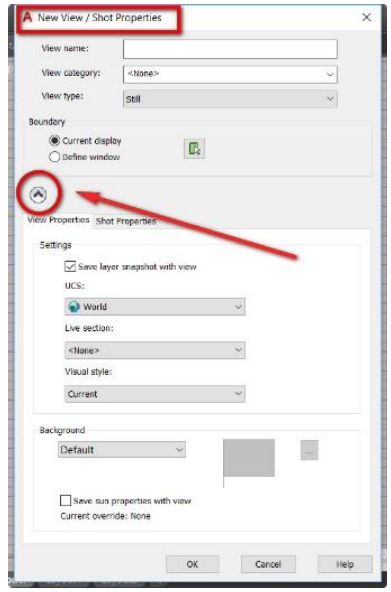


fig.11

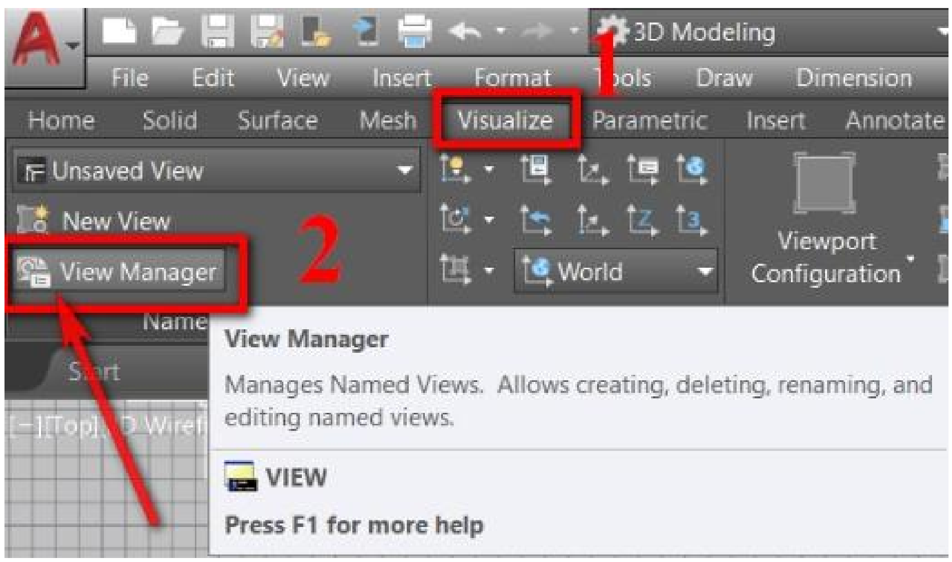


fig. 12

In the **AutoCAD 2019** version, instead of **J** ⇒ **Enter**, you can move the cursor to the Justify command line and click on it with the left mouse button.

In later versions of **AutoCAD 2013**, instead of typing the letter indicated by the capital letter, it is possible to bring the cursor to the corresponding subcommand in the command line and click on it with the left mouse button.

Conclusion:

The article discusses the methods of obtaining screen views, it should be noted here that screen views can be used both in model space and in paper space, and each of them can have both the same and different scales.

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Consequences of Design and Rechnological Errors in Construction

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Annotation

Buildings of any purpose (civil, industrial, hydrotechnical, road and others) must be sustainable and ensure human safety during the entire period of its operation. Therefore, it should be impossible to destroy objects designed and built in full compliance with construction norms and rules due to natural and man-made disasters (earthquakes, storms, floods, etc.). even during Nevertheless, due to design and technological errors, there are frequent cases of their partial or complete destruction all over the world, which is almost always followed by human casualties.
Key words: ruin, mistake, building, victim, cause, tragedy

1. Introduction

Construction cannot tolerate inaccuracy. During the design of a new construction object, a number of necessary conditions must be observed on the surface, so that the final product, in the form of a finished building, can function normally during the guaranteed operational period. One of the main conditions is the correct selection of the construction area. This first of all implies a precise geological survey of the existing soil and groundwater. In case of weak soils, it is necessary to strengthen them. and in the presence of groundwater, its removal and the arrangement of a full-fledged foundation of the building. Mistakes are common in design. One of the special cases happened on June 27, 2009, in Shanghai. One 13-story building from a large residential complex (11 houses) fell without collapsing. But all of its hinges were broken (Fig. 1). It was not yet inhabited and only one person died, otherwise the casualties would have been much higher. The house was built by the river. During the design, the possible impact of water was not taken into account, and the foundation was washed away with the flood of the river. Accordingly, the beams were not properly calculated and their insufficient section could not withstand unexpected loads.

Fig. 1. A collapsed house in Shanghai

In addition, it is necessary to accurately consider expected seismic and wind impact forces, snow load, climatic and temperature changes. It is with such an approach that the first skyscraper in the world, more than half a kilometer high, Taipei 101, was built in Taiwan. It is rightfully considered one of the most reliable structures, despite the fact that it is built in a place most prone to strong earthquakes and storms. Instead, the greatest destruction and loss of life occurred in the February 6, 2023 earthquake in Turkey, due to inadequate seismic-proofing measures during construction. As a result of the study of the incident, it became clear that many mistakes were made during the production of construction processes. Due to this, more than 150,000 buildings were destroyed or seriously damaged, 50,500 were killed, and 107,204 were injured by the 7.8-magnitude earthquake in southeast Turkey (Fig. 2).

Fig. 2. Turkey earthquake

There are many other reasons for the collapse of buildings, and in order to take them into account, it is necessary to consider such cases and determine the main causes of accidents and disasters. For this purpose, some of the world's most high-profile cases of design and technological errors are discussed below.

2. Main part

In history, the largest loss of buildings was caused by the September 11, 2001 terrorist attack in New York City, when two skyscrapers of the World Trade Center were destroyed by a plane crash. It was a case where it was impossible to blame the designers or the builders. Therefore, it is believed that the largest number of casualties among buildings that collapsed as a result of design and technological errors was recorded on April 24, 2013, during the collapse of an 8-story building in the city of Savar, Bangladesh (Fig.3). It is officially believed that 1,134 people died, and more than 2,500 people were injured. In total, up to 5,000 people worked in the building in various institutions (bank, shops, offices, etc.). Among them there were several sewing enterprises, which had switched to a 24-hour mode of activity. The day before the tragedy, due to the appearance of large cracks on the facade of the building, everyone except them stopped working. Moreover, despite being aware of the serious damage to the building, the owners of the garment factories forced out about 3,000 workers under the threat of dismissal. The building collapsed instantly, in a matter of seconds, except for the first floor, and all the working personnel were buried under the rubble. There were so many reasons for the destruction that it was surprising how the building existed at all. It was found that after commissioning, three floors were added to the initially five-storey building without any strengthening. Heavy sewing machines were placed on the mentioned floors. And, for smooth operation, large diesel generators located on the roof had a strong dynamic impact on the entire building, which was not considered at all during its design. In addition, the foundation was laid on the previously existing underground lake, which was only filled with garbage. It should be noted that due to the lack of proper equipment, the authorities refused to clean up the ruins and in the first days only volunteers worked. The United Nations intervened in this case. All this had a very negative impact on the quality of rescue operations. The last living person was pulled out two weeks after the collapse.

Fig. 3. Ruins of the building in St. Savar

In 1995, in Seoul, South Korea, a large number of victims were involved in the demolition of the shopping center "Sampoon" (Fig. 4). As a result of the collapse of construction structures, according to various data, more than 500 people died, and more than 1500 people were injured. The building was handed over in 1990 and on average more than 40 thousand people entered it for shopping every day. According to eyewitnesses, the entire building suddenly collapsed in just 20 seconds. The tragedy was preceded by several suspicious circumstances, which the local authorities did not pay attention to. At first, the object was a 4-story apartment building, and during the construction process, it was decided to change its functional purpose. According to the new project, in order to arrange escalators in the shopping center, the roofs between the floors were cut without any reinforcement. Then the fifth floor was added without strengthening the foundations and supporting structures. In 1993, three 15-ton air conditioners were installed on the roof. As a result of the investigation of the incident, it was established that despite so many design and technological errors, it was the air conditioners that caused the disaster. As a result of the vibration caused by them, the reinforced concrete slab of the roof first cracked, and then the part of the south wing completely collapsed and caused the collapse of all the load-bearing structures below it.

Fig. 4. Ruins of "Shampoon"

In November 1999, a 6-story, 26-unit apartment building collapsed in 19 seconds in Foggia, Italy (Fig. 5). At that time, 67 of the 71 people who were there died. During the study of the causes of the tragedy, many negative details were revealed. The house was built in 1960. At that time, there was a huge shortage of housing in Italy and everyone was trying to take advantage of this business. Due to the lack of qualified personnel in the field of design and construction works, often inexperienced architects and engineers performed the design and construction. It is for this reason that the load-bearing structures of the building did not have adequate reserves. A number of support structures were not arranged in the basements, which were supposed to distribute the loads received from the above-ground part of the building, the foundation was arranged on the soil with increased moisture, without its preliminary drying and strengthening. Almost all residential and non-residential buildings throughout Italy were inspected after the tragedy. Among them, several thousand were dismantled, which posed a special threat to people's lives.

Fig. 5. A ruined house in Foja

On June 24, 2021, the disaster occurred in Surfside, a suburb of Miami (USA), when the northeastern part of a 12-story residential building collapsed in 9 seconds and completely destroyed 55 of the 136 apartments. 98 people died because the collapse occurred at night and was accompanied by fire. The house was built in 1981 and its useful life was defined as 40 years (with a further 40-year deferment), which exactly coincided with the actual term. Three years before the tragedy, the population asked the authorities to pay attention to the cracks in the columns and roof tiles of the underground parking lot and to the systematic accumulation of water in the basement. Ironically, the preparation of the design documentation for the purpose of liquidating the existing damage was so long that the relevant works had to be started a few days after the disaster. The main cause of the collapse was the washing away of the foundation of the building located on the beach, which was not properly taken into account during its design. In recent years, as a result of the rather rapid movement of the ground, the concrete cracked, and the reinforcement rusted, and this part could no longer withstand the loads transmitted from above. After the tragedy, in the USA, they began to inspect buildings older than 40 years and develop new standards for building certification. and caused the armature to oxidize (Fig. 6)

Fig. 6. Wing collapse in Miami

In the largest city of Nigeria, Lagos, which was its capital until 1991, on November 1, 2021, a 21-story high-rise building under construction completely collapsed in a few seconds. 42 people were killed and several dozen people were injured, mainly the personnel working on the construction of the facility. Among them was the owner of the construction company, who was there at that time and inspected the construction. The company was engaged in the construction of elite residential houses, not only in Nigeria but also abroad. The cause of the tragedy was the violation of the permit issued by the State Construction Agency, which provided for the construction of only a 15-story building. As a result of arbitrarily adding six floors, the reinforced concrete frame building could not withstand the excessive loads and collapsed upon reaching the critical limit (Fig. 7).

Fig. 7. A dilapidated house in Lagos

Many other examples can be cited regarding the demolition of buildings of various purposes, but even more often there is the destruction of individual elements of the building, which results in serious casualties. In this regard, the collapse of the roof of the "Transvaal" sports and entertainment complex in Moscow on February 14, 2004 should be especially noted. In Moscow, 28 people were killed and more than 100 people were injured in the water park accident that took place 19 months ago, and most of them were permanently disabled. Among them were citizens of Georgia. 5000 m2 of the central part of the metal roof with an area of 20.2 thousand square meters collapsed instantly and 400 people bathing in the pools fell (Fig. 8). Most of them were found under the rubble outside in -200 C freezing conditions. Many rescuers and technical means participated in the unprecedented rescue operation. The investigation lasted for 20 months and it was finally established that the cause of the collapse was due to errors in the design solutions and the building did not meet operational standards. One of the main factors was the stress developed in the metal constructions due to the large difference between the indoor and outdoor temperatures.

Fig. 8. "Transvaal" roof accident

The number of human casualties in the USA cannot be singled out in 1981, when 114 people died and 216 were injured when metal platforms suspended in the atrium of the Hyatt Regency Hotel in Kansan City, USA, collapsed. Before the terrorist attack on the World Trade Centers, it was the largest in this case.

Conclusion

1. Despite the many cases of building collapses and human casualties worldwide due to design and construction errors, such facts are still often caused by elementary negligence. There are many accidents caused by the installation of heavy-weight engineering equipment on the roofs and floors more than planned, when the appropriate load-bearing structures are not strengthened;

2. Most often, the cause of building collapse is improper geological and hydrogeological study of the construction area. At this time, less attention is paid to the washing of the foundations and the possible settlement of the ground, which becomes especially dangerous over time;

3. Calculation of new structural elements and ensuring their carrying capacity also require special attention in the process of designing buildings. Ignoring minor details has led to such great tragedies as the collapse of the hanging platforms in the atrium of the hotel in Kansas City in 1981 and the collapse of the roof of the Aqua Park in Moscow in 2004;

4. During the construction of buildings, the main technological mistakes are caused by the use of low-quality construction materials, deviation from the requirements of project documentation and, most importantly, improper observance of construction norms and rules. A clear example of this is the earthquake that occurred in Turkey in 2023, as a result of which many buildings collapsed and many people died.

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Organizational Issues of the Formation of the Architectural and Planning Structure of the Network of service in the Resorts, in Places of Mass Recreation and Tourism of Georgia

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Abstract: We consider the sphere of recreational services as a complex, polyfunctional system, the main elements and subsystems of which differ in their socio-economic, demographic, environmental, ideological, aesthetic and other "coloring", range and significance, development patterns and ability to organize space.

Considering the concept of the consistent formation of different ranges and types of recreational formations, we find it advisable to determine the place and role of objects of an open network of cultural-residential services and catering in the formation of recreational structures, based on urban planning principles considering architectural and planning features.

Keywords: seasonality, peak period, resort and recreational facilities, public catering, low capacity and fragmentation of facilities.

Introduction

The organization of public catering in resorts, places of mass recreation and tourism is of great socio-political importance. In addition, the improvement of the quality of functioning of the public catering system is hindered by the problem of "seasonality", the difficulty of solving which is associated with the existence of the so-called "peak" period, which in turn requires a temporary expansion of the open network during periods of seasonal loads.

This problem is most pronounced in the open network of public catering. This problem is especially relevant in the specific conditions of Georgian resort and recreational formations, since here quantitative (increase in the scale of construction, sharp fluctuations in the number of vacationers, etc.) and qualitative (formation of a developed network, improvement of technical equipment, etc.) changes are especially clearly manifested.

Main Part

The Tskaltubo city is a balneological resort of world importance. It is located 235 km northwest of Tbilisi and 12 km from Kutaisi. This resort town is distinguished by its abundance of balneological springs and is located in a picturesque valley, surrounded by slope hills and rich vegetation. The city is located on an area of 730 ha, of which 10.9% (80 ha) is occupied by a resort park. The climate is warm, moderately humid. The average annual air temperature is 14.7℃. In the autumn-winter and spring periods, northeasterly winds prevail, and in the summer - southwesterly winds.

The main treatment represents weakly radioactive, mineral thermal water with a temperature of +32-35℃, which is used to treat diseases of the musculoskeletal system, blood circulation, the nervous system and some gynecological diseases. It is necessary to emphasize the fact that the development and formation of the resort town of Tskaltubo, unlike many resort towns in the country, is carried out with special observance of health, resort rules and requirements, which is why such shortcomings characteristic of resort and recreational areas as excessive construction have been avoided., which cannot be said about Borjomi and Batumi. In Tskaltubo, the resort zone is strictly limited and removed from the residential area, which contributes to strict adherence to the resort regime, which is an important factor in treatment.

The Borjomi city is an administrative-district center with a resort recreation area and public and cultural-household institutions. Borjomi - one of the most popular resort towns among the mountain-climatic and balneological resort towns of our country, with picturesque mountains and evergreen coniferous forests. The climate here is warm and moderately humid, winters are mild, summers are hot. The average annual temperature is +9.2℃, the average annual relative humidity is up to 77%. The annual amount of precipitation is 595 mm. Northeast and east winds prevail. The main healing (drinking, bathing) remedy at the resort is volcanic mineral water.

The Batumi city is the capital of Adjara, one of the country's main seaports, and one of the most popular among the climatic resort cities of the Batumi-Tsikhisdziri recreational group on the Black Sea coast of Georgia.

The subtropical climate of Black Sea of Batumi is very warm and humid. The annual precipitation rate is about 2418 mm, including 1460 mm in the warm period of the year. The largest amount of precipitation falls in the month of September. Spring here is short and relatively cold, autumn is warm, but with an increased amount of precipitation; winter is very mild, summer is hot and long, the maximum temperature reaches +36 ºC. The average annual temperature is +14.5 ºC, and the relative humidity is about 80%.

The main recreational potential and therapeutic and prophylactic means of Batumi are the mountain and sea climate, sun and water baths. Batumi is especially charming due to the abundance of subtropical and ornamental plants, a picturesque seaside boulevard, a beautiful beach along the coastline, magnolias, palm alleys and other evergreen plants, citrus plantations, a unique subtropical botanical garden. Batumi is especially attractive for vacationers in the warm and hot season of the year, which is why the city's recreational system is characterized by a certain overload of vacationers during this period.

The resort recreational space of Batumi, its urban planning structure with all the phenomena of service and recreation (biocenosis), is disrupted due to the large-scale construction activities underway here. The formation of the service sector system in these resort cities is not based on the results of scientific research, but rather spontaneously. The open network of public catering and other facilities of the trade and household services sector are incorrectly and unevenly distributed in the planning of these cities. More than 70-80% of these institutions are concentrated in the central part of the city. Such eccentricity of the location of these facilities creates discomfort for both the local (permanent population) and temporary residents of various categories. In addition, the distance (movement distance) to these institutions exceeds the limits of permissible pedestrian accessibility norms and in some cases is 1.5-3.0 km, which leads to significant congestion of intra-city transport and congestion of the center with the flow of people.

These overloads especially affect the entire system of service sector and communications during the summer period, when the population of these resorts increases significantly. This situation is observed in almost all resorts of Georgia. Such shortcomings of the recreational system as the low capacity and fragmentation of service sector facilities in Georgian resorts, mass recreation and tourism areas are generally associated with the chaotic process of development and formation of the public catering system. The conduct of these processes in this way is determined by the following factors:

1. Absence of district planning schemes of resort-recreational areas.
2. Insufficient calculations were made on the prospective forecast of the development of the recreational service system and the resort-recreational sphere in general.
3. The architectural and planning flaws of the existing service system facilities and the incorrect calculations of the organization of the functional structure of public catering facilities in technological schemes.

In the conditions of the Georgian resort and recreational system, the trends in the fragmentation of catering facilities were mainly determined by specific regional-planning (geographical and natural-climatic, relief structure, ecosystem and other factors) and social-demographic (local traditions, aboriginal lifestyle, structure and character of the accommodation system) peculiarities.

Unfortunately, the construction of public catering facilities is mainly carried out using the "project-free method", while the organization of the catering system is spontaneous, "self-flowing" without taking into account any correlations and interconnections between the basic directions and the links of the entire resort and recreational service system (zone, area, etc.).

Conclusion

1. Considering the concept of coherent formation of recreational formations of various ranks and types, we consider it appropriate to determine the place and role of cultural-domestic and public catering open network facilities in the mentioned system during the organization of recreational structures based on urban planning principles and taking into account the peculiarities of the formation of the architectural-planning structure of various types of recreational spaces.

2. The paper proposes integrated, mixed-type dispersed-group and linear-polycentric architectural-planning models, justifying the feasibility of their cultivation in a given region.

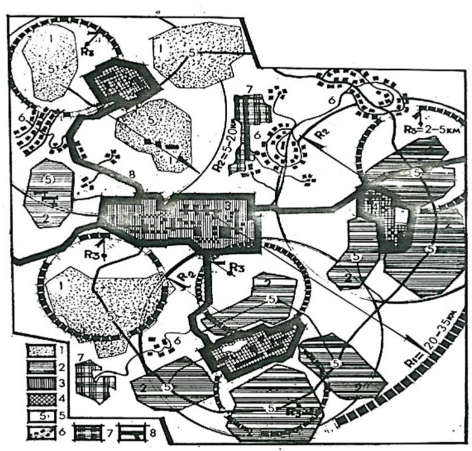

Fig. 1

Principle scheme of architectural and planning formation of the area and subarea of the Georgian recreational and tourist system.

1 Dispersed recreational and tourist complexes of low and medium-rise buildings.
2 Recreational complexes, large buildings in the structure of developed recreation centers.
3 Administrative and public centers of the area.
4 Public center of cultural and household services of the subarea.
5 Centers of complexes.
6 Accommodation system for service personnel.
7 Industrial and agricultural and warehouse areas.
8 Transport and pedestrian communications.
Basic parameters:

R_1=20–35 км, R_2=5–20 км, R_3=2–5 км

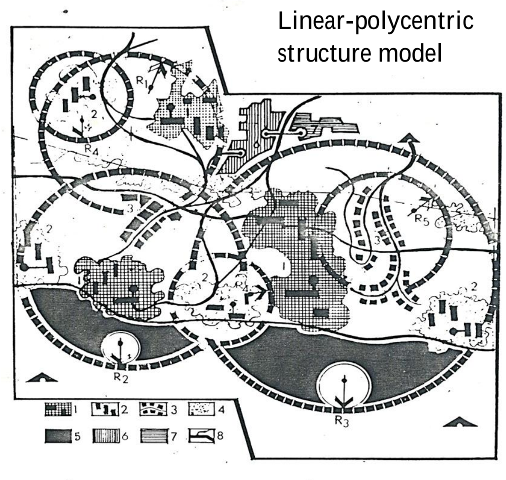

Fig. 2

The principle scheme of the architectural and planning structure of the recreational and tourist complexe[s] ... recreational space of Ge[orgia]

Dispersion-group
planning structure model

1 Recreational and tourist centers of the complexes.
2 Densely built-up recreational complexes with multi-story buildings (total area of the recreation area - 2.5-4.5 sq. km.)
3 Medium and low-rise (below 9 floors) development perpendicular to the coastline (total area of the recreation area - from 7.2 to 12.6 sq. km.) considering the increase and decrease in the number of stories of buildings.
4 Intensively developed greening (forest and forest park) recreation centers.
5 Water areas.
6 Service personnel (emergency)

accommodation zone
7. Recreational agricultural-industrial and warehouse areas.
8 Transport and pedestrian communications.
Basic parameters:

R_1=2-3 км, R_2= 0.9 км, R_3=1,2 км, R_4=1,5 км, R_5=1,2-1,5 км, R_6=1,5-1,8 км

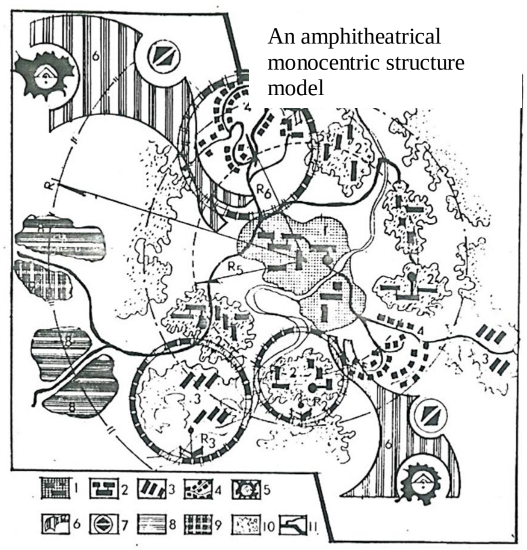

Fig.3

The principle scheme of the formation of the architectural and planning structure of the recreational and tourist complex of the Georgian mining and recreational space.
1 Recreational and tourist centers of the complexes.
2 Recreational simplexes with multi-story buildings (9-12 floors) densely built (total area of the recreation area - 2.5 sq. km.).
3 Recreational simplexes with medium-density development of 3-7-storey buildings (total area of the recreation area - 4.5 sq. km.).
4 Recreational simplexes with low-density development of small-story (2-3 floors) buildings (total area of the recreation area - 7.2 sq. km.).
5 "Chalet", "Bungalow" and other types of buildings (cottages).
6 Recreational activity (main specialized types by profile: ski areas, trails, solariums, beaches, etc.) recreation areas.
7 Direction of the main flow of recreationists.
8 Service personnel accommodation areas.
9 Recreational industrial-farming and warehouse areas.
10 Recreational areas of intensive use green plantations (cover) (forests and forest parks).
11 Transport and pedestrian communications.
Basic parameters:

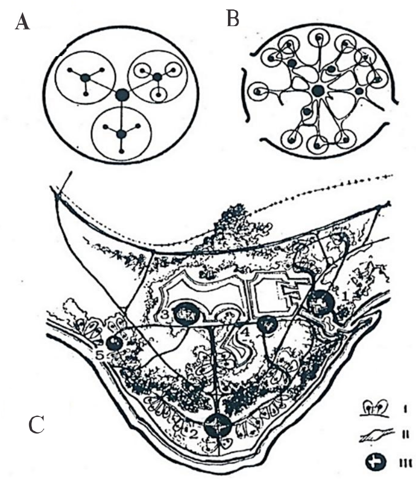

Fig. 4

Comparative graphic-analytical characterization of traditional models of cultural-household services in the conditions of resort-recreational systems (retrospective-perspective).
A. Three-tier service organization model
B. Service core-network organization model
C. Core-network structure of cultural-household services of the resort-recreational area of the coastal zone:
I. Local service groups;
II. Dispersed service network;
III. Community centers (1 - administrative-trade, 2 - cultural-mass, 3 - sports, 4 - exhibition, 5 - children's).

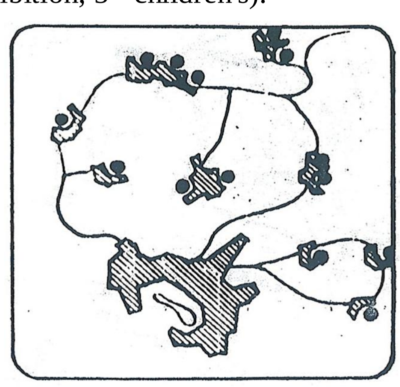

Fig. 5

The agglomeration of existing accommodation systems predetermines: the formation of recreational tourism systems, coherent with existing settlement systems, the network of cultural and household services, and the mutual arrangement of functional zones.

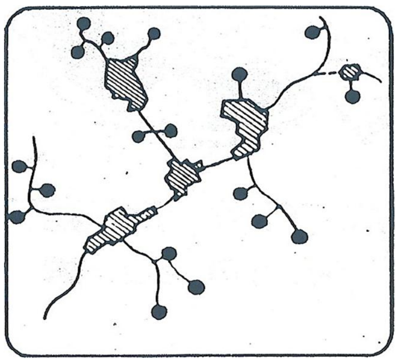

Fig. 6

The agglomeration of the recreational-tourist network of the created accommodation systems predetermines:

Under the conditions of rational use of the territory, the formation of optimal systems of cultural-household services and accommodation, coherent with the conditions of the existing recreational systems.

Features of the architectural and planning formation of various types of recreational space (a - the principle scheme of existing settlements and other agglomerations; b - the principle scheme of the existing network of the recreational and tourist system of accommodation and other agglomerations):

1 System of settlements and other agglomerations

2 Recreational and tourist complexes (simplexes)

3 - Main transport communications

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Assessment of the residual load-bearing capacity of reinforced concrete structures in service based on their physico-mechanical properties

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Abstract This section discusses the service life of reinforced concrete structures according to design data until their reliability decreases to the permissible limits (see point "Б" in Figure 1.1). In this case, the actual climatic conditions of the location of the structure and the expected static-dynamic loads are taken into consideration. At this stage, the residual resource of the bearing capacity of the beams and slabs is predicted based on the first limit state calculation, strength and bearing capacity. The criteria and requirements of construction norms and rules [1] are utilized in the calculation, and the change in the characteristics of concrete and vivacity over time is likewise envisaged . The design loads are: permanent and temporary loads regarding HK, strength and durability being considered.

Keywords: serviceablity, stability, deformation, elasticity, deformation-plastic.

Introduction

While examining reinforced concrete structures, one of the important factors is the determination of the durability indicators of the structure, which determine the performance of reinforced concrete structures during operation. This problem is surmounted in the work by developing a methodology for determining the residual resource and operation of reinforced concrete structures based on the physical and mechanical characteristics of concrete and reinforcement. The paper elaborates the methodology for determining the residual resource and suitability of a structure based on the change in the strength characteristic over a certain period of time, the ability to resist external influences during a certain time interval (during the operation period) of static and dynamic loads acting over a certain time interval (during the operation period), as well as the characteristics of physical wear caused by structural changes as a result of atmospheric exposure over the years, and the gradual degradation of the structure (we are referring to concrete erosion and metal corrosion). This methodology allows us to determine the durability of reinforced concrete structures during the operation period. That is, to determine the load-bearing capacity of the structure due to its aging and changes in the parameters of structural changes over the years. Thus, by using this methodology, we are able to determine the period of safe operation (without failures) of reinforced concrete structures and assess the risk factors expected during their further operation (degree of failure) and timely identify restoration and strengthening measures with intent to prevent the expected development of destructive processes in reinforced concrete.

Prediction of Concrete Strength Variations (Considering the Concrete Degradation Model with Freeze-Resistance Factors)

$R_ბ$ - Concrete Load-bearing Capacity and modulus of elasticity

$E_ბ$- degradation of ductility modulus during t – years is calculated by the formula below:

$$R_{B1} = \gamma_{Ra} \cdot R_B \,, \qquad (3.1)$$

$$E_{B1} = \gamma_{Ra} \cdot E_B \,, \qquad (3.2)$$

Where R_B და E_B represent, respectively, the concrete's design resistance and the ductility model;

γ_{Ra} and γ_{Ea} – Coefficient of serviceability calculating concrete constructions:

INDEX	Water saturation state	Construction zone	Very strict E= 300		strict F= 300		moderate F= 200	
			D_R	D_E	D_R	D_E	D_R	D_E
1A	water-saturated state	Transitional water level (failure of waterproofing, facilitated water drainage, water infiltration) in the deformed joint zone, and the flaking of the tiles	13,5	20,9	6,0	9,6	3,0	4,8
1B	Episodic water saturation process	Upper water zones (concrete surface exposed to atmospheric influences), facade surfaces (structural supports)	9,0	13,8	3,0	4,6	1,6	2,5
1C	The state governed by air humidity	Water-covered zones, surfaces under influence of atmospheric precipitation	4,5	6,0	2,0	3,0	1,0	1,5

$$\gamma_{R(B)a} = 1 - K_S K_t \cdot \Delta_{R(b)} \omega t , \qquad (3.3)$$

where K_S –the coefficient depended on the aggressive state of water.

$K_S = 1,0$ – when concrete comes into contact with fresh water.

$K_S = 1,25$ – concrete comes into contact with salty water.

K_t - coefficient corresponding to the transition from the properties of a cube to a prism, where $K_t = 1,675$;

D_R and D_E – represent complexies that affect concrete during freeze-thaw cycles at given humidity conditions (see table 3.1);

W – shows the level of destructive process velocity.

t – period of exploitation according to years;

D_R and D_E – meanings of these complexes are calculated according 3.1 and 3.2 schedules in lights of probability – by providing 0,95.

The development of destructive processes in concrete products is posed by the level and type of stress state, the ability of concrete to absorb water, and the aggressive environment in contact with the concrete product. The following ought to be given due regard when calculating concrete constructions:

a) Alterations in the structural characteristics and baseline parameters of concrete, including its strength, frost resistance, and water saturation, are discerned.

Schedule 3.1

b) Environment effect (climate conditions, salinity of water and environment);

c) Frequency of temperature variations within 0°C at each cycle;

d) The level and type of tensed condition.

At the same time, two processes occurring within the concrete are taken into consideration.

– The assessment of strength over a span of 5 to 20 years, as stipulated by the required standards, is conducted.

– Destruction of concrete products during the period of exploitation;

– D_R and D_E are the values of parameters for water saturation and frost resistance conditions, as defined by the standards;

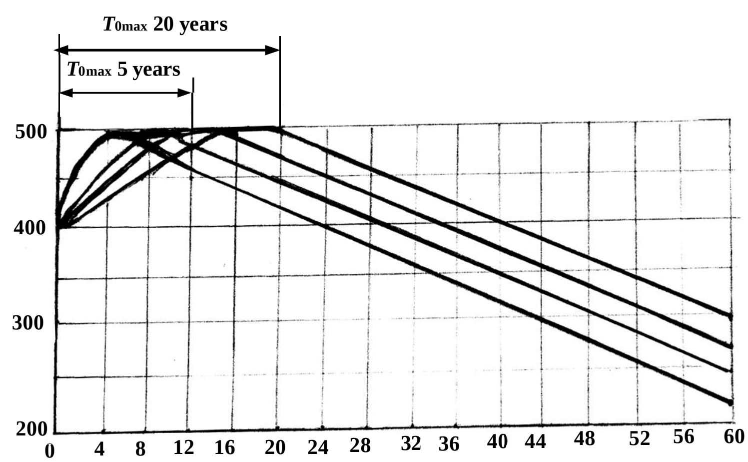
hedule 3.2

W – The value of parameter, taking into consideration frost resistance and tensed state

$W \cdot 10^3$

	$\frac{\sigma_{min}}{R_b}$	F= 200		F= 300	
		compression	streching	compression	streching
1	0,01	4,86	5,00	3,28	3,33
2	0,05	4,42	5,02	3,04	3,34
3	0,10	4,04	5,06	2,84	3,36
4	0,15	3,79	5,14	2,70	3,39
5	0,20	3,64	5,26	2,60	3,45
6	0,25	3,56	5,42	2,55	3,52
7	0,30	3,54	5,63	2,53	3,60
8	0,35	3,59	5,90	2,53	3,71
9	0,40	3,70	6,25	2,58	3,85
10	0,45	3,90	6,69	2,66	4,01
11	0,50	4,21	7,27	2,78	4,21
12	0,55	4,68	8,04	2,95	4,46
13	0,60	5,38	9,09	3,21	4,76
14	0,65	6,08	10,60	3,54	5,14
15	0,70	6,80	12,90	3,88	5,63
16	0,75	7,52	16,84	4,23	6,27
17	0,80	8,23	25,00	4,57	7,14

The characteristic strength of concrete, as stipulated by construction standards and regulations, ranges from 5 to 20 years, beyond which a decline in strength properties occurs. The graph depicting the time-dependent behavior of strength over the years is shown in Figure 3.1



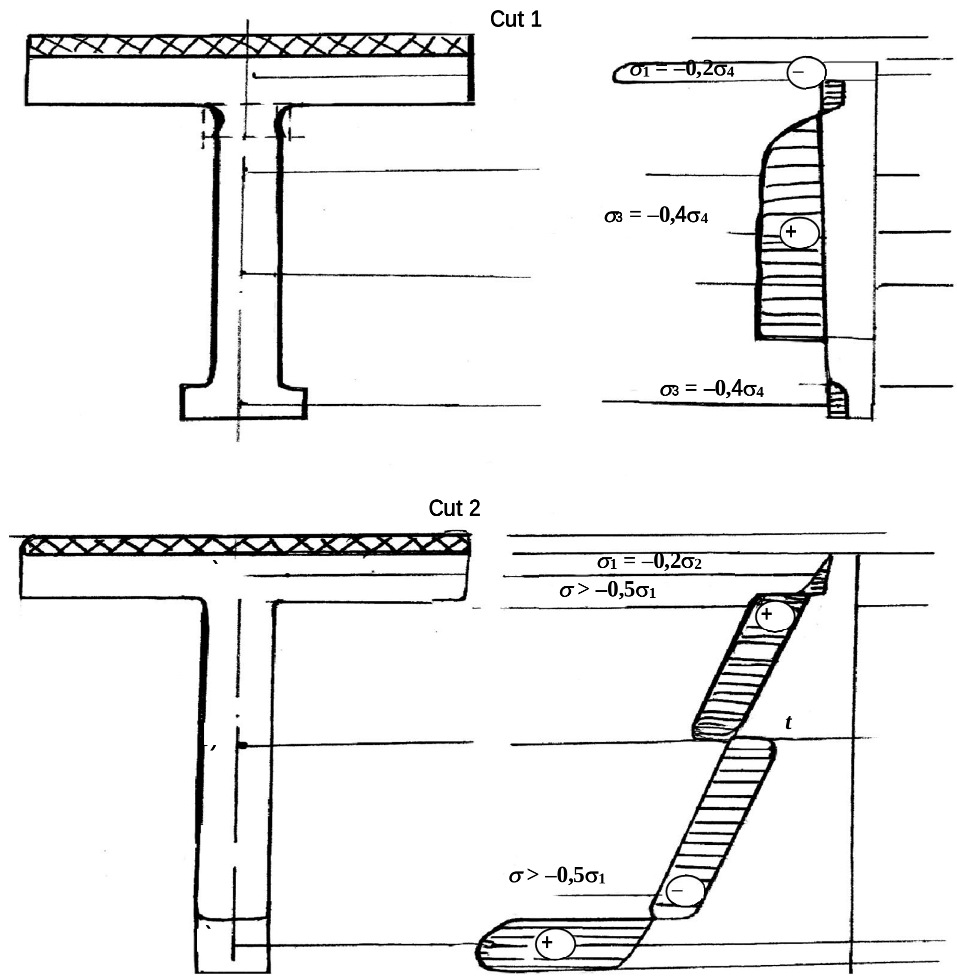
picture. 3.1. Age of concrete structure T_0- years

3.2. The stress in concrete elements owing to sharp temperature fluctuations

Sharp increases or decreases in environmental temperature lead to the development of normal tensile or compressive stresses in concrete elements. Such stresses occur in the slab, wall, and lower part of the beam. The magnitudes of these stresses are considered when evaluating the stressed-deformed state of the structure during the calculation of strength and load-bearing capacity [19].

The determination of stresses is implemented in the following sequence:

- The cross-section is divided into individual elements;
- The thickness value of the elements in the cross-section, dj, is determined;
- The conditional calculated temperature, tj, is computed for the elements under conditions of sharp temperature increase or decrease;
-
- The stress value, σ, is calculated for each element
- The division of the cross-section of the product into elements is shown in Figure 3.2. Each cross-section is conventionally divided into the following elements: reinforced concrete slab, reinforced concrete column flange, lower column flange or part of the lower base of the wall, the height of which is equal to the wall thickness.



picture 3.2. Graphs of calculated voltages

thickness of cross-sectional elements are calculated by the formula:

$$\delta_i = \frac{2 f_i}{S_i}$$, meter

where f_i – cross-sectional area of a single element,1meter^2.

f_i - The perimeter of a product's cross-section that is in contact with the surrounding air.

Conditionally calculable t(temperature) is defined according to 3.3 schedule:

Schedule 3.3

Specifically calculated temperature values of cross-sectional elements:

d_i	∂	0,02	0,04	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,9	1,1
t_i	C°	9,3	8,5	6,8	5,0	3,7	2,7	2,0	1,4	1,0	0,5	9

The tensile stress at the center of the rib in prestressed coils may be calculated utilizing the formula presented herein : $\sigma = \alpha E \cdot \Delta t \cdot P$, , kgf/cm² (3.5)

where $\alpha = \frac{1}{(1+ f_m / f_\alpha)m}$ – Indicator of the mass of the element, f_m – cross-sectional area of the mass, whereas f_α – the rest part of the cross-sectional area; *m* – correcting coefficient, which is shown on picture. 3.2 for calculating schemes. 2,5 is got On first cut 1and 2 –for second cut,; *E* – modulus of concete elasticity.

Δt emerges as change in temperature between the element of small mass and average temperature. The average value of temperature of the rest elements are calculated by the outlined formula:

$$t_{Med} = \frac{\sum_{i=1}^{n} f_2 \cdot t_2}{f_a}, \quad (3.6)$$

n is the amount of elements prevailing in the cross-section besides the elemnts possesing masses of– f_m (in the case of picture. 3.2 $n = 2$).

Temperatural voltage in need of calculation subjects to the formula

$$\sigma_t = \sigma_Z \cdot S_1 \cdot S_2 \cdot S_3 \cdot S_4 , \quad (3.7)$$

where, σ -the value of voltage according to Fig. 3.2 drawing from the dependance (3.5). S_i is correcting coefficient.

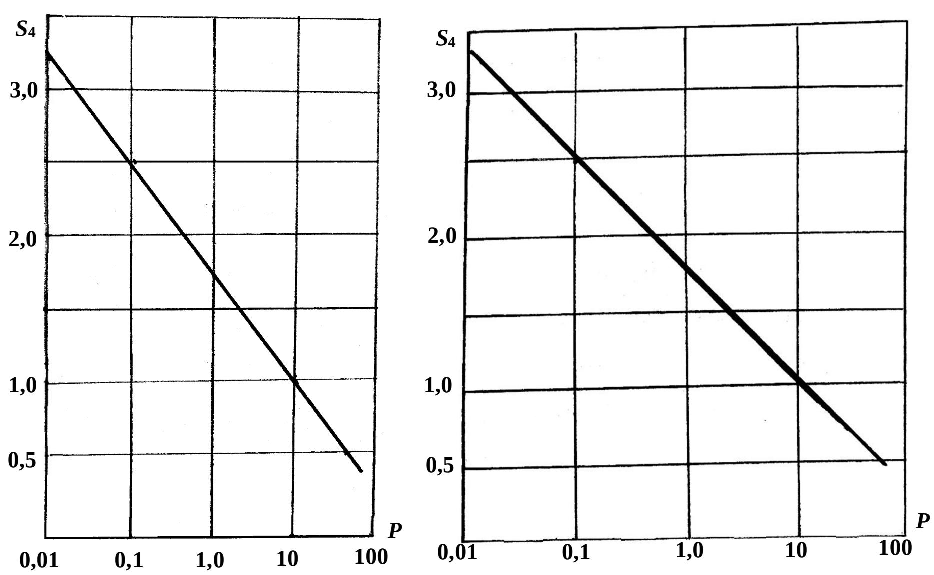
Sharp increase and decrease are defined in every cross-section. At the same time, it should be noted that the value of S_1 is respectively taken from the range $-1{,}0 \div +1{,}3$.

S_2 – coefficinet is taken from 0,0374A by envisaging climatic conditions, where A represents the diurnal temperature variation amplitude, in accordance with construction standards and regulations

S_3 – is taken according to the state of the coil and cross-section. 1,0 utilized for average diameter of ∅.

∅ –for outer coils $S_3 = 1{,}25$.

S_4 – is taken This coefficient is taken according to different values of stresses induced in the cross section and is obtained as 0.5; 1; 0.5; 1.75; 3.0 in the case of repetition: 50 times, 10 times and 1 time per year and 1 time within 50 years (see Fig. 3.3).



(1 times100 years) (1times 10 years) (once in a year) (100 times in a year)

Fig. 3.3. the probability of calculating voltage repetition

The calculated values of temperature stresses are taken into account:

$K_4 =$ When calculating slabs, when adding the Sp-value, taking into account the compressive stress, when 0.5;

$K_4 =$ When checking the serviceability of coils, when attaching the Sp-value in the direction of the main stresses, we take into account the values of the main tensile and compressive stresses, on the coil wall, when 1.75;

$K_4 =$ When determining the stresses in the compressed area in coils, we take into account the addition of the Sp-value, when 2.5

3.2.5. This is approximately the repetition

Calculating tempretura; voltage values can be determined by the following formula:

$$\sigma_t = \sigma_Z \cdot S_1 \cdot S_2 \cdot S_3 \cdot S_4 , \quad (3.7)$$

where σ- voltage value which is defined by structural diagrams of voltage (Fig. 3.2) and (Fig. 3.5) concentration of exhaust in the tile (W_t) derived from Dakhans . *DT* – rested resource. S_i is correcting coeficcient.

Each cross-section is considered for two types of impacts and takes into account a sharp decrease and increase in air temperature. At this time, the value of the magnitude in the temperature range from -1.0 to +1.3 is taken into account.

S_2 – coefficient presupposes the characteristics of climatic regions and is taken from:

$$S_2 = 0{,}0374A, \quad (3.8)$$

where *A* is diurnal temperature change amplitude and is taken according to region climate conditions.

S_3 – The coefficient takes into account the location of the coil in the cross-section of the product.

∅ For coils with medium cross-section $S_3 =$ 1,0.

∅ –for outer coils $S_3 = 1{,}25$.

The coefficient takes into account the degree of stress repetition and is taken with values equal to 0,5; 1,0; 1,75; 3,0 depending on how many times the repeated reaction occurred, 50; 10 and 1-times in a year and 1-times in 50 years (see. Fig. 3.3).

– When calculating slabs, the value of the compressive stress σ_3 must be additionally taken into account.

3.3. Prediction of concrete carbonation

The carbonation characteristics of concrete are obtained according to the values given in the table (Table 3.4), which are obtained on the foundation of statistical analysis of experimental results conducted at the test site of various reinforced concrete structures.

„*a*" The importance of the protective layer thickness on the carbonation time of concrete products– $T_{carb.}$ Determined by the formula:

$$T_{kar\ b} = m_1 \cdot m_2 \cdot m_3 \cdot m_4 \cdot \frac{a}{K}, \quad (3.9)$$

Where *a* is the thickness of the concrete protective layer specified in the project in mm;

K – normative value of the velocity of carbonization mm/year (schedule3.4);

m_1 –Coefficient selected according to the type of construction; (concrete compression ratio); $m_1 = 0{,}6$ – For foundry columns with conventional reinforcement;

$m_1 = 1{,}0$ – For prestressed structures;

m_2 – Coefficient according to surface layout;

$m_2 = 2{,}0$ –For medium surfaces of slabs and coils;

$m_2 = 1{,}0$ – For facade surfaces;

m_3 – coefficient depending on the aggressiveness of the air and is taken as: 2.0; 1.3 and 1.0 – for environments with a weak, medium and high degree of aggressiveness;

m_4 – coefficient, which takes into account the size of the protective layer on the bottom and side surfaces of the plates and coils;

$m_4 = 1{,}5$ $-T_s = 3 \div 7$ – For year-round insulative fencing;

$m_4 = 3{,}0$ For protective labor working throughout the year $T_s = 30$ (when $t < 3$ years $m_4 =$ 1, when $t = 7 \div 30$ year defined by interpolation).

Schedule 3.4

Normal values of carbonation of concrete products (for aggressive environments)

nomination	raise	normal	low	remark
Concrete strength	0,86	B 82	< 0,82	–
Watertightness stamp B	W B8-B6	B 4	< B 4	
Carbonization speed *K* mm/year	0,25 – 0,75	1,0	2.0	–

3.4. Reinforcement corrosion prediction

The time required for the development of reinforcement corrosion T_a – time is taken into account, which is necessary for the complete neutralization of the concrete protective layer (see Appendix 3.3). The function of reducing the cross-section of the reinforcement corresponds to the function of the failure in the reliability theory.

For long-term reinforced concrete structures, reinforcement corrosion can be predicted from the calculation relationship of the wear-and-tear:

$$Sc= \Delta F_a = \left(a^{i*(1-T_a)K} - 1\right) \cdot 100\% , \quad (3.10)$$

where ΔF_a – The area of corroded reinforcement in %, determined by comparing the corroded area with the initial cross-section. It is an indicator of the corrosion function, which characterizes the corrosion rate under different operating conditions;

t – age of the structure (in years);

Tcarb – carbonization time of the protective layer of concrete;

K – accelerated corrosion growth coefficient due to external factors, which is calculated by the formula:

$$K = K_1 \cdot K_2 \cdot K_3 , \quad (3.11)$$

K1 – coefficient determining the formation of cracks at the design stage after the manufacture of the slab K1 = 1.0;

KH – coefficient determining the quality of waterproofing K2 = 1.0;

K3 – coefficient taken according to the climatic zone (K1 = K3 during design).

The influence of cracks on the corrosion process can be determined according to the instructions of BCH 32-89 [10].

The quality of waterproofing is indicated for three conditions:

a) in the absence of defects (taken during design);

b) a single trace of leakage from concrete is observed on the cantilever surfaces of the slabs;

c) leakage is observed over the entire surface of the longitudinal seam on the monolithic slab.

Schedule 3.5

K_{crc} and K_3 – coefficient values

The crack formation coefficient Kcrc is taken according to the crack size, ; K3 – coefficient according to climatic zones.

Reinforcement types *Q* mm stretched	<0,2∂∂<	0,5 ∂∂>	10,5∂∂	north	center	south
Reinforcement on the transverse seam	1,0	1,10	1,25	1,20	1,0	0,9
(consolidation of the lower row)	1,0	1,1	1,25	1,5	1,2	0,9
On the facade surface	1,1	1,25	1,25	1.20	1,0	0,9
On the inner surface of the coil On the lateral coils and	1,1	1,25	1,50	1,1	1,0	0,9
On the slabs; On the main reinforcement on the intermediate coils	1,0	1,10	1,25	1,1	1,0	0,8

Schedule 3.6

*K*3 - Waterproofing coefficient values

Reinforcement types			
Longitudinal seams	1,0	1,1	1,25
Facade surfaces of edge coils	1,0	1,2	1,5
Intermediate coils and slabs	1,0	1,0	1,1

At the design stage, Kbz = 1.0 and Kh = 1.0. In this case, it is possible avail the privelege of basic graph of corrosion (see Fig3.4)

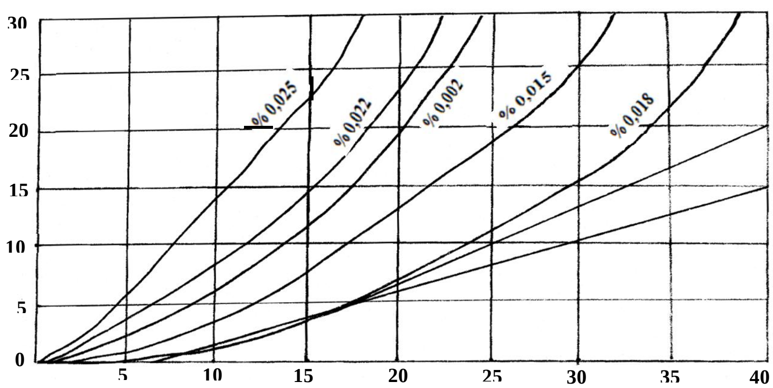


Fig. 3.4. Graph of basic reinforcement corrosion rates when Tkr=0; Kbz=Khydr.=K3 = 1.0

schedule 3.7
Baseline values for reinforcement wear
Reinforcement location

Reinforcement type	Longitudinal seams during monolithic	Facade overhangs, edged with corrugated iron panels	Intermediate Fili's mid-aled coil
Reinforced concrete product with conventional reinforcement, bottom row of main reinforcement	–	0, 0220	0,0120
Next rows	–	0,0160	0,0120
Bent rods	–	0,0160	0,0120
Straps	0,0200	0,0250	0,0150
Rebars on longitudinal joints Slab reinforcement	–	0,0200	–0,0150
Reinforced concrete products with tensioned reinforcement Lower rods, lower on the arch	–	0,0150	0,0100
Rods on the wall	–	0,0100	0,0080
Rebars on longitudinal joints	0,0200	0,0100	0,0080

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Modern methods of tunnels waterproofing and types of waterproof materials

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Abstract The work describes, considers and systematizes new engineering and technical solutions of tunnels dewatering and waterproofing measures.

Measures of the second direction (tunnel waterproofing) foresees provision of water impermeability of the tunnel support itself or rock massif surrounding the mine working that is achieved using the following methods:

- Tunnel support waterproofing through application of different insulating materials on its internal or external surface;

- Tunnel support water impermeability provision through support erection from water-proofing materials;

- Tamping of mountain massif and space behind the support.

Due to diversity of geological and hydrogeological features of mountain massifs the conditions of their intercrossing tunnels' service-maintenance and operation are different and, in some cases, differ considerably from each other.

Keywords Tunnel; Waterproofing; Materials.

Introduction

In order to secure normal operation conditions for transport tunnels it is necessary to solve many difficult problems, and one of the most important among then is a tunnel protection from underground waters, which endanger safe traffic.

Ground waters is the main problem for tunnel constructors and in general for people involved in the underground structures' construction. Underground waters substantially complicate the processes of tunnel driving and reinforcing during construction of the underground structures, and their leakage in most cases leads to insoluble problems in the underground structures being in operation. Basedon this fact, tunnel designing and construction with consideration to the measures for avoidance the underground waters impact on the structure is a high-priority task in order to provide normal operation of tunnels for securing safety traffic.

Main part

The norms and standards determining selection of methods for underground structures' water protection under specific engineering and geological conditions still have not been developed.

Different technologies of tunnels waterproofing provide different levels of moisture protection. Motorway or railway tunnels, pedestrian crossings and subways (undergrounds) must have maximal level of waterproofing according to standards, which make appearance of wet spots, condensate or moisture dropsinadmissible.

At the appearance of signs of waterproofing defect, the repair works are conducted immediately.

In the hydraulic engineering tunnels and communal facilities appearance of wet spots, condensate or drops of moisture is admissible depending on the tunnel purpose and waterproofing class.

For each type of facilities, the relevant technologies are used, depending on constant dynamic and static load, availability of transport or pedestrian traffic, depreciation properties of materials, ground features and presence of ground waters.

Waterproofing technologies:

- *membrane waterproofing*. Modern methods of membrane use provide application of quality waterproofing without considerable thickening of concrete constructions. Roll membrane materials are the most sought-after materials used for quality tunnel waterproofing.

- *waterproofing by means of profiled membrane*. There are used profiled roll PVC (polyvinylchloride) materials of high strength.
- insulation using roll membrane is taken as a basis, when operating in deep tunnels with high requirements to dryness.
- vacuum membrane technologies. There is used a trademark waterproofing package containing polymer fillers and composed of several membrane layers. It is used for waterproofing of transport tunnels operating under high loading.
- waterproofing by means of welded, bitumen, roll materials. This is one of the most effective methods for elimination of washout and leakage at relatively small depth (up to 10 meters).
- except for welded roll materials, it is possible to use closed waterproofing membranes in tunnels.
- Application of sprayed materials, "liquid rubber" and polymers in combination with membrane technology.
- spraying of special composition to inner and outer sides of structures, which increases waterproofing properties, plugs up seams (joints) and structural junction points.
- the given method provides maximal insulation of surfaces and makes it possible to avoid material damage (breakdown) and increased porosity of concrete structuresdue to effect of ground waters and ground. Spraying is performed by special devices under high pressure.

The easiest and most labor-consuming method is pumping of sand-cement mortar into the structure in order to eliminate contact with soil and ground waters. Modern concrete additives secure sufficient plasticity and flow ability of a mass.

The mixture grouts into holes and thereby provides waterproofing. Installation of steel shields or roll waterproofing layer is added to this method. Application of this technology is reasonable when conducting the works at great depth or if the danger of ground waters breakthrough exists.

If there is a hazard of soil sliding, it is necessary to strengthen waterproofing with steel or cast-iron structures, waterproofing with extra-strong concrete and installation of additional concrete structures. There are formed high-strength concrete structures with consolidating blocks.

It is possible to use different complexes; water drainages are installed, and holes are plugged with concrete pads and shields. In combination with modern materials and membranes it makes possible provision of reliable packet waterproofing with minimum resources consumption.

Shield methods of waterproofing are used for tunnels with a depth up to 10 meters and more.

Tunnel waterproofing repair

Experts conduct studies and determine the capability of repair works related to waterproofing of tunnels, seams and cracks, and insulation of ground waters and aggressive grounds. Concrete structure studies are carried out according to standards.

State-of-the-art methodologies of waterproofing if timely addressed make it possible to enhance structural strength and extend the tunnels' operational life.

Tunnels must be obligatorily inspected every year, with conducting of studies related to availability of cracks, microcracks, material wear, waterproofing defect, and repair works must be carried-out timely.

High-quality waterproofing may improve tunnel performance properties and extend its operational life up to 10 years.

Basic techniques for waterproofing repair are as follows:

1. Spraying and welding on of bitumen and polymer materials according to standards.
2. Installation of new waterproofing using profiled roll membranes.
3. Injection method;
4. Penetrant method;
5. Pumping of cement and cement-polymeric, polymeric mortars.

Fig.1.Injection technologies with the use of concrete and polymeric materials

At appearance of insignificant cracks, it is possible to apply injection technologies, when polymeric waterproofing materials are directly grouted into structure by means of properly disposed boreholes.

As a result, polymeric membranes are formed inside the structure, which fill cavities, microcracks, and structural gaps. These operations require special equipment and specific polymeric, epoxydic, acrylate and polyurethane compositions.

- in some cases, injection technologies and application of inner membranes with polymeric fillers makes it possible to insulate numerous minor cracks and attain complete waterproofing of the structure;
- when cracks extend, polymers fill the volume and thereby provide reliable waterproofing under complex conditions – in case of shaking and increased depreciation loads on tunnels;
- special polymeric mixtures are activated in touch with water only;
- in case of leakage and water appearance hazard, the pumped injection polymers form protective film membranes, which are absolutely impermeable (waterproof) for moisture;
- application of modern materials and engineering technologies makes it possible to reach high quality of waterproofing within a shortest time possible.

Penetrating repair waterproof mixtures

Penetratingwaterproofing method is based on the use of special finely dispersed reagents, which penetrate into material pores and minute cracks and thereby form waterproof layer on contact with water and as a consequence promote concrete quality enhancement – increase frost resistance, strength, resistance to depreciation load, and attain more plasticity to material.

Fig.2.Tunnel waterproofing with polymeric membrane

Spraying of insulating materials or membrane waterproof package are used in case of a great number of communication connections and availability of increased depreciation loads.

Modern synthetic coatings during reconstruction and construction of tunnel facilities

Based on the critical review and analysis of synthetic waterproofing materials there has been considered reasonable to study main characteristics of the following coatings:

- epoxy resins;
- Isoplast;
- Monoflex.

Among still less explored characteristics of the mentioned coatings are: water impermeability, adhesion degree, deformability, hardening terms, frost resistance.

Waterproof tests have been carried out using the special device, in which water pressure on the coating was created by means of compressed air.

Samples, which withstood 5 atm pressure, have been tested to frost resistance, for this purpose specimens have been placed in water for one day at +15°C temperature, and afterwards have been hold for 24 hours in the refrigeration chamber, where -25°C temperature was kept. If surface destruction didn’t observe after 25 cycles of freezing and melting, it is considered that a surface withstood the tests. Afterwards the samples have been retested to water impermeability, at that water pressure was getting increased up to 15 atm.

The degree of surveyed material bonding with concrete is established through small size concrete tiles adhesion. Load has been applied on bonding surface and the load value has beenrecorded at the press.

The results of water impermeability, frost resistance and concrete bonding degree tests have showed that coatings prepared on the basis of epoxy resins, polyurethane varnish and Monoflex are distinguished by the best performance among the coatings. Study of deformability and hardening terms, as well as full-scale test has been conducted for coating based on epoxy resin, which had the best waterproofing performance.

Use of Monoflex for tunnel waterproofing

Waterproofing guniting mortar “Monoflex” is a mixture of non-contracting portlancement or expanding portlandcement “Monoflex” with construction sand taken in 1:1 proportion, to which water is added.

Tunnel section, where waterproofing works are in progress, must be provided with forced ventilation, water- and 30-volt electric supply.

Use of Isoplast fortunnel waterproofing

Waterproofing material “Isoplast P” is a bitumen-polymeric fusible roll material.

“Isoplast P” is prepared on the polyester base with double-sided application of a binder. This binder consists of bitumen, polymeric additive and filler.

This material can be used under any climate conditions.

Conclusion

The work describes, considers and systematizes new engineering and technical solutions of tunnels dewatering and waterproofing measures.

Experts conduct studies and determine the capability of repair works related to waterproofing of tunnels, seams and cracks, and insulation of ground waters and aggressive grounds. Concrete structure studies are carried out according to standards.

State-of-the-art methodologies of waterproofing if timely addressed make it possible to enhance structural strength and extend the tunnels’ operational life.

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High-quality waterproofing may improve tunnel performance properties and extend its operational life up to 10 years.

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About logarithmic deformation

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Abstract: As known, the conditional stress is determined by the ratio of the load to the size of the initial cross-section of the sample, and the relative elongation as the ratio of the increase in length to the graduated initial length of the sample. A conditional stress-strain diagram is a load-elongation diagram for a specimen whose cross-sectional area and length are equal to one.

Key words: voltage; logarithmic deformation; plasticity.

1. Introduction

Thus, for the most necessary and widespread processes in practice (metallurgy, machine-building), we have determined the true (logarithmic) relationship between stresses and plastic deformations. Let's use the appropriate formulas

Let's determine the relationship between the height of the slab's board obtained by the punch's action and the punch's diameter for a separate case. After that, let's consider calculating the work spent in the mentioned process and get the corresponding results in the form of an equation for calculating the work.

2. Let's consider the laboratory experiments on stretching.

Consider the true stress diagram, or logarithmic diagram, which gives a true picture of deformation. It represents the ratio of the load and the cross section at the current moment. That is, the ratio of two variables, this approach fully characterizes the plastic property of the test material. Let's follow the event. (Change in volume due to scarcity may not be considered).

$$XP = X_0 l_0 (1)$$

where $X -$ is the magnitude of the current cross-section of the sample; l- current length; i.e. X_0 და l_0 The sample is the initial settings. If Pwe denote the current load by and σ the true (logarithmic) voltage, then we get

$$P = \sigma \cdot X \quad (2)$$

$$\textit{That is } \sigma = \frac{P}{X_0} \cdot \frac{l}{l_0} = \sigma_0(1 + l) \quad (2)$$

where $\sigma_0 -$ Conditional stress: $l = \frac{l - l_0}{l_0}$ is the linear relative deformation of elongation, at the moment of maximum load $dp = 0$,(2) from this we get:

$$\sigma dX + X d\sigma = 0 (4)$$

Based on the incompressibility condition:

$$ldX + Xdl = 0 (5)$$

(4) and *As a result of a simple mathematical operation using (5*), the true voltage is expressed as follows:

$$\frac{d\sigma}{d} = \frac{dl}{l} = d\varepsilon \quad (6)$$

From *(6) we can get the logarithmic deformation image:*

$$\varepsilon = \int_{l_0}^{l} \frac{dl}{l} = l_n \frac{l}{l_0} = l_n(1 + l) (7)$$

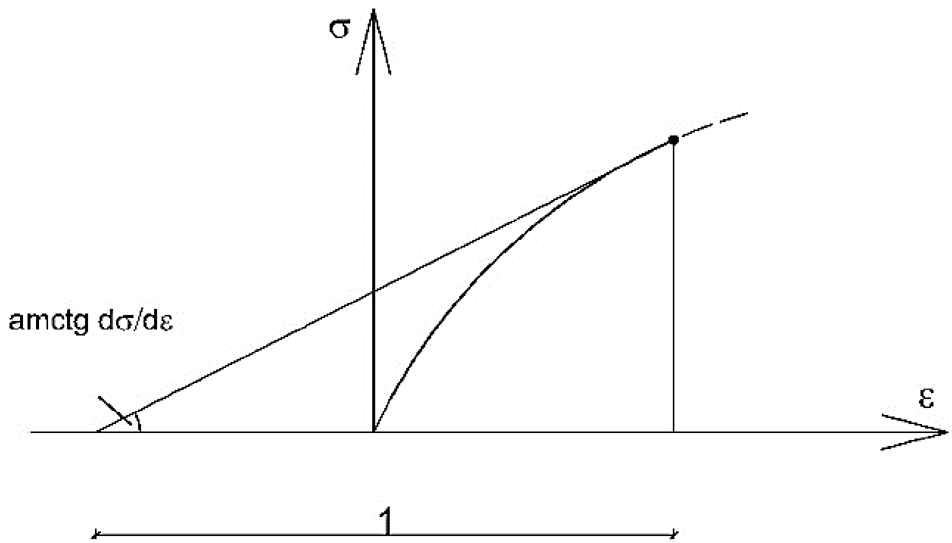
Maximum load moment

$$\frac{d\sigma}{d\varepsilon} = \frac{\sigma}{l} \textit{ That is } \frac{d\sigma}{dl} = \frac{\sigma}{(1+l)} = \sigma_0 (8)$$

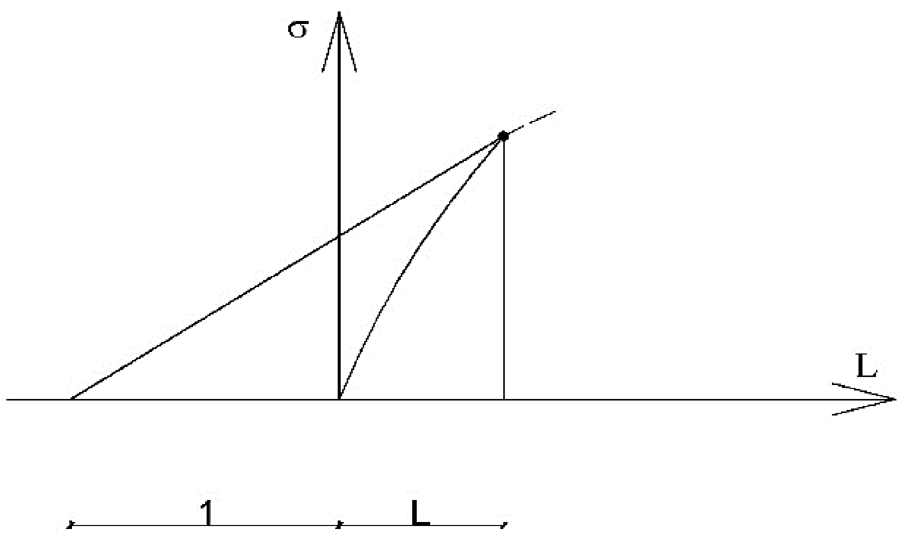
Now let's build the corresponding diagrams. Let's measure the true stress σ and logarithmic strain on the coordinate axis ε. As can be seen from diagrams (a) and (b), the true stress is defined as the tangent of the angle of inclination to the shoulder curve at the point in question. (figure a) similar to (figure b) for linear relative deformation (σ − ε).

Thus, Figures (a) and (b) show the true stress-strain curve in simple tension for determination at the point corresponding to the moment of necking on the specimen.

The use of logarithmic deformation in practice has two main advantages:



1 a



1 b

1. Unlike relative linear deformation, logarithmic deformation has the property of additivity, which follows from the definition of deformation itself. This property can be illustrated as follows. Let's take a sample whose graduation (working) working length is l_1, apply an axial load to it. Let's say the next mission of the deformation is the length l_2, then the deformation $\varepsilon_1 = l_n \frac{l_2}{l_1}$;if we continue the stretching process $l_2$from to $l_3$then the further deformation $\varepsilon_2 = l_n \frac{l_3}{l_2}$, and the total deformation

$$\varepsilon = l_n \frac{l_2}{l_1} + l_n \frac{l_3}{l_2} = l_n \frac{l_3}{l_1}$$

2. Experiments show that in the case of large plastic deformations, almost always following pressure treatment, the material can be considered as compressible. The condition of volume constancy will take the following form using relative linear deformations.

$$(1+l_1)(1+l_2)(1+l_3)=1 \quad (9)$$

Using logarithmic deformations (9) is simplified

$$\varepsilon_1+\varepsilon_2+\varepsilon_3=0 \quad (10\ a)$$

Both of these images are fair for any deformations. At the same time, in the case of small deformations, which correspond to the elastic deformations of the metal, it is possible to ensure the product of deformations and (9) reaches the following form

$$\varepsilon_1+\varepsilon_2+\varepsilon_3=0 \quad (10\ b)$$

In the cylindrical coordinate system (r, θ, z), expression (10a) will be replaced by (10g) .

$$\varepsilon_\theta+\varepsilon_r+\varepsilon_z=0 \quad (10g)$$

where ε_θ- logarithmic tangential deformation;

ε_r- logarithmic radial deformation and $\varepsilon_r$algorithmic linear deformation. Multi-line tests have shown that the steel volume decreases by 0.6% and copper by 1.3% during stamping processing of metals. Fibrous materials e.g. Wood and cast iron gain their initial volume after unloading during compression.

Now let's consider an example that will serve as an illustration of the volume constancy condition (10a), the deformation will be Let's imagine a plastic plate of constant thickness (h_0) which is pierced at a slow rate without friction $2b_0$by a Poisson of diameter (Fig. 2) The tile of the current process will change shape and will take the form shown in (Fig. 2.). A, H is the height of the cylindrical hole obtained on the nose. Its thickness at distance z from the edge of the board is h. We assume that each element of the board is deformed by the main tensile stress. For a tile with $\frac{h_0}{b_0}$a small size, this assumption is as realistic as possible. We will write the condition

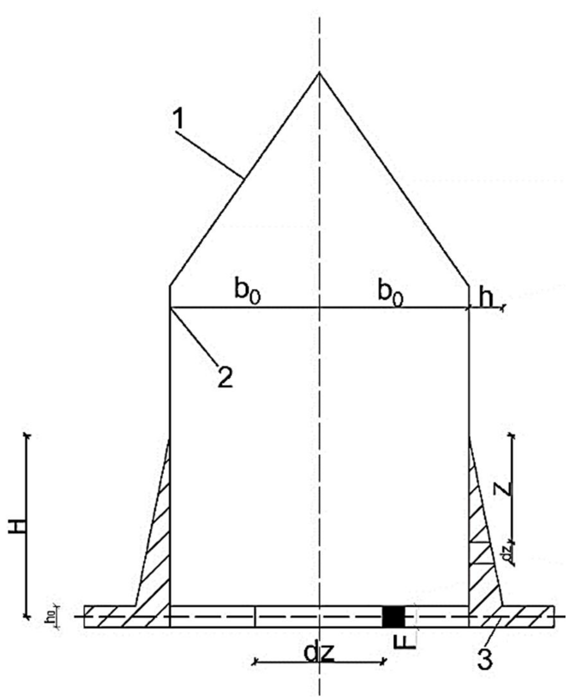


Fig. 2

of constancy of volume for each element.

$$2\pi s ds h_0 = 2\pi b_0 dz h (11)$$

$$l_n \cdot \frac{b_0}{s} + l_n \cdot \frac{h_0}{h} + l_n \cdot \frac{dz}{ds} = 0$$

$$(10g)\ \varepsilon_r + \varepsilon_\theta + \varepsilon_z = 0$$

In this case, ε_r, ε_θ და $\varepsilon_z$the logarithmic deformations are in the radial, tangential, and along-board directions respectively, if the element is deformed only in the tangential direction, then the other two (radial and longitudinal) will be equal.

From (11) we get

$$\frac{s}{b_0} = \left(\frac{h}{h_0}\right)^2; h = h_0\sqrt{\frac{s}{b_0}} (12)$$

otherwise$\frac{ds}{dz} = \sqrt{\frac{b_0}{s}}$;$\int_0^{b_0} \sqrt{s} \cdot ds = \int_0^H b_0\, dz (13)$

Hence: $\left[\frac{2}{3} s^{\frac{2}{3}}\right]_0^{b_0} = \sqrt{b_0}$H; $H = \frac{2}{3} b_0 (14)$

Conclusion:

We have used the law of constancy of volume for one particular case, which is widespread in metallurgy and mechanical engineering. Determine the relationship between the board's height and the punch's diameter. Under the conditions of the development of plastic deformations, mainly tensile normal stresses. To present the issue, we considered a slightly different second problem, where a hole with a diameter a 0 ($b_0 > a_0$) is bored as a result of the frictionless impact of a punch with a cone of diameter b 0 and a $b_0 > a_0$slab of constant thickness. The resulting board height is H. Calculate this height based on previous experience. The procedure is the same as in the previous case, with the difference that S,a_0 და b_0The limits of the integrals of are such that the equality holds.

$$\int_{a_0}^{b_0} \sqrt{z} \cdot dz = \int_0^H \sqrt{b_0}\, dz \qquad (15)$$

Hence

$$\frac{2}{3}\left[b_0^{\frac{3}{2}} - a_0^{\frac{3}{2}}\right] = b_0^{\frac{1}{2}} * H \text{ ანუ } H = \frac{2}{3} b_0 \left[1 - \left(\frac{a_0}{b_0}\right)^{\frac{3}{2}}\right] \qquad (16)$$

and the thickness of the board$h_0 = \sqrt{\frac{a_0}{b_0}}$

Now let's find the work of plastic deformation if, $a_0 = 0$and the curve of steel reinforcement is expressed by the law $\sigma = y + p * \varepsilon$. Let's start with the fact that the product of the work done on the plastic deformation of the plate dw, which is spent on the formation of the board, is equal to the product of the volume of the element, which is spent on the plastic deformation of the unit volume on the elongation of the element in the process of simple stretching. i.e. on the $dw = 2\pi s h_0 ds \sigma ds$change of σlogarithmic εstrain $\varepsilon$from$\varepsilon + d\varepsilon$

$$w = 2\pi s h_0 ds \int_0^\varepsilon \sigma * ds (17)$$

because $\sigma = y + p * \varepsilon$where y- yield stress and p - modulus of plasticity. The work done on the plastic deformation of the unit volume considering simple stretching is defined as follows

$$\int_0^\varepsilon \sigma d\varepsilon = y * \varepsilon + p\frac{\varepsilon^2}{2} \qquad (18)$$

respectively for the entire tile

$$w = \int_0^b 2\pi h_0 \left[y l_n \frac{b_0}{s} + \frac{p}{2}\left(l_n \frac{b_0}{s}\right)^2\right] s * ds \qquad (19)$$

But because $s = l_n \frac{b_0}{s}$that's why the final image of the work will be:

$$w = \frac{\pi b_0^2 h_0 y}{2}\left(1 + \frac{p}{2y}\right) (20)$$

Acknowledgments

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Analysis of plastic torsion using physical analogies

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Abstract calculating the torsional deformations of a complex section is a rather complex task even in the elastic stages. Additional difficulties arise when it is necessary to calculate rods of complex cross-section at the stage of plasticity. To at least partially get rid of these difficulties, this work uses a method widely known as the method of analogies. We specifically use a branch of this method that we call physical analogies. In particular, the so-called membrane analogy and hydrodynamic analogy. The problem of torsion of a homogeneous shaft is discussed. The latter is based on the phenomenon that the process of torsion of a solid rod (no matter what cross-section it has) is mathematically expressed by the same formulas as the flow of an ideal fluid.

Key words: membrane analogy, hydrodynamic analogy, rod of constant cross-section, plastic torsion, shear stress.

1. Introduction

In our work [4] were considered the difficulties that accompany the calculation of complex cross-section rods for torsional deformation in the elastic stage. The aim of this paper is to calculate rods also of complex cross-section for torsion, in the plastic stage, which is associated with additional difficulties. Let us turn first to the analogy with a membrane, according to which at the initial stage the membrane moves in a plane (x, y). Let's influance on it by a little pressure p. As a result, the membrane deflects slightly so that the tensile strain per unit length S becomes constant, i.e. the membrane contour will remain in the plane $z = 0$. It's equation of balance will be

$$S\frac{\partial^2 z}{\partial x^2} + S\frac{\partial^2 z}{\partial y^2} + p = 0; \quad \nabla^2 z = -\frac{p}{S} \qquad (1)$$

This equation is similar to the equation given in our paper [4].

where, ψ - stress function, G - shear modulus, θ - relative shear angle. We can exploit this similarity in the following way: ψ – are identified with transverse displacements z of membrane points, and $2G\theta$ - with relation p/S. On this basis, if the contour of the membrane is the same as the cross section of the rod, then the surface of this membrane as a result of the pressure being in equilibrium determines the stress function for the rod cross section. Griffith and Taylor developed apparatus that is now widely used for practical experiments.

2. Main part

As an example, consider the problem about torsion of a homogeneous shaft (Fig. 1). According to formula (1), a flat annular membrane connected to a circular frame with radius a, under transverse pressure p stretches and takes the shape of a paraboloid segment. The sum of projections of forces acting on the membrane on the vertical axis will be

$$p\pi r^2 = -S \cdot 2\pi r\frac{\partial r}{\partial z}; \quad \frac{\partial z}{\partial r} = -\frac{rp}{2S} \qquad (3)$$

where S - power. acting per unit length. Accordingly $z = -\frac{pr^2}{4S} + C$.

If $z = 0,\ r = a$, then $z = (a^2 - r^2)$.

so,

$$\psi = (a^2 - r^2)G\frac{\theta}{2} \qquad (4)$$

Since the maximum tangential stress at the point $|grad\psi|$, i. e. -$\frac{d\psi}{dr}$, then $\tau = G\theta r$.

τ_{max} is going to come up when $r = a$ and respectively $\tau_{max} = G \cdot \theta \cdot a$

Volume between the plane and the membrane $V = \int_A z \cdot dA = \int_0^a \frac{P}{4S}(a^2 - r^2)2\pi r dr = \frac{P \cdot \pi \cdot a^4}{8S}$. (5)

Torque

$$T = 2V = G\theta\pi \cdot \frac{a^4}{2} = G\theta I,$$

where $I = \frac{\pi a^4}{2}$ - polar moment of inertia about the central axis.

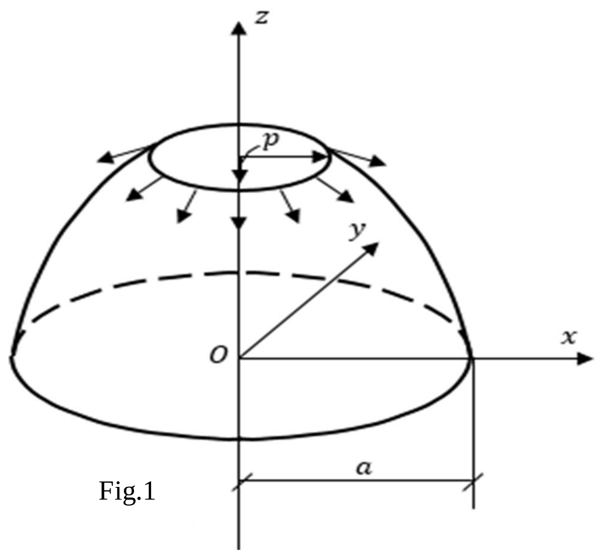

Fig.1

In many cases, the maximum tangential stress occurs at the point on the perimeter of the rod cross-section closest to the central axis. However, this regularity is broken for cross sections of some shapes.

The next analogy used in the study of torsion is known as the hydrodynamic analogy. It is based on the assumption that the torsion of a rod of constant cross-section is mathematically described by the same formulas as the flow of an ideal fluid flowing through a pipe of the same cross-section with constant angular velocity. At that, the fluid circulation velocity at some point corresponds to the tangential torsional stress at the same point. There is an analogy between the cylindrical torsion of a rod and the potential of a plane fluidity field. It is used to study the concentration of tangential stresses at characteristic points (e. g. edges). Let us now turn to those analogies which, according to our observations, give better results in cases of calculations in the plastic stage of torsion. As stated, $|grad\psi|$ denotes the total tangential stress developed at the point. Its physical interpretation would be the maximum slope of the membrane surface at the same point. let τ_{fl} will be the stress corresponding to the yield strength, i.e. under conditions of plastic deformation $|grad\psi| = \tau_{\text{fl}}$ and hence, the value that the gradient takes at the specified point is bounded. As the torque increases further, the area over which the tangential stresses reach the yield strength increases. In (Fig. 2) the increase of plastic flow areas depending on the increase of the torsion angle of the rod is shown. For a section of equilateral triangle shape (shaded areas), according to this analogy, plastic deformations tend to appear near the surface and spread inward toward the central axis. At plastic deformation of areas adjacent to the outer surface, the tangential stresses are equal to the yield stress at shear, to which is corresponded the constancy of the membrane slope.

For elastic deformation regions, the tangential stresses from the value σ_{fl} at the boundaries of the plastic and elastic regions decrease to zero on the axis (meaning an ideally plastic material). Accordingly, the value of the membrane slope changes. Since the tangential stresses are continuous at these boundaries, in the plastic deformation region

$$\left(\frac{\partial\psi}{\partial x}\right)^2 + \left(\frac{\partial\psi}{\partial x}\right)^2 = \tau_{fl}^2 \quad (6)$$

and in the region of elastic deformations

$$\left(\frac{\partial\psi}{\partial x}\right)^2 + \left(\frac{\partial\psi}{\partial x}\right)^2 = -2G\theta \quad (6')$$

The use of the membrane analogy in the analysis of elastic-plastic flow faces great difficulties, and in the case of ideally plastic flow, the work of calculating the torque is significantly simplified, since the membrane is completely in contact with the curved surface and the entire section is covered by plastic deformations (there is no longer an elastic core).

The problem is solved more easily when using the so-called sand analogy, which is as follows: dry sand is poured onto a plate, which has the cross-sectional shape of a prismatic rod, which maintains a constant angle of inclination. The use of this analogy is especially useful when the cross-sectional shape is too complex to be described mathematically.

We use this technique to find the torque that causes plastic deformation of the entire section for the following sections: a) circular b) equilateral triangle c) rectangle

a) circular cross-section with radius a, slope $\frac{h}{a} = \tau_{\text{fl}}$, volume $\frac{1}{3}\pi \cdot a^2 \cdot h$. Torque

$$T = \frac{2}{3}\pi \cdot a^3 \cdot \tau_{\text{fl}} \quad (7)$$

b) an equilateral triangle with side $2a$: slope $\frac{h}{\frac{1}{3}a\sqrt{3}} = \tau_{fl}$. Torque

$$T = \frac{2a^3\tau_{\text{d}}}{3} \quad (8)$$

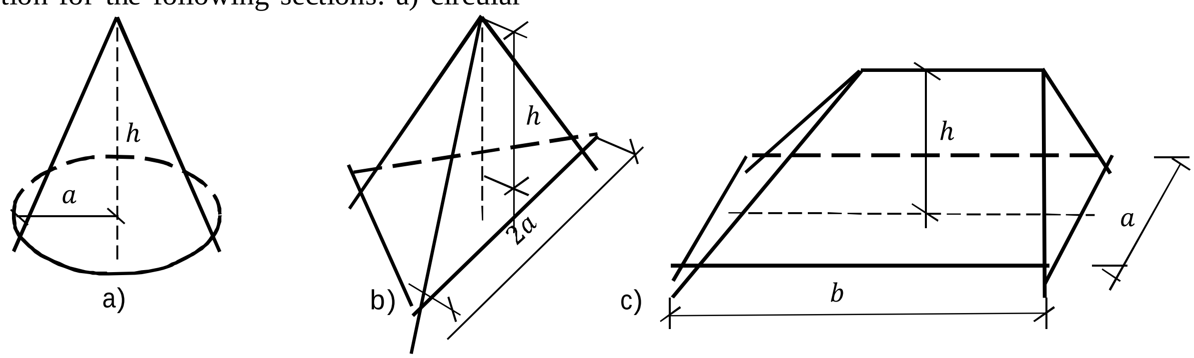

Fig. 2

c) a rectangle with sides a и b: slope: $\frac{h}{\frac{a}{2}} = \tau_{fl}$, The volume is equal to $(b - a)\frac{ah}{2} + 2\left(\frac{1}{3}\cdot\frac{a^2h}{2}\right)$,

Torque

$$T = a^2\tau_{fl}\frac{(3b-a)}{6} \quad (9)$$

In case of square

$$T = \frac{a^3\tau_{fl}}{3} \quad (10)$$

As can be seen from what has been discussed, when using the sand analogy method, you always have to calculate the volume of sand. The more complex the cross-sectional shape, the more difficult this task becomes. Therefore, in the scientific, expert, experimental laboratory of the Faculty of Civil Engineering of the Georgian Technical University, we replaced the complex process of calculating volume with the process of weighing sand, which greatly simplified the solution of the tasks and we obtained accurate results, of course, as a result of comparison. Using the sand analogy method led us to the following conclusions that in some cases its use is limited for the following reasons:

1) Metals used in practice undergo partial hardening during torsional deformation, so plastic deformations do not completely cover their cross sections.

2) The cross sections of the rods change their shape before plastic deformation covers the entire section, i.e. we have both elastic and plastic deformations at the same time. Therefore, ignoring changes in this form affects the accuracy of the calculation.

3) Due to side effects, the length of the rod changes during the torsion process.

Despite the above, in the absence of a better method, analogies with sand are used in practice, since, in spite of everything, they make it possible to quantify the work of metals at the plastic torsion.

Conclusion

A number of problems of torsion of homogeneous rods of complex cross-section at the stage of plastic deformation, interesting for small and medium-sized fields of mechanical engineering, have been studied. The so-called method of physical analogies was used. Expressions of torques and stresses for specific cases were obtained. A comparative analysis of the phenomena of elastic-plastic and ideal plastic flow is carried out. The difference characterizing these two processes is shown.

It is shown for the first time that the problems of ideal plastic flow presented in the article can be solved in a simpler way than is achieved when considering the phenomenon of elastic-plastic flow.

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Modern methods for extending the service life of buildings

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Abstract The article discusses the main methods and ways of extending the service life of buildings, in particular, maintaining its sustainability, functionality, safety and values. It is discussed, with modern methods, how to carry out a structural inspection of the structural elements of buildings, foundations, walls, ceiling and roofing elements in order to detect possible deformations or damages in time.

key word: Sustainability, functionality, security, Inspection and diagnosis, Foundations, walls, roof covering, Heating, ventilation, air conditioning.

Introduction

Modern urban development and the increasing physical and moral obsolescence of buildings pose a serious challenge to the safety and sustainability of infrastructure. For many buildings, especially those of economic or cultural importance, the extension of their service life is becoming relevant. This is due to both technical needs and environmental and financial considerations, which determine the maximum use of existing resources and the minimization of new construction. This process is accompanied by the introduction of innovative approaches and technologies, which not only ensure the preservation of the functionality of buildings, but also increase their efficiency and energy efficiency.

Main part

Extending the service life of buildings plays an important role in maintaining their sustainability, functionality, safety and value. There are several key conditions that are necessary to extend the life cycle of buildings:

1. **Timely inspection and diagnostics**

• Structural inspections should be conducted on the structural elements of buildings, foundations, walls, ceiling and roofing elements, in order to identify possible deformations or damage in a timely manner.

• Mechanical systems inspections should be conducted on the electrical, plumbing, heating, ventilation and air conditioning systems of buildings.

The inspections and diagnostic of the buildings should be conducted regularly, depending on the type of building, its age, and its condition.

In new buildings (0 to 10 years old), structural inspections should be performed once in every 5 years. Mechanical systems should be inspected annually, and electrical and plumbing systems should be inspected annually, but more frequently if there are high load and usage factors.

In middle-aged buildings (10 to 30 years old), structural inspections should be performed once in every 3 years. Mechanical systems should be inspected annually, and electrical and plumbing systems should be inspected once in every 6 months, with particular emphasis on systems that have become more sensitive due to age.

In older buildings (over 30 years old), structural inspections should be performed once in every 2 years or more frequently if the building is subject to heavy loads or structural deterioration. Mechanical systems should be inspected once in every 6 months, and electrical and plumbing systems should be inspected in every 3-6 months, with particular emphasis on safety issues to prevent accidents and malfunctions.

In high-risk buildings (public, industrial, public places), structural inspections should be carried out once a year, and mechanical systems should be inspected once a year or more often, depending on the intensity of use. Electrical and plumbing systems - once in every 3-6 months, since safety standards in public places should be particularly high.

Best practice provides the frequency of inspections, which depends on the age of the building, the nature of use and environmental conditions. Regular inspections and diagnostics help to detect potential problems in time and avoid more serious difficulties and costs in the future.

2. **Preventive maintenance**

- Repair minor damage or malfunctions to prevent major problems.
- Regularly clean systems, lubricate them, and perform other preventive maintenance to keep them functioning.

Preventive maintenance of buildings includes various activities aimed at regular inspection, maintenance and repair of building elements and systems to prevent malfunctions and damage. These measures reduce long-term costs and ensure the proper functioning, safety and extension of the building's life cycle.

Services of structural element

- Periodically inspect the condition of the foundation, detect cracks and crevices. If necessary, reinforce the foundation.
- Inspect the condition of the walls and ceilings for cracks and damage. Check the condition of the thermal insulation.
- Inspect and maintain the roofing material to prevent leaks and water ingress. Clean the roof before the winter season.

• Service mechanical systems: In heating, ventilation and air conditioning systems:

- Regularly change filters to ensure clean air supply.
- Clean the condenser tubes to prevent condensate accumulation and difficulties in the operation of the system.
- Check the proper operation of the sensors so that the system regulates the temperature correctly.

In plumbing systems, check:

- The condition of plumbing pipes to detect malfunctions, leaks, and corrosion.
- Water pressure periodically to ensure the system is working properly and does not cause interruptions.
- Drainage systems should be cleaned periodically to remove accumulated debris and prevent interruptions.

3. **Electrical systems maintenance, check:**
   - Electrical distribution boxes, for overheating, cracks or other damage.
   - The condition of transmission lines and if damage or deformation is detected, their timely replacement.
   - The operation of automatic circuit breakers and their replacement if necessary.

4. **Emergency systems maintenance, check:**
   - Fire protection systems, such as fire detectors, water distribution systems and emergency exits.
   - Emergency lighting systems and their operation.
   - Security and alarm systems, including cameras and sensors.

5. **Management of necessary materials and supplies**
   - It is necessary to manage the supplies of materials required for repair work so that they can be accessed quickly and easily if necessary.
   - It is necessary to periodically check the condition of technical equipment, tools and materials and update them.

6. **Construction and Repair Planning**
   - Within the framework of preventive maintenance, it is necessary to determine priority repair works and their timely implementation.
   - If necessary, repair and modernization works should be planned, which will ensure the improvement of the functionality and safety of the building.

Repair works

In order to prevent premature failure of buildings and to effectively manage their exploitation, a number of necessary systems of planned preventive repairs have been established, which include organizational and technological measures, examination and repair of structures, sanitary-technical systems, engineering equipment, as well as their maintenance and adjustment according to a pre-prepared plan. Timely and high-quality repairs ensure the normative terms of the service of buildings.

Planned renovation: Periodic planning of renovation works ensures the renewal of the main elements and systems of the building.

Full renovation: If necessary, the renovation carried out includes the renewal of both structural and visual and functional elements. There is the following classification of renovation:

- Planned-preventive (complex) repair;
- Selective repair;
- Planned-preventive (preventive) current repair;
- Adjustment and maintenance of sanitary-technical systems and building engineering equipment;
- Emergency (unscheduled) current repair.

Repair involves the replacement of unsafe elements of a building or the restoration of engineering equipment structures in the event of their physical and moral wear and tear, as well as increasing the level of amenities.

The main type of repair of residential buildings is planned-preventive (complex) reapir, i.e. repairs to restore the operational properties of all unsafe elements, the service life of which is equal to the inter-repair cycle. The inter-repair cycle is called the duration of the operation of building elements between repairs. During complex repair, the simultaneous restoration or replacement of all unusable structures and engineering equipment and the improvement of the building's amenities are provided: redevelopment of utility apartments into residential apartments, arrangement of elevators, garbage chutes, etc.

During selective repair, individual structures or their elements that have partially worn out are replaced and their repair cannot be postponed until the next planned preventive repair.

Current repairs are related to the daily operation of the building. It includes works that are systematically carried out to detect premature wear of building structures and engineering equipment. The physical condition of the structures is not changed, but they are preserved in the design state. The time for carrying out planned preventive (preventive) current repairs of the facility is planned in advance. This type of repair is the main factor in ensuring the preservation of the building.

Emergency (unscheduled) current repairs provide for the rapid restoration of unscheduled minor damage.

Repair and construction works can be carried out with the evacuation of residents (partially or completely) or without it. In order to reduce the time required for repairs without eviction, it is necessary to take into account the maximum combination of repair and construction processes and industrialization.

Construction and repair works should be carried out on the basis of a work production project, which takes into account: the development of the necessary technical documentation, the organization and technology of repair of individual objects or their groups, the sequence of works, the timing of their implementation, the demand for labor, the supply of materials and semi-finished products, machines and mechanisms, the arrangement of open and closed warehouses, engineering communications, household premises and other temporary structures at construction sites.

7. **Ongoing monitoring and reporting -** It is necessary to constantly monitor the condition of building systems in order to quickly identify potential problems; to document the results of inspections and services, which ensures the robustness of technical solutions.

Preventive maintenance of buildings includes systematic measures that ensure the proper functioning, safety and extension of the life cycle of structural and mechanical systems. These processes include inspection, repair, improvement and continuous monitoring, which prevents failures in the first place and allows us to optimally manage building resources.

To improve resilience to seismic and other natural disasters, it is necessary to strengthen the building structure to withstand earthquakes and other natural disasters. To assess the risk of natural disasters, it is necessary to develop strategies to minimize damage in the event of natural events.

A building monitoring system involves the implementation of a continuous monitoring system that monitors the condition of building structures and mechanical systems. An integrated building management system (BMS) is a system that integrates all key technical and safety processes, ensuring effective building management and extending the life of the building.

8. Implementation of energy efficiency and environmental practices

Energy-efficient technologies significantly reduce energy consumption and contribute to the sustainable development of buildings. Their implementation not only contributes to energy savings, but also reduces greenhouse gas emissions and improves the overall comfort of buildings. The following are the main energy-efficient technologies that can be used during the construction and modernization of buildings:

Thermal insulation

- High-performance thermal insulation materials, such as polyurethane foam, extruded polystyrene (XPS), and fiberglass, reduce heat loss from the walls, floors, and roof of a building.
- Thermally insulated windows - double or triple glazing, which provides high thermal insulation and reduces heat loss through windows.

Renewable energy sources

- Solar panels convert sunlight into electricity. This system contributes to the energy independence of the building.
- Geothermal heating systems use the heat of the earth to heat and cool the building, which ensures a constant temperature and energy savings.

Heating, ventilation, and air conditioning (HVAC)

- Heat recovery ventilator (HRV) - recovers heat from the exhaust air and transfers it to the incoming air, which reduces heating and cooling costs.
- A heat pump is used to heat or cool water, which reduces energy consumption.

Intelligent Building Management Systems (BMS)

- Building automation - are intelligent systems that control lighting, heating, ventilation and air conditioning, ensuring efficient energy management. These systems use sensors and algorithms to optimize energy consumption.
- Timers and motion sensors - Lighting and other electrical devices are controlled by timers and motion sensors, which reduces energy consumption when no one is in the building.

For energy-efficient lighting, it is recommended to use efficient LED lamps rather than traditional incandescent lamps, which consume 75% less energy.

- When designing a building, glazing areas and their arrangement should be considered to maximize the use of natural light, which reduces the need for artificial lighting.

For energy-efficient windows and doors - the use of low-emission (Low-E) glass helps maintain internal temperatures. Air-tight doors and windows ensure minimal heat loss.

Energy-efficient management of water resources

- The use of solar panels for water heating reduces energy consumption.
- Rainwater collection and use systems reduce water consumption and energy consumption during its recycling.

Green roofs and facades provide additional thermal insulation, reduce building cooling costs and improve the microclimate, as well as vertical green gardens on facades, create additional thermal insulation and improve the ecological sustainability of the building.

The use of energy-efficient

technologies in housing construction creates environmentally friendly and economically beneficial spaces. Their implementation significantly reduces energy consumption, improves building comfort and safety, and ensures sustainable development.

- It is desirable to use environmentally friendly and sustainable building materials that contribute to the assessment of environmental impact.
- Low-emission building materials are characterized by low energy consumption in the production process and low environmental impact.
- The use of recycled and secondary materials reduces the consumption of primary resources and energy consumption.

Financial management and investments

- A long-term financial plan is a plan that includes covering the costs of maintaining, repairing and modernizing the building.
- Investments in innovative technologies ensure the extension of the building's life cycle and reduce costs.

Conclusion

Extending the service life of a building depends on a comprehensive approach that includes regular inspections, preventive maintenance, the use of energy-efficient and sustainable materials, as well as ongoing monitoring and financial management. Given these conditions, it is possible to maintain the longevity and safety of a building, which ultimately increases its value and environmental sustainability.

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