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Port Classification: Understanding the Types and Their Functions

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Abstract: Ports play a crucial role in global trade and the economy by facilitating the transfer of goods and passengers. This article explores the classification of ports based on various criteria such as location, function, and ownership. By understanding these classifications, we can better appreciate the diversity and specialization of ports around the world.

Key words: ports, classification, maritime, trade, transportation.

Introduction:

Ports have been essential hubs of trade and transportation for centuries, evolving with advancements in technology and changes in global trade patterns. The classification of ports helps in understanding their specific roles and the services they provide. This article will discuss the different types of ports, categorized by location, function, and ownership.

Main Part:

1. Classification by Location:

Ports can be classified based on their geographical location into the following categories:

- **Seaports:** Located along coastlines, seaports handle the majority of international trade. They are equipped to manage large vessels and heavy cargo. Seaports are often the most complex and busiest types of ports, featuring extensive infrastructure such as container terminals, bulk cargo terminals, and liquid bulk terminals. Examples include the Port of Shanghai, which is the world's busiest container port, and the Port of Rotterdam, which is a major hub for goods entering and leaving Europe. Historically, seaports have been central to the development of coastal cities and have driven economic growth by facilitating international trade.
- **River Ports:** Situated along rivers, these ports facilitate inland trade and connect smaller regions to larger trade networks. River ports play a vital role in linking remote areas with the global economy, providing access to goods and services that would otherwise be unavailable. Examples include the Port of Hamburg on the Elbe River, which serves as a gateway for goods moving between Germany and the rest of the world, and the Port of New Orleans on the Mississippi River, which is a key hub for agricultural exports from the United States. The development of river ports has often paralleled the expansion of inland waterways and improvements in navigation technology.
- **Lake Ports:** Found on the shores of large lakes, these ports often handle both cargo and passenger traffic. Lake ports are particularly

important in regions where overland transportation is difficult or expensive, providing a cost-effective alternative for moving goods. Examples include the Port of Chicago on Lake Michigan, which handles a diverse range of cargo including steel, grain, and petroleum, and the Port of Toronto on Lake Ontario, which supports both commercial shipping and recreational boating. The strategic importance of lake ports has been highlighted by their role in regional trade networks and economic integration.

2. Classification by Function:

Ports can also be categorized based on their primary functions:

- **Commercial Ports:** These ports handle the majority of global trade, dealing with various types of cargo including containers, bulk goods, and liquids. Commercial ports are characterized by their extensive infrastructure and advanced technology, which enable them to efficiently manage large volumes of goods. Examples include the Port of Singapore, one of the world's busiest and most efficient ports, and the Port of Los Angeles (Fig. 1), the largest container port in the United States. Technological advancements such as automation, digitalization, and improved logistics have significantly enhanced the efficiency and capacity of commercial ports.

Fig.1

- **Passenger Ports:** Specializing in passenger services, these ports are often located in tourist destinations and major cities. Passenger ports provide facilities for cruise ships, ferries, and other vessels that transport people. They are typically equipped with amenities such as passenger terminals, customs and immigration facilities, and transportation connections. Examples include the Port of Miami(Fig.2.), known as the "Cruise Capital of the World," and the Port of Venice, a popular destination for Mediterranean cruises. The growth of the global tourism industry has driven the expansion and modernization of passenger ports, with a focus on enhancing passenger experience and safety.

Fig.2

- **Fishing Ports:** Dedicated to the fishing industry, these ports provide facilities for fishing vessels, processing plants, and storage. Fishing ports are crucial for the supply of seafood and support a wide range of activities including fishing, processing, and distribution. Examples include the Port of Tokyo, one of the largest fish markets in the world, and the Port of Busan, which is a major hub for the South Korean fishing industry. Sustainable practices and technological innovations in fishing and processing have become increasingly important for the long-term viability of fishing ports.

3. Classification by Ownership:

Ownership and management structures can also differentiate ports:

- **Public Ports:** Owned and operated by government entities, these ports often serve the public interest and promote economic development. Public ports typically focus on providing reliable and efficient services to support trade and transportation. Examples include the Port of New York and New Jersey, which is managed by the Port Authority of New York and New Jersey, and the Port of Long Beach, which is operated by the City of Long Beach. Public ports often benefit from government funding and policy support, which can enhance their capacity to invest in infrastructure and technology.
- **Private Ports:** Owned by private companies, these ports focus on profitability and efficiency. Private ports are often more flexible and innovative than public ports, as they can quickly adapt to changes in the market and invest in new technologies. Examples include the Port of Felixstowe in the UK, which is owned by Hutchison Ports, and the Port of Pusan Newport in South Korea, which is operated by Pusan Newport Co. Ltd. Private ports tend to prioritize cost-effectiveness and operational efficiency, often leading to higher levels of service and competitiveness.
- **Mixed Ownership Ports:** Combining public and private ownership, these ports benefit from public investment and private sector efficiency. Mixed ownership ports can leverage the strengths of both sectors to provide high-quality services and support economic

growth. Examples include the Port of Antwerp, which is managed by the Antwerp Port Authority and private companies, and the Port of Valencia, which is operated by the Port Authority of Valencia and private terminal operators. Collaboration between public and private stakeholders in mixed ownership ports can drive innovation and enhance operational performance.

Technological Advancements in Port Operations:

The evolution of ports has been significantly influenced by technological advancements. Innovations such as automation, digitalization, and the use of artificial intelligence have transformed port operations, enhancing efficiency, safety, and sustainability. Automated container terminals, for instance, use robotic cranes and vehicles to handle cargo with minimal human intervention, reducing operational costs and improving turnaround times. Digital platforms and data analytics enable real-time tracking of goods, optimizing supply chain management and reducing delays. Additionally, environmental technologies such as shore power systems and green fuels are being adopted to minimize the environmental impact of port activities.

- **Case Studies of Specific Ports:**

Examining specific ports provides valuable insights into the diverse roles and functions of ports around the world.

- **Port of Rotterdam (Fig.3):** Known as the gateway to Europe, the Port of Rotterdam is the largest seaport in Europe and one of the most important logistics hubs in the world. It handles a wide variety of cargo including containers, bulk goods, and liquid bulk. The port's strategic location and advanced infrastructure make it a key transshipment point for goods moving between Europe and other continents.

Fig.3

- **Port of Singapore (Fig.4):** As one of the busiest ports in the world, the Port of Singapore plays a critical role in global trade. It is renowned for its efficiency, advanced technology, and extensive connectivity. The port handles millions of containers annually and serves as a major transshipment hub, connecting shipping routes between Asia, Europe, and the Americas.

Fig.4

- **Port of Los Angeles (Fig.1.):** The largest container port in the United States, the Port of Los Angeles is a vital gateway for goods entering and leaving the country. It is equipped with state-of-the-art facilities and infrastructure to handle a diverse range of cargo. The port's significant contribution to the U.S. economy is underscored by its role in facilitating international trade and supporting numerous industries.

Conclusion:

Understanding the classification of ports by location, function, and ownership helps in recognizing their diverse roles in the global economy. Each type of port serves specific purposes and contributes uniquely to trade, transportation, and economic development. By appreciating the differences and specializations among ports, stakeholders can make informed decisions about investments, policies, and strategies to enhance the efficiency and sustainability of maritime trade. The future of ports will likely be shaped by ongoing technological advancements, evolving trade patterns, and increasing emphasis on environmental sustainability.

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Peculiarities of Influence of Relative Air Humidity on Building Materials, Taking into Account the Construction Climatic Regions of Georgia

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Abstract. Sustainable building covers a wide range of criteria including environmental, social and economic issues. Relative humidity of the internal environment belongs to the group of social criteria dealing with the quality of indoor microclimate and is one of the important indicators. Low humidity level can cause dry skin, throats and nasal passages and can cause annoying static electric sparks. High humidity level can lead to growth of moulds and bacteria and can cause condensation problems on the cold surfaces. Appropriate levels of relative humidity can be operated by building service systems which increase operating energy in buildings and is sensitive to correct set up, control and monitoring. Relative humidity can be also influenced by the choice of building structures and structural materials without any operating energy. The paper summarizes latest research on the influence of relative humidity on health hazards and influence of building structures and structural materials on the relative humidity.

Key words: relative humidity; Influence of relative humidity: thermal conductivity coefficient of the material; Determination of the

dependence of the coefficient of thermal conductivity on the humidity of building materials.

Introduction. The main component of the process of heat transfer to the enclosing wall is the thermal conductivity of the material layers over the entire thickness of the structure. V.N. Bogoslovsky defined the coefficient of thermal conductivity of building materials as a cumulative equivalent coefficient that takes into account the structural parameters of the material and all the physical processes taking place in it [1]. The value of thermal conductivity is significantly influenced by the composition, structure, thermal and humidity conditions of the material. Thus, one of the defining issues when calculating heat from an external enclosing structure is the moisture content of the materials in the structure.

Scientific papers [2, 3] have established that the thermal conductivity increases with the increase in the moisture content of materials, although the degree of change in the coefficient of thermal conductivity of the material is different for different humidity ranges.

According to the ISO 6949 standard, the correction coefficients defined according to ISO 10456 have been implemented in world practice, which allow converting the properties of heat exchangers from one condition (λ1, R1) to values valid for other conditions (λ2, R2). The correction coefficients take into account the influence of environmental conditions that are as close as possible to the actual operation of the enclosing structure (temperature, humidity and the effect of aging of building materials), which is a clear advantage of foreign standards.

Currently, there is no regulatory document on the method of determining the dependence of the coefficient of thermal conductivity on the humidity of building materials. It is also impossible to establish a general mathematical relationship for all building materials, because factors such as chemical and mineralogical composition, structure and porosity have a significant influence. Therefore, the research will be reduced to the detection of the empirical dependence of the coefficient of thermal conductivity (λ) on moisture (W) - λ(W) for individual materials [4]

Even when there is no moisture condensation, the humidification of materials in winter conditions can increase as a result of sorption of water vapor. The dampening of the material, as well as the thermal conductivity in the thickness of the enclosing structure can be different.

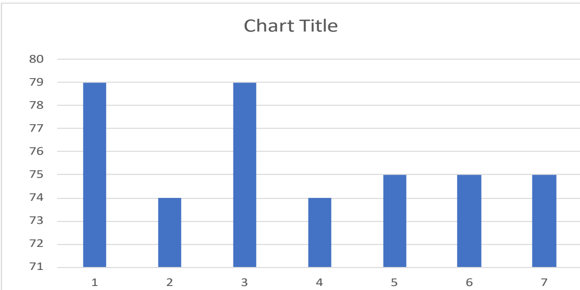
In accordance with Resolution 354 in force in Georgia (minimum energy efficiency requirements of buildings, parts of buildings and elements of buildings), the territory of Georgia is divided into three construction climatic zones. Climatic zoning took place in accordance with the location of settlements above sea level. Therefore, the maximum permissible heat transfer coefficients Umax of each element of the thermal shell of the building construction were created:

Main part: The goal of our research is to report the maximum permissible heat transfer coefficient, taking into account the relative humidity of the air and the climatic conditions of Georgia.

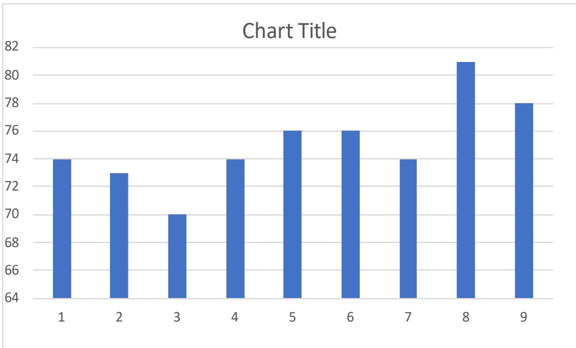
Graphs of temperature and humidity of populated areas according to construction zones were constructed to visualize and distinguish the correspondence of the same external reference temperature and annual average relative humidity

The results for the first construction zone

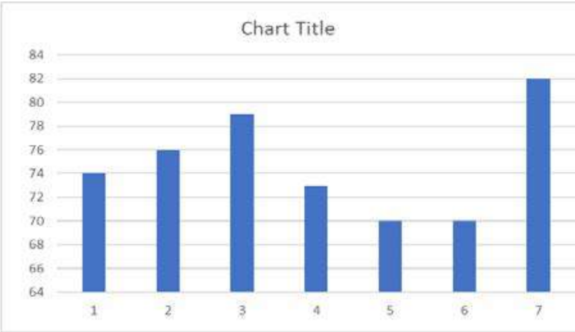
Khelvachauri	-2	79
Senaki	-2	74
Poti	-2	79
Gulriffshi	-2	74
Sukhumi	-2	75
Gagra	-2	75
Gudauta	-2	75



Khoni	-3	74
Tskaltubo	-3	73
Kutaisi	-3	70
Abasha	-3	74
Samtredia	-3	76
Zugdidi	-3	76
Tsalenjikha	-3	74
Kobuleti	-3	81
Martvili	-3	78

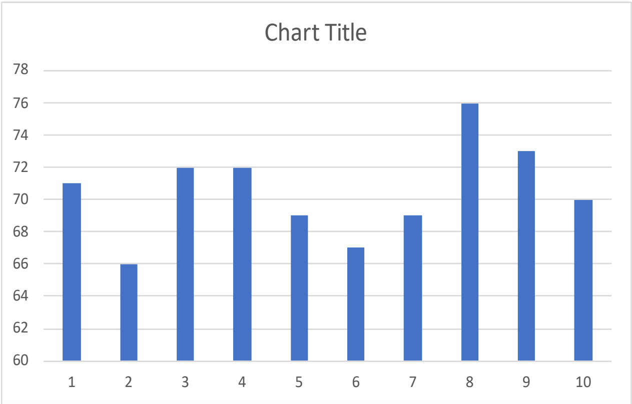


Vani	-4	74
Ozurgeti	-4	76
Gali	-4	79
Zestafoni	-4	73
Baghdadi	-4	70
Chokhatauri	-4	70
Ochamchire	-4	82

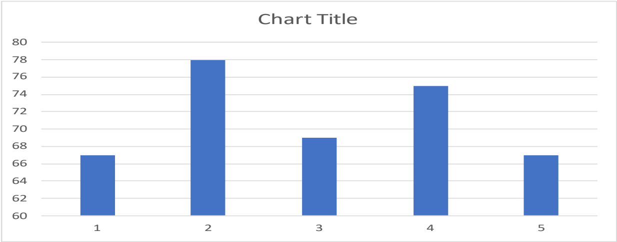


The results for the second construction zone

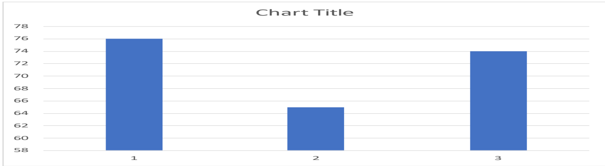
Lagodekhi	-8	71
Rustavi	-8	66
Gurjaan	-8	72
Kvareli	-8	72
Akhmeta	-8	69
Bolnis	-8	67
Telavi	-8	69
Satchere	-8	76
Signagi	-8	73
Khulo	-8	70



Mtskheta	-9	67
Tsager	-9	78
Marneuli	-9	69
Ambrolauri	-9	75
Caspian	-9	67

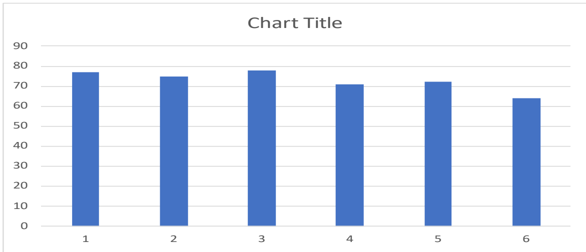


chiathura	-6	76
lying	-6	65
Shuakhevi	-6	74

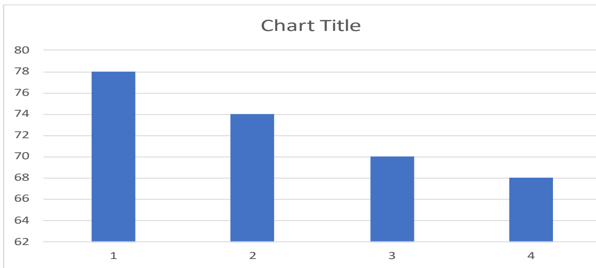


The results for the third construction zone

Borjomi	-11	77
Khashuri	-11	75
Lentekhi	-11	78
Tetritskaro	-11	71
Akhalgori	-11	72
Aspindza	-11	64



Tianeti	-14	78
Tsalka	-14	74
desert	-14	70
Kazbegi	-14	68



In our analysis, we grouped the data for the three climate zones together with their temperature and relative humidity. For each climatic zone, we have grouped according to the same winter external reference temperature (minimum five-day). It appeared that each settlement, which had the same outdoor reference temperature, had a completely different average annual relative humidity according to construction climatology. [5 construction climatology]

When calculating the heat transfer coefficient of the wall, which is defined according to the 354 resolutions for all three climatic zones, it is necessary to take into account the influence of the relative humidity of the environment on the building materials.

Material characteristics (bulk weight, porosity, shape and dimensions, etc.) and basic physical characteristics (humidity and temperature) affect the coefficient of materials thermal conductivity.
Empirical dependence of the coefficient of thermal conductivity in relation to the humidity of thermal insulation building materials.

Calculation formula	Material characteristics
$\lambda_w = \lambda(1 + \frac{W_м \cdot k}{100})$ (1)	Organic thermal insulation materials
$\lambda_w = \lambda(1 + \frac{W_{об} \cdot k}{100})$ (2)	Materials of inorganic origin
$\lambda_w = \lambda \cdot (1 + kW)$ (3) $\Delta\lambda_w = a \cdot W^k$ (4)	Organic materials of cellular origin
$\lambda_w = \lambda \cdot e^{k \cdot W}$ (5)	Organic materials of fibrous origin
$\lambda_w = \lambda + k \cdot W_{об}$ (6) $\lambda_w = k \cdot \frac{W}{100} + a$ (7)	Inorganic materials of cellular origin

where: λ and λW are thermal conductivity coefficients of dry and wet materials, respectively, W/(m·°C); ΔλW is the correction coefficient of thermal conductivity, W/(m·°C); Wm and Wob – moisture content of the material in volume and mass %; e natural logarithmic base; k, a empirical coefficients.

As a result of increasing the humidity of materials, their thermal conductivity coefficient increases and varies according to humidity.

The study of the dependence of the coefficient of thermal conductivity in relation to the humidity of materials is an actual issue and will allow us to determine the thermal technical characteristics of the enclosing structure.

Figures 2 and 3 show the dependence of the thermal conductivity on the degree of experimental humidity for different materials, it turns out that the dependences of λ(W) have both linear and non-linear forms.

A non-linear form of dependence appears at low humidity values (Fig. 2b) and after increasing the humidity to a certain value in Fig. 3a ≈ 15%, and fig. 3b ≈ 8%.

Figures 2f It is clear that the graphs of dependence of λ(W) for aerated concrete of different densities are located almost parallel, 2g. It can be seen from the graph that the porosity of the material depends on its density. The increase in thermal conductivity from moisture is more pronounced for aerated concrete with a lower density. To explain this, it is necessary to consider the micro- and macrostructure of the material. Aerated concrete is characterized by evenly distributed spherical pores throughout the volume of the material, the pores are closed, not connected to each other. Average pore size is (cells) Ø 1-3 mm. At the same time, porosity is observed in the walls of the pores and depends on the density of aerated concrete, in combination with the volume of pores (cells) and the volume of the pores, the cell walls change, accordingly, the degree of influence of moisture in the materials and the effect on their thermal conductivity changes.

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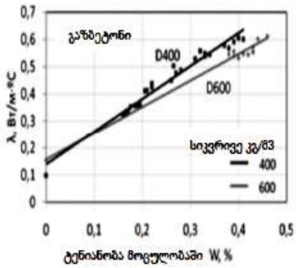

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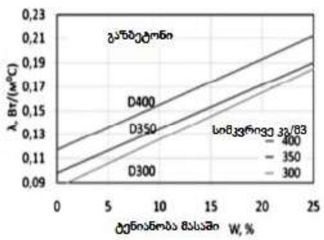

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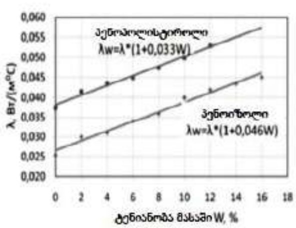

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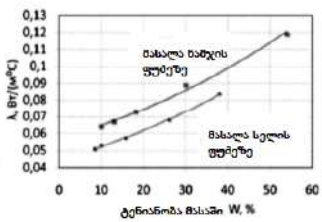

Fig. 2. Dependence of thermal conductivity on humidity for different materials

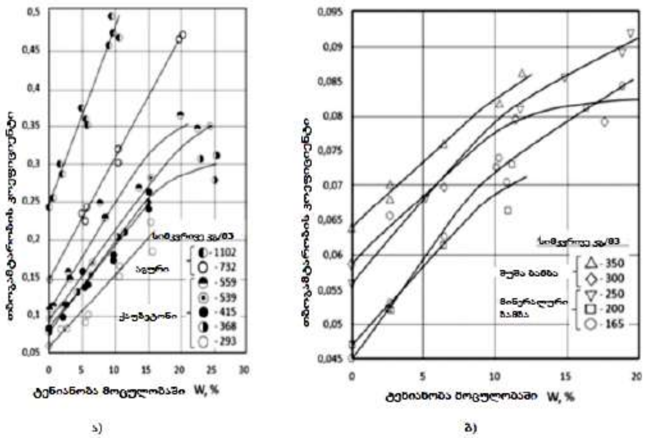

fig. 3. Influence of humidity on thermal conductivity of (a) cellular and (b) fibrous materials

Thus, due to the large number of pores and high density in the cellular material, the change in the λ coefficient is less. B.P. Kaufman, T.I. Rubashkina, I. Ia. Gnipa, S.A. Veyalisa, R. Drochitka [6], N.V. Davidenko [7], Z. Suchorab [8] conducted a study to determine λ(W) in a wide range of changes in moisture content of materials. However, sorption, capillary and supersorption wetting are not defined in these works. It is known that as the relative humidity increases, the moisture in the air is absorbed into the inner surface of the pores and capillaries, so-called monomolecular and polymolecular layers of moisture are formed, which are held by capillary forces and wetting forces. These processes are well described in the literature. Therefore, in known works, the main dependence of λ(W) is studied under conditions of high humidity, and less attention is given to studying the results of sorption and capillary humidity.

When we consider the energy efficiency of buildings, it is necessary to carry out an optimal cost analysis - from a financial perspective (calculation) the prices paid by the user, including all applicable taxes, including VAT and taxes, in a combination of approach and definitions:

- EN 15459 Energy efficiency of buildings - Procedure for economic evaluation of energy systems in buildings.

$Rd(p) = (1 / (1 + r / 100))p.$

- (EU) No. 244/2012 on the energy efficiency of buildings establishing a comparative methodology framework for calculating the optimal level of minimum energy efficiency requirements for buildings and building elements

- and connection with EN 15603 and EN 15217 definitions and requirements.

Global cost of financial calculation (GEL, GEL/m2): means the sum of the present value of the initial investment costs, the sum of current costs and replacement costs (referring to the starting year), as well as disposal costs, if possible. :

$Cg(\tau) = CI + \sum j\ [\sum \tau i=1\ (Ca,i(j) \times Rd(i)) - Vf,\tau(j)]$

where: τ - means the calculation period - 30 years

Cg(τ) means the global value (means the starting year τ 0) in the reporting period

CI stands for initial investment costs for measure or set of measures j

$C_{a,i}(j)$ means the annual cost for measurement in year i or set of measurements j

$V_{f,\tau}(j)$ means the residual value of the measure or set of measures j at the end of the reporting period (discounted to the starting year τ_0).

$R_d(i)$ denotes the discount factor for year i, based on the discount rate r, calculated as follows:

Based on the calculations of primary energy consumption (step 3) and global costs (step 4) associated with different measures/packages/options (step 2) for certain reference buildings evaluated (step 1), graphs can be created for each reference building describing the primary energy use (X-axis: kWh primary energy/(m2 usable area and year) and global costs (Y-axis: GEL/m2 usable area) Depending on the number of evaluated measures/packages/options of different solutions, a specific cost curve (=lower area a limit marked by data points of different variants).

We have calculated energy efficiency measures for conditional multi-apartment buildings and single-apartment houses intended for one family.

If the packages have the same or very similar cost, then the package with the lowest primary energy consumption (= left end of the optimal cost range) should, if possible, be the basis for determining the optimal cost level.

Conclusion:

The methodology for dynamic sorption tests developed within the project was found sufficient to assess different structures and provides valuable results. High potential of natural porous materials was proved by preliminary tests and research in this field will continue. Principals of passive moisture buffering can be used for modern sustainable construction to help to keep the quality of internal microclimate regarding appropriate level of relative humidity without any operating energy and can effectively reduce operating costs.

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Brachistochrone Curve in Engineering

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As a key problem in slope-stability analysis, searching for potential sliding surfaces has attracted the attention of experts and scholars for a long time. However, the commonly used sliding surface curves are only considered in terms of shape approximation and lack physical significance. The search process involved in stability analysis of multi- level slopes is complex and a large amount of calculation is required. In order to solve this problem, this paper proposes a new sliding surface form based on physical interpretation of the brachistochrone and establishes a search model for the brachistochrone sliding surface of a multi-level loess slope. At the same time, in order to further expand the search range and find a more ideal potential sliding surface curve shape and position with a lower safety factor. We compared the calculation results for the position of the potential sliding surface and the stability safety factor with the corresponding results for an arc sliding surface to verify its rationality.

Main part

As a classical problem in soil mechanics, slope-stability analysis is an ancient and dynamic subject in the field of geotechnical engineering. The key to this type of analysis is finding the best method to evaluate stability, which involves two key problems: calculation of the stability safety factor and searching for potential sliding surfaces. The search for potential sliding surfaces is the main purpose of slope-stability analysis. Once a potential sliding surface has been determined, the safety of the slope can be determined according to the shear strength of the potential sliding surface; therefore, this determination has always been the focus of experts and scholars in the field of slope stability. At the same time, with the continuous growth of the construction scale of transportation infrastructure, a large number of high and steep slopes are appearing. The corresponding instability accidents occur repeatedly. In order to ensure slope safety, the actual engineering design is often based on comprehensive considerations of safety and economy. The potential sliding surface may be on a certain secondary slope or run through the whole slope. Therefore, finding an accurate and rapid way to search for the potential sliding surface is very relevant.

In research on potential sliding surfaces, experts and scholars have achieved many fruitful results. Among many methods, the circle center grid search method based on an arc is the one most favored by the engineering community, and the related research is also the most abundant. At the same time, as our understanding of slopes improves, we have gradually realized that the most dangerous type of sliding surface is not an arc, but rather other regular or irregular curve forms similar to the arc. Therefore, many scientists are looking for other sliding surface forms that can replace the circular arc sliding surface model; the logarithmic helix is the most recognized form. These two regular sliding surface curve forms have been verified as safe and feasible in many engineering scenarios and have accumulated a lot of exposure in theory and practice, but there are also some deficiencies in this approach. For one thing, these forms are only approximations of the actual shape and lack physical specificity. Also, the position of the rotation center of the sliding surface and the distance between the rotation center and the curve need to be determined during the search process. The search time will increase as search range and search accuracy grow. Due to their multiple levels, the position of potential sliding surfaces in multistage slopes is very uncertain, the search range is larger, and the search workload increases significantly. At the same time, combining a potential sliding surface search with intelligent optimization algorithms enables searches for arbitrary sliding surfaces; Obviously, intelligent algorithms require corresponding analysis software for application, and the calculation process is more complex when they are used. On the whole, the existing potential-sliding-surface search methods are very rich, and various optimization methods have developed rapidly, but their application in the field of practical engineering is still quite limited.

Based on analysis, it is evident that determination of potential sliding surfaces is not only affected by the calculation of the safety factor, but also related to the particular sliding surface and search strategy. The focus of the existing research is too concentrated, research on the topic is scant, and there is a lack of exploration of other possible sliding surface forms. Choosing a curve form only involves approximating the shape and does not take into consideration whether the curve has actual physical meaning. Therefore, it is necessary to explore further and find a sliding surface form with physical meaning and a more efficient search method.

The Italian scientist Galileo first raised the problem of the brachistochrone in 1630, and came to the wrong conclusion that the curve is a circular arc. Subsequently, the European mathematics community was involved in intense discussions on this question. Many mathematicians such as John and Jacob Bernoulli, Newton, Leibniz, and L'Hôpital reached a common correct conclusion, namely that the brachistochrone is not a straight line or an arc, but a cycloid. It is the optimal path by which a point mass goes from one point to another point that is not vertically below the starting point. It gives the fastest energy conversion and the shortest conversion time.

Sliding surface parameter equation

we assume that the coordinate of the slip-out point of the brachistochrone sliding surface is (a,b) and the coordinate of the sliding-in point is (m,h). Then the parameter equation of the brachistochrone sliding surface is as follows:

$$x=r(t-\sin t)+m$$

$$y=-r(1-\cos t)+h$$

Obviously, r and the value range of independent variable t should be obtained to determine the parametric equation of the brachistochrone sliding surface. The solution process is as follows.

① Substituting the sliding-out point coordinate (a, b) into the sliding surface parameter equation gives the boundary value t′ of the independent variable at the sliding-out point; the value range of the independent variable t is (t′,0).

② Then, substituting the coordinate (a, b) of the sliding-out point and the boundary value t of the independent variable at the sliding-out point into the parametric equation, the value of r can be obtained.

From the parameter equation of the brachistochrone sliding surface, it can be seen that in the process of moving the apex position (m, h) of the sliding surface curve along the slope line to find the potential sliding surface of each level of slope, the brachistochrone only requires an unknown quantity of the abscissa m of the vertex of the sliding surface. However, it is clear from the curve equations of the circular arc and logarithmic spiral that when the potential sliding surface of each step of the slope is assumed to pass through the slope toe of the step, determination of the circular arc and logarithmic spiral requires two unknowns. Therefore, using the brachistochrone for the sliding surface will significantly reduce the search workload and improve search efficiency.

Searching the improved brachistochrone sliding surface

In order to further expand the search range, one must find a shape and position for the potential sliding surface curve that is more ideal and has a smaller safety factor. We introduce the parameter μ into the original equation and define it as an improvement coefficient. The classical brachistochrone is thus improved into the following formula:

$$x=r(t-\sin t)+m$$

$$y=-\mu r(1-\cos t)+h$$

It can be seen from the improved sliding surface curve equation that the sliding surface changes with the value of μ, and the curve corresponding to the minimum safety factor is the potential sliding surface to be searched.

Physical meaning of the improvement of coefficient

The curve of the brachistochrone is actually the trajectory formed by a certain point on a particular circle when the circle advances along a fixed straight line (a typical cycloid). From the formation of the cycloid, it can be seen that the improvement coefficient μ has the following physical significance:

1. When $\mu < 1$ and the circle advances along a fixed straight line, it is accompanied by sliding in the direction of advancement, which accelerates the circle's rolling along the fixed straight line.

2. When $\mu = 1$, the curve is the classic brachistochrone;

3. When $\mu > 1$ and the circle advances along a fixed straight line, it is accompanied by a sliding movement opposite to the direction of advancement, which delays the circle's rolling along the fixed straight line.

Conclusions

In this study, we established a sliding surface search model for Brachistochron sliding surfaces. The sliding surface curve equation was improved, and the potential sliding surface was continuously found, and then the rationality of the approach was confirmed by a calculation example. The main conclusions are as follows:

1. Compared with the existing commonly used sliding surface curve form, the brachistochrone has a specific physical meaning.
2. Using the brachistochrone to search for the potential sliding surface can prevent the problem of finding the rotation center of a circular arc or logarithmic spiral sliding surface in the search process. The search only requires moving the positions of the two ends of the sliding surface, a simpler process which is easier to program for calculation and involves a small workload.
3. the brachistochrone sliding surface of multi-level loess slopes can accurately and quickly search the potential sliding surface corresponding to each step in a multi-level slope. The position of the original brachistochrone sliding surface obtained and the improved brachistochrone sliding surface are in agreement with that of the classical

arc. The stability safety factor is also similar, and the potential sliding surface after introduction of the improved coefficient is more ideal.

4. The results of this study provide a new form of sliding surface curve for slope-stability analysis, one which can significantly improve efficiency.

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Marketing Environment in the Construction Reality of Georgia

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Abstract: Today, construction marketing is an important element in increasing the competitiveness of construction organizations around the world. In Georgia, due to the characteristics of the construction industry, it is not clearly defined how to use marketing in construction organizations. However, construction organizations recognize the importance and necessity of using marketing in the management system.

The use of marketing allows us to qualitatively satisfy customer requests and changes occurring in the construction services market.

Key words: construction marketing, construction organization, marketing environment, marketing tools, marketing methods.

I. Marketing features of the concept of organization and construction management

Marketing solves such problems as calculating the volume of construction and its direction, when and how to use capital investments, determining the best financing conditions, etc. An effective marketing system allows you to beat competitors and achieve high results in your field of activity.

In Georgia today there are no precise technologies for developing marketing in construction activities. The reason for this is the complex structure of commercial relations between construction participants (customer, general contractor, subcontractor, logistics provider, designer, investor).

Features of marketing in construction activities include:

1. Construction organizations and their divisions.

This is a fairly extensive network, both in one territory and in different cities and regions. However, construction work may be seasonal or temporary. Therefore, each unit must be mobilized and, at the request of the customer, be able to switch to another object that currently requires the greatest attention.

2. Order fulfillment conditions.

Factors such as the timing and conditions of the order, as well as the forecast for the completion of the entire construction and individual facilities, depending on the climatic and natural conditions of the area, must be regulated quite strictly.

3. Work that must be taken into account when putting the facility into operation.

Commissioning of a facility is accompanied by a large volume of various works and services (monolithic work, construction and installation work, carpentry and landscaping).

4. Organization of participation in the market.

Organizing participation in the market requires large expenses from construction companies.

5. Results of the construction organization's activities.

A negative factor on the performance of construction companies may be a lack of working capital and uneven construction work. Organizing participation in the market requires large expenses from construction companies.

Construction organizations in Georgia can solve the above problems in their activities using modern marketing tools and methods.

Marketing activities and analysis of construction organizations are managed by a specially organized marketing department. The analysis takes into account real indicators of construction production and sales of manufactured products. Based on the results of the analysis, the marketing service makes proposals for adjusting long-term goals and further long-term development of the organization in accordance with the means developed by marketing programs.

Developed marketing programs are the basis of all construction plans, and all other plans must follow them. I. Laguta notes that “such programs allow an organization to correctly assess its capabilities, shortcomings and differences from competitors. Also, in order to avoid errors in work, using the program you can distribute financial and material resources, as well as intangible assets” (sketch. 1.)

2. Marketing tool for a construction organization.

One of the most effective means of attracting customers is Internet marketing, which consists of three main elements:

1. Effective website.

The first thing any construction company must do to be successful in the future is to create/develop an effective website.

2. Social networks and online advertising.

Effective use of social networks and online advertising is important for successfully running a construction business in the Internet space. The most effective marketing tools in Georgia are: Facebook page management and advertising.

3. Attractive photo and video material.

To convey your voice to Internet users through a website and social networks, it is necessary to prepare effective photo and video material, for which effective photo and video shooting is important.

Conclusion

Construction marketing in Georgia is focused on customer interests and customer service.

The concept of the construction marketing environment implies the influence of a set of forces that exist and operate outside construction organizations and are not subject to their control. When developing a company's marketing activities, internal factors must be taken into account.

At the same time, the organization of construction is influenced by internal factors, such as scientific and technological progress, the state of the economy, politics, environmental requirements, cultural environment and demography.

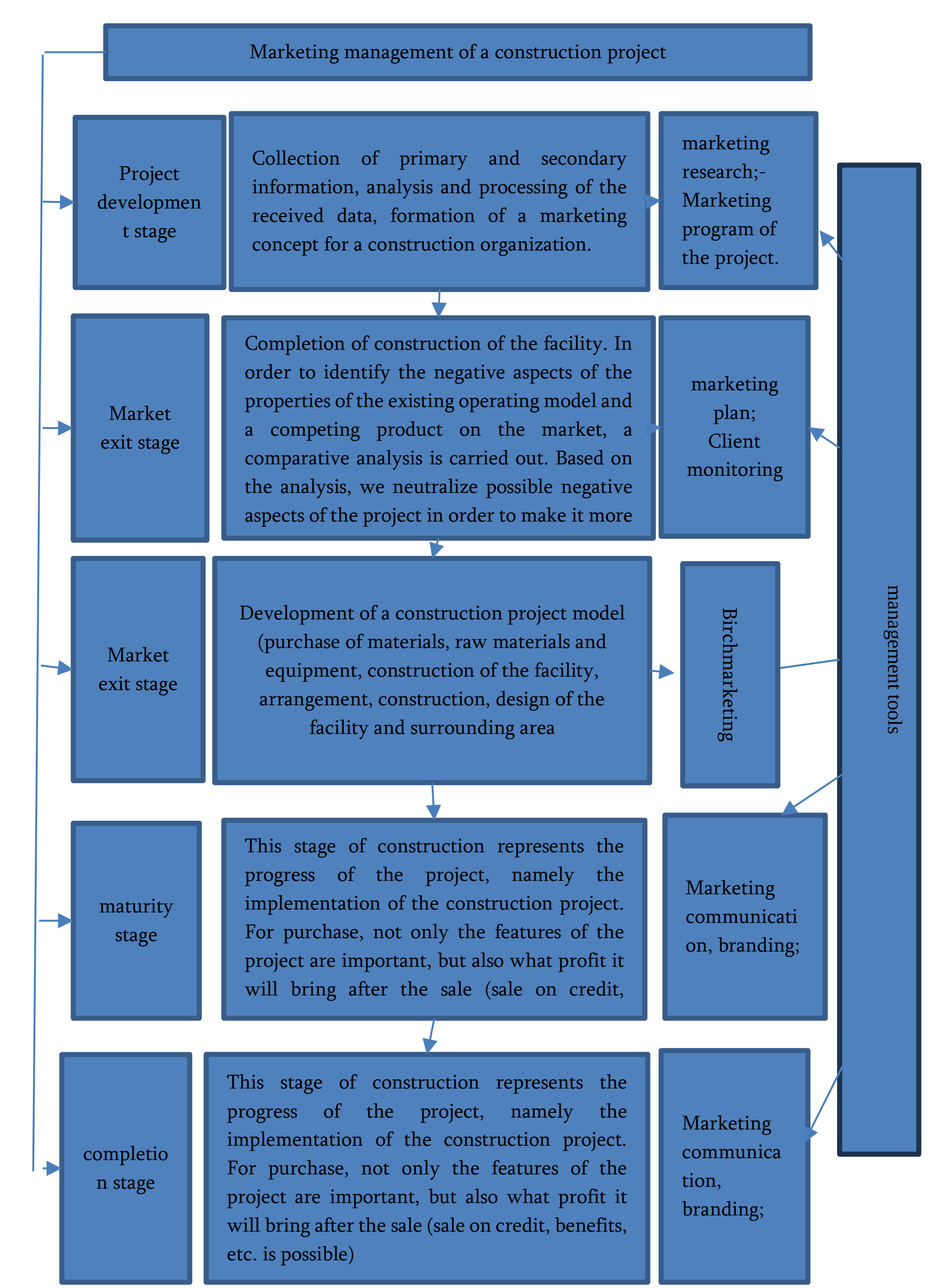

Fig 1. Scheme of marketing management of the organization's activities.

The construction business is more successful if you create an effective website and online advertising. The biggest advantage is the availability of resources such as; A variety of advertising channels, technical capabilities and a team that makes optimal use of this resource and cares about the reputation, success and results of the organization.

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Mathematical model for determining the possibility of transforming a traffic street into a pedestrian one

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Abstract. The article discusses the actual problem characteristic of modern cities, the transformation of the traffic street into a pedestrian space. A mathematical model is proposed, which allows us to quantitatively evaluate the possibility of transforming a traffic street into a pedestrian street by redistributing the existing traffic flows to the rest of the streets. The criterion for determining the possibility is the traffic load level of the streets left for traffic, which should not exceed the value determined by the norms.

A list of traffic organization and infrastructural measures is provided, which make it possible to implement the decision in practice.

Key words: Traffic and pedestrian streets; traffic load level; remaining bandwidth reserve.

Introduction.

The example of the advanced countries of the world shows that one of the powerful factors in the development of local and foreign tourism is the transformation of a part of the network of city streets into pedestrians. Paris, Madrid, Rome, Barcelona, Florence, etc. At least 10% of the street network of world-renowned tourist centers is intended for pedestrian traffic only. If we consider the historical central parts of these cities, this figure is much higher. The share of residential houses in the development along the pedestrian streets is minimal. In the vast majority of buildings there are hotels, public catering facilities, various entertainment facilities, branded hypermarkets and kiosks selling souvenirs.

Some streets are given pedestrian status periodically, on weekends or holidays. The number of pedestrian streets is increasing even more due to the rapid development of tourism in the world. In such conditions, the question of the possibility of transforming the traffic-purpose street into a pedestrian street becomes relevant. According to the author's personal observations, public, including underground rail transport plays a crucial role in the movement of passengers in large cities of advanced European countries, with some exceptions (eg Paris). The center of big cities is less loaded with light traffic. Such cities include Rome, Vienna, Barcelona, Bilbao and others. In these cities, changing the street status based on the use of quantitative criteria is not an urgent necessity, nor have appropriate methods been developed. It is often enough to reach an agreement between municipal bodies and make a decision based on a qualitative analysis.

In cities, where the role of public transport in the movement of passengers is relatively small and the level of street traffic is high, traffic jams are frequent, the possibility of transforming any street into a pedestrian one must be substantiated by mathematical methods, based on the analysis of quantitative data.

Along with Paris, Tbilisi is one of such cities, where the problem of overloading the streets with dense flows of light vehicles is acute. At the same time, tourism has become a field of primary vital importance for our country, and for its successful functioning, it is necessary to widely use the streets for pedestrians in the central and especially - historical parts of Tbilisi, Kutaisi, Batumi, Poti, Telavi and other cities. Currently, in Tbilisi only the part of D. Aghmashenebeli Avenue, Shardeni Street and a small area around it are reserved for pedestrians. As early as the early 1960s, the question of transforming Rustaveli Avenue into a pedestrian street was raised into its duplicates today's R. using Tabukashvili and Chonkadze Streets (with its extension to the end of Kakabadze Brothers Street). In the conditions of the current level of automobileization, this issue is a rather difficult technical-economic task and requires a deep, thorough justification. But it is obvious the need to study this issue and transform part of the streets for pedestrians even at the end of the week or during the holidays.

This issue is particularly relevant, first of all, in Tbilisi's Kala district, then in Chugureti, the so-called For Vorontsov and Plekhanov districts, for part of the streets near Mtkvari beach, etc.

Its positive solution will make Tbilisi even more attractive for tourists, many new jobs will be created and income from tourism will increase significantly.

Main part

We can use as a criterion for assigning the pedestrian status of the street: canceling the traffic function of the street should not lead to the mechanism of street traffic, which should contain a normative condition inside. This ensures a special economic course of the transport-operation of the network, maintaining it at an efficient level, not covering safety, environmental friendliness and comfort.

The traffic of the projects and the load level for the streets, i.e. the traffic intensity of the flow, should not exceed 0.6, and for the credit car 0.75 - the business of the prospective period of traffic.

Let's assume that the amount in the bank in the area under consideration flows with different bandwidths and intensities. Traffic load levels on these streets will be:

$$Z_1 = \frac{N_1}{A_1};\ Z_2 = \frac{N_2}{A_2};\dots\ Z_n = \frac{N_n}{A_n} \qquad (1)$$

where N_1, N_2,...,N_n, – the intensity of the flows in the peak period is reduced to light in d.a./h;

A_1, A_2, A_n, – street capacity in d.a./h.

Let's say we canceled the traffic function of N_2 and N_4 streets and made it pedestrian. Traffic flows with intensity N_2 and N_4 will be distributed on the remaining streets and we will get new values of load levels:

$$Z'_1 = \frac{N_1+x_1N_a}{A_1};\ Z'_3 = \frac{N_3+x_3N_a}{A_3}\quad Z'_n = \frac{N_n+x_nN_a}{A_n}\ ; \qquad (2)$$

where : N_a – additional stream $N_a = N_2 + N_4$;

x_1, x_3, x_n – The amount of additional flow redistribution to the remaining traffic destination streets in unit parts.

Obvious x_1 +x_3 +...+ x_n= 1.

Our task is to understand the new load levels Z'_1, Z'_3,... Z'_n,. For this, it is necessary to select the values of shares x_1, x_3, ... $x_n$and determine if the new load level on any street has exceeded the normatively permissible level. If this happens, measures should be taken to increase the traffic flow or reduce the flows on these streets.

X We use the remaining size of the bandwidth reserve for each n streets as a criterion for the selection of shares:

$$R_n = A_n * k - N_n \tag{3}$$

Where : R_n – Remaining bandwidth reserve;

A_n – Street capacity;

k – Normative level of street traffic load k = 0,4÷0,75;

N_n– The intensity of the flow of traffic on the street during the rush hour.

We rank the streets according to the absolute size of the bandwidth reserve, e.g. We have 8 streets, of which N_2 and N_4 streets do not participate in the ranking (Fig. 1).

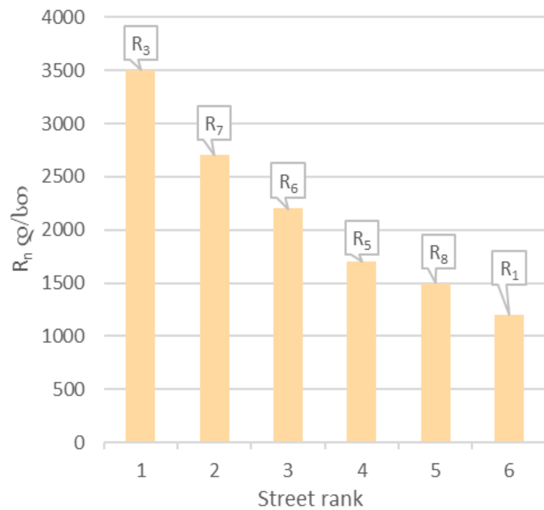

Fig.1. Street ranking according to bandwidth reserve

The abscissa axis shows street ranks, the ordinate axis shows the remaining reserve.

$R_3 = A_3 * k - N_3;$

$R_7 = A_7 * k - N_7 \;;$

$R_6 = A_6 * k - N_6 \;;$

$R_5 = A_5 * k - N_5 \;;$

$R_8 = A_8 * k - N_8 \;;$

$R_1 = A_1 * k - N_1 \;;$

The selection process is carried out in the following order:

1. rank height;

2. directional coincidence with the direction of N_2 and N_4 flows;

3. Analysis of certain subjective and objective factors (convenience and safety of traveling by public transport, protection from noise, etc.).

Suppose we select the first three streets with the maximum reserve. They must meet the following conditions:

$$R_3+R_7+R_6 \geq N_2+N_4.$$

If it is completed, the task is solved. If this condition is not met, we add the next streets in order of rank or we take certain measures to increase the capacity of the first three streets. After that, only X_3, X_7, and X_6 parts need to be selected. We select them in proportion to the relative size of the street reserve, for example

$$X_3 = \frac{R_3}{N_2+N_4}\,; \quad X_7 = \frac{R_7}{N_2+N_4}\,; \quad X_6 = \frac{R_6}{N_2+N_4} \quad (4)$$

To get a final conclusion on the results of the calculation, we check whether Z_1', Z_2', ... Z_n', has exceeded the permissible normative value. If there is no excess, the task is solved.

Three types of measures can be used to increase street capacity for the above purpose.

Traffic organization - optimization of marking and road sign placement schemes, introduction of one-way and reverse traffic, transfer of traffic lights from rigid mode to flexible and coordinated modes, prohibition of parking and stopping of vehicles, etc.

Development of infrastructure - widening of the carriageway, arrangement of oncoming traffic lanes, separate lanes for public and private transport, bicycles and electric scooters, sewerage of junctions with safety islands, opening of junctions, separation of pedestrian and vehicle flows with small depression tunnels, overpasses, etc.

Decisions of the City Hall and the City Council - introduction of the two-wheeled public transport rental system, timely and effective implementation of new legislative and normative acts, consideration of the peculiarities of the road network of individual districts when determining the directions of public transport development, etc.

Conclusion

The main criterion for the effectiveness of the implementation of any type of measures for pedestrian transformation of the streets is the existing traffic load levels and the levels obtained after the implementation of the measures. It is also necessary to estimate the influence of the factors determining the capacity of the streets with the maximum accuracy for the calculation of the load levels, taking into account the peculiarities of the street network and the mentality of the traffic participants.

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Cathodic protection of underground and underwater metal linear installations and reinforced concrete structures against electrochemical corrosion

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Abstract: The rapid development of industry and transportation in the world has led to a sharp increase in the beauty of underground communications and structures, such as high-pressure underground steel main gas pipelines, oil pipelines, water pipelines, cables and others. The efficient and reliable operation of all areas of industry depends on the reliability of underground communications and structures.

From the point of view of satisfying energy security, it is important and promising to ensure effective functioning of underground metal communications and structures related to corrosion damage, analysis of the results of threat and risk assessment. In recent years and in the future, in connection with the development of the infrastructure of underground metal communications and buildings, the interest in simple, effective and reliable protection systems has increased significantly. The use of such protection systems in the field of energy and industry imposes strict requirements on them, because corrosion, and mainly electrochemical corrosion, is one of the main reasons for the reduction of the service life of underground metal communications.

In order to avoid energy security and environmental disasters, it is necessary to have smooth and reliable operation of underground and

underwater metal linear installations and structures, the main cause of which is electrochemical corrosion.

Environmental protection and security issues require a joint complex approach, long-term state visions, high awareness and modern professional knowledge. The gradual convergence of the legislation regulating these processes with the relevant regulations of the European Union requires ensuring a safe energy supply.

One of the necessary conditions for the development of energy infrastructure is to minimize damage caused by electrochemical corrosion of underground and underwater linear installations and structures, which can be implemented by installing new, modern, efficient and long-lasting improved cathodic protection systems. In particular, the creation of new systems of protection against electrochemical corrosion and the complex of their improved properties are promising and in demand. From the point of view of satisfying energy security, it is important to ensure effective operation related to corrosion damage, analyze the results of hazard and risk assessment. In recent years, the interest in simple, efficient and reliable cathodic protection systems has grown considerably in connection with the development of the infrastructure of underground and underwater linear installations and structures, since corrosion is one of the main reasons for reducing the duration of their effective operation. For example, electrochemical corrosion in Georgia caused damage to the Kesalo 55 km Kazakh-Saguramo 100 mm diameter main gas pipeline, which resulted in the release of 3.6 million m3 of gas and interruption of supply. Lemshvenieri 61 km Kazakh-Saguramo main gas pipeline with a diameter of 1000 mm was damaged, resulting in a gas spill of 2.8 million m3, interruption of supply and transit. In 1984, a reservoir in India exploded due to corrosion damage, killing 3,000 people and injuring 500,000. In China, in 2013, due to corrosion damage, the Dunhuang 11 oil pipeline in Qingdao exploded, resulting in an environmental disaster, killing 62 people and injuring 136. It is worth noting the fact that 20% of the metal produced in the world is destroyed by corrosion, and today the loss amounts to 2 trillion US dollars.

The process of electrochemical corrosion is related to the movement of electric charges in underground and underwater metal linear installations and structures and in the substance surrounding them. The process is accompanied by the passage of an electric current, as a result of which two directions of reaction are formed, minus-cathode and plus-anode. Underground and underwater metal structures are in electrical contact with the surrounding environment, an electrically conductive environment-electrolyte is formed, through which a certain electrochemical potential, cathodic and anodic areas are arbitrarily formed on the surface of the protected metal. In today's cathodic protection systems against electrochemical corrosion, the negative pole of the constant current source is connected to the contact of the protected metal, and the positive pole is connected to the anode electrode, as a result of which the potential of the protected metal will shift to the negative side. This process is called cathodic polarization. As a result of cathodic polarization, the protected metal object becomes the cathode, and the anodic grounder becomes the anode. During electrochemical corrosion, the latter gradually breaks down and goes out of order, which causes the unreliability of the entire cathodic protection system. In the cathodic protection system, the anodic grounder (electrode) is the most important and basic element, the so-called The basis on which the effective and successful operation of the superstructure-cathodic protection system is built.

Different types of anodic earthers are distinguished in order to prolong the operation:

1. according to the material of the working electrode - metallic (steel, cast iron, iron filings) and non-metallic (graphitized, graphite layered, coal);
2. According to the shape of the electrodes - tubular, angular, rail, rod-shaped, rod-shaped;
3. According to the nature of the work - bare, with coke stack;
4. according to manufacturing technology - packed and not packed;
5. according to the arrangement of working electrodes - vertical, horizontal, combined;

6. According to the configuration - single-row, double-row, complex configuration;

7. According to placement in the soil - shallow, deep;

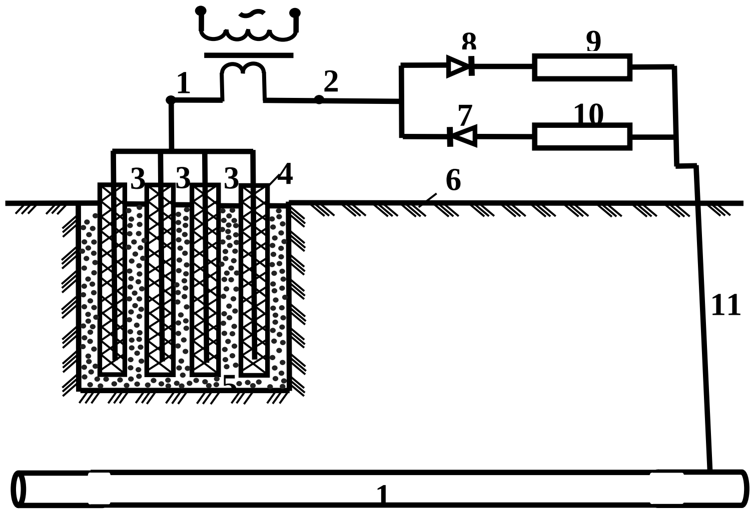
8. According to the distance of removal from the protected object - distant, close;

9. In relation to the length of the protected object - point, collected, distributed.

In order to increase the efficiency of the cathodic protection system, it is better to use capacitor-type anodic earthers, which will no longer disintegrate as a result of electrolysis.

Cathodic protection device with capacitor anodic earthing. The novelty of the scientific research in the project is that alternating current and capacitor anode grounders are used in cathodic protection systems against electrochemical corrosion. This innovation gives us a new picture of protection and new approaches to research. In particular, an alternating current passes through the protection circuit, and in the capacitor anode grounder, there is a replacement (induction) current.

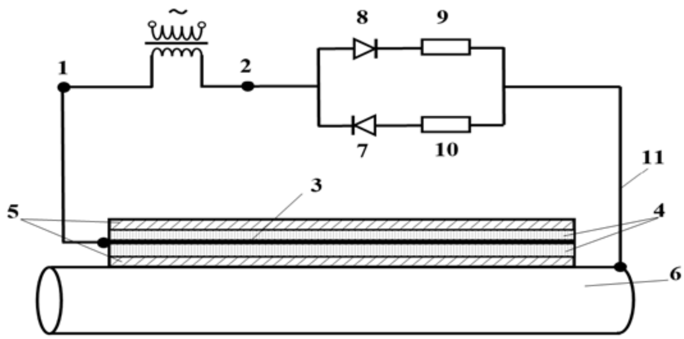
The presented cathodic protection device has both scientific and technological innovation, which makes the proposed product competitive in the international market and determines its superiority over existing prototypes. The innovation of the scientific approach is the main factor that leads to the creation and manufacture of a new electrochemical corrosion protection system with significant and commercial potential.



In particular, it is proposed for the first time to use a capacitor anode earther as an anodic earther for cathodic protection, during which the anode earther works not in continuous charging mode, but in induction mode, where for the first time the method and means of regulating the potential of protection against electrochemical corrosion by adjusting the capacitance of the earther and the amount of alternating current passing through the system will be presented.

Cathodic of underground linear installations and constructions protection condenser Anodic A device with a grounder. 1- of the transformer The output , which is connected metallic with the plate ; 2- of the transformer The output , which parallel to each other included of diodes and resistors Through is connected Underground metal tube Kathdur with the producer ; 3- metallic Plate ; 4- dielectric ; 5- coke powder 6- soil ; 7, 8 - diodes ; 9, 10- resistors ; 11- cathodic output 12- metal pipe

Cathodic protection against electrochemical corrosion presented in the figure is performed anodic of the capacitor with the device. This the last one contains variable Dennis source two with output. one output connected metallic with the plate, which is covered with dielectric and represents condenser Anodic Earther one It covers, while Anodic Earther second will cover represents Coke powder, which connected with the soil. Second output connected underground metal tube Cathodic with the producer Mutually Meeting - parallel United of diodes and objections Through, when Dennis source first will take me out has Positive sign opens one diode but second closes. this in case on the dielectriThrough. Fashionable will be Coke powder from the side and metallic plate from the side this as a result in the circuit will pass permeability Danny , while in the dielectric replacement Current (induction electricity). similarly the event will have place voltage second half in the period underground metal pipe Protective potential magnitude It depends objections magnitudes Mutually on the ratio . Their Mutually ratio by changing possible will be underground metal on the pipeline for protection Required negative potential establish.



A cathodic protection device with a capacitor anode grounder for underwater linear installations and structures, one of the linings of which is a metal pipe covered with an insulating material, and the other is a metal tape covered with a dielectric spirally wound on the metal pipe.

1 and 2-Transformer output, 3-Metal tape, 4-Dielectric, 5-Insulating material, 6-Metal tube, 7 and 8-Mutual parallel-connected diodes, 9 and 10-Resistor, 11-Cathode output.

When the output of the variable voltage of the transformer 1 has a positive sign, the diode 7 is opened, and the diode 8 is closed. In this case, the voltage on the dielectric 4 will be generated from the metal tape 3 and the metal tube 6. As a result, the diode 7, the resistor 10, the cathode output 11, the metal tube 6 will have a forward current, and the dielectric 4 will have a shear current. Similarly, the current will pass in the second half-period (diode 7 is closed, and diode 8 is open). The magnitude of the potential on pipeline 6 depends on the ratio of resistances 9 and 10. By changing them, it will be possible to establish the value of 10 necessary protective negative potential on the metal pipe.

In Georgia, the user and interested organization of the underground metal constructions protection system from electrochemical corrosion developed in the domestic market is the Georgian Oil and Gas Corporation, because the most efficient means of gas and oil transportation are main and industrial underground gas pipelines and oil pipelines. The length of main gas pipelines in Georgia is about 2000 It is km. According to the YEA sustainable development scenario, gas will be the most widely consumed energy resource by 2040. Also, in 2016, oil production in the world increased by 1.5% compared to the previous year. All this indicates that their transportation through underground main metal pipelines should be increased, and for the purpose of their ecological and energy security, it will be necessary to restore and develop the systems of protection against electrochemical corrosion. In addition to main and industrial underground gas pipelines and oil pipelines, the objects to be protected from electrochemical corrosion are: pipelines of compressor and pumping stations; casing pipes of gas wells; underground metal reservoirs; gas storage stations; Underground metal reservoirs of petrol stations and gas stations and others, where research results will be disseminated.

Unfortunately, up to now, the design, construction and operation of gasoline filling stations are carried out according to the old Soviet norms, without taking into account effective electrochemical corrosion protection. At the same time, it is necessary to note that the Soviet norms at the same time strictly required the location of BGSs away from residential areas and places of mass gathering of people, maintaining a mandatory, safe distance, while today BGSs operating in our country are mainly located in populated areas, often close to densely populated areas and their In the vicinity, which is allowed by international standards, although different from the Soviet safety, with the conditions of using means of protection against passive and electrochemical corrosion. As a result, there is a high probability of FGD exploding and injuring people and/or damaging property. The problem is especially relevant for car gas stations, the tanks of which are placed underground.

Based on the above, taking into account the actual situation in the country, it is necessary to implement active protection of underground metal cisterns from electrochemical corrosion with cathodic stations with capacitor anodic earthing. The problem, in addition to BGSs, also concerns many other underground and underwater linear installations and constructions, the effective protection of which allows obtaining significant economic benefits (savings) in addition to safety. This is confirmed by frequent accidents on water pipelines, gas distribution networks, etc., which have been working without electrochemical protection for the last 20-30 years.

The proposed innovation leads to the replacement of the anodic grounder with a capacitor-type anodic grounder in the existing cathodic protection against electrochemical corrosion of underground and underwater metal structures, which will lead to the efficiency and durability of the protection system. The proposed electrochemical protection capacitor method with increased indicators of its characteristics significantly increases the potential of industrial use.

The protective objects of the cathodic protection station against corrosion with a capacitor anodic earther are: main gas pipelines; Gas station and gas station steel reservoirs; foundations of seaside residential buildings; reinforced concrete tunnels; swimming pools; parking structures; reinforced concrete highways; bridges; Mast foundations; Casing steel pipes laid under wells, railways and highways; Water transport with metal hull and others.

Steel armature Corrosion

Corrosion of steel reinforcement is a worldwide problem, causing a number of economic, aesthetic and operational problems. But if the effects of corrosion are considered at the design stage and the right decisions are made before construction, then reinforced concrete building structures can work for more than 50 years.

The urgency of solving the problems of protection of reinforced concrete is dictated by the need to preserve natural resources and protect the environment. This problem is widely covered in the press. Scientific works, brochures, catalogs are published, international exhibitions are organized in order to increase the experience among the developed countries of the world. The main condition for protecting metals and alloys from corrosion is to reduce the cost of corrosion. It is possible to reduce the rate of corrosion by using various methods of corrosion protection of metal structures.

Corrosion affects buildings all over the world to varying degrees. Annual costs in economic terms are recorded in the billions of dollars. In infrastructurally developed countries, the damage caused by corrosion is equal to 2-3% of the value of the country's gross domestic product. Despite the efforts of world scientists to fight against corrosion, the development of effective methods of protection against corrosive breakdowns remains the main problem.

The peculiarity of the corrosion of reinforced concrete is that it grows and worsens like a tumor over time. That is why it is called "concrete cancer". Corrosion is one of the main reasons for the collapse of reinforced concrete structures. All over the world, such as tunnels, bridges, offshore platforms, swimming pools, parking structures, foundations of high-rise buildings, especially in coastal areas, are exposed to aggressive chloride masses and show signs of corrosion after a short period of operation.

Corrosion of reinforcement is the main cause of deterioration of concrete, such as spalling or spalling. In reinforced concrete structures, the reinforcements are connected together electrically by means of electric welding or wires, and the concrete acts as a conductor of ions - this is the case in all reinforced concrete structures.

It is worth noting that everyone agrees that cathodic protection is the only major means of reducing chloride corrosion of reinforced concrete steel reinforcement.

lofty buildings Reinforced concrete foundations Protection

High-rise buildings require the use of pile or slab foundations. The foundations of these buildings are present at the ground water level. The use of waterproofing cannot completely stop water penetration into the concrete, and basements are often in a non-hermetic condition and are submerged in groundwater, or are in a state of visible leakage. Pumping water from basements will not alleviate the current situation. This is a path to disaster, because despite pumping out the water, there is still a large amount of corrosion in the reinforced concrete.

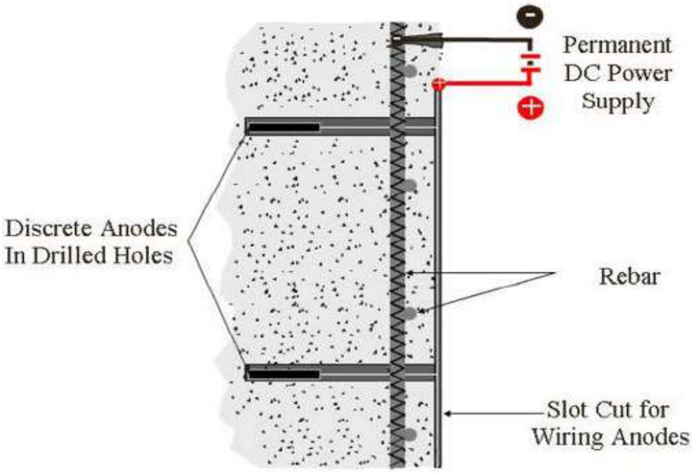
Consider how it is related Building stability and corrosion with each other. If we use cathodic protection to protect the foundation reinforcement from corrosion, then we can safely say that the stability of the building depends greatly on its protection from corrosion. If we do not act in time to stop the corrosion of reinforced concrete, it will make the building unsafe and risky. Once corrosion begins, it slowly and stealthily continues to wear down the reinforced concrete structure and eventually bring it to a deplorable state.

The recipe for corrosion of reinforced concrete - salt, water, moisture, oxygen.

Often, reinforced concrete cracks caused by leaks are filled with concrete again. This is a temporary injection, but the corrosion is still going on.

There are many methods of treating reinforced concrete against corrosion, but in practice there is only one method that stops corrosion in its tracks, and that is cathodic protection.

The use of cathodic protection to eliminate armature breakdown is the standard method used worldwide.



Schematic showing ICCP installation process using discrete anodes

Fig. 1

Figure 2.

Figure 3.

Figure 2, 3. The method of placing galvanic anodes between reinforcements in reinforced concrete construction.

Parking lot Reinforced concrete constructions and highways Corrosion

Parking structures are shelters for vehicles. One of the most serious problems associated with damage to parking structures is corrosion of embedded reinforcement. We know that concrete protects the reinforcement embedded in it from corrosive effects caused by water and salts, but it does not protect it completely. Damage to the surface of concrete (cracks and cracks) causes the reinforcement placed in it to oxidize, as a result of which the reinforcement expands and the concrete is damaged, cracks and crumbles. We have a similar picture on reinforced concrete highways, with the difference that we use anti-icing salt on the roads. These salts contain chlorides, which penetrate the concrete and damage the reinforcement embedded in it, resulting in corrosion.

The most common method for parking structures and highways is cathodic protection.

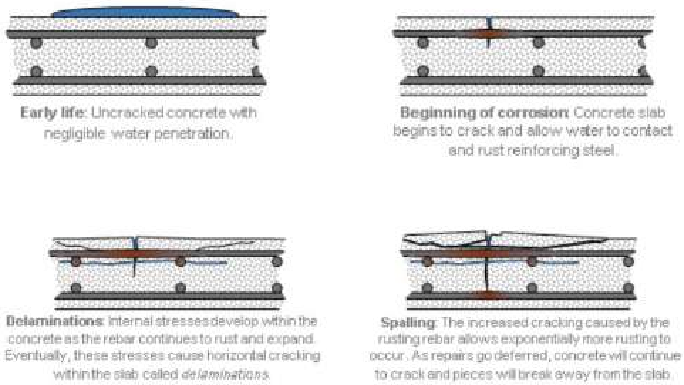


Figure 8

Figure 9. Damage caused by corrosion of reinforced concrete parking structures.

Of bridges and of the sea platforms Protection Electrochemical from corrosion

Corrosion is the main cause of collapse of reinforced concrete structures of bridges. Conventional seam repair of concrete, unless the root cause of corrosion is eliminated, will lead to repeated repairs of concrete that are temporary and eventually lead to its inevitable failure. Most of the world's existing reinforced concrete structures, such as offshore platforms, are exposed to aggressive chloride environments. Corrosion of steel rebar rods is the main cause of concrete spalling. Anti-icing chemicals and seawater are sources of chloride formation. According to the Federal Division of the US Department of Highways, cathodic protection is the primary and only method of protecting it against chloride corrosion. Cathodic protection stops phenyl salt fouling corrosion of bridges regardless of the number of chlorides that penetrate the concrete.

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Svaneti tower

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Svaneti, both by nature and cultural heritage, and by the harmonious synthesis of these two facts, is one of the particularly impressive corners of Georgia. The villages of Svaneti, grouped together with towers and residential houses, take the form of a single architectural ensemble. Along with social, household, economic and defense functions, Svan residential complexes also have a cultic load.

Despite the great variety of rural residential houses, three main groups are distinguished in Georgia according to the territorial principle:

- Plain regions of eastern and southern Georgia.

- Western Georgia, excluding Svaneti and Mtsi Rachi.
- Caucasus mountains.

It is in the latter, on the mountainous slopes of the Caucasus

Together with the architecture of various corners, traditional Svan dwellings are also considered and it is certainly presented as a unique phenomenon. Svan houses are sharply different from Imereti and Kolkheti clothing in general. Here everything is condensed and compressed into a small area. It is also essential that, unlike the bar residences in Georgia, the Svaneti residence also has defense functions. The building material is also different: it is true that wood occupies a prominent place in the building, but the building material is only cobblestones, slate was used in Ushgul. The Svan tower is either connected to the house or stands alone.

Traditional Svan dwelling

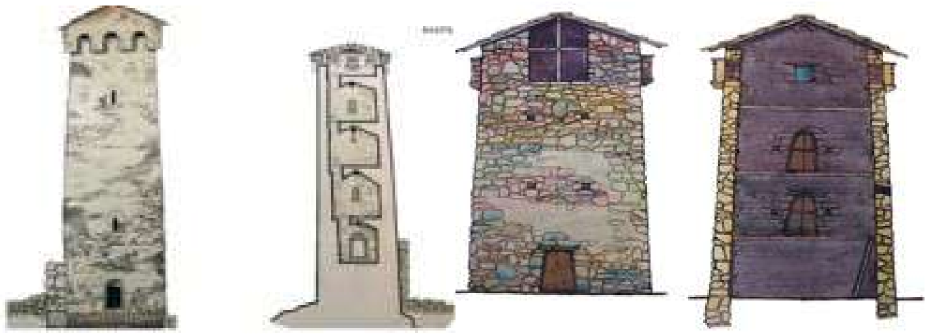
Two main types of ancient dwellings have been established: the castle house and the thatched house. Samples of the castle-house remained only in Ushguli within Svaneti, but apart from Svaneti, it also existed in Mta-Racha, in the village of Ghebi, and houses of a related or parallel character were confirmed in Khevsureti, Tusheti and Khevi.

Balszemot Svaneti

In a relatively older castle-house, residential, economic and defense functions are gathered in one building. Usually, this is a three-story residential house with an area of 80-100 square meters. M. area. In the vaulted first floor, there is a badger-watermelon stall with a hearth in the middle and in the same room a space for goods. On the second floor, above the badger, there is a hall - a summer residence, where hay is stored in the winter. The height of the stalls in the machvib and hall of the castle is from 3 to 4.5 meters, the light penetrates only through narrow tunnels, and therefore it is always dark here. The walls of the castle-house are built with slate; Their thickness reaches 1.2=1.3 meters on the first floor, and decreases to 80-90 cm on the upper floor. Roofing between floors is common for Svaneti - stone, double-sided, built on wooden rafters... or wooden - round logs... to connect the floors, together with the usual Svan stair-staircase, in Ushguli houses, sometimes a stone staircase with very steep steps was built.

Outwardly, the castle-house resembles an ordinary Svan tower, although it is lower and wider than the latter.

A murkvamian or tower house, especially when the fence of its yard is made of wood, is the most developed and finished form of Svan dwelling. The main elements of this house are: a two-story (rarely one-story) residential house; A tower (mulberry tree) standing next to it and a courtyard. "One family's plot of land is surrounded by a stone fence, inside of which there is a residential house and capital or light buildings connected to it. Here, the defense function is separated from the residential-economic functions and is carried out by a specially built tower. The floors in the residential house are distributed in the same way as in the castle: below is the living room, above is the hall. The area of a badger is equal to an average of 10 × 12 square meters. meter, its floor is earth. The room is rectangular, windowless, in the middle, as usual, there is a hearth, which is the node, the core, which has been determined since ancient times in different types of dwellings. An elongated corridor (hagam) leads to the badger - this is the entrance of the badger.



A two-story house with a porch and a hall, a tower and a yard, within which there is a barn and various farm sheds - these are the necessary components of the old house-door of Balszemo Svaneti. Obviously, not all homes are the same standard. The individual pattern differs in scale, placement on the terrain, relationship between the tower, the house and the yard.

In addition to the towers of the houses, in Zemo Svaneti, separate standing towers were also built for common defense. These towers are no different from the towers of houses, only slightly larger. A defensive structure, usually 20-25 meters high. It consisted of 4-5, or rarely 6 floors. The lower floor, the walls of which are up to 1.5 meters thick, is mostly deaf, the entrance is arranged at the level of the second floor. The height of the tower narrows and the thickness of the walls decreases to 0.7 - 0.8 meters. The floors are connected to each other by wooden stairs. On the last floor of the tower, finished with a crown, there is a fighting platform. It is covered with a two-tone roof.

Balskvemo Svaneti

There are four types of housing:

- (a) A house with thistles, the same as it was above Balsam.
- b) Swaniriani house.

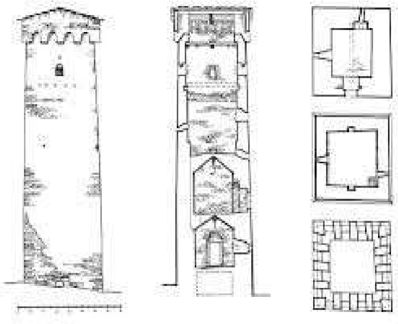
It consists of two parts: one is the kor, an ordinary Svan two-story house, made of stone, with a badger and a hall; The second is the Svanir, a two-story or three-story tower, much lower than the Murkvam. Food was stored on the first floor, living room on the second floor, defense room on the third floor, as well as the upper floor of Murkvam.

Therefore, the compositional principle – combining the tower and the house, the horizontal and the vertical – here seems to be the same as in the house with Balszemo, but the sharpness of the ratio is greatly slowed down here, and in some places it does not exist at all, because some svanir are as high as the house, and some are lower.

- c) a house with a nose. Ukoshkoa, "the function of defense is performed by a stone nest built on one corner of the house, which has guns attached to it."
- d) A house that does not have defense elements.

The houses of Balskvemo Svaneti without defensive elements are close to the bar houses of Western Georgia. However, there are also examples of houses without walls, which belong to the circle of Svan folk architecture and remind us of castles.

Interior elements in a traditional Svan dwelling



When discussing the architecture of the Svani residence, the characterization of the interior is of great importance. The front-east side of the hearth, that is, belonged to Katsakhash men. Inside and behind the hearth was the abode of the women of the West - Lazvraal. On the men's side, in Katsakhashi, there was the seat of the head of the house - Sakurtskhil (Sakartskhul, Haskam).

The main component of a Svan house, furniture, is distinguished by its monumentality. It has a simple design, beautiful proportions and a graceful silhouette. Swan furniture is closely related to the interior of the home and is a kind of accessory.

When making furniture, Svan carefully chooses wood material, tools, time and method of cutting wood, ornament, shape. It is interesting that when cutting a tree, they take into account "Khocha Doshdul" (a good moon when cutting a tree, Cato, Pliny, Vitruvius and others also mention it in their works).

The problem of transformation of traditional Svan housing

The spread of modern type of housing in Svaneti was fast. Today, there is almost no household left that does not have a new type of house, completely different from the old one. Swans easily mastered its construction techniques. The period of conception of new types of residential buildings begins at the end of the nineteenth century and continues until the first years of the Soviet government. The change in the architecture of the residential buildings mentioned in our chapter was caused by many factors, the first among which is the change in people's way of life and, to some extent, their activities, the entry of civilization into remote villages of highland Svaneti.
The interior of the house also changed over time. Since the middle of the 20th century, furniture has been bought in local stores and furniture stores in Zugdidi. Dishes and other household items are also changed, which improved family conditions.

Tourism and popularity

Since the last years of the 20th century and in the 21st century, the introduction of communications in Svaneti and the dissemination of information about the most beautiful Svaneti has aroused the interest of the world. The mass movement of tourists led to the formation of a completely new activity of the population in the mountains of Svaneti. The Svans began to set up family hotels, which also significantly contributed to the loss of ancient buildings.

The development of the tourist infrastructure has recently brought modern trends to Svaneti, changing the face of some of its parts... As you know, the development of the tourism industry is accompanied by significant threats, which are manifested in the change of the historical landscape, cultural landscape, traditions and immovable monuments.

The value of cultural heritage preserved in Zemo Svaneti goes far beyond the borders of Sakarvelo and is gaining world importance. Even in the second half of the 20th century, not only individual monuments of Zemo Svaneti were included in the list of monuments of Georgia, but also entire settlements - 42 villages of Zemo Svaneti were recognized as monuments by city planning. Also, in order to preserve the monuments of Svaneti, in 1970 Mestia district Lagham was declared a reserve, and in 1971 the Ushgul-Chazhash reserve was created. Based on the nomination of the Government of Georgia, since 1996, the village of Chazha of the Ushguli community has been included in the list of the best monuments of UNESCO's world heritage. In addition, in 2011, at the international competition of stone architecture (International Award Architecture in Stone), he was awarded with the "People's Architecture" prize.

Swan towers waiting to be saved

Despite the popularity of the towers, about 160 of the 3,500 remaining towers in Svaneti are on the verge of collapse and need urgent rehabilitation. According to specialists, the reason for this is mainly faulty construction of the roof, and sometimes negligence. There are cases when one tower is damaged by water falling from the rainwater of another tower. All this, not infrequently, becomes the reason for the destruction of towers and machubs. The National Agency for the Protection of Cultural Heritage is working on the rehabilitation of towers and machubs. The 11th-12th century ancestral tower of Charkvians, which collapsed in the summer, is to be fully restored. Giorgi Charkviani, one of the owners of the tower, recalls that the state agencies were contacted about the state of the building almost a year before the collapse. A positive response was received and the rehabilitation had to begin, however, due to the climatic conditions and the fact that the complex of the village of Chazhashi, included in the list of world heritage monuments, was in a more difficult situation, the tower could not be saved.

Ancestral Tower of Charkvians

There are 41 towers, 7 churches and 87 machubs in Ushguli community. Among them are the ancestral tower of the Charkvians and the Machub of the Chelidzes.

According to the information of the agency, this year, in Mestia municipality, about 40 towers and machubs are being completely rehabilitated. Restoration of each tower, if part of it is preserved, costs about 60 to 80 thousand GEL. And if the building is demolished, the rehabilitation of the monument costs twice as much.

In conclusion I think that future architects should conduct a deep research and search of the traditional architecture of Svaneti and the corners of Georgia in general, in order to reveal which elements are the most important to preserve for future generations, as well as to represent Georgia on the world stage. I think that the most valuable is the kind of architecture that is based on local characteristics and at the same time wisely and tastefully combines with modernity.

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Heat-Resistant Concretes Based on Silicate-sodium Mortar

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Key words: silicate-sodium, effective materials, nanotechnology.

Introduction

One of the main tasks of the modern development course of the public economy, which aims at the all-round improvement of human living conditions, is the acceleration and expansion of home construction. To fulfill this task, it is necessary to supply the building complex with the required building materials. One of the effective materials that provide the best sanitary conditions in a residential building, as well as wide possibilities in construction design, is clay brick. The further development of the production of this essential construction material and the increase in production volume are highly dependent on the perfection of the combustion wagons. Incorporating advanced technologies, such as silicate-sodium compounds and nanotechnology, can significantly enhance the efficiency and quality of these materials.

Buildings made of one-piece fired products (i.e., tile bricks) fail within 4-5 months. As a result, expensive restoration work on the wagon bodies is constantly being carried out in large volumes in production, leading to a decrease in the enterprise's output. The cost of expensive and scarce fire retardants, which are imported to Georgia from other regions, is increasing, significantly raising the price of the products. Reducing the cost of wagons in brick production by utilizing production waste and local raw materials, improving their quality through large-sized elements made of refractory concrete, increasing thermal stability, and reducing mass to minimize the use of technological fuel is a highly promising complex task.

In recent years, various types of refractory concrete have been widely used in global practice. They have replaced 60-70% of expensive materials and are being intensively adopted in industries in America, Japan, Germany, and other countries. Such concretes offer several advantages compared to single-fired structures:

- Their technology does not require the most expensive and difficult process—roasting;
- They acquire operational properties from exposure to high temperatures during the work process;
- They enable the production of large-sized modern products with a minimum number of joints;
- They allow for the consideration of the characteristics of the aggressive environment and working conditions for any thermal aggregate and their separate parts, with pre-planned properties of concrete.

From the point of view of technological, economic, sanitary-hygienic, and scarcity considerations, there is great interest in refractory concretes based on silicate-sodium systems. Fundamental studies have been conducted to obtain refractory concretes using liquid glass. The high viscosity of liquid glass leads to the production of high-quality refractory concretes. However, this high viscosity also results in significant expense due to the large amounts of liquid glass required. Additionally, a large amount of water is included in the concrete along with the liquid glass, which weakens the concrete structure.

In this context, replacing liquid glass with finely ground silicate rock (a byproduct of glass production) has shown promising results. This substitution improves the homogeneity of the concrete mixture, eliminates the energy-intensive process of producing liquid glass from silicate rock, and reduces the amount of boiling water needed, thereby increasing the concrete's strength. The use of silicate rock also lowers costs and enhances the temperature resistance of the concrete. Moreover, it allows for the centralized production of a dry mix that can be transported over long distances and prepared directly by the customer.

These advancements have led to the selection of silicate-sodium anhydrous binder compositions for producing lightweight, heat-resistant concretes.

Similar concretes were also adopted in Georgia, both for low-temperature ceramic plants and for high-temperature metallurgical plants. Local raw materials (volcanic slag) were used, glass slag, fireclay slag. These materials were used both in the binder and as a filler, which led to a small number of components, which led to the simplification of the technology, the reduction of the cost of the product, and the same material composition of the binder and the filler guarantees that the internal stresses will not be large when the temperatures change, especially in the contact layers, which leads to the thermal stability of the material. increase.

Production of new generation heat-resistant concrete is possible on the basis of modern scientific and highly developed technologies, which leads to high quality of products, ecological safety, effective use of raw materials and economy of resources. One of the highly developed technologies for the production of nano-refractory materials is nanotechnology, which is at the initial stage of the production of refractory materials. On the basis of many studies, highly flame-resistant, nanostructured, heat-resistant corundum has been obtained, in which nanostructured sodium silicate is used as a binder.

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Engineering systems and structures in skyscrapers

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Abstract: Skyscrapers symbolize human innovation and achievement, showcasing advances in architecture and engineering. From the first steel-framed buildings to today's sustainable high-rises, each marks a milestone in urban development. Recent advancements in materials and construction techniques have enabled greater heights and environmental responsibility. This presentation explores notable skyscrapers, highlighting the designs and innovations that shape our city scapes.

Keywords: Skyscrapers, Innovation, Architecture, Engineering, Urban Development, Milestones, High-rises, Sustainability, Materials, Construction Techniques.

1. Introduction

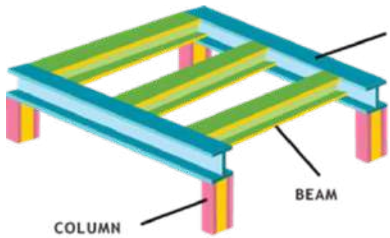
Skyscrapers are iconic symbols of human ingenuity, representing the pinnacle of architectural and engineering achievement. From the early steel-framed structures that revolutionized city skylines to today's soaring marvels that touch the clouds, these towering buildings showcase our relentless pursuit of height and innovation. Each skyscraper not only defines the skyline of its city but also tells a story of technological progress, economic growth, and cultural significance.

In recent years, new construction decisions in skyscrapers have been driven by advancements in materials, sustainability practices, and cutting-edge technology. Innovations such as high-strength concrete, composite materials, and sophisticated aerodynamic designs have allowed buildings to reach unprecedented heights while maintaining safety and stability. Sustainable design principles, including energy-efficient systems, green roofs, and environmentally friendly building practices, are now integral to skyscraper construction, reflecting a growing commitment to environmental responsibility.

This presentation will take you on a journey through some of the most notable skyscrapers in history, highlighting their groundbreaking designs, the milestones they represent in the ever-evolving narrative of urban development, and the innovative construction decisions that have shaped the modern skyline.

2. Construction of skyscrapers

New engineering solutions, the use of light structures, metal frames above 23 floors, allowed the construction of an unlimited number of floors. In the metal frame of a skyscraper, vertical steel columns are rigidly connected to horizontal coils and interfloor slabs. The systematic cross-connection of structures allows for equal distribution of loads on the foundation (picture 1.)



picture. 1. Skyscraper foundation

The main factors to consider when building skyscrapers are:

City skyline, facade, elevation, floor, roof, building exterior, water supply systems, elevators, stairs, electrical wiring and communications.

City silhouette. Architects must think not only about the facade of a new skyscraper, but also how it will look next to the buildings that will be on its flanks, behind and in front of it. All these buildings together form the silhouette of the city.

Height and floors. Skyscrapers must be at least 150 meters high and 30 stories high. Initially, only offices were located in skyscrapers. Now most of the skyscrapers have a residential floor. Some skyscrapers are actually small cities where everything a person might need is located on different floors.

Technical floors. Water supply, drainage, heating, cooling and electrical systems are located in the floor levels.

Facade and roof. Facade and roof can be both decorative and utilitarian. The outer wall is not load-bearing, so it can be made of different materials. Skyscrapers can be topped with clocks (as on the Royal

Clock Tower in Mecca), radio and television towers and decorative spires, decorative lighting, panoramic terraces and roof gardens.

Carrying constructions. In 1884, William Le Baron Jenney realized that metal structures could withstand much greater loads and therefore metal frames could be used to construct high-rise buildings. Before Jenny's discovery, any tall building rested on its own walls, and the taller the building, the thicker the wall had to be.

Skyscraper design. The design of a skyscraper depends on the layers of ground beneath the skyscraper. The metal frame and the strength of the foundation allow the building to withstand both permanent and temporary loads. To prevent the building from collapsing due to strong winds and earthquakes, it is constructed in such a way that it sways slightly under the influence of external forces. It is not dangerous, but it can make people in the building sick. That's why engineers place giant counterweights called inertial dampers on top of buildings. Inertia dampers move with the building and create a force in the opposite direction that keeps the building stable. Skyscrapers are protected from lightning by lightning rods. Lightning can strike a skyscraper twice or eight times. Instead of the building, the lightning strikes directly on the lightning rod, then travels to the wire on the wall of the building and goes into the ground through the grounding electrode.

Elevators and stairs. Elevators are often located in the frame of the building, that is, in the central part of the building, where the mechanical equipment is installed. One elevator can serve 15-20 floors, two - up to 35 floors. Three elevators are needed to serve 40-45 floors, etc. Sh. A very tall skyscraper, over 60 stories, may require separate elevators that go up to any floor and express elevators that go directly to the upper floors. Each elevator may have its own rules, such as left serving floors 1 to 30 and right serving floors 30 to 60. Or some elevators may only serve residential or commercial floors. Although elevators are convenient, skyscrapers still have stairs. Typically, a building has at least two staircases located on opposite sides of the building. People can use the stairs to avoid waiting for the elevator or if the elevators are not working, especially in emergency situations such as power outages or fires when the elevators become unsafe. In emergency situations, evacuating people by stairs takes about one minute per floor. A complete evacuation of a very tall building can take up to two hours, but even so, the stairs remain the safest way to evacuate.

Water supply systems. On every floor of a skyscraper, people need water for drinking, sewage, washing and many other things. Water is also needed for fire sprinklers in case of fire. Water is a heavy liquid and it needs to be pumped to a great height in a skyscraper. Providing water to all floors of a skyscraper is a difficult engineering task. The city's water supply system only has enough pressure to supply water up to the first floor of a high-rise building. Therefore, engineers use electric motors to supply water to all floors of the skyscraper. As the water is pumped, it fills the tanks located on the technical floors. Reservoirs provide a backup source of water in case the power goes out and the pumps are unable to pump water for a period of time. Reservoirs also reduce the high water pressure needed to rise, so water flows more slowly from faucets and toilets. But what goes up must come down. Toilets, sinks, and bathtubs on each floor are connected to drain pipes that carry waste and sewage to sewer pipes. Pipes also go up, through the roof, to let gas and stale air out. Water from the building flows through drain pipes into the city's sewer system.

Electrical systems. Electricity enters the building at high voltage through a transformer. Transformers reduce electrical voltage, making it safe to use in all areas of the building. Electric current is transferred to the distribution mechanism. The distribution mechanism transmits electricity safely and efficiently to the technical floors of the building. Technical floors contain safety devices such as switches, which consist of small switches called circuit breakers. They can cover an entire floor of a building, or a small system. Automatic switches allow the power to be turned off in emergency situations or when electrical work is being carried out. If electricity consumption in one location is too high, circuit breakers and distribution panels will automatically cut off the flow. Excess energy can be dangerous and cause overheating, melting, and sometimes even fire.

3. Skyscrapers of the world

1. Home Insurance Building (Chicago, USA, 1885) 42 meters, Architect William Le Baron jenney (picture. 2.).

Picture 2. Home insurance building

2. Singer Building, New York, USA, 1908. 47-floor, architect Ernest Flagg (picture. 3.).

Picture 3. Singer building

3. Metropolitan Life Insurance Company Tower, New York, USA, 1909. 50-floor, 213 m. (picture. 4.).

picture. 4. Metropolitan Life Insurance Company Tower

4. Woolworth Building, New York, USA, 1913, 57 floors, height 241 m. Architect Cass Gilbert (Picture. 5.)

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Picture. 5. Woolworth Building

5. Chrysler Building, New York, USA, 1930, 77 floors, 319 m. Architect William Van Allen (Picture. 6.).

Picture. 6. Chrysler Building

6. Empire State Building, New York, USA, 1931, 102 floors, 443.2 m. (Picture. 7.).

Picture. 7. Empire State Building

7. The North Tower of the World Trade Center, New York, USA, 1972. 110 floors, 417 m. Architect Minoru Yamasaki (Picture. 8.).

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Picture. 8. The North Tower of the World Trade Center

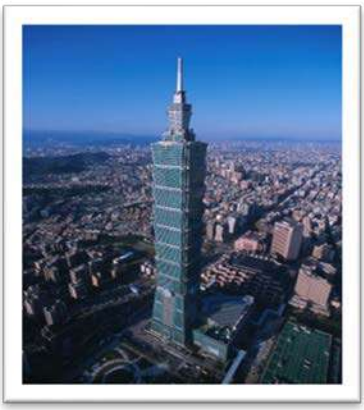
8. Sears Tower (Willis Tower), Chicago, USA, 1973, 108 floors, 442 m. Architect Bruce Graham (Picture. 9).

Picture. 9. Sears Tower

9. Petronas Towers, Kuala Lumpur, Malaysia, 1998, 88 floors each, 452 m. by architect Cesar Peli (Picture. 10.).

Picture. 10. Petronas Tower

10. Taipei 101, Taiwan, 2004, 101st floor, 508 m. Architect C.Y. Lee (Picture. 11).



Picture. 11. Taipei 101

11. Shanghai World Financial Center, China, 2008. There are 101 floors, 492 m. Architect Kohn Pedersen Fox (Picture. 12.).

Picture. 12. Shanghai World Financial Center

12. Burj Khalifa, Dubai, UAE, 2010, 163 floors, 828 m. Architect Adrian Smith, Skidmore, Owings & Merrill. (Picture. 13).

Picture. 13. Burj Khalifa

13. Shanghai Tower, China, 2015, 128 floors, 632 m. Architect Gensler (Picture. 14).

Picture. 14. Shanghai Tower

14. Abraj Al Bait Clock Tower, Makkah, Saudi Arabia, 2012, 120 floors. 601 m. (Picture. 15.).

Picture. 15. Abraj Al Bait Clock Tower

15. Lotte World Tower, Seoul, South Korea, 2016, 123 floors, 555 m. Architect Kohn Pedersen Fox (Picture. 16.).

Picture. 16. Lotte World Tower

16. Ping An Finance Center, Shenzhen, China, 2017, 115 floors, 599 m (Picture. 17.).

Picture. 17. Ping A Finance Center

17. Steinway Tower, New York, USA, 2021, 84th floor, (Picture. 18.).

Picture. 18. Steinway Tower

18. Merdeka 118, Kuala Lumpur, Malaysia, 2022, 118 floors, 78.9 m. (Picture 19).

Picture. 19. Merdeka

5. Conclusion

Building skyscrapers is an effective engineering solution for urban development. The construction of skyscrapers forever changed the image and appearance of cities, contributed to the development of construction and new technologies in megacities. Skyscrapers are presented in the paper in ascending order from the lowest to the leader, height and number of floors. Also, engineering solutions are discussed.

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Anti-seismic measures in ancient Georgian architectural monuments

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Abstract: Ever since people began to build religious buildings, they tried to make them quite high, as close as possible to the sky - symbolically to God. A large part of such buildings could not stand the test of time, but those that were built with certain knowledge and experience survived. The pyramids of Egypt, one of which is included in the seven wonders of the world, were built 2600 years before BC and are the oldest structures. Also, the Pyramids of the Sun and the Moon - in the territory of present-day Mexico.

Key words: architectural monuments, buildings, temples, wall, metal, monastery, slot, pile .

Introduction

When building architectural monuments, the builder had to first of all take care of the stability of the building, which depended on many factors. Taking into account that our territory is located in a zone of high seismic activity, the architects needed certain knowledge and experience, the use of which would make the building stable, so the buildings built in this way survived Earthquake impact for centuries. Because of all this, even before Christ, our ancestors resorted to anti-seismic measures in order to preserve the magnificent temples-shrines or other purpose-built buildings.

Main part

This was also the case in Georgia, considering that our territory is located in a zone of high seismic activity, here too the architects needed certain knowledge, the use of which would make the building stable, so the buildings built in this way have withstood the effects of earthquakes for centuries. Because of all this, even before BC, our ancestors applied anti-seismic measures in order to preserve the magnificent temples-shrines or other purpose-built buildings.

Old Shuamta

It was built in the 5th century **Nekres was built in the 4th century**

The Sun Temple of Nekresi is located in Kakheti, Kvareli Municipality, in the village of Shilda, adjacent to the Nekresi Monastery. It is also known as the Big Square. The building dates back to the 1st-3rd centuries and is a former Christian temple complex. The ensemble consists of seven independent buildings, which are surrounded by a square-shaped border. The square has a cross plan. Today, the building is almost at the foundation level. Nekresi Sun Temple is an important and unique monument of Georgian culture, both from the historical and architectural point of view.

Here it is clearly seen that the temple was placed on a wide plane, the purpose of which should have been to preserve the majesty.

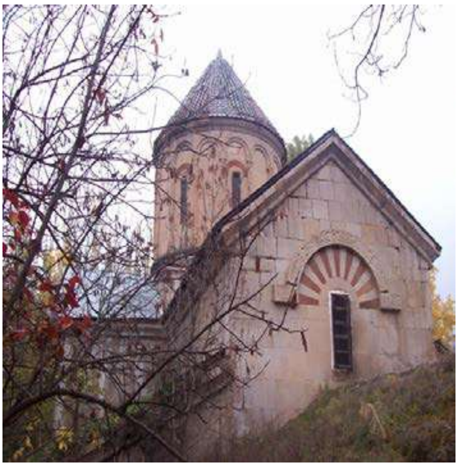
The anti-seismic measures applied by our then architects in construction conditions are very diverse, where their knowledge and experience intersect. History has preserved many reports about devastating earthquakes. This is confirmed by the materials studied and published by scientists using modern techniques, but regardless of time and time, these buildings still surprise the visitor. One such method used in construction is the "full girder" or "chain girder", an ancient anti-seismic girder that has been used as far back as the 4th century AD. BC in the fortress-city of Baginet.

It seems that long before lime solution was used in the construction of buildings, our ancestors had mastered the so-called "Dry pile" - with cleanly smoothed squares. Also used was an interesting and very original saw-square with a "tooth" to prevent the seam from tearing.

Armazi Castle, the remains of a pagan temple (Bagineti)

On the ancient Georgian monuments: Khakhuli (X century) and Changlo (X century) in southern Georgia, (currently the territory of Turkey), a "whole belt" with smoothed stones is used, in which each stone has a length cut, a "tooth". The entire contour of the building has such a belt only in the crowning parts, where the arches are placed and where the amplitude of the vibrations caused by the earthquake is felt the most.

Khakhuli Temple

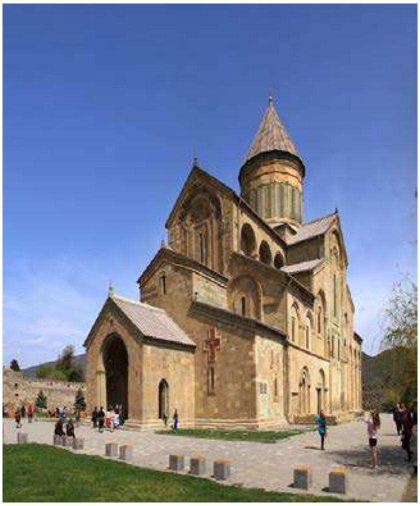


It is interesting that in the walls of the XI facade of the Svetitskhovli temple, at a height of 2 m from the ground surface, wrought iron strips arranged in horizontal seams can be found almost everywhere, which seem to belong to ancient, pure metals.

This shows that our ancestors tried to protect the building from the impact of the earthquake with such methods. The distribution of the external forms and masses of the temple, the proportions are subject to the high dome erected in the middle, under which are the arms of

the cross covered with gabled roofs, and between the arms are the stalls covered with low gabled roofs. These were anti-seismic measures that our architects applied in the conditions of the construction at that time.

Svetitskhovli Cathedral

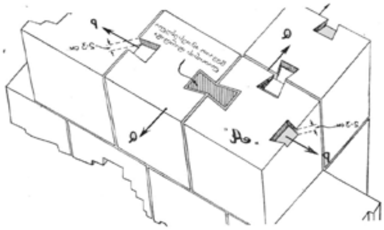


The next stage of anti-seismic measures should be the so-called "Swallow's tail", in which metal already participates. This rule of tying the pile still dates back to the c. Before registration, it was used in the construction of the Baginet fortress in the 2nd century. In each boundary stone, the so-called "Swallowtail" about 12 cm long and 8-9 cm wide. The width of the "throat" was 5-6 cm, and the depth was 2-4 cm. In some cases, the width of the "throat" decreased to 3 cm. It was impossible to use wooden material in objects of such small dimensions, so there were 2 options: either inserting a metal plate, or inserting heated lead into the "swallow's tail". This rule was used not only in longitudinal or one-way walls, but also in bonding longitudinal and transverse walls.

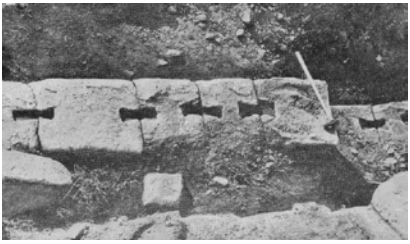
Armazi Castle - Baginet

In the drawings below, it is clearly visible how the metal plates receive tensile forces, and when the seam is opened, in the direction of the longitudinal axis of the wall, the metal plate works on tearing, tearing. When the stones, under the influence of horizontal forces, move in the transverse direction, the same plate works for cutting with its narrow "throat".

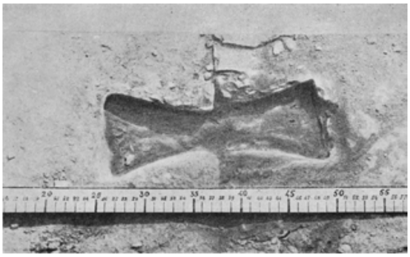
Scheme of work of nodal stone with "swallow tail" jamming



Dry wall installation with "swallow tail" jamming



"Swallow's tail" jamming in the stack, detail



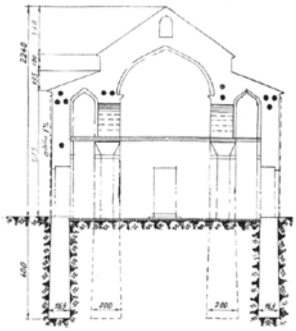
In addition to the above-mentioned examples, attention is drawn to the strengthening of piles and especially important structures with wooden elements, which were used to create a horizontally bonded anti-seismic belt.

For example, 6 rows of anti-seismic connections made of oak material in the arch of the Jigrashen temple form a polygonal frame in plan. Because the dome was a twelve-sided prism, the 5-row frame consisted of twelve elements. And the sixth frame, directly under the throat, was pentagonal, which represented a stronger element in cross-section. The length of each coil of the pentagonal frame was equal to 5 m, and the diameter was 30 cm.

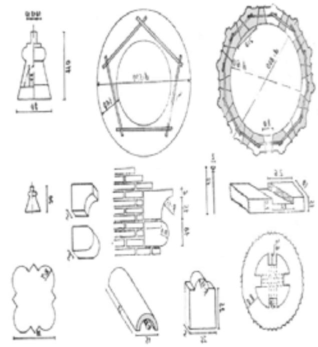
In the other 5 rows (tiers), the section of coils was rectangular 15X15 cm, and the length was 216 cm. It should be emphasized that the coils on top of the openings are for anti-seismic purposes only.

Armenian Church named after Jigrashen in Old Tbilisi

Cross-sectional diagram of the jigarashen



The scheme of the cut of the dome drum with anti-seismic wooden ties on the joist and curved bricks in the form of a cross



Wooden anti-seismic belts, which were often up to 30 cm in diameter and had the purpose of receiving tensile forces, were found in Tsrom, Ninotsminda (Sagarejo), where they were used in the restoration of the 5-story bell tower in the 16th century. in an idol place.

To create a large vaulted space in the corners of the central square, between the four apses, an additional small stall is inserted on the diagonal axes. From the outside, the temple was a star-shaped building with semicircular apses arranged alternately according to size. Only the apse of the sanctuary in the middle part, where the windows are cut, has a rectangular shape

Ninotsminda (Sagarejo)

As for the history of the construction of the Tsromi Cathedral, as noted by Academician Giorgi Chubinashvili, the current domed temple of Augia Tsromi was built by Erismtavar Stefanoz II. The temple was damaged and rebuilt several times: between the 11th and 12th centuries and in the 16th and 17th centuries. On September 24, 1731, during the invasion of Lekta, the wall collapsed.

The earthquake of May 8, 1940 severely damaged an important part of the temple: the dome collapsed, the walls of the square under the dome and a large part of the cylindrical arches of the western and southern arms, the western wall was bent.

Nevertheless, the original plan and overall composition of the temple remained unchanged. The anti-seismic measures implemented during the construction of the Tsromi Cathedral had a great impact on the construction art and construction of a number of later buildings.

Temple of Tsrom VII c

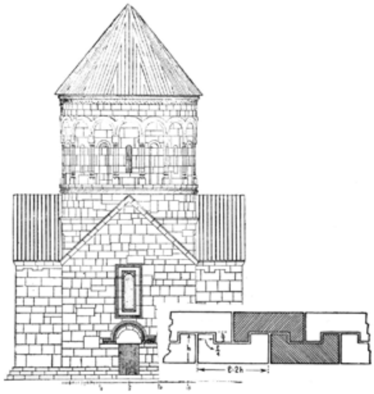
For the first time, anti-seismic belts of wooden material were used in ancient architectural monuments during the construction of Tsromi Cathedral (beginning of VII century). Such belts were also used in residential houses built of cobble stone in Kartli and Kakheti.

The central dome does not rest on the outer walls, but on 4 standing columns that form a square.

The deformation curves constructed as a result of the study of the deformations of the temple showed us that the columns, which had undergone settlement, moved away from the walls, independently settled together with the structure of the dome. Roofs and arches are only brought to the dome and are not connected to it (neither rigidly nor by joints). i.e. In modern technical language, it was distinguished by anti-seismic seams.

Anti-seismic belt with stone pile.

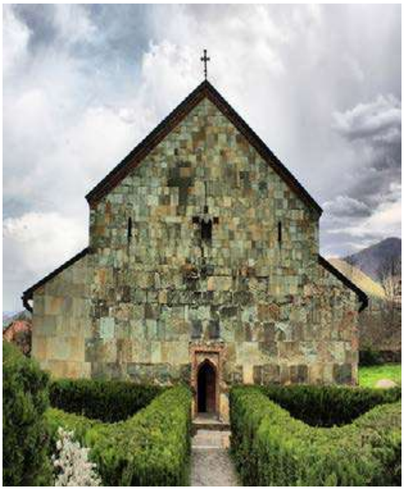
Anti-seismic belt operation scheme



It is also interesting, the so-called The arrangement of lunettes, the light opening left in the arrangement of the arch or dome. A wedge-shaped arched barrier (made of brick or cut stone) is arranged to relieve the load of the stone barrier located on top of the opening, which transfers the vertical load to the supports of the barrier and does not bend the stone anymore. The space between both barriers can be filled with relatively light material or left for lighting.

We find several constructive solutions that were forgotten and today we consider very rational. This is on the Temple of Zion (V) in Bolnisi. It is a constructive solution for the unloading of the stone fence. It is known that stone curbs perform poorly in bending. Kalatoses of that time knew this very well, and therefore they used a very original way:

Sion of Bolnisi



within the opening, they arranged a hole for unloading the fence, the dimensions of which are small compared to the opening.This relieved the limiter from the stress caused by bending. The vertical forces were transferred to the supports of the fence and caused only compressive loads.

Conclusion

Therefore, as we have seen above, the listed anti-seismic measures show that Georgian builders, masters, architects, endless invasions, destructive earthquakes have taught such methods so that their future descendants would receive the eternal monuments built by their hands, which is our indelible history.

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Cable-Stayed and Suspended Structures in Civil Engineering

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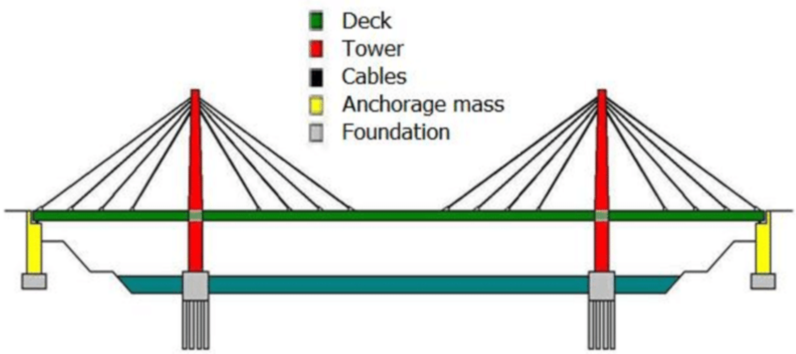
Abstract: Cable-stayed structures represent a significant advancement in engineering, providing innovative solutions for various architectural and infrastructural projects. Utilizing flexible cables and rigid supports, these constructions achieve exceptional strength, stability, and aesthetic appeal. The cable is one of the key elements for many modern and technologically advanced structures. Its use allows us to create solid yet flexible structures that withstand diverse environmental impacts.



In this discussion, we will review the primary areas of application for cable-stayed and suspended structures, re-evaluate traditional methods, and highlight issues that previously received less attention. This focus has led to the development of new technologies and the acquisition of advantages in the contemporary era.

Main Areas of Application:

Cables are used in various structures, such as suspended bridges, towers, roofs, and other constructions.

A roof, whose main load-bearing structure consists of cables (wires placed on central supports and fixed with tension devices at the ends). Suspended roofs and large spaces, such as sports arenas and concert halls, benefit from suspended roofs supported by cables. This design provides large, unobstructed interior spaces and their flexibility. For example, the Olympiastadion (Munich).

Geodesic and other large-scale, futuristic architectural structures use a network of cables to maintain their shape and stability, enabling innovative and unique designs.

Tall towers, often used for telecommunications and satellite purposes, use cables for additional stability and to withstand environmental forces such as wind and earthquakes.

Metal Cable-Stayed Bridges

The length of bridges with large spans, unfavorable dynamic characteristics, and the adverse shapes of the stiffness beam cross-sections necessitated a re-evaluation of traditional methods for designing engineering structures. This shift brought attention to issues that previously received less consideration.

For this type of bridge, the main types of loads include, along with their own weight (static), temporary dynamic loads: moving vehicles, wind, and seismic forces. However, for conventional structures, wind load played a secondary role, and thus, its impact on the strength and reliability of the structure received little attention.

It was only after the famous 1940 Tacoma Narrows Bridge collapse in the United States that the issues of the stability and strength of bridges and flexible systems, in general, in relation to wind loads were given proper attention. This bridge, with a main span of 854 meters, resisted strong winds well but was found to be highly sensitive to relatively weak winds, which initially caught researchers' attention. The study by N.

Bowers on the bridge's span with an H-shaped cross-section in an aerodynamic tunnel showed the structure's low aerodynamic stability. Consequently, measures were developed to enhance the bridge's stability, but nature did not allow researchers to complete their work. The bridge collapsed, leading to intensive investigations into the causes of the failure, which transitioned into the search for a satisfactory physical model of flexible systems.

Cable-stayed bridges, such as the "Golden Gate Bridge" in San Francisco and the "Brooklyn Bridge" in New York, are renowned examples of this technology. The use of cables allows for the coverage of large distances without intermediate supports, making these bridges both efficient and visually appealing.

Advantages of Cable-Stayed Structures

Structural Flexibility: These structures are designed to withstand dynamic loads such as wind and seismic activity, ensuring high durability and safety.

Material Efficiency: Cables require less material compared to traditional rigid structures, making them lightweight and cost-effective while maintaining high strength.

Economic Benefits: Reduced material costs and simplified construction processes contribute to overall project savings, making cable-stayed designs a cost-effective choice for many projects.

Aesthetic Appeal: The modern appearance of cable-stayed structures enhances their aesthetic appeal.

Suspended Structures

Suspended structures are roofs where the main elements of the load-bearing structures work under tension. In most suspended roofs, the primary load-bearing element is a cable—made from high-strength wire twisted into a strand. When using cable strands or rebar rods, the system is called a suspended structure with flexible stays.

Types of Supporting Structures:

- Curved columns and pylons
- Frames and stands
- Bound supporting contours

Single-ring systems with radial stays can also be used for rectangular roofs. For this purpose, a support ring with a suspended membrane is attached with additional stays to the corner supports of the rectangular support contour.

Suspended Structures:

Bay Bridge

The bridge between San Francisco and Oakland (also known as the Bay Bridge) is a suspended bridge that connects the cities of San Francisco and Oakland. Construction began on July 9, 1933, and was completed on November 12, 1936. The bridge is divided into two parts: the western suspension section (2,822 meters) and the eastern cantilever section (3,101 meters), connected by Yerba Buena Island. To connect both parts of the bridge, a 23-meter tunnel was constructed on Yerba Buena Island.

Ataturk Bridge

The first bridge over the Bosphorus Strait connects the Asian and European parts of Istanbul. The bridge is 1,560 meters long and 33 meters wide. Construction began in 1950 and it was opened in 1973.

Millau Viaduct

One of the most beautiful and the tallest cable-stayed bridge in the world is the Millau Viaduct, which connects the southern part of France to the Tarn Valley. Its highest point is 343 meters above sea level. The Millau Viaduct was built in three years and opened in 2004. Crossing this bridge gives everyone an impression of infinity due to the small radius of the viaduct's curves and its virtually transparent 3-meter high guardrail.

Octávio Frias de Oliveira Bridge

In Brazil, the only bridge in the world with an X-shaped support is the Octávio Frias de Oliveira Bridge. Due to the unique shape of its pylons, 138 meters high, the powerful 144 steel cables, and excellent LED lighting, the Oliveira Bridge has become one of the symbols of São Paulo.

Modern Cable-Stayed and Suspended Structures in Georgia:

"Bridge on River Managa"

"Vepkhi Da Mokme Suspended Bridge" is a vulture. It connects Vashlijvari's new road with Samtredia Street. Its source will have the shape of King Erekle II's sword.

Similarly, **the Bridge, connecting Bagi and University Street**, is a pedestrian bridge whose author is our famous scientist Gogi Kartsivadze.

In conclusion, Examples of Georgian and cultural constructions discussed by us will show us the main spheres of application of these types of constructions, the transition from traditional methods and the exploration of such issues on the previous plan, which previously received less attention, and the pursuit of new technologies in the construction of small-scale constructions and their advantages in modernity."

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Complex analysis AD systematic assessment of the Aragvi River catchment basin (Mtskheta-Mtianrti Municipality),

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Georgian Technical University

Abstract: The Aragvi River catchment basin in the Mtskheta-Mtianeti Municipality of Georgia is a region of significant ecological, hydrological, and socio-economic importance. This study presents a comprehensive analysis and systematic assessment of the basin, integrating hydrological data, environmental parameters, and socio-economic factors. Through extensive field measurements and remote sensing data, we examined the river's hydrodynamics, sediment transport, water quality, and land use patterns. The assessment identified key environmental pressures, including deforestation, agricultural runoff, and urbanization, which impact water quality and biodiversity. Hydrological modeling revealed critical areas prone to flooding and erosion, emphasizing the need for sustainable water management practices. Socio-economic analysis underscored the river's role in local livelihoods, highlighting the dependence of communities on water resources for agriculture and domestic use. The findings advocate for integrated watershed management strategies, promoting ecological restoration, sustainable agriculture, and community engagement to enhance the resilience of the Aragvi River catchment basin. This study provides a foundation for policymaking and planning aimed at balancing

environmental conservation with socio-economic development in the region.

Keywords: Catchment Basin, Hydrological Modeling, Environmental Assessment, GIS Technologies, Digital Elevation Model (DEM)

Introduction

The Aragvi River catchment basin in the Mtskheta-Mtianeti Municipality of Georgia is critical for both ecological balance and local livelihoods. This study aims to conduct a comprehensive analysis of the basin's hydrology, sediment transport, water quality, and land use. By using field measurements, remote sensing, and hydrological models, we will identify key environmental challenges such as deforestation, pollution from agriculture, and urban development. Additionally, the socio-economic reliance of communities on the river for agriculture and domestic needs will be examined. The goal is to provide insights that will aid in the development of sustainable management practices to protect and enhance the basin's ecological and socio-economic health.

Study Area

The Aragvi River is located in the Mtskheta-Mtianeti region of eastern Georgia and includes the historical-geographical provinces of Khevi, Ertso-Tianeti, Pshavi, Khevsureti, Mtiuleti, Gudamakari, and partially Ksniskhevi. It is bordered by the republics of the Russian Federation: North Ossetia, Ingushetia, and Chechnya in the north; the

Kakheti region in the east; Kvemo Kartli in the south; and Shida Kartli in the west. The administrative center of the district is Mtskheta.

In the lowland part of the Mtskheta-Mtianeti side, the weather is moderately humid with cold winters and long, hot summers. The average annual temperature is 11°C, and in January it is below 0°C. In the mountains, there is humid highland air devoid of a real summer, and above 3300–3400 m, there is highland air with excessive snow and glaciers. On the mountain ridges, the air is relatively cool. The climate in the mid-mountain zone is rather humid, with moderately cold winters and long, warm summers.

The Aragvi feeds on groundwater, rain, and snow, as well as glaciers and permafrost. Groundwater accounts for 40-70% of the annual runoff in different parts of the river, while rainwater and snow water separately reach 16-30%. Flooding begins in spring and lasts until mid-August, with frequent floods in autumn. There is little water in winter. It is 39.3% of the Aragvi River, 30.8% in summer, 19.5% in autumn, and 10.4% in winter. The river does not freeze.

The Mukhran-Saguramo plain is dominated by alluvial carbonate and meadow brown soils. Brown meadow soils are also present on the Mtkvarispira plain and in the foothills of the northern slope of the Trialeti range. Forest brown soils are also widespread. On the ridges of Skhaltbi, Saguramo, and Trialeti, you can find forest soil. The river terraces are dominated by alluvial loamy carbonate soil.

Forests and bushes occupy only 17% of the entire territory of the municipality. However, the flora is diverse. The municipality includes the Jageklian steppe with forest elements such as Shavjaga, Grakla, Dzedzvi, Georgian almond, and Bersela. The slopes of the Saguramo Ridge are covered with deciduous (oak, alder, and beech) forests. There are also relict Kolkhi elements: sycamore, ivy, and boxwood. In the lower part of the northern slope of the Skhaltbi ridge, there is an oak forest and a beech forest in the high Adils. The forest on the southern slope of the Skhaltbi range is invaded by vegetation of the Kolkhi flora (Tagvisara). On the northern slope of the Armazi range, there is an arid, bright forest where mostly juniper thrives. On the slopes of the Lis ridge, we find groves of artificial forest (mostly pine). Above the river Digmiskali, there is a spruce forest. On the banks of the Aragvi lowland, oak, willow, poplar, and elm flourish. The Saguramo nature reserve is also rich in flora, with more than 50 species of trees and shrubs, including hornbeam, beech, elm, oak, panta, and others.

The zone is spread over the territory of the region, with about 40% in the northwest and northeast. Atmospheric precipitation is 300-500 mm in the cold period and 800-1000 mm in the warm period. In the middle part of the region and relatively small in the northwestern part, the sum of atmospheric precipitation is 400-500 mm in the cold period and 600-800 mm in the warm period. To the west, south, and southeast of the region, the sum of atmospheric precipitation averages 150-300 mm in the cold period and 400-700 mm in the warm period. In the southwestern part of the region, the amount of atmospheric precipitation is 120-180 mm in the cold period (November-March) and 390-500 mm in the warm period (April-October).

Fig.1. Mtskheta-Mtianrti Municipality

Methodology and Results

Based on the research, we have studied the Aragvi River catchment area in detail using GIS technologies. The 90 m resolution DEM (coordinate system D_WGS_1984) obtained from the SRTM (Shuttle Radar Topographic Mission) of the region was used for modeling, based on which the hydrological characteristics of the Aragvi River catchment were determined.

To delineate the boundaries of the Aragvi River catchment, a digital relief model (DEM) was processed using the ArcGIS 10.8.2 tool - Hydrology. At the first stage, the DEM file was processed with the "Fill" (Hydrology - Fill) tool to correct the local depressions and elevations. The purpose of this is to eliminate the relief errors, ensuring an accurate representation of catchment basins and surface runoff. [1, 2].

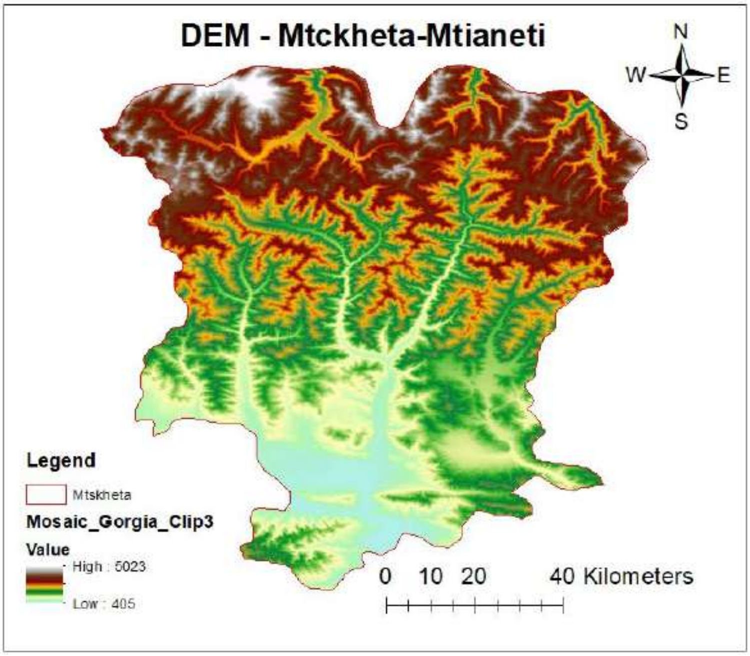


Fig.2. Digital Elevation Model of Mtskheta-Mtaineti Municipality

After eliminating the defects, to obtain the hydrological characteristics of the surface, the flow direction (Hydrology – Flow Direction) was determined. The Flow Direction tool includes three flow modeling algorithms: the D8, Multiple Flow Direction (MFD), and D-Infinity (DINF) methods. In our case, the D8 method was used. Each cell of the flow direction raster carries information about the flow direction.

Based on this, surface runoff and river basin contours are calculated. Raster cells take one of nine possible values [3, 4, 5] (Figure 3), and Figure 4 shows the flow direction.

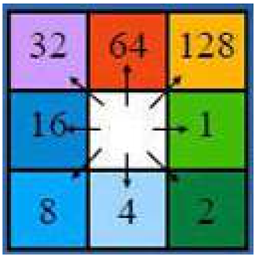


Fig. 3. Coding of flow direction

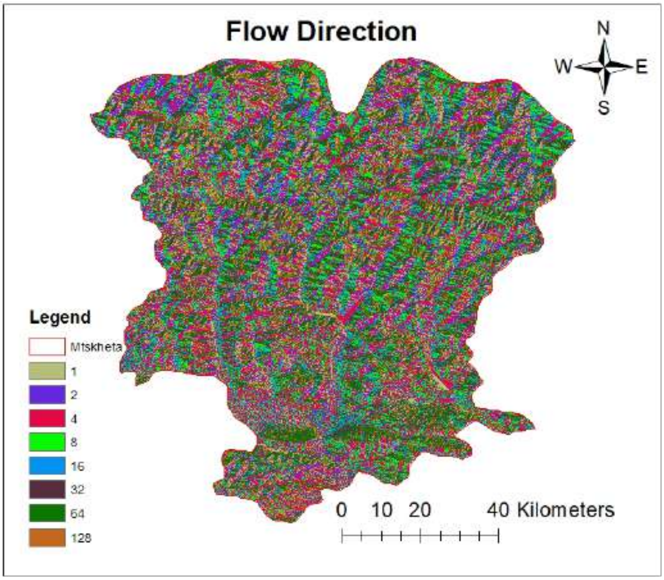


Fig. 4. The direction of the surface runoff of the Aragvi River catchment basin

The further task of the research is to determine the surface runoff accumulation zones in the catchment basin, the river network, and its parameters. For this, we use the hydrology tool. To get the final result, the following calculations were made:

1. Determination of flow accumulation zones (Flow Accumulation). These zones are classified under the condition that "Flow_Accumulation.tif" > 1200.

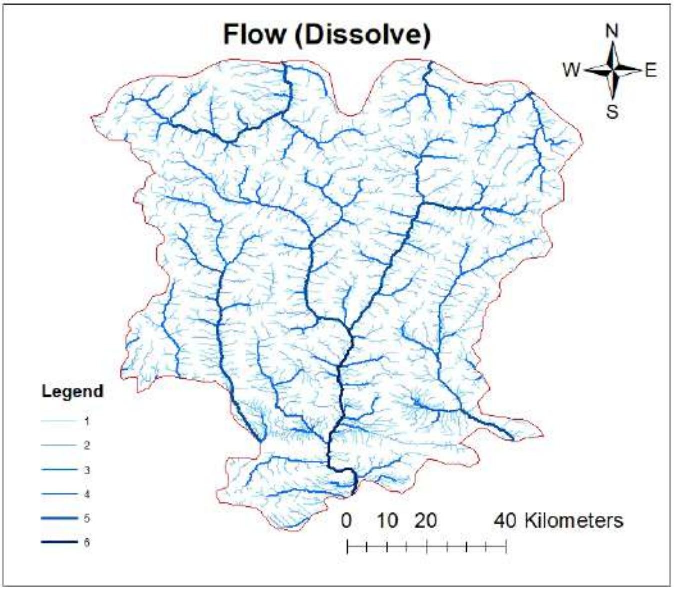
2. Determination of the stream order (Stream Order).

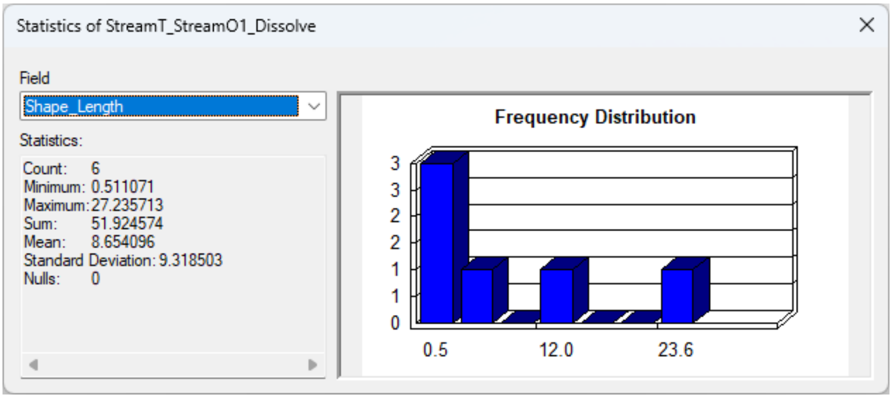
We used Strahler's method, developed in 1952. This method implies that the order of flows increases only if the intersection of flows of the same order occurs. Accordingly, after combining the first and second-order segments, the second-order flow is obtained, not the third order.

3. Conversion of received results to raster (Stream to Feature) and classification.

Figure 5 shows the hydrographic network of Mtskheta-Mtianeti municipality, and Figure 6 shows the classification of streams according to water abundance.

Based on the DEM analysis and using Strahler's method, the hydrographic network formed by the surface runoff in the Mtskheta-Mtianeti municipality is classified into six ranks according to water abundance. The total length of the first row (the smallest tributaries) is 27,236 km; the second - 13,248 km; the third - 6.5815 km; the fourth - 2.3324 km; the fifth - 2.0162 km; and the sixth most watery section - 0.511071 km. The total length of the Aragvi River and its tributaries is 51.9249 km.





It should be noted that in order to identify water erosion centers in the Aragvi River basin and to develop appropriate anti-erosion engineering measures, a detailed study of the basin's soils, relief, green surface, and climatic conditions is necessary.

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Gravitational Field of a Large Mass

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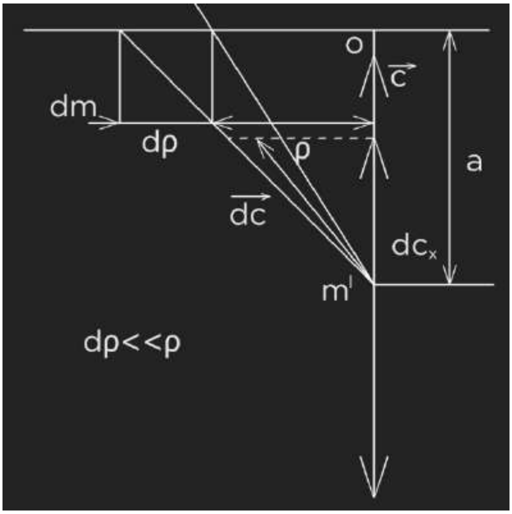
Abstract: The text explores gravitational interaction in a spherical system with uniformly distributed mass μ\muμ. It discusses the force acting on point A at distance D from the mass, considering the gravitational force per unit area μ\muμ.

Main Part

Topics include differential area dmdmdm, density gradient of the field dρdρdρ, force balance in the X direction, and an analogy with Earth's gravitational force and its division into spherical panels for analysis. It shows that the center of gravity of the outer spherical layers is concentrated at the center of the sphere, explaining the concentration of mass mmm at its center.

The conclusion examines changes in integration limits for different spherical regions, confirming conclusions about equilibrium and mass distribution in the system.

the entire mass of this object μ is uniformly distributed. We need to find the force acting on a point A at distance D from this mass, considering the gravitational force per unit area μ. dm is the differential area of the surface of the mass, and let's calculate the force of gravity acting between dm and m^'. dρ is the density gradient of the field, not exceeding the distance ρ, and not more than (ρ + dρ) from the point O.



I In a gravitational field of large magnitude

$\overrightarrow{dc}$=$G\frac{dm-m^{'}}{r^3}\vec{r}$ $\quad m^{'}=1 \quad$ $\overrightarrow{dc}$=$G\frac{dm}{r^3}\vec{r}$

These forces are balanced among themselves and result in equilibrium in the X direction

dc_x= $G\frac{dmr_x}{r^3}$= $G\frac{dma}{r^3}$

Let's calculate the area of the circle,

$S_{რგ} = \pi\rho \times d\rho$ ხოლო $dm = \mu 2\pi\rho d\rho$

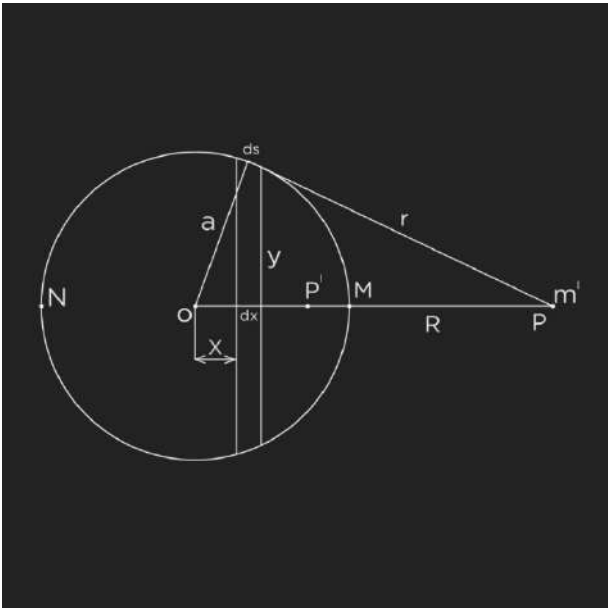
$r^2 = \rho^2 + a^2$ let's differentiate $2rdr = 2\rho d\rho + 0;\ rdr = \rho d\rho$

$dc_x = G\mu 2\pi\rho d\rho\frac{a}{r^3} = G\mu 2\pi dr\frac{a}{r^2} = G\mu 2\pi dr\frac{a}{r^2}$ let's integrate

$$C_x = 2\pi\mu Ga\int_a^\infty \frac{dr}{r^2} = 2\pi G\mu a\left(\frac{1}{a} - \frac{1}{8}\right) = 2\pi G\mu$$

It turns out that the force is not dependent on the position P relative to the direction of this inexplicable result. Let's try to solve this situation: Instead of an infinite substance, we have a cone whose surface area increases proportionally with ρ, meaning its mass increases in square law, while the force acting on P decreases in square law, keeping the total the same. True to this inexplicable result.

II **immense space**



Let's assume the entire sphere's symmetry. It's known that the force by which the Earth attracts objects on its surface or higher up is uniformly distributed as a vector towards its center, and two-point forces attract each other. This unity requires a thorough understanding. To achieve this, let's divide the Earth into smaller spherical panels. Let the mass of the entire sphere be denoted as 'm'. Now, let's calculate the distance 'R' outside the sphere's center. (To simplify the problem, it is more convenient to operate with scalar dimensions). Now, let's consider a small section 'dx' along the sphere's equator, with its center 'x' distance from the sphere's center.

Then, the total force 'dm' on 'dx' is uniformly distributed along the sphere's radius, and 'r' is the distance from point 'P' on the sphere's surface.

$$dw = -G\frac{m^{'}dm}{r};$$

$$dm = 2\pi y ds\mu = \frac{2\pi y\mu dx}{sin0} = \frac{2\pi y\mu dxa}{y} = 2\pi a\mu dx$$

Where μ is the surface gravity $\mu = m/4\pi a^2$

$$dw = -\frac{Gm^{'}dm}{r} = -\frac{Gm^{'}2\pi a\mu dx}{r}$$

We can write from the drawing $r^2 = y^2 + (R - x)^2 = y^2 + x^2 + R^2 - 2Rx = a^2 + R^2 - 2Rx$

let's differentiate

$$2rdr = 0 + 0 - 2Rdx$$

$$rdr = -Rdx$$

$$\frac{dx}{r} = \frac{dr}{R}$$

$$dw = -\frac{Gm^{'}2\pi a\mu}{R}\int_{R-a}^{R+a} dr = -\frac{Gm^{'}2\pi a\mu}{R}(R + a - R + a)$$

$$= -\frac{Gm^{'}4\pi\mu a^2}{R} = -\frac{Gm^{'}(4\pi a^2\mu)}{R} = -\frac{Gm^{'}m}{R}$$

Let's proceed to show that the center of gravity of one of the outer spherical layers is concentrated at the center of the sphere; the same will be true for the other layers, thus it is already clear why the mass mmm is concentrated at the center of the sphere If we consider point p, the limits of integration change between the spheres: from M, it is distanced by $(a+R)$ and from N, it is distanced by $(a-R)$ Therefore

$$\boldsymbol{dw = -\frac{Gm^{'}2\pi a\mu}{R}\int_{a-R}^{a+R} dr = -\frac{Gm^{'}2\pi a\mu}{R}(a+R-a+R) = Gm^{'}4\pi a\mu}$$

$$\boldsymbol{= -\frac{Gm^{'}m}{a} = const}$$

Since the space inside the Earth is equipotential, we come to the following conclusion: the gravitational field compensates itself, or the object is in a state of weightlessness.

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Risk Engineering: New Technologies

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Abstract: Civil security remains a significant challenge in the modern world. Various types of disasters pose substantial threats to contemporary society. Risk engineering and innovative technologies play an essential role in mitigating these threats. This article aims to discuss how modern innovative technologies can be used to reduce risks caused by disasters.

Risk Engineering

Risk engineering is an interdisciplinary field that combines knowledge from various domains, such as engineering, management, economics, and more, to assess and reduce risks. Its primary goal is to manage unforeseen events and minimize their consequences. Risk engineering includes various methods and tools that assist in prediction and prevention, such as statistical analysis, modeling, and simulation.

In other words, risk engineering helps organizations identify, assess, and manage potential risks, preventing disasters and reducing their impact. This can include technical, financial, organizational, and social risks.

New Technologies for Risk Reduction, Sensors and Early Warning Systems

Sensors and early warning systems play a critical role in disaster risk management. The use of sensors enables the timely and accurate detection of signs of natural disasters. For example, earthquake sensors located in seismically active zones allow for timely warnings about imminent earthquakes. Similarly, flood monitoring systems with sensors ensure timely data collection and warnings.

Japan - Earthquake Early Warning System

Japan has established a wide network of seismic sensors that allow for timely warnings about the onset of an earthquake. This system significantly reduces the potential damage and number of casualties.

Drones and Satellite Technologies

Drones and satellite technologies play an essential role in assessing damaged infrastructure and conducting search and rescue operations. Drones can be used for quick and detailed assessment of damage in disaster zones, aiding rescue teams in better planning and executing operations. Satellite technologies, on the other hand, provide large-scale data collection, assisting in disaster prediction and monitoring.

United States - Use of Drones during Hurricane Harvey

During Hurricane Harvey, drones were used for rapid and detailed assessment of damaged infrastructure and the population's condition, aiding rescue operations.

Internet of Things (IoT)

IoT (Internet of Things) technologies, such as smart sensors, enable real-time data collection and transmission, improving disaster risk management. Smart sensors can be placed on various critical infrastructures, such as bridges, buildings, and roads, to continuously monitor their condition and respond quickly to changes.

Blockchain

Blockchain is an innovative technology that ensures data security and management. Blockchain technology can enhance data protection and guarantee its immutability, which is particularly important in disaster risk management. Blockchain can be used for secure and transparent data sharing among different organizations, promoting better coordination and information exchange.

BIM (Building Information Modeling) and its Role in Risk Engineering

Building Information Modeling (BIM) is a modern tool that helps identify and manage risks in construction and infrastructure projects through detailed modeling. The use of BIM allows for the early detection of potential problems and risks, ensuring safety and sustainability.

BIM can detect conflicts between different systems (e.g., structural, and mechanical systems) early on, preventing waste of time and resources and quality issues.

BIM provides 3D modeling and visualization of a project, aiding in identifying potential problems and predicting hazards.

BIM also has capabilities for 4D and 5D modeling.

Time Management (4D BIM)

Animation of the construction process over time helps control and predict project stages.

Cost Management (5D BIM)

Predicting and controlling costs at various stages of the project, reducing the risk of budget overruns.

BIM is a powerful tool that significantly improves risk identification, assessment, and management in construction projects. Its use ensures better communication and coordination, cost and time management, quality improvement, and ecological sustainability. As a result, projects are executed more efficiently, safely, and sustainably, ensuring success and high-quality outcomes.

Implementing and using modern technologies in disaster risk management involves certain challenges, including financial, technological, and organizational issues. It is essential for countries and organizations to continue investing in these technologies and support innovative research and development. Future perspectives include new initiatives aimed at creating more effective and sustainable solutions.

Overall, the use of innovative technologies in risk engineering and disaster risk management plays a crucial role in ensuring the safety of modern society. Sensors, drones, IoT, and blockchain help identify, monitor, and manage risks, while BIM ensures the sustainability of projects and infrastructure. The implementation and development of these technologies are necessary to reduce the impact of disasters and improve society's preparedness and response.

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Sky-High Dreams: The Most Fascinating Unbuilt and Built Skyscrapers of the World

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Abstract: This article investigates the domain of architectural innovation, examining both unrealized and actualized skyscraper projects. The analysis focuses on the grandiose visions and engineering prowess behind some of the most ambitious unbuilt structures, as well as the technical and aesthetic achievements of the tallest completed buildings. By juxtaposing these projects, the article illuminates the limitless potential of human creativity and the relentless pursuit of architectural excellence.

Keywords: Skyscraper construction, urban skyline, megatall skyscrapers, urbanization, vertical cities, sustainable construction, high-rise design, modern urban landscape, iconic architecture, tall structures, landmark buildings, structural engineering.

Introduction

Since their inception in the late 19th century, skyscrapers have not only addressed urban density challenges but also captivated imaginations with their towering presence akin to modern-day pyramids. Much like these ancient marvels, skyscrapers stand as testaments to human ingenuity and ambition, pushing the boundaries of architectural possibility. This article delves into the origins of skyscrapers, tracing their evolution from functional solutions to urban growth to becoming symbols of technological prowess and artistic achievement in city skylines worldwide.

The main part

Burj Khalifa, completed in 2010, stands at 828 meters as the tallest building globally, a pinnacle of modern engineering and architectural innovation. Designed by Skidmore, Owings & Merrill LLP (SOM), it features a distinctive tapered design clad in reflective glass and constructed primarily of reinforced concrete. Inspired by traditional Islamic architecture and the desert flower hymenocallis, its stepped form reduces wind forces while enhancing aesthetic appeal.

Fig.1. Burj Khalifa

Engineering challenges included managing unprecedented loads, designing a robust foundation, and implementing advanced technologies for sustainability. The structural system, a buttressed core and perimeter tube, ensures stability against Dubai's winds and seismic activity. Burj

Khalifa's impact extends beyond its height, setting new standards in high-rise design and inspiring future architectural achievements worldwide.

Shanghai Tower, completed in 2015, stands at 632 meters, making it the second tallest building in the world. Designed by Gensler, this architectural marvel showcases a distinctive spiraling form that reduces wind loads and enhances structural stability. Its double-skin façade improves energy efficiency, while the sleek glass exterior symbolizes modernity and progress.

Fig.2. Shanghai Tower

Constructed with a composite of high-strength concrete and steel, Shanghai Tower incorporates cutting-edge engineering solutions. The tower's foundation system includes deep piles and a thick mat foundation to support its immense weight. Advanced dampers counteract wind and seismic forces, ensuring stability and safety.

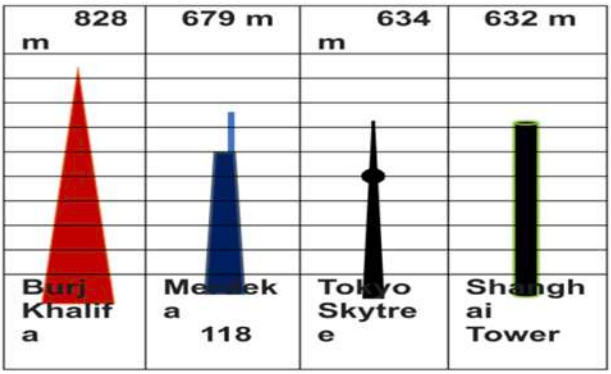
Merdeka 118 is a skyscraper in Kuala Lumpur, Malaysia, reaching a height of 644 meters with 118 floors. Constructed with a reinforced concrete core and a steel frame, its facade is made of glass and steel panels. The project, developed by Permodalan Nasional Berhad (PNB) and designed by Fender Katsalidis Architects, began in 2016 and was completed in 2022. The design of Merdeka 118 is inspired by the hand gesture of Malaysia’s declaration of independence, symbolizing progress and unity. The building serves multiple purposes, including commercial offices, residential units, a hotel, and an observation deck. It stands near historic sites like Stadium Merdeka and Stadium Negara, further enhancing its cultural significance.

Fig.3. Merdeka 118

Tokyo Skytree is a broadcasting and observation tower in Tokyo, Japan, standing at 634 meters tall. Constructed with a steel frame, its structure incorporates seismic proofing to withstand earthquakes. The project, developed by Tobu Railway and a group of six broadcasting companies led by NHK, began in 2008 and was completed in 2012. Designed by architect Tetsuo Tsuchiya, Tokyo Skytree's architectural style blends futuristic elements with traditional Japanese aesthetics. The tower serves as a broadcasting tower, with observation decks offering panoramic views of Tokyo, and houses restaurants and shops, making it a major tourist attraction.

Fig.4. Tokyo Skytree

Skyscraper Comparison Diagram



The X-Seed 4000: A Visionary Skyscraper

The X-Seed 4000, designed by Taisei Corporation in 1995, is a conceptual skyscraper aimed to be the tallest building ever, at 4,000 meters (13,123 feet). Its massive 6,000-meter (19,685 feet) wide base would provide stability, allowing it to house up to 1 million people. This self-contained vertical city would feature residences, offices, shops, schools, hospitals, and recreational facilities.

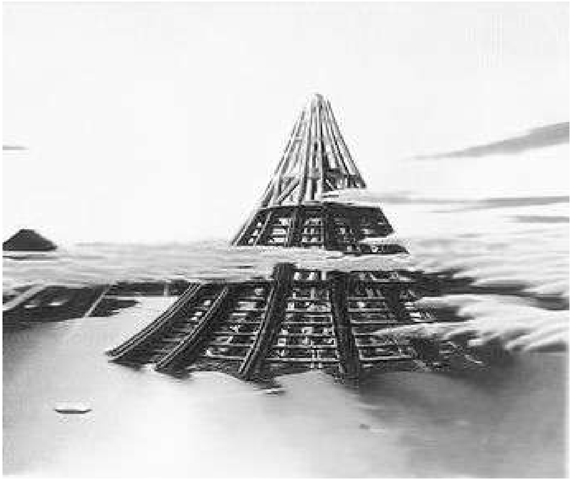


Fig.5. *X-Seed 400*

Emphasizing sustainability, the X-Seed 4000 would incorporate renewable energy sources and advanced transportation systems. Despite its ambitious design, it remains unbuilt due to financial and technological challenges. Nonetheless, it stands as a symbol of future architectural and engineering possibilities.

Palace of the Soviets: Materials and Construction

The Palace of the Soviets was envisioned as a grand skyscraper and a symbol of Soviet power and progress. It was planned to be built on the site of the demolished Cathedral of Christ the Saviour in Moscow. The project, developed in the 1930s, required the use of several key materials for its construction.

The core structure of the Palace of the Soviets was to be a robust steel frame. Steel was chosen for its strength and flexibility, essential for supporting the massive building and withstanding external forces like wind and seismic activity.

Concrete was to be used for the main structural elements, including the foundations, columns, and floor slabs. It provided additional fire resistance and sound insulation, crucial for a building of this size.

The exterior of the building was to be clad in various stone materials such as marble and granite. These materials would give the palace a majestic appearance and ensure its durability.

Various metal alloys were to be used for decorative elements and ornaments. This included the statue of Lenin that was to crown the building and other architectural decorations.

Fig.6. The Palace of the Soviets

The Palace of the Soviets project incorporated many advanced engineering solutions of its time. These included heating and ventilation systems, water supply and sewage systems, and complex electrical wiring. Special attention was given to the safety and comfort of accommodating a large number of people within the building.

Although the Palace of the Soviets was never built, its project remains a vivid example of the ambitious architectural plans of the Soviet Union. It demonstrates how the advanced materials and engineering solutions of the time could have been used to create one of the most grandiose buildings in the world.

The Shimizu Mega-City Pyramid is an ambitious and unbuilt architectural project designed by the Shimizu Corporation. It was envisioned as a massive pyramid structure standing at 2,004 meters (6,574 feet) tall, capable of housing up to one million people. The pyramid's design included residential, commercial, and recreational spaces, making it a self-sufficient city.

Constructing the pyramid would require advanced materials like carbon fiber to support its immense weight and structural stresses. The framework would consist of megatrusses, supporting numerous smaller buildings within the pyramid. The design also incorporated renewable energy sources such as solar and wind power, aiming to minimize environmental impact and promote vertical living.

Despite its groundbreaking design, the project faces significant challenges, including technological and financial constraints. Current engineering practices and materials technology are not yet advanced enough to make the project feasible. Additionally, the social and logistical aspects of housing a million people within a single structure pose complex problems.

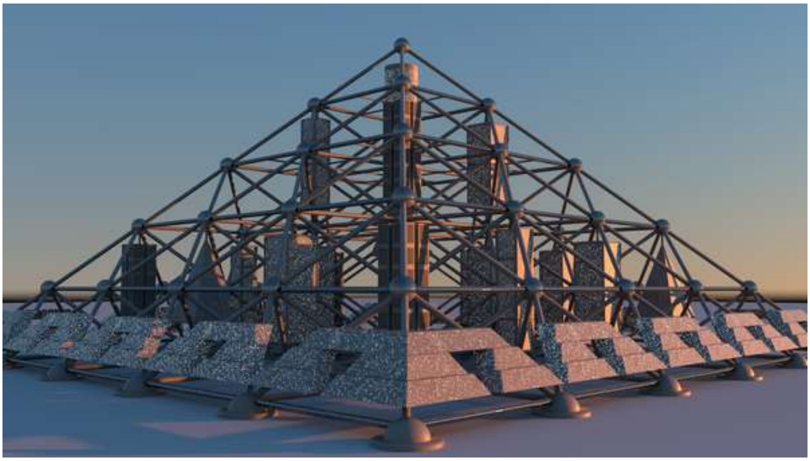


Fig.7. The Shimizu Mega-City Pyramid

Though it remains unbuilt, the Shimizu Mega-City Pyramid has influenced architectural and urban planning discussions, inspiring creative solutions for overpopulation, resource management, and sustainable living.

Conclusion

Skyscrapers stand as iconic symbols of human achievement, blending architectural innovation with engineering prowess to reach staggering heights and reshape urban landscapes. They not only house thriving communities and bustling businesses but also serve as testaments to our aspirations for vertical living and sustainable urban development. As cities grow denser and land becomes scarcer, skyscrapers offer solutions to accommodate expanding populations while conserving valuable resources. With each new skyscraper, we push the boundaries of what is possible, forging ahead into a future where towering heights and sustainable design coexist harmoniously in our ever-evolving cities.

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A System of Stable Equilibrium in a Conservative Force Field. Location Survey by Two Methods

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Abstract: The topic of the report is the definition of system sustainability. In the field of construction, it is necessary to use two methods that give us an accurate answer about both stability and support reactions. All this is necessary to avoid further complications.

One problem is considered, in which the location of stability equilibrium and reaction forces are solved.

I. Introduction

As we know from analytical mechanics of mechanical system The equilibrium condition with a generalized coordinate has the following form $Q_j=0$, $j=1,2,\ldots,s$

The state of equilibrium can be stable, unstable and indiscriminate.

A position of equilibrium is called stable when the points of the mechanical system leaving this position move in the vicinity of their equilibrium position under the influence of force (fig. 1,A).

Unstable is a position of equilibrium from which, when the points of the system are slightly deviated, the acting force will move the points further away from the position of equilibrium. (fig.1,B).

Indiscriminate is the equilibrium position of the system in such a way that with any small displacement of a point of the system from this position to a new position, the system remains in equilibrium at the new position. (fig. 1, C).

A) B) C)

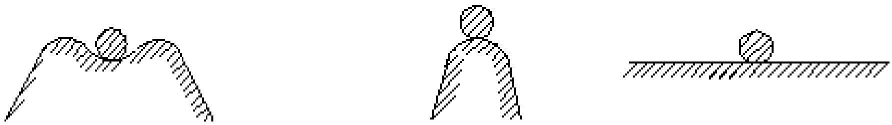

Fig. 1. A) The equilibrium of the ball is stable, **B)** The equilibrium of the ball is unstable, **C)** The equilibrium of the ball is indiscriminate

The location of the stable equilibrium can be determined by the Lagrange-Dirichlet theorem.

Theorem: If the system is in a conservative force field and the potential energy of the system at the equilibrium position has a minimum, then the equilibrium position is stable.

In the case of a stationary force field, the potential energy Π of a system with one degree of freedom is a function of the generalized coordinate, i.e.

$$\Pi = \Pi(q). \tag{1}$$

Any of the generalized coordinate $q*$ At the value of, this function has a minimum if

$$\left(\frac{\partial^2 \Pi}{\partial q^2}\right)_{q*} > 0 \tag{2}$$

(2) The representation is called the Lagrange-Dirichlet criterion for the equilibrium state of the mechanical system in a conservative field.

According to this theorem, to prove that the equilibrium location of a conservative system is stable, it is enough to make sure that the potential energy has a minimum at this location.

Thus, the necessary condition for the existence of a minimum for a system with one degree of freedom is formulated as follows: the derivative of the second order of the potential energy with the generalized coordinate in the equilibrium position must be positive. i.e.

$$C_{11} = \left(\frac{\partial^2 \Pi}{\partial q^2} \right)_0 > 0 . \tag{3}$$

Therefore, the stability criteria for a system with one degree of freedom will have the following form:

$$C_{11} = \left(\frac{\partial^2 \Pi}{\partial q^2} \right)_0 \begin{cases} < 0 \\ > 0 \end{cases}$$

II. systems with two degrees of freedom potential energy

Consider a mechanical system with two degrees of freedom, whose potential energy is $\Pi = \Pi(q_1, q_2)$, where q_1, q_2- are generalized coordinates that determine the location of the system at each moment in time.

Let's say a system is in equilibrium at some location and its potential energy at that location is zero:

$$\Pi_0 = \Pi(0.0)=0. \tag{4}$$

From analytical mechanics we know that in the equilibrium location q_1 and q_2 all generalized forces corresponding to generalized coordinates are equal to zero, i.e. $Q_1=0$; $Q_2=0$. Accordingly, if the system is in the conservative force field, then we have:

$$\frac{\partial \Pi}{\partial q_2}=0 \; \frac{\partial \Pi}{\partial q_1}=0\,. \tag{5}$$

Let's break down the potential energy according to Macleron's row q_1, q_2-s As a row of numbers:

$$\Pi(q_1,q_2)=\Pi(0,0)+\left(\frac{\partial \Pi}{\partial q_1}\right)_0\cdot q_1+\left(\frac{\partial \Pi}{\partial q_2}\right)_0\cdot q_2+$$

$$+\frac{1}{2}\left[\left(\frac{\partial^2 \Pi}{\partial q_1^2}\right)_0\cdot q_1^2+\left(\frac{\partial^2 \Pi}{\partial q_1 \partial q_2}\right)_0\cdot q_1 q_2+\left(\frac{\partial^2 \Pi}{\partial q_2^2}\right)_0\cdot q_2^2\right]+\cdots \tag{6}$$

Here, the square brackets are followed by dots q_1, q_2-s towards high-ranking members.

In 6), the first summation according to (4) is equal to zero. also q_1, q_2-s The coefficients are also equal to zero in the equilibrium position according to equations (5). Therefore, (6) will take the following form:

$$\Pi=\frac{1}{2}\left[\left(\frac{\partial^2 \Pi}{\partial q_1^2}\right)_0\cdot q_1^2+2\left(\frac{\partial^2 \Pi}{\partial q_1 \partial q_2}\right)_0\cdot q_1 q_2+\left(\frac{\partial^2 \Pi}{\partial q_2^2}\right)\cdot q_2^2\right]+\cdots\,. \tag{7}$$

Now let's denote the coefficients of the members of the second degree as follows:

$$C_{12}=\left(\frac{\partial^2 \Pi}{\partial q_1\cdot \partial q_2}\right)_0. \tag{8}$$

These coefficients are called generalized stiffness coefficients, which are calculated at the equilibrium location when $q_1=q_2=0$, therefore all C_{12}-is a constant number, and they are symmetric.

$$C_{12} = C_{21}. \tag{9}$$

If we consider the notes made, we get potential energy q_1 and q_2-s Expand the following formula in terms of degrees:

$$\Pi = \frac{1}{2}(C_{11}q_1^2 + 2\,C_{12}q_1q_2 + C_{22}q_2^2) + \ldots \tag{10}$$

where the higher-order terms are denoted by dots.

III. Lagrange-Dirichlet theorems and Sylvestri's criteria On stability of equilibrium of systems

Assume that the resulting quadratic form is positive definite. In this case, in the vicinity of equilibrium $q_1=q_2= 0$, The squared part of the potential energy and the total potential energy will be positive. because $\Pi(0,0)=0$, Therefore, the potential energy will have a minimum at this location and, therefore, this location of equilibrium will be stable according to the Lagrange-Dirichlet theorem. **Theorem: if a conservative mechanical system obeys ideal and stationary bonds and its potential energy can be minimized in the state of equilibrium, then this state of equilibrium is stable.**

For the quadratic part of the potential energy, we have the following Sylvester theorem: in order for the quadratic form to be positive definite, it is necessary and sufficient that all the main diagonal minors of the matrix of the quadratic form are positive.

(10)-s A square matrix and its main diagonal minors are written as follows:

$$M = \begin{Vmatrix} C_{11} & C_{12} \\ C_{21} & C_{22} \end{Vmatrix}, \tag{11}$$

$$\Delta_1 = C_{11}, \quad \Delta_1 = \begin{vmatrix} C_{11} & C_{12} \\ C_{21} & C_{22} \end{vmatrix} \ . \tag{12}$$

Thus, Sylvester's criteria determining the positivity of (12) will have the following form:

$$\Delta_1 = C_{11} > 0 \ , \ \Delta_2 = \begin{vmatrix} C_{11} & C_{12} \\ C_{21} & C_{22} \end{vmatrix} > 0 \, . \tag{13}$$

Now we can see the sequence of using the Lagrange-Dirichlet theorem for a system with two degrees of freedom: we need to expand the potential energy q_1,q_2-s as a row of degrees and limit ourselves to the members of the second row, let's define C_{ij} Generalized stiffness coefficients and form (13) minors. if all $\Delta_i > 0$, Then the equilibrium location is stable.

The Lagrange-Dirichlet theorem only gives us a necessary condition for the stable equilibrium of a conservative system, but it does not provide any basis for comparing whether the system is stable or unstable in the equilibrium position, if the potential energy in this position does not have minima. In this case, the following Lyapunov theorem gives the answer: The equilibrium location of a conservative system is unstable if we decompose the potential energy into a row and there are no minima in the equilibrium location for its second-order members.

IV. A system with one degree of freedom is stable. Determination of equilibrium by two methods

It is often necessary to determine the location of stable equilibrium of building structures. It is impossible to investigate this actual issue under the conditions of static equilibrium. Therefore, we use the extreme values of the potential energy of the system in the conservative force field to solve the problem.

For example, if a conservative force field with one degree of freedom is required P Deduction of the stable equilibrium location of a uniform weight pole, i.e. When the aim of the study is to determine the position of possible stable equilibrium of the pole and to calculate the reactions of the supports in this position. In this case, the possible location of the stable equilibrium can be investigated by two methods: 1) by the theory of oscillations (using potential energy) and 2) by static equilibrium conditions.

By solving the problem with two methods, it is established that the first method directly gives the location of the stable equilibrium of the system, but with this method we cannot determine the reactions of the supports. With the second method, the equilibrium position of the system is determined and the reactions are calculated, but it cannot be estimated whether this position of the system equilibrium is stable or unstable (see problem).

Therefore, when designing building structures and lifting machines, it is necessary to investigate and evaluate the necessary and sufficient conditions for the location of the stable equilibrium of the system, taking into account the operating loads.

Consider a specific problem for a system with one degree of freedom that is in a conservative gravity force field. The possible location of equilibrium can be defined in two ways: 1) based on the oscillatory theory (using potential energy) and 2) static equilibrium equations.

Problem. P A uniform prismatic pole of weight, which I dissected α m It is a square with a side of length, with its smooth sides resting on two parallels in the same plane A and B Tsibo, the distance between which b m-s It is equal to that $b < \sqrt{2}a$ (fig. 2,a).

The goal of the problem is to find the position of possible stable equilibrium of the pole and the reactions of the supports corresponding to this position. Determine the conditions for the location of equilibrium. We will also compare and analyze the discussed methods.

solution. To solve the problem, we will find the equilibrium location of a system with one degree of freedom, the location of which is determined at each moment of time q with a generalized coordinate.

From analytical mechanics, we know that the force corresponding to the generalized coordinate at the equilibrium position is zero. Therefore, for a system with one degree of freedom, according to (3.8) we have

$$Q = -\frac{\partial \Pi}{\partial q} = 0\,, \tag{14}$$

where $Q-$ is a generalized force; $\Pi = \Pi(q)$ potential energy.

After expanding the potential energy of a system with one degree of freedom into a Macleron row, we get:

$$\Pi = \frac{1}{2}\left[\left(\frac{\partial^2 \Pi}{\partial q_1^2}\right)_0 \cdot q_1^2\right]. \tag{15}$$

Let's introduce the notation:

$$C_{11} = \left(\frac{\partial^2 \Pi}{\partial q^w}\right)_0 . \tag{16}$$

here C_{11} The coefficient is a constant number and is called the generalized stiffness coefficient.

If the considered system with one degree of freedom is in a conservative force field, then the necessary condition for the stability of the equilibrium of the system is determined by the following theorem of Lagrange-Dirichlet: **If the system is in a conservative force field and the potential energy of the system at the equilibrium location has a minimum, then the equilibrium location is stable.**

According to this theorem, to prove that the equilibrium location of a conservative system is stable, it is enough to make sure that the potential energy has a minimum at this location.

Thus, the necessary condition for the existence of a minimum for a system with one degree of freedom is formulated as follows: the derivative of the second order of the potential energy with the generalized coordinate in the equilibrium position must be positive. i.e.

$$C_{11} = \left(\frac{\partial^2 \Pi}{\partial q^2}\right)_0 > 0 . \tag{17}$$

Consider the equilibrium of a prismatic pole in a conservative gravitational force field. Let's remove the supports in the imagination and change their action $\vec{R}_A$ and $\vec{R}_B$ with reactions (fig. 2.,b).

Let's choose between the diagonal and vertical of the pole as a generalized coordinate $q = \theta$ The angle that determines the position of the pole (fig. 2.,b).

Let's find it AB Horizontal circle and gravity C between the center h the distance:

$$h = \frac{a}{\sqrt{2}}\cos\theta - b\sin\theta_0\cos\theta_0$$

So

$$h = \frac{a}{\sqrt{2}}\cos\theta - \frac{1}{2}b\sin 2\theta_0 . \tag{18}$$

θ_0 Let's show the angle generalized θ at an angle.fig 2,b

$$\theta_0 + \theta = \frac{\pi}{4} \Rightarrow \theta_4 = \frac{\pi}{4} - \theta ; \quad 2\theta_0 = \frac{\pi}{2} - 2\theta .$$

(18)- We will have from

$$h = \frac{a}{\sqrt{2}}\cos\theta - \frac{b}{2}\cos 2\theta . \tag{19}$$

The potential energy of the force of gravity is equal to

$$\Pi = Ph = P\left(\frac{a}{\sqrt{2}}\cos\theta - \frac{b}{2}\sin 2\theta\right). \tag{20}$$

Finding the derivative of the potential energy with θ and setting it equal to zero, we get:

$$\frac{1}{P}\cdot\frac{d\Pi}{d\theta} = \left(-\frac{a}{\sqrt{2}} + 2b\cos\theta\right)\cdot\sin\theta = 0 \ . \tag{21}$$

(21) It can be seen from the equation that two equilibrium positions of the pole are possible. The first location of equilibrium will be when $\sin\theta = 0$, so $\theta = 0$.

The second location of equilibrium will be when a) $-\frac{a}{\sqrt{2}} + 2b\cos\theta = 0$. This location of equilibrium is possible if $\cos\theta = \frac{a}{2\sqrt{2}b}$, b) This location of equilibrium is possible if

$$\frac{a}{2} < b\sqrt{2}. \tag{22}$$

a) b)

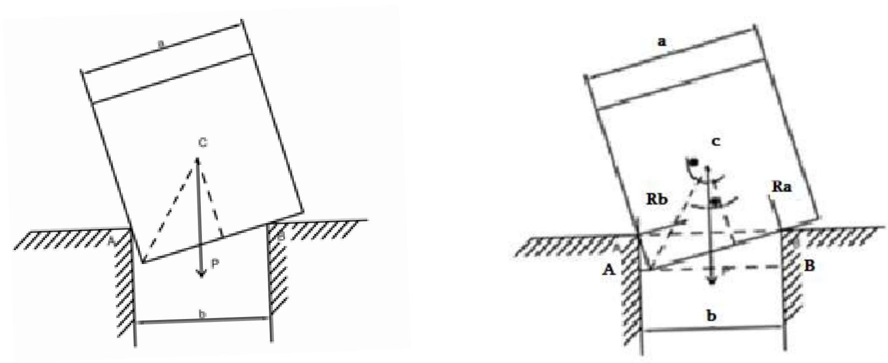

fig. 2

Now let's find the derivative of the second order:

$$\frac{1}{P}\frac{d^2\Pi}{d\theta^2} = -\frac{a}{\sqrt{2}}\cos\theta + 2b\cos 2\theta. \tag{23}$$

In order to solve the question of the location of a stable equilibrium, we need to determine for each possible equilibrium location $\frac{d^2\Pi}{d\theta^2}$ mark. In the first case $\theta = \theta_1 = 0$. If we insert this value into equation (23), we will have:

$$\frac{1}{\rho}\frac{d^2\Pi}{dt^2}\bigg|_{\theta_1=0} = -\frac{a}{\sqrt{2}} + 2b\,.$$

Therefore, according to the Lagrange-Dirible theorem, this equilibrium location is stable if

$$b > \frac{a}{2\sqrt{2}}\,,$$

Otherwise, this equilibrium location is unstable. In the second position of equilibrium

$$\theta = \theta_2 = \arccos\left(\frac{\sqrt{2}}{4}\cdot\frac{a}{b}\right).$$

$\theta_1 = \theta_2$ Enter the value of in equation (23).

$$\frac{1}{P}\frac{d^2\Pi}{d\theta^2} = \frac{1}{b}\left(\frac{a^2}{4} - 2b^2\right).$$

But according to (22). $\frac{a^2}{4} - 2b^2 < 0$. therefore,

$$\frac{1}{P}\frac{d^2\Pi}{d\theta^2} < 0\,,$$

i.e. $\theta = \theta_2$ According to the Lyapunov theorem, it is unstable in the location. An exception is the case when $\theta = 0$ and $\frac{a^2}{4} - 2b^2 = 0$, which corresponds to the first location of equilibrium.

The possible location of the equilibrium can be determined by another method. Let's compile three equations of static equilibrium for any location of the pole (Fig. 2, b) determined by the angle θ. we have

$$\sum F_x = R_A\cos\theta_0 - R_B\sin\theta_0 = 0\,, \tag{24}$$

$$\sum F_x = R_A \sin\theta_0 - R_B \cos\theta_0 - P = 0\,, \tag{25}$$

$$\sum M_A(F_k) = R_b \cdot b\cos\theta_0 - P\left(\frac{a}{\sqrt{2}}\sin\theta + b\sin^2\theta_0\right) = 0\,. \tag{26}$$

We find from equations (24) and (25).: $R_B = P\cos\theta$.

Putting this value in (26), we get:

$$b\cos 2\theta_0 - \frac{a}{\sqrt{2}}\sin\theta = 0\,,$$

$$b\cos 2\left(\frac{\pi}{4} - \theta\right) = \frac{a}{\sqrt{2}}\sin\theta = 0\,.$$

finally

$$\sin\theta\left(2b\cos\theta - \frac{a}{\sqrt{2}}\right) = 0\,.$$

from where we can find it θ Two values of the angle corresponding to the two equilibrium locations:

1. $\sin\theta = 0$, And therefore $\theta = \theta_1 = 0$;
2. $\cos\theta = \dfrac{\sqrt{2}a}{2b}$ And therefore $\theta = \theta_2 = \arccos\left(\dfrac{\sqrt{2}a}{4b}\right)$.

The first solution corresponds to the symmetrical location of the pole when its legs are inclined to the horizon 45°- angle.

The second solution is possible when $a < 2\sqrt{2}b$. when $a = 2\sqrt{2}b$, Then we will find it $\cos\theta_2 = 1$, ე.ი. $\sin\theta_2 = 0$, And we return to the first case.

Now find the reaction values for the first possible equilibrium location:

$$R_A = R_B = P\frac{\sqrt{2}}{2}.$$

For the second location of equilibrium

$$R_A = \frac{\sqrt{2}}{4b} \cdot \sqrt{4b^2 - a\sqrt{8b^2 - a^2}}.$$

$$R_A = \frac{1}{4b} \cdot (a + \sqrt{8b^2 - a^2})P.$$

From the comparison of solutions by both methods, it can be seen that the first method gives the equilibrium position of the system in a direct way and the nature of the equilibrium in this position, but with this method we cannot determine the reactions of the supports. The second method directly gives us the possible location of the equilibrium of the system and its corresponding reactions, but cannot estimate the location of the equilibrium of the system and the nature of the equilibrium state in this location.

How Taiwan's tallest skyscraper withstood the earthquake,

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Abstract: A 7.4 magnitude earthquake struck Taiwan on April 4, 2024, killing at least nine people and damaging 770 buildings; According to the island's National Fire Agency (NFA), it was the worst earthquake in Taiwan in the last 25 years. Buildings in the capital, Taipei, just 80 miles from the epicenter, also shook violently, but thanks to a triumph of modern engineering, Taipei 101 - once the world's tallest skyscraper - escaped the island's seismic event unscathed. Footage of the earthquake clearly shows the 508-meter-tall tower swaying slightly, its structural flexibility contributing to the earthquake's strong motion.

Keywords: magnitude, earthquake, damper, seismic.

Introduction

On April 4, 2024, a magnitude 7.4 earthquake struck Taiwan, killing at least nine people and damaging 770 buildings; It was Taiwan's worst earthquake in 25 years. However, thanks to a triumph of modern engineering, Taipei 101 - once the world's tallest skyscraper - emerged unscathed from the island's seismic event. Footage of the earthquake clearly shows the 508-meter-tall tower swaying slightly, its structural flexibility contributing to the earthquake's strong motion. Combining the compressive strength of concrete with the tensile strength of steel makes the building flexible enough to withstand vibrations and also rigid enough to withstand the strong winds and typhoons that are common in Taiwan. The principle that buildings can withstand seismic forces by moving harmoniously with them, not against them, has guided the traditional architecture of earthquake-prone East Asian countries for centuries.

Main part

The earthquake is mainly caused by tectonic processes. The center of the earthquake is the area of the earth's core, where the energy accumulated in the rocks for a long time is released. The strength of the earthquake is measured by the magnitude (total energy of the waves) and points. The size of the ball depends on the depth and magnitude of the hearth.

The Ring of Fire, also referred to as the Pacific Belt (Tectonic Belt of Volcanoes and Earthquakes), is a path across the Pacific Ocean characterized by active volcanoes and frequent earthquakes. Most of the Earth's volcanoes and earthquakes occur along the ring of fire (Fig. 1). It is about 40,000 km long and 500 km wide and surrounds most of the Pacific Ocean. About 90% of the world's earthquakes, including the largest earthquakes, occur within this belt.

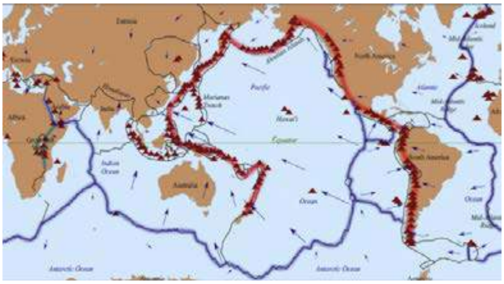

Fig. 1. Pacific Rim of Fire

General overview of earthquakes characteristic of Taiwan

Taiwan, located along the western Pacific seismic belt, is constantly under threat of earthquakes. According to Central Bureau of Meteorology (CBM) data from 1991-2006, about 18,500 seismic events occur every year, including 1,000 major earthquakes. On average, the entire population experiences 51 events per day, although most of them are shallow earthquakes at depths of 0-30 km. Most of Taiwan's earthquakes are caused by the island's geodynamic configuration, as well as the junction between the Philippine Sea and the Eurasian Plate to the east of the island. The topographic-bathymetric background map was made using GMT software (Fig. 2). Thick black lines indicate major subduction boundaries—the uplifted side with triangles; The Philippine Sea plate subducts northward beneath the Eurasian plate along the Ryukyu Trench east of Taiwan, and the Eurasian plate subducts eastward against the Philippine Sea plate south of the Manila Trench.

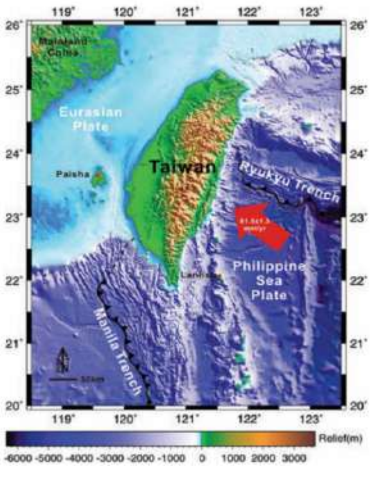

Fig. 2. The tectonic framework of Taiwan

In Fig. 2, the motion of the Philippine Sea plate relative to the China shelf is shown by the red arrow, with an azimuth of 306◦ ± 1◦ ◦ (rotation approx. 36° clockwise, northward from 305° to 307°) and a velocity of 81.5 ± 1.3 mmyr–1 (millimeters per year / ±1.3 + actual speed from 80.2 to 82.8 millimeters per year).

East of Taiwan, the Philippine Sea plate subducts beneath the Eurasian plate along the Ryukyu Trench (Fig. 3,b).

To the south, the South China Sea of the Eurasian Plate subducts eastward beneath the Philippine Sea Plate along the Manila Trench (Fig. 3.c). An active collision zone connects these active subduction systems (Fig. 3.d). The island can be considered as a product of collision and subduction processes (Fig. 3.d).

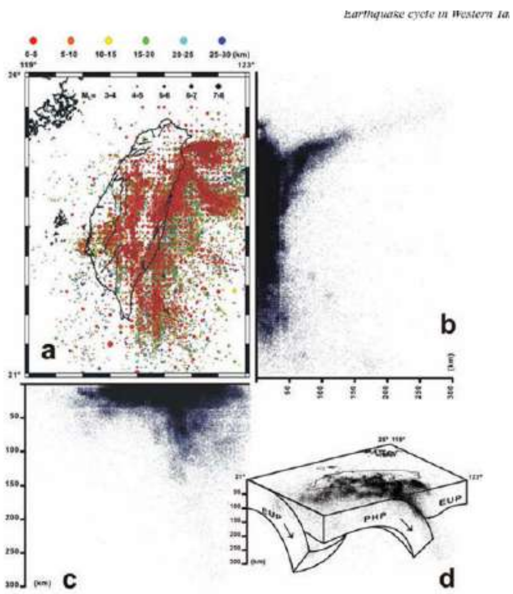

Fig.3.

Many of the earthquakes that occurred on the island were destructive or destructive in nature. 97 seismic events from 1900 to 2006 were classified as destructive, many of them having a magnitude greater than or equal to 5. The 1935 Taichung-Hsinchu earthquake (ML = 7.1, focal depth 5 km) caused the largest loss of life in Taiwan in the 20th century. Another important destructive earthquake was the 1999 Chi-Chi earthquake (ML = 7.3, focal depth 8 km).

In 1992, the Institute of Earth Sciences, Academia Sinica, launched the BATS (Broadband Array in Taiwan for Seismology) project; This has greatly contributed to seismotectonic research in Taiwan, as broadband seismographs are already capable of recording low-frequency seismic waves. The BATS network was designed with 15 permanent stations and 15 portable units covering an area of approximately 350 × 400 km. As a result, earthquake parameters are regularly evaluated in the Taiwan region...

How Taiwan's tallest skyscraper withstood the earthquake; The 580-meter-tall skyscraper is equipped with another technological innovation that reduces the overall sway of the building by 40 percent during earthquakes and wind. This is a 730-ton spherical device known as a "tuned mass/seismic damper". Suspended from 92 thick cables between the 87th and 92nd floors, the golden steel sphere can move about 5 feet in any direction. As a result, it acts like a giant pendulum that resists swinging. When the building moves in one direction, the steel sphere oscillates in the other direction, maintaining the overall balance of the building. If wind or earthquake forces push the tower to the right, the sphere will immediately create an equal force to the left, canceling the initial movement (Fig. 4);

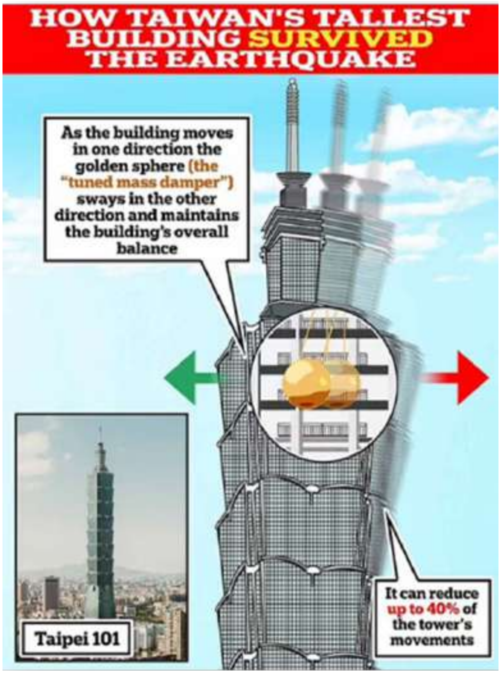

Fig.4.

The Taipei skyscraper has already witnessed a magnitude 7.1 earthquake during construction, as well as a Category 5 typhoon in 2015.

architectural features

The 101-story skyscraper combines modern, postmodern, and ancient Chinese architectural traditions. The repeated segments of the building remind us of the architectural rhythm of the "pagoda" (a tower that connects heaven and earth) common in Asia. The construction of the skyscraper consists of 8 sections, each of which consists of 25 floors (in

Chinese culture, the number 8 is associated with success and rebirth). The 101-story skyscraper has a complex structural system to withstand the harsh climatic conditions (typhoon winds and earthquakes) prevalent in eastern Taiwan. To reduce the movement of the building during strong winds and earthquakes, as well as to ensure the comfort of the residents, the project team designed a mass damper (custom mass/seismic mass damper) 730-ton pendulum located between the 87th and 92nd floors of the building. and helps reduce vibration caused by wind and earthquakes. The project team also used high-tech, energy-saving, thermally transparent glass materials and innovative lighting design to create a crystal-clear building. The facade consists of double-glazed green-glass curtain walls; Green glass is reflective in nature, blocks half of the solar radiation waves, and creates a very comfortable environment inside the building. Additionally, the building has several energy-saving systems such as rainwater harvesting and natural ventilation. The architectural model of the building is zoned on two different levels depending on its commercial requirements; The square-shaped complex is a shopping center building, and the tower structure occupies office space. Located on the 89th floor of the building is the observation deck, which is a popular tourist spot and offers visitors spectacular views of Taipei and the surrounding area. The tower's high-speed elevators take just 39 seconds to reach the observatory on the 89th floor. Depending on the current day of the week, the sections of the skyscraper are illuminated in the colors of the light spectrum, that is, each day corresponds to its color.

foundation system. Skyscraper foundation system consists of soft clay soil that vertically surrounds loose soil and has low load capacity. A 21-meter-deep basement and an 80-meter-deep solid foundation with concrete beams were arranged on the site to distribute the load of the structure. Construction of 1.2-meter thick and 47-meter deep diaphragm walls facilitated excavation work and foundation preparation below ground level. The foundation of the tower building has a 1.5 m diameter monolithic reinforced concrete slab-slab foundation; piers sunk into the ground 262 feet; 380 chimineas are inserted under the skyscraper, and 167 chimineas are placed under the podium; A continuous concrete slab transmits a point load. Each pier is 5 feet in diameter and can support 100-1450 tons. To transfer the load on the columns and walls, the piles were covered with concrete slabs from 3 to 4.7 meters high (Fig. 5).

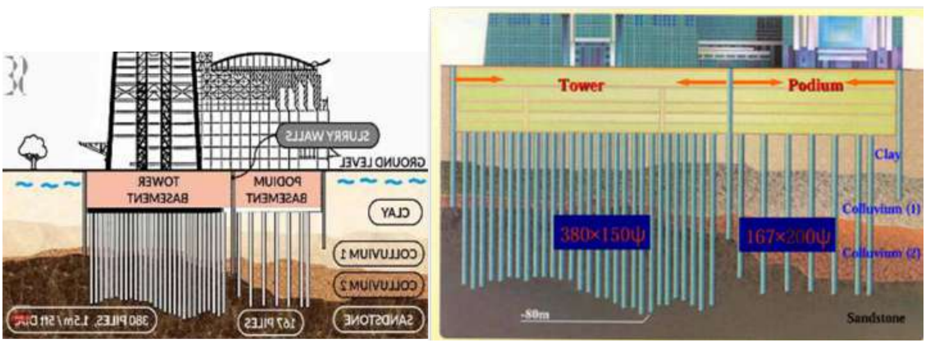

Fig.5.

constructive design. Taipei1O1 is considered an architectural and engineering marvel due to the technical innovations incorporated into the building to maintain structural stability in a disaster-prone and hazardous environment. The building is built 508 meters above the ground and resembles ancient pagodas. The structure of the skyscraper is a biomimicry of bamboo, light, flexible, and durable; Bamboo joints are the source of strength, which is repeated throughout the building in the form of braces and girders every 8 floors. The shape of the base module is a truncated pyramid, which resists lateral stiffness compared to cuboidal blocks; The floor consists of composite steel and 135 mm thick concrete. The steel used in 80 percent of the structure is 420 MPa strength, and the concrete strength is 70 MPa.

Taipei 1O1 experiences wind speeds of 156 km/h impacting the building due to the vortex of air masses (tornado), dislodging the winds, and generating alternative wind vortices that affect the facade. The building is designed in such a way that its sharp angle has a greater effect on the force of the wind, and the sawn edges of the building reduce the shear force of the wind on the facade. Lateral loading from earthquakes was another challenge, requiring a strong building core and perimeter columns (Fig. 6). The building has 8 "super columns" or "mega columns", which are steel boxes filled with high-strength concrete. Special steel clamps connect steel and concrete. The core of the structure allows the building to withstand a peak ground acceleration of 0.5 gravity. These types of calculations are used to design buildings or other structures to withstand earthquakes. PGA is calculated using the following formula: PGA = M * g * T^-0.5, where M is the mass of the structure, g (gravity) is the acceleration due to gravity, and T is the duration of the earthquake.

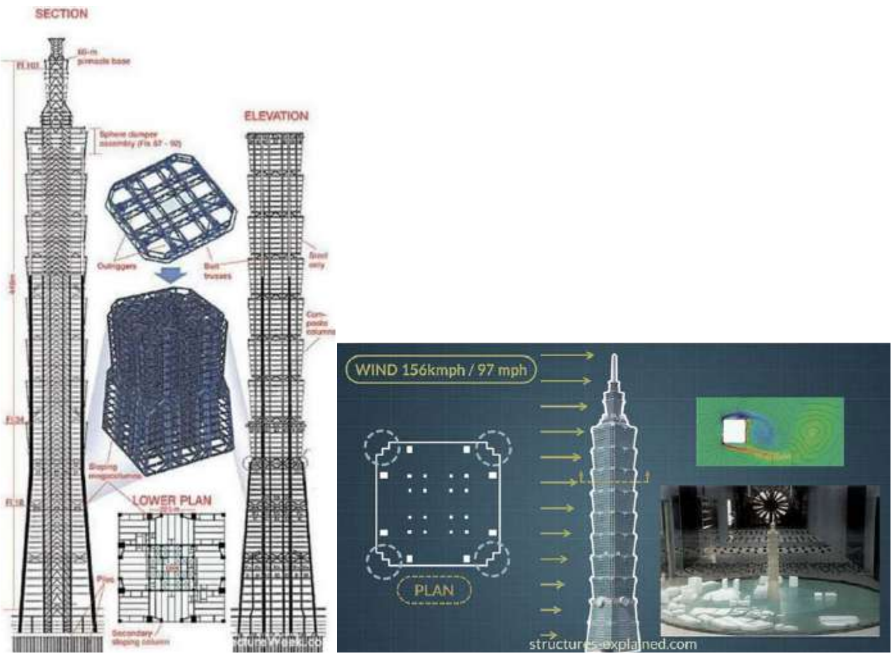

Fig.6.

The skyscraper's floor plan features box-shaped composite mega-columns arranged in four rows and supported by load-bearing frames between floors. The core of the perimeter consists of eight super-columns 3 meters long and 2.4 meters wide, made by welding 50 to 80 mm thick steel plates. The columns are present on the perimeter of the building, 2 units on each side, and control the vibrations, since the lower floors generate most of the vibrations due to the deflection rotation. The super columns were constructed up to level 90 of the tower and they were also filled with 69

MPa concrete below the basement level up to level 62. Internal cross braces prevent the column from buckling. Shear studs connect the concrete and steel, while rebar reinforces the concrete. Additional structural elements are also used in the building, namely supports and girders to protect the balance and to resist the turning forces. These girders connect the perimeter columns and are used to distribute tensile and compressive forces across a large number of exterior frame columns. Two-story girders are used below level 27 - on levels 9, 19, and 27, while girders on the upper floors are single-story; Each of the 8 floors is connected to the main perimeter columns by cross braces. This rack collects and transfers weight around the perimeter to two super pillars on each side. Two small buttresses connect the central columns of the core to the inclined I-shaped columns. In the building, supports were also used by fixing the floor girders vertically at every 8 floors, similar to bamboo joints. **Mass shock absorber (seismic mass damper).** Between the 86th and 92nd floors of the building, an inertial pendulum - known as a tuned mass/seismic mass damper - is installed; (TMD Tuned mass damper); Its weight is 730 tons, and its diameter is 6 meters. Anti-wind dampers reduce building sway during typhoons and improve occupant comfort during strong winds. This damper uses the movement of the building to push and push giant shock absorbers. When the building swings, the pendulum moves in the opposite direction. It is constructed of thick steel plates and weighs 0.24% of the total building weight. In 2015, a category 5 typhoon caused a record damper swing of 100 centimeters (Fig. 7). Two additional 7-ton dampers control the vibration of the 60-meter peak, which rises from 101 levels. In the event of an earthquake, the sudden shock blocks the pendulum to ensure safety during seismic events.

Fig.7.

Conclusion

Taipei 101 is a special building in the world of engineering and architecture. It has already proven time and time again that it is capable of handling any challenge that nature throws at it, and it will remain a symbol of seismic resilience for many years to come.

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Modern building materials and innovative technologies in construction

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Abstract: All economic entities associated with construction (scientific and design development firms, laboratories, construction materials production enterprises and construction organizations) are looking for solutions in terms of development, production and use of new building materials, constructions and technologies. All this leads to the improvement of the technical characteristics of construction objects, reduces operating costs during their use, and increases economic efficiency during the entire operation of the objects. New innovations are aimed at increasing the building's strength and durability, frost resistance, corrosion resistance and other parameters.

Introduction

Considering the current state of development of the construction industry, innovative solutions are most in demand. The prospects of working on new construction materials are evidenced by the fact that almost a quarter of inventions are in this field. This is confirmed by the changes in the division of construction materials markets, which is also related to the continuous growth of the purchasing power of households and the volume of residential and industrial buildings.

Main part

The development of construction technologies, the development and use of new construction materials are carried out in the following directions:

- Reduction of time and increase of profitability of construction;
- Reduction of material consumption and costs during construction, operation and repair,
- Increasing the durability of construction structures and buildings (structures and buildings) in general;
- Improvement of architectural forms, space planning and functional solutions and achievement of diversity, improvement of physical parameters of existing and built objects.

To fulfill these tasks, all economic entities associated with construction are looking for solutions in terms of development, production and use of new construction materials, constructions and technologies. In the end, this leads to the improvement of the technical characteristics of the construction objects, reduces the operating costs during their use and increases the economic efficiency during the entire operation of the objects.

New materials and constructions are used for the construction of all building components

Not so long ago, about 50 years ago, a new technology for protecting building walls appeared - "ventilated facades". The ventilated facade is a very complex construction consisting of an external screen, laths, air seam and thermal insulation layer. In addition, it is the air seam that is mandatory. Its main purpose is to drain condensate from the facade and create additional thermal insulation.

The most important advantages of using ventilated facade technology are:

>Protection of external structures of buildings from environmental influences (humidity and temperature drop);

> Giving buildings a beautiful and well-kept look;

> Creation of new architectural lines and color schemes of buildings: various finishing options and colors (ceramic - granite, composite, metal or other panels), heating of buildings and improvement of their thermal technical characteristics;

> Ease of installation of prefabricated elements (Fig. 1).

Fig. 1.

Modern ventilated facades

To protect buildings from environmental influences, there is an excellent modern technology - ventilated facades, which gives the most modern appearance to very old buildings and significantly extends the service life of each building! In addition, in the conditions of necessary energy saving, ventilated facades provide an additional layer of air or insulation that increases the thermal characteristics of buildings. As a result, the cost payback of a ventilated facade is 5-6 years, and 30-40 years of operation without repair, and, most importantly, the cost of such a facade is incomparably lower than the construction of a new damaged building.

Modern construction technologies do not stand still. New ways of creating the strongest structures are created every day in the world, completely new, sometimes very unusual materials. Here are some of them:

Smart Communications:

Fig. 2.

Like smartphones and smart TVs, elevators are becoming more technological. As skyscrapers continue to climb to more dizzying heights, elevator manufacturers have created elevators with new technical features designed to transport passengers safely and quickly.

So are smart highways, which involve using sensor technology to make traffic safer. Sensor technology provides drivers with information about traffic, parking, weather, etc., and also allows electric cars to generate energy, they are charged by streetlights for driving.

Conclusion

All the new building materials and technologies allow to speed up the pace of construction, reduce the cost and laboriousness, create materials and constructions with high technical characteristics, which will extend the life of the building.

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About the origin and development of the construction of railway rails

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Abstract: The article discusses the history of the origin and development of the construction of railway rails from the time of ancient Egypt to the present day. It is believed that the prototype of the modern railway track was wooden sleeper rails, which prevented the wheels of heavily loaded carts from sinking into the ground and allowed the mining of ore, coal, etc. smooth shipping. The use of angular and comb-shaped construction rails made the rolling stock more resistant to derailment. The article discusses the changes in the shape and geometric dimensions of the rails over the years.

Keywords: broad footed, deterioration rail, I-beam, rail, rail supports, rolling of the rails. switch, wheel flange.

Introduction

A rail is a metal pole with an original cross-section, located on multiple supports, on which rail transport moves. During the construction of the pyramids in ancient Egypt, wooden pulleys were used to transport heavy loads. In ancient Rome, and in medieval mines, man-made wooden bed rails have been found.

Main part

From the 13th century, the track gauge was used in many mines and shafts, as well as in the construction of military fortifications. At first, the carts were moved by hand, and later they began to be driven by horses.

A sleeper road is a track made of longitudinal wooden stakes that are driven or buried at ground level. The study of this type of track made it possible to create an idea about the feasibility of the construction, which consists of longitudinal load-bearing sleepers and transverse ones, which connected the sleepers at a certain necessary distance from each other. Then they started to lay rounded beds, and grooves appeared on the wheels of carts (Fig.1).

The sleepers not only performed the function of direction, but also took the main load on themselves. In 1630, in the New Castle coal mine, a bed road with longitudinal beds of rectangular section was built (Fig.2). It consisted of longitudinal wooden posts connected to each other by transverse posts every 0.6 m.

The space between the posts was filled with gravel or gravel. This type of gauge was equipped with simple arrow transducers. Four-wheeled carts moved with loads using horse traction along longitudinal poles. Such longitudinal poles wore out quickly.

From the beginning, the detorated wooden poles were covered with planks, and later the longitudinal poles were covered with iron strips.

The origin of the iron strip rail is explained by the desire to protect wooden elements from the direct impact and wear (Fig. 3). With the laying of metal strips, the demand for horses was significantly reduced.

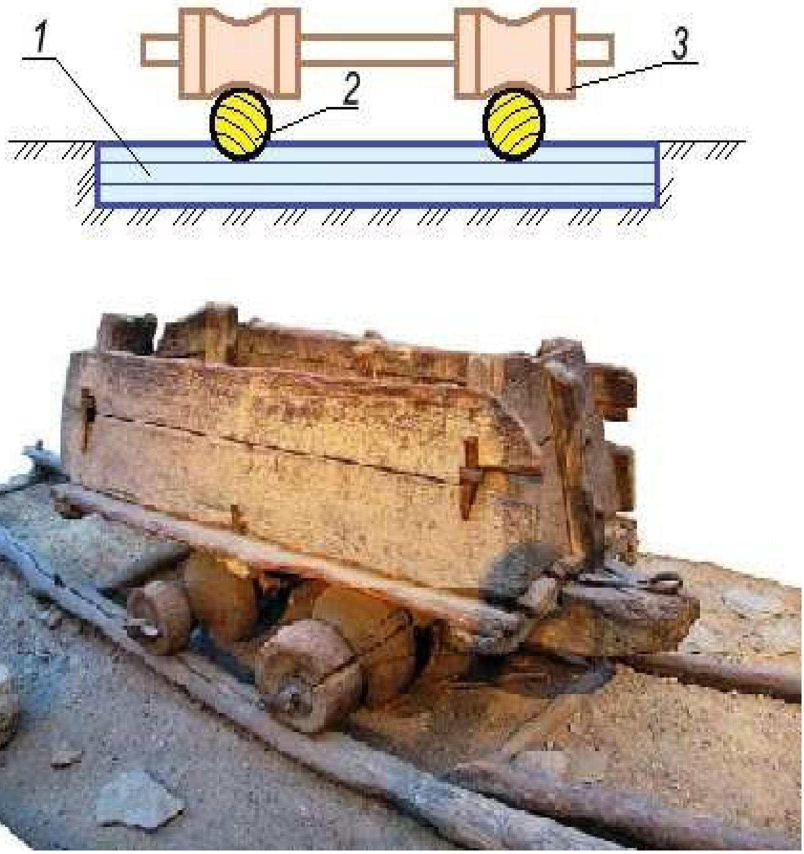


Fig.1. A rounded shape rail supports

1 – transverse pole; 2 – rail support; 3 – A pair of grooved cart eyes.

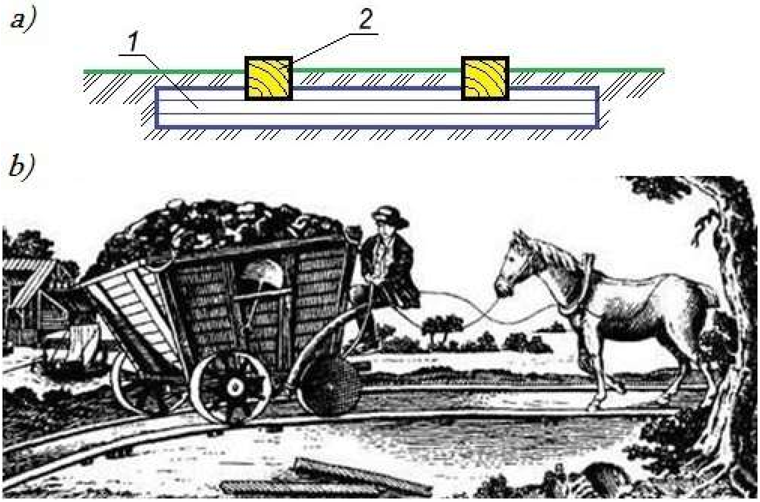


Fig.2. Rectangular support without cover
ა) scheme, ბ) Mockup; 1 – transverse pole; 2 – rail support.

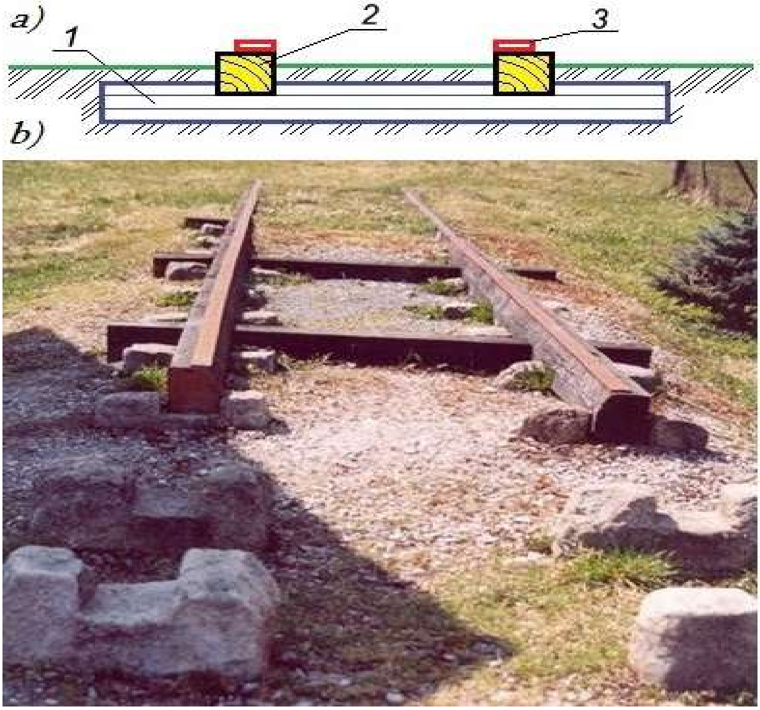


Fig.3. Rectangular rail support with iron coating a) scheme, b) mockup
1 – Transverse pole; 2 – Rail support; 3 – cast iron plate

Thanks to the metal coating, conditions were created to replace the wooden wheels of the cart with more durable cast iron wheels. Due to the flat section of the iron strips, there was also a significant inconvenience: the flat surface of the rolling was quickly thrown by loose cargo and soil, which caused a delay in the process of transportation, and also the absence of grooves on the metal strips caused the wheels of the cart to fall into the track. In 1767, R. Reynolds made special grooved (or comb-shaped) cast-iron rails (Fig.4) for covering longitudinal wooden posts.

Reynolds rails had the shape of the Latin letter "U" in cross-section. Grooved rails were attached to longitudinal wooden posts with three nails. Grooved recesses gave direction to the eye of the cart. This type of rail greatly reduced the resistance to movement, but did not guarantee derailment of the cart wheels due to the low edges and the difficulty of keeping the groove clean. This construction can be considered as the first iron rail.

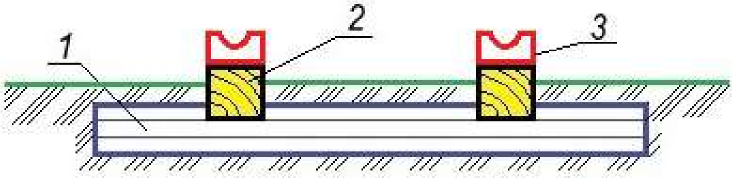


Fig.4. Rectangular section sleepers with grooved cast iron Reynolds rails: 1 – Transverse pole; 2 – Rail supports; 3 – grooved Reynolds rails

In 1776, for the construction of a new railway on the coal mines in Sheffield, they began to use angular cast iron rails (Fig.5). The angle was originally attached to the longitudinal beams of the tree. Then they started laying the rails on wooden crossbars or on separate stone supports. Construction significantly reduced labor costs.

The angular rail construction protects the carts from falling into the tracks but does not solve the problem of the rails getting dirty. To eliminate this shortcoming, the construction of high rails was developed, which required a special rolling stock with chemical beads. V. Jessop developed the construction of mushroom-shaped rails (Fig.6), which were laid in England in 1789. The rail had a well-defined head with a vertical ridge below. Holes were made on the base of the rail, so the rails were attached to the supports by means of brackets. Jessop rails were laid on stone supports. The width of the rolling surface of the new rail head was 44.5 mm, the height was 95 mm, and the length varied from 914 mm to 1219 mm. Thanks to these technical features, the rails have become more reliable in terms of traffic safety. Another advantage of Jessop's invention was the self-cleaning of the rail. Dirt and foreign objects did not stick to the surface of the rail head.

Due to the fragility of cast iron, high rails often broke. Therefore, at the beginning of the 19th century, they preferred to lay angular rails on wooden beds.

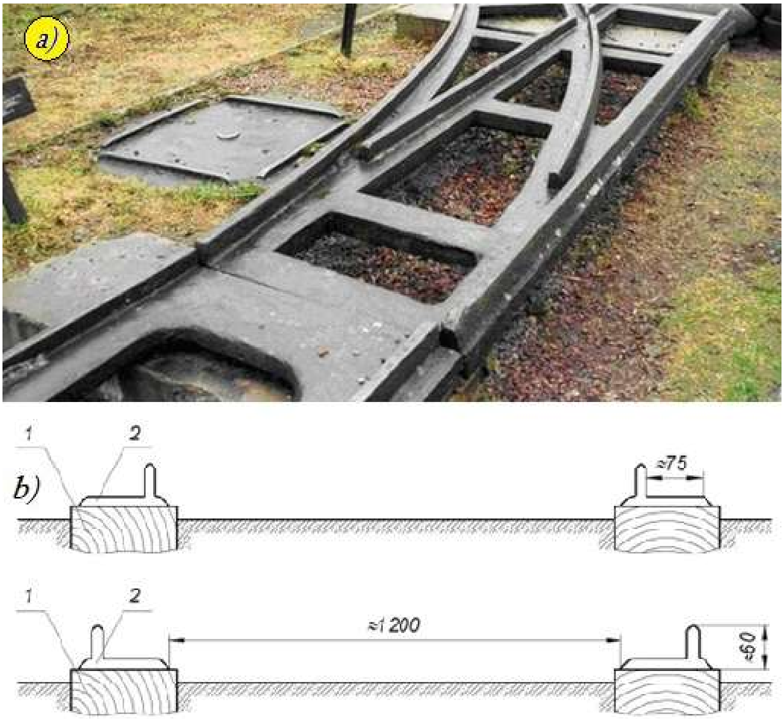


Fig.5. Angular shaped cast iron rails: a) Mockup, b) Scheme,
1 – Rail support; 2 - cast iron plate

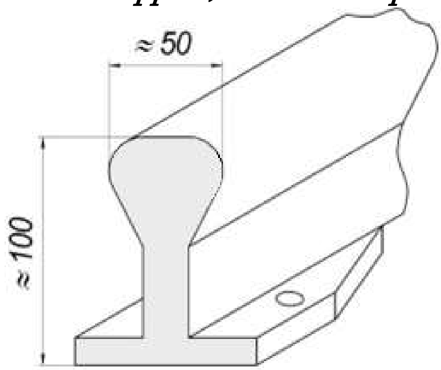
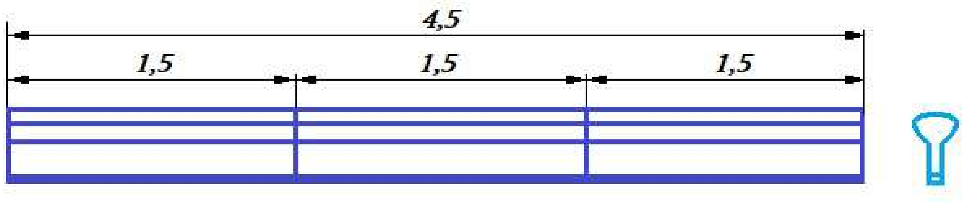


Fig.6. Mushroom shaped high iron Rail

There have been many attempts to perfect cast iron rails. Since 1779, they began to produce rails with a variable height of the rail, thus achieving an equal resistance outline of the pole. Such rails resembled a fish and were often referred to in the literature as "fish belly".

In 1820, J. Birkinshaw (England) invented the method of rolling the iron profile, which made it possible to increase the length of the rails by about 4 times. Originally, rolled iron rails were attached to the pads and supports of older structures, it was necessary to cut out part of the rib, which gave the rail a coil shape with equal resistance in each section. Such "wavy" rails (Fig.7) were laid for the first time on a public railway in England, but due to the high cost of processing, the use of "wavy" rails was refused.



Fif. 7. Iro "wavy" Rails

Thanks to the emergence of steam traction and the intensive development of steam locomotives, the load on the axle increased, the characteristics and working conditions of the rail changed, the choice of its profile and dimensions changed, which led to a new stage in the development of its construction.

A rail can be thought of as a coil that rests on multiple supports. The best form of bending coil is the Ortes coil, which is based on the transverse profile of the rail.

Since the rolling surface of the rail head is bent not only by bending but also by wear, the main mass of the metal was concentrated (with wear stock) in the upper part (head) of the Ortes coil rather than in the base.

The desire to use the rail itself (in case of wear of the upper part) of the lower part of the Ortes coil led to the creation of a double-headed rail (Fig. 8). The double-headed rail was used in England in 1835 by J. Stephenson during the construction of the first English railway and is known in the literature as Stephenson's rail. However, the idea could not be implemented, because during the operation, along with the wear of the upper part of the rail, deposits appeared on the lower part of the rail in the places of support, and the rail became unsuitable for reuse.

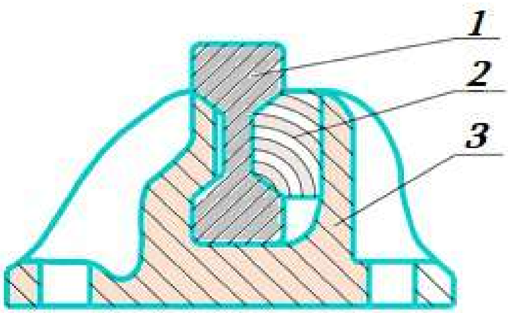


Fig.8. Double headed Rail
1 – Double headed Rail ; 2 – wooden wedge; 3 – Support

The origin of the wide base rail (Fig. 9) was determined by the desire to simplify the method of laying rails. Such a rail was proposed by the American engineer R. by Stevens in 1830. Since 1832, thanks to the engineer Vignoles, the rail of this construction has been widely distributed in Europe under the name of Vignoles.

The wide-base rail consists of three main parts: head (1), base (3) and throat (2). The distribution of the area of the rail profile allows to fully use the advantages of the Ortes coil as a coil construction. The rail base made it possible to lay the rails directly on the sleepers, without using special "pillows".

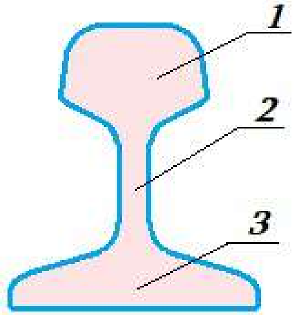


Fig.9. cross-section of broad footed rail

The use of cast iron as the main material made it possible to create a modern track construction - a rail laid on sleepers. In the process of operation, the advantages of area-based rails were revealed.

In 1866, experimental areas with steel rails were laid on European railways. One long meter of rails weighed about 30 kg and was 5.4 m long. Currently, P50 and P65 type rails are mainly used in Georgia, and European UIC60 type rails are used in a small section. The numbers used in the designation indicate the approximate weight in kilograms of one longitudinal meter of rail.

Long rails up to 150 meters in length are currently being made in different countries of the world. To obtain direct rails, the rails are welded together. Figure #10 shows the evolution of rails from 1767 to the present day.

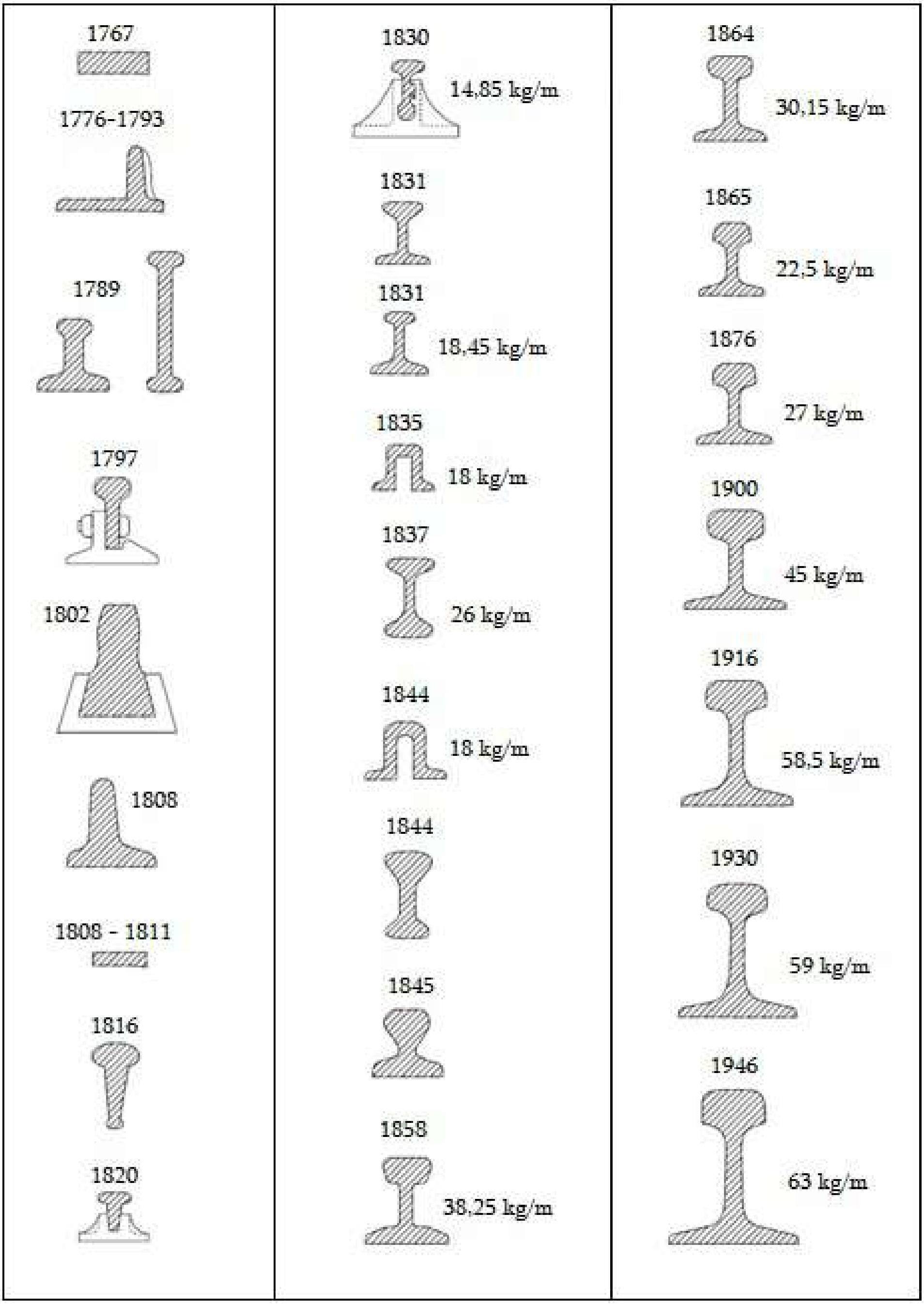


Fig.10. Changes in the shape and geometric dimensions of the rails over the years

Conclusion

Changing the round profile of the sleeper rail to a rectangular section and installing metal strips on its working surface, and then an angular profile, made it possible to significantly increase the durability of the sleeper rail and reduce the frequency of derailment of carts.

The study of the history of the development of the transverse profile of the rails made it possible to determine that the most efficient use of the section of the Ortesian coil, with the difference that the main mass of the metal was placed in the rounded head of the rail, and in order to increase stability, the base of the rail was widened, which reduced the load on the sleepers. In order to increase the strength of the rail, easily brittle cast iron was replaced by steel.

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Building Information Modeling, Virtual Reality and Robotics

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Abstract: The article discusses how robotics is revolutionizing the construction industry by increasing accuracy, efficacy, and safety. Automated machines, such as brick-layer construction robots and autonomous vehicles, enhance productivity, reduce human error risks, and expedite project deadlines. Drones are used for site surveys and inspections, ensuring precise data and reducing the need for mechanical scaffolding. Robotic exoskeletons assist workers in heavy lifting tasks, minimizing physical strain and injury risks. In addition, 3D printing robots quickly assemble complex structures with minimal waste. Alongside technological advancements, it is foreseeable that robotics integration in construction will increase, enhancing efficient, safe, and precise construction practices.

Key Words: Modeling, virtual reality, robots.

Construction is a crucial sector in economic activity, intended to improve the living conditions of individuals. The construction sector is one of the most dynamic and rapidly growing sectors.

Contemporary technologies and recent developments in work methodologies have significantly influenced every sphere.

Notable progress has been made in architecture and engineering. A significant breakthrough has been the adoption of Building Information

Modeling (BIM) at the epicenter of innovation. BIM incorporates digital representations of the physical and functional characteristics of construction projects.

The term BIM (Building Information Modeling) was introduced in 2002 when Autodesk unveiled an informational document describing its collaborative model and advantages. Several programs are used for informative modeling of buildings.

Key advantages of BIM in the construction process include:

- Construction processes detailed in virtual parametric models.
- Integration of cost estimation documentation with BIM models for simplification.
- Easily perceivable and informative 3D models.
- Streamlined and managed budgeting.
- Centralized databases facilitating rapid information exchange.

Continuous access to information.

- Rapid error correction: Errors are corrected quickly.
- Reduction in documentation errors: Reduced by 61%.
- Reduction in errors during construction processes: Reduced by 35%.
- Reduction in construction costs: Reduced by 10-30%.
- Reduction in construction time: Reduced by 22%.
- Reduction in project correction time: Reduced by 17%.

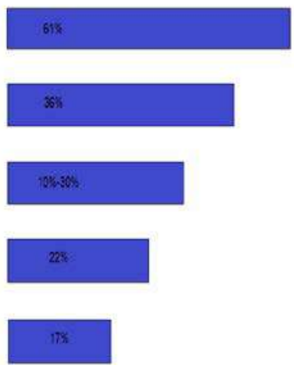
documentation errors

errors during construction processes

construction costs

construction time

project correction time



Through the use of BIM:

- Delivery deadlines have been simplified.
- Work hand management has been simplified.
- It became possible to organize construction management without project documentation.

A significant advancement occurred in architecture and construction with the advent of Virtual Reality (VR). VR primarily found its use in the military and aviation sectors, but recently, it has developed in various directions. No other method offers users a clearer perspective of construction and architectural objects than what Virtual Reality accomplishes. Such presentations provide a more accurate depiction of housing and construction areas, rational utilization of space, and accurate selections of colors and styles. Construction and architectural companies have become more active in utilizing Virtual Reality technology.

Extensive use of 3D printing and robotics has been found in construction. 3D printers are used for creating facades and construction elements, enabling the production of detailed models of structures and significantly reducing production time. Their operation over several hours replaces physical labor that would typically take two to three months, resulting in low production costs.

The use of 3D printing in construction has significantly increased. One reason is the saving of time and financial expenses. 3D printing significantly reduces time, material quantities, logistical costs, and the number of workers needed. Skilled operators are essential for the operation of 3D printers.

In the near future, the use of robotics and advanced technologies will become a significant part of the construction sector. During the manufacturing phase, robots are highly beneficial for the difficult construction and assembly of structures. Architects also utilize robots because they can efficiently create complex forms and structures.

The advantages of using robots include:

- Reduced duration of work;
- Accidents are avoided (decreased likelihood of human errors);
- Consistency in the structures they produce;
- Capability to create complex and precise designs.

These advancements highlight the growing importance of robotics and advanced technologies in the construction industry.

One example of the integration of robotics in construction is a project created by Swiss builders and architects using flying robots. This is an example of how different types of robots can be integrated into building processes. Flying robots assembled a 6-meter-tall tower installation. The tower was made up of lightweight polystyrene bricks, which were easy for the drones to lift. This installation demonstrated how robots can be utilized in creating complex but precise structures.

DIGITAL FABRICATION HOUSE

It's a futuristic structure where robotics was involved at every stage of construction. This house is a prime example built with the assistance of robots and advanced methods. Technologies such as 3D printing and robotic manufacturing were utilized in construction. Structural elements were created using robotic technology.

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XXI Century and Prestressed Concrete

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Abstract: The construction industry worldwide is making great efforts to improve energy resources and optimal design methods. In this process, prestressed reinforced concrete structures, which are widely used in modern construction industry, play a significant role. Prestressed reinforced concrete structures are distinguished by high rigidity and crack resistance, which will ensure the longevity of the structure and the building as a whole in the future.

Introduction

The technology of prestressed reinforced concrete was developed in the mid-20th century by engineers such as Freyssinet and Dischinger. Their innovations and achievements laid the foundation for the development of modern technologies, which are now widely used worldwide. Prestressed reinforced concrete structures were created in the early 1900s and developed over the following decades, but their widespread use began after World War II. Currently, reinforced concrete, being the main construction material, is characterized by high weight, low tensile strength, and premature cracking. All these factors prevent its wide use in large-scale and other types of buildings. To solve this problem, the prestressing method has been implemented in economically advanced countries, resulting in numerous extensive projects. For example, the Danyang-Kunshan Grand Bridge (Shanghai, China), the longest bridge in the world; Burj Khalifa (Dubai, UAE), the tallest skyscraper in the world; Allianz Arena (Munich, Germany), and many other types of construction projects.

Fig. 1. Danyang kunshan bridge

Fig. 2. Allianz areana

Main Part

Prestressing refers to the artificial creation of compressive stresses in reinforced concrete structures during their manufacturing, where tensile stresses are expected. There are three methods of prestressing:

1. Prestressing before concreting – tensioning the reinforcement on special jacks.

2. Prestressing after concreting – tensioning the reinforcement on the hardened concrete.

3. Self-stressed structures.

Using prestressing can reduce the total weight of buildings by up to 40%, indicating a significant reduction in construction material consumption (primarily expensive reinforcement and concrete), while maintaining high levels of building reliability. As a result, the cost of building construction decreases by up to 30%.

Advantages of prestressed reinforced concrete.

1. **Strength and Durability:** Prestressed reinforced concrete structures are strong and durable, allowing them to withstand heavy loads and tensile forces.

2. **Economic Efficiency:** Using prestressed reinforced concrete significantly reduces construction material costs, enabling companies to save resources and reduce the overall construction cost.

3. **Weight and Volume:** Prestressed reinforced concrete structures are lighter than traditional reinforced concrete, aiding in weight reduction of buildings and giving them more flexible and efficient characteristics.

4. **High Stability and Safety:** Prestressed reinforced concrete structures are stable and safe, making them suitable for complex and large-scale projects, such as bridges, tunnels, and skyscrapers.

Conclusion

The technology of prestressed reinforced concrete has become an important part of modern construction industry. Its use enables the implementation of large-scale, economically efficient, and stable projects.

Innovations of the 21st century, such as new materials, chemical additives, nanotechnologies and materials, digital modeling, and others, enhance and improve the use of prestressed reinforced concrete. The advantages, such as strength, economic efficiency, and high durability, make it a significant technology for future constructions.

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Modification of Concrete with Superplasticizers

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Abstract: This study aimed to study the effects of a super plasticizing admixtures, namely, Sikament MR 50-S and SikaVisconcrete Hi-tech 4127 superplasticizers, on concrete properties, such as workability and compressive strength.

Key words: superplasticizer, concrete, Workability, concrete strength, Concrete Slump Test, water-cement ratio.

Introduction. Concrete is the most widely used building material. Over time, the technology of concrete production has improved and reached unprecedented heights. Modern construction trends require improved concrete manufacturing technology and adjustment of properties as needed. Different admixtures are used to regulate the properties of the concrete mixture and to economy the cement. They are divided into two types: chemical, which is added to concrete in a small amount (0.1 ... 2% of the cement mass) and appropriately changes the concrete mixture and its properties. Mineral additives (5...20% of cement mass).

The same supplements often produce different effects at different dosages. Can speed up or slow down the hardening of concrete and other properties. For example, an excessive amount of superplasticizer delays the hardening of concrete. Addition of concrete hardening accelerator $CaCl_2$

excessive dose causes corrosion of the reinforcement, which is why its use is limited to 2%.

Among the chemical additives, the role of superplasticizers in modern concrete production technology is noteworthy. Superplasticizer - the most effective additive for concrete, dramatically increases the plasticity of the mixture and significantly improves technical properties.

As it is known, the superplasticizer increases the concrete slump and reduces its water demand by 20-30%. This allows us to use concrete with a low water-cement ratio, to obtain high-strength concrete more easily than with other technological methods, and to reduce the cost of cement. The low water-cement ratio allows us to obtain concrete with doubled strength.

Main part. The subject of study is the effect of plasticizers on the strength of the concrete along with the increase of the concrete slump. To determine the strength of concrete, we use the standard method, testing a concrete cube (15x15x15 cm) under press. The study included 3 trials. At the first stage, we developed the proportions necessary to obtain the selected class of concrete, with which we made sample concrete cubes without additives. Then, based on the given proportions, we determined the amount of additive for both plasticizers.

It is known that the concrete mixture, before the hydration process takes place, represents a multi-component polydisperse system in which a three-component structure can be distinguished: macrostructure (sand-cement boiling); Mesostructure (sand-cement dough), microstructure (cement dough consisting of cement and additives dissolved in water). Within the framework of the research, we changed the microstructure of the standard concrete mixture with the use of additives in order to improve its physical and mechanical characteristics, at the same time, in order to conduct the technological process of concreting in accordance with the standards, compared to the sample (standard mixture), we increased the workability of the mixture.

Sikament is light brown liquid, with specific gravity – 1.05-1.07 kg/l, pH-Value 4-6. It is used for the following structural elements: Foundations; Floor slabs; Slender components with densely packed reinforcement; walls, columns, beams;

Sikament As a superplasticizer with set retarding effect: Highly effective without increased w/c ratio; Lastion control of slump loss; Controlled setting time; Avoidance of cold joints; No adverse effect on ultimate strength.

As a water reducer: Strength significantly increased; Allow substantial cement reduction compared to plain concrete; Especially suitable for hot climate; No excessive air entrainment; No adverse shrinkage effect; Improved surface finish.

Sika ViscoCrete is light brown liquid, with specific gravity – 1.05 g/cm^3, pH-Value 4-6. It is used for producing: High-performance concrete (HPC); Flowing Concrete; Dourable Concrete; Pumped Concrete.

Sika ViscoCrete characteristics / Advantages : High water reduction, resulting in higher density, higher strength and reduced permeability; Easier and faster pumping of concrete; Increased workability and easier placebility, Increased concrete durability and uniformity; Reduced shrinkage and cracking;

By using superplasticizers, it is possible to increase slump of concrete and reduce the water demand by 20-30%.

In the first attempt, we made concrete without additives, with a water-cement ratio of 0.58. The slump of concrete was 15 cm. cubes were tested at 7 and 28 days of age. The result obtained during the test at the age of 7 days was 14.1 MPa, and at the age of 28 days it was 21.61 MPa.

In the second attempt, we made admixed concrete with a water-cement ratio of 0.52. We reduced the water content at the expense of an additive (Sikament MR 50-S), which we added to the mixture in the amount of 0.5% of the cement mass.The slump of concrete was 16 cm. Cubes were tested at 7 and 28 days of age. At the age of 7 days, the test result was 16 MPa, and at the age of 28 days, it was 26 MPa.

In the third attempt, we made admixed concrete with a water-cement ratio of 0.35. As an additive, we used SikaVisconcrete Hi-tech 4127, which we added to 0.5% of the cement mass. The concrete mixture did not form, we got a moistened mass that did not have a concrete structure. Within the framework of this test, a mixture with a water-cement ratio of 0.47 was initially prepared. We used the same additive again, in the amount of

2.5% of the cement mass. The concrete mixture was formed satisfactorily, and The slump of concrete was 19 cm. Cubes were tested at 7 and 28 days of age. The result obtained during the test at the age of 7 days was 22.33 MPa, and at the age of 28 days it was 38.24.

As expected, samples of concrete cubes with relatively low water-cement ratio showed high strength.

	W/C	additive	Additive % from cement mass	Strength of concrete 7 days (MPa)	Strength of concrete 28 days (MPa)	Concrete Slump cm
Attempt 1	0.58	-	0	14.1	21.61	15 (S3)
Attempt 2	0.52	Sikament MR 50-S	0.5	16	26	16 (S4)
Attempt 3	0.47	SikaVisconcrete Hi-tech 4127	2.5	22.33	38.24	19 (S4)

The object of study of our research is two characteristics of concrete: Concrete Slump and the strength of concrete. Comparing the results of the tests, it becomes clear that the use of plasticizers with the correct dosage is the best way to improve the physical-mechanical characteristics of concrete. With properly selected plasticizers and dosing, it is possible to reduce the amount of water in the concrete mixture and save cement, because as a result of reducing the ratio of water to cement, the strength of concrete increases and it is a good way to economy cement.

In addition, If we do not add enough water, it will not form satisfactorily. We had a similar case during the first attempt to make the mixture corresponding to the third test, when the mixture, with a water-cement ratio of 0.35, did not have the typical structure of concrete. At the same time, the amount of additive was 0.5% of the cement mass was not enough for the formation of needed concrete. The second attempt to make the third test was successful. The concrete mixture, with a water-cement ratio of 0.47, with an additive of 2.5%, from the mass of cement, was formed satisfactorily and according to the Concrete Slump (19 cm), we got a movable mixture (S4). Based on the received data, we can say that we have received concrete with appropriate flexibility for the proper management of the technological process at the site. It should be noted that it is convenient and appropriate to use concrete (S4) for the production of concrete works of both, vertical and horizontal reinforced concrete elements.

Conclusion

Comparing the results of the tests, it becomes clear that the use of superplasticizers with the correct dosage is the best way to improve the physical-mechanical characteristics of concrete. With properly selected plasticizers and dosing, it is possible to reduce the amount of water in the concrete mixture and economy cement, because as a result of reducing the ratio of water to cement, the strength of concrete increases and it is a good way to reduce the cost of cement.

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The Future of Water Conservation: Innovations and Technology

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Abstract: Water scarcity and pollution are the epicenter of the global challenges, which we can fix with technological advances. For water conservation, there are various technologies to help to minimize water use. Drip irrigation systems deliver water directly to the root zone of plants, reducing losses from evaporation and runoff. Micro-sprinkler systems similarly allow for precise water delivery, with lower water usage compared to traditional sprinkler systems.

1. Introduction

The issue of water shortage and pollution is global. Many modern technologies have been created for the purpose of saving water. Different types of new generation technologies, which are currently under development, help reduce water consumption and also filter it. These technologies can be considered a great achievement for the world, as they play a big role in ensuring a water-safe future.

2. The main part

Agriculture is characterized by high water consumption and pollution, technologies effectively help us to solve this. for example: Soil moisture sensors provide real-time data about the water needs of plants, preventing over-irrigation. They work by detecting the water content of the soil and can relay this information to farmers or directly to irrigation systems, thereby automating irrigation scheduling and saving water.

Furthermore, smart irrigation systems are being developed that assess the weather and soil conditions to provide optimum water supply to crops, thus ensuring effective use of water in agriculture, which is one of the largest consumers of water.

Protecting water quality is another critical aspect of sustainable agriculture, and technology can contribute significantly in this area. Biofiltration systems, which use microorganisms in soil or other media to remove pollutants from water, are a simple yet effective technology for treating agricultural runoff. These systems can significantly reduce the levels of nutrients, pesticides, and other contaminants entering water bodies from agricultural fields.

Constructed wetlands are another nature-based technology for water quality protection. They mimic natural wetlands and are engineered to treat agricultural or other wastewater, removing pollutants through a combination of physical, chemical, and biological processes.

Rainwater harvesting systems are also emerging to conserve water and minimize savings. These systems capture, store, and utilise rainwater, reducing reliance on public water supplies, particularly in areas prone to drought or water scarcity.

Rainwater harvesting is beneficial both for the environment and for homeowners. It helps decrease water runoff, reducing soil erosion and the pollution of waterways, while also saving money on water bills. Advances in technology have made these systems more efficient and easier to install, with options ranging from simple rain barrels to more complex systems incorporating filtration and pumps.

Moreover, these systems can be seamlessly integrated into urban and rural environments. In urban settings, they can be connected to rooftops to collect rainwater, which can then be used for gardening, cleaning, or even as grey water in toilets. In rural areas, they can help farmers conserve water for irrigation and livestock.

As the importance of water conservation becomes increasingly recognised, the trend towards installing rainwater harvesting systems is expected to continue. By embracing this simple, yet effective technology, we can contribute to the sustainable management of water resources for future generations.

Here at Smart Water, we are helping to facilitate the management and monitoring of rainwater harvesting through our innovative water tank level monitoring system. Our market-leading product provides a wireless water tank management solution with mobile app connectivity, allowing you to manage and monitor the water you harvest from anywhere.

In the cities of the world, we often encounter the problems of water pollution and conservation, where developing modern technologies are also applied for more efficient water purification. Smart technologies, such as IoT (Internet of Things) sensors and AI (Artificial Intelligence), are being deployed to monitor water quality, detect leaks, and manage water flow, significantly reducing wastage and increasing overall efficiency.

In Singapore, for instance, the Public Utilities Board has implemented a smart water grid system that leverages IoT technology. This system provides real-time monitoring and control of the water supply network, enabling the immediate detection and repair of leaks.

Similarly, in Barcelona, the city has embraced technology for the conservation of water resources. The city's smart irrigation system uses weather forecasts and soil moisture data to optimise the watering of its public parks, reducing water consumption by 25%.

By harnessing the power of technology, cities can take major strides towards water conservation, helping to ensure the sustainability of this precious resource for future generations. This integration of technology into water management not only promotes efficiency but also contributes towards the larger goal of creating smart, sustainable cities.

We also see the most impressive smart home water device out there Wi-Fi smart water leak detector, which monitors whole home water flow and usage in plumbing and water-based appliances.

Users can place these sensors in specific locations around their home, and the sensors will alert them via a notification to a phone app if water is detected where it should not be. Provided these sensors are placed within 6 feet of a water source, they should be able to detect a leak. They also allow homeowners to monitor their daily water usage, again via an app, and make note of where they could save money on their water bill.

Manufacturers are also now introducing smartphone apps that can be linked up to whole house water filters and water softeners via Wi-Fi. These allow for remote system management, enabling users to monitor their system, receive alerts for potential issues, and even input certain programming features from their smart device. Rather than having to access the control panel of their filtration system or water softener, users can simply view all the important data in one place on a designated app.

Conclusion

In conclusion, There are many technologies available to save water, improve efficiency and protect water quality. These technologies can easily solve water problems. Through continued innovation and collaboration, we can harness the power of technology to ensure sustainable use of our precious water resources, ensuring food security and environmental health for future generations.

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The Arched Dams

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Abstract: This article explores the remarkable engineering of arched dams, focusing on their massive structures and innovative design principles. It covers the Lajanuri and Enguri Hydroelectric Power Stations, highlighting their essential roles in regional power generation and water management. Additionally, it discusses the top three highest-arched dams worldwide—Jinping-I, Xiaowan, and Grande Dixence—showcasing the engineering excellence and ingenuity that make these dams remarkable symbols of human achievement. Through these examples, the article emphasizes the significant contributions of arched dams to sustainable energy and infrastructure.

Keywords: Arched dams, Engineering marvels, Structural design, Hydroelectric power, Lajanuri Hydroelectric Power Station, Enguri Hydroelectric Power Station,Jinping-I Dam, Xiaowan Dam, Grande Dixence Dam, Sustainable energy,Water management, Infrastructure, Engineering excellence, Human ingenuity, Renewable energy.

Introduction

Arched dams are impressive structures in civil engineering designed to hold back large amounts of water using the natural strength of an arch. These dams are not only engineering marvels but also play a crucial role in generating hydroelectric power, managing water resources, and preventing floods. Examples of notable arched dams include the Lajanuri and Enguri Hydroelectric Power Stations. Additionally, the top three highest-arched dams in the world—Jinping-I, Xiaowan, and Grande Dixence—showcase human ingenuity and engineering prowess.

The main part

Arched dams are curved structures with their convex sides facing upstream. This curvature helps to transfer the water pressure from the dam directly to the abutments (the sides of the valley). This makes them more efficient in terms of material usage compared to other types of dams. The arch action allows these dams to resist large forces with relatively thin structures, making them suitable for narrow, rocky gorges.

The Lajanuri Hydroelectric Power Station, located in western Georgia, symbolizes the country's use of natural resources for energy and infrastructure. Built in 1960, the arched dam spans the Lajanuri River, strategically positioned to maximize the region's hydroelectric potential. The dam's design blends seamlessly with the rugged terrain, utilizing the natural topography to create a reservoir that not only facilitates power generation but also supports irrigation and flood control efforts throughout the year. The Lajanuri Hydroelectric Power Station has a significant impact on Georgia's energy landscape, contributing approximately 116 MW of electricity to the national grid. This capacity plays a crucial role in meeting the country's energy demand, reducing dependency on fossil fuels, and enhancing energy security. The dam's operational flexibility allows it to adapt to fluctuating water levels, ensuring consistent electricity production even during dry periods. In addition to its role in energy generation, the Lajanuri Dam supports local communities by providing a reliable water supply for agriculture and municipal use. The reservoir created by the dam also enhances recreational opportunities and biodiversity conservation in the surrounding area. The construction and ongoing operation of the Lajanuri Hydroelectric Power Station reflect Georgia's commitment to sustainable development, balancing economic growth with environmental stewardship.

The Enguri Hydroelectric Power Station, situated on the Enguri River in northwestern Georgia, is a monumental engineering achievement and a cornerstone of regional energy infrastructure. Completed in 1987, this concrete arch dam towers at a height of 271.5 meters, making it one of the tallest structures of its kind in the world. The dam's primary purpose is to generate electricity, with an impressive capacity of 1,300 MW, making it the largest hydroelectric plant in the Caucasus region.

Beyond its role in energy production, the Enguri Dam plays a crucial role in water management and flood control in the region. The reservoir formed by the dam regulates the flow of the Enguri River, mitigating floods during periods of high water levels and ensuring a stable water supply downstream for agricultural, industrial, and municipal use. This function is vital for maintaining ecological balance and supporting sustainable development initiatives across Georgia.

The construction of the Enguri Hydroelectric Power Station required advanced engineering techniques to manage the complex geological and environmental conditions of the Enguri River basin. The dam's design incorporates sophisticated monitoring and control systems to optimize electricity generation and ensure the safety and stability of the structure. Despite the technical challenges involved, the Enguri Dam stands as a symbol of Georgia's capacity for innovation and its commitment to harnessing renewable energy sources.

Top Three Highest Arched Dams in the World

1. **Jinping-I Dam (China)**
    - **Height:** 305 meters (1,001 feet)
    - **Completion Year:** 2013
    - **Location:** Yalong River, Sichuan Province
    - **Capacity:** 3,600 MW
    - **Significance:** The Jinping-I Dam is the tallest arch dam in the world. Its construction posed numerous challenges due to its location in a seismically active area and the need to tunnel through mountains to divert the river. This dam plays a vital role in flood control, irrigation, and power generation in the region.

Xiaowan Dam (China)

- **Height:** 292 meters (958 feet)
- **Completion Year:** 2010
- **Location:** Lancang River, Yunnan Province
- **Capacity:** 4,200 MW
- **Significance:** The Xiaowan Dam is the second tallest arch dam globally. It serves multiple purposes, including hydroelectric power generation, flood control, and navigation improvement. The dam's construction involved advanced engineering techniques to deal with the complex geological conditions of the site.

Xiluodu Dam (China)

- **Height:** Approximately 285.5 meters (936 feet)
- **Completion Year:** 2013
- **Location:** Jinsha River, Yunnan Province
- **Capacity:** 13,860 MW
- **Significance:** The Xiluodu Dam stands as one of the tallest arch dams globally, representing China's engineering prowess in hydroelectric power. It harnesses the Jinsha River's flow to generate substantial clean energy, supporting regional development and bolstering China's renewable energy goals.

Conclusion

In summary, the development of arched dams signifies a significant achievement in civil engineering, demonstrating human ingenuity in harnessing natural resources for sustainable energy production. These structures not only produce clean electricity but also play vital roles in water management, flood control, and regional development. By utilizing natural topography and engineering innovation, arched dams show how countries can attain energy security while minimizing environmental impact. The examples discussed highlight the diverse benefits of arched dams, from enhancing energy resilience to supporting agricultural irrigation and urban water supplies. Their construction involves detailed planning and careful execution to overcome complex geological and environmental challenges. Furthermore, arched dams symbolize technological advancement and environmental stewardship, contributing to global efforts toward renewable energy adoption and climate resilience. Ultimately, arched dams serve as symbols of human progress, showcasing our ability to innovate and construct sustainable infrastructure that meets present needs without compromising the future. As countries continue to invest in renewable energy sources, arched dams remain essential for achieving a balanced energy mix and ensuring a sustainable future for generations to come.

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Aspects of the use of stone and gravel in construction

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Abstract: In the construction industry, one of the most crucial components is the aggregate material derived from natural rock. These valuable mineral deposits are primarily quarried from riverbeds, as rivers provide the essential material. However, hydraulic structures built on rivers often become significant barriers to the movement of riverine sediment. Additionally, the uncontrolled exploitation of aggregates can lead to an irreplaceable deficit in river valleys and cause abrasive processes at river mouths.

According to the United Nations Environment Programme, the extraction of construction materials, particularly aggregates, ranks first worldwide in terms of volume in the mining industry. Globally, 32 to 50 billion tons of aggregates are extracted annually.

Main Part

Humanity has been extracting and utilizing stone and gravel since time immemorial. This valuable mineral resource is primarily used in construction activities (including in Georgia) - for building structures, roads, and other infrastructural projects, as well as for land reclamation (e.g., combating coastal erosion). In addition to these purposes, stone and gravel can also be extracted for: increasing the water conveyance capacity of riverbeds after floods; making rivers navigable; and extracting gold from alluvial deposits (for instance, in Georgia, there are plans to implement a project for gold extraction in Upper Svaneti using placer mining). These are the most common purposes for stone and gravel extraction worldwide.

Due to the large quantity of these natural resources and the inexpensive extraction technology, the costs of extraction are generally dependent on transportation costs. Therefore, extraction sites are often located close to the consumer (market or project).

Rivers are considered the best source for stone and gravel extraction for several reasons: cities are often located along riverbanks, thus reducing the transportation costs of the extracted valuable minerals. Rivers, with their energy, naturally break down boulders into gravel and sand, thus eliminating the crushing costs when extraction is done from rivers. In rivers, the natural sorting and deposition of various sizes of solid sediment also simplify and reduce the costs of extraction. **Types of Stone and Gravel Extraction**. One of the main determining factors of the potential impact of stone and gravel extraction is the method of extraction. The work related to stone and gravel extraction from rivers can be divided into three main categories:

- Wet extraction of stone and gravel from rivers
- Dry extraction of stone and gravel
- Extraction of stone and gravel from the riverbank (known as scalping)

Wet extraction involves extracting stone and gravel from the riverbed, directly within the river channel or within the boundaries of the river valley.

Stone and gravel extraction typically involves the crushing, sorting, and washing of the extracted material (often carried out near the extraction site). These activities, along with the extraction itself, impact the natural and social environment.

Figure 1. Quickstream on the banks of the Rioni river

River Channel Dynamics. River systems are corridors that connect inland areas with seas and oceans. Through the movement of water and sediment, they shape river, coastal, and floodplain habitats. The presence of water and sediment in rivers is driven by dynamic hydrological and geological processes occurring within river basins, as well as changes induced by human activities. The temperature and precipitation regime within a river basin significantly influences the weathering of rocks and the subsequent introduction and movement of sediment into river systems. Climate change and the periodic degradation and activation of glaciers also impact sediment deposition. Prolonged, large-scale human activities alter the regime of sediment formation in rivers.

Sediment undergoes a complex accumulation process in rivers and floodplains, which depends on the magnitude, duration, frequency, seasonality, and extent of water flow changes. Sediment, often called riverine solid discharge, consists of particles and granular fractions of various sizes. These fractions are transported in different ways within the river. Fine-grained sediment, mainly produced by the physical weathering of soft rocks, chemical weathering of silicate minerals, and decomposition of organic matter, moves quickly within the river due to its small size when mixed with water. This type of sediment deposits only in environments with very slow water flow, such as calm waters and floodplains. Fine-grained sediment travels throughout the year, carrying nutrients. It impacts water quality and the productivity of estuarine and coastal areas.

Medium-sized sediment, composed of both fine and coarse sand, can move in suspension or along the riverbed, depending on the hydraulic conditions in the river. This grain size fraction can travel suspended in water during high flow rates and along the bed during low flow rates. The movement of sand within the river system can take many years. Sand accumulates on the riverbed, banks, and bars. Continuous sand transport at the river mouth is particularly important for maintaining the stability of the estuary and coastal zone. This natural defense mechanism is crucial during storms and extreme weather events.

Impact of Stone and Gravel Extraction on the Natural Environment. Removing sediment from rivers, as is the case with stone and gravel extraction, leads to physical changes in the river valley. All parts of the river valley are sensitive to these changes, but sediment removal is considered to have a more significant impact near riverbanks, bars, and floodplains. A dynamic equilibrium exists in rivers between water discharge, valley slope, sediment quantity, and sediment size. Any change in these factors results in deposition or erosion, leading to a new equilibrium state in the river. If an appropriate quantity and size of sediment are transported, the river channel can regain its original geometry. However, if the sediment quantity is either too low or too high, the river morphology changes. This process is seasonal - sediment deposits during low flow periods and moves actively during high flow periods. This represents the dynamic equilibrium and natural changes within the river.

Erosion process can spread both upstream and downstream from the extraction site, eventually leading to the deepening and narrowing of the river channel. As a result of this deepening, the river may become disconnected from its floodplains.

Figure 2. Exposed rocks and remaining trees as a result of extracting stone and gravel in river bank in Dighomi [1]

Figure.3 A floodplain on the right bank of the Rioni River [1]

In a braided river system (where multiple channels separated by mobile islands exist), the incision of the riverbed due to stone and gravel extraction can lead to fundamental changes in the river system. For instance, deepening of the channel can cause the water flow to shift entirely into one channel. As a result of such changes, the former channels and bars will start to vegetate, erosion will diminish, and the islands will stabilize, leading to the formation of a single-channel river system.

Figure.4 Incised River Channel, Iori River near the village Khashmi [1]

The dry extraction of stone and gravel from the floodplain (outside of the water flow) can also alter the river's flow. Such extraction often leaves deep pits near the river. During floods, these pits can fill with water, experience erosion, and connect with each other. As a result, an alternative channel may form where water continues to flow even after the flood ends. Due to these sudden changes, stagnant lakes can form, erosion processes intensify, and the extraction of useful minerals can be disrupted. Additionally, the extraction of stone and gravel from the floodplain can impact groundwater levels and cause contamination of aquifers.

Other impacts of stone and gravel extraction on the river, which alter the river's physical state, include the formation of turbid flows diluted with sediment during extraction. These flows move in the direction of the river's current and deposit in areas where they would not otherwise accumulate.

Piles of extracted stone and gravel increase erosion, which in turn leads to the deposition of eroded rocks in the channel. Riverbanks can also collapse due to the pressure of heavy loads from stored minerals.

Figure 5. Piles of Stored Stone and Gravel and Access Road to the Quarry in the Coastal Zone of the Mtkvari River [1]

In addition to piles of extracted stone and gravel, the construction of access roads to quarries contributes to the degradation of coastal zones. Such quarry roads are necessary to transport the extracted material from the extraction site or storage area for further transport. Quarry roads, compacted by the movement of heavy trucks, often have puddles that collect rainwater, creating their own runoff. This process intensifies erosion; the eroded material then enters the river, causing turbidity and polluting the water with harmful substances.

Coastal zones often serve as resting and nesting areas for migratory birds. The destruction of these zones through stone and gravel extraction naturally impacts migratory birds, including species that may be specially protected under international agreements and local laws. In addition to birds, stone and gravel extraction directly affects fish species in the river, particularly their spawning areas.

Types of Negative Environmental Impacts.

Fauna: Habitat destruction for various species, Reduction in fish populations, Restriction of fish migration, Replacement of species living in flowing water with those in still water, Disappearance of some local species, Spread of invasive species, Limitation of fish reproduction, Impact on the structure of the food chain, Reduction of oxygen in the water.

Flora: Loss of benthic organisms, Removal of vegetation cover, Destruction of coastal habitat.

Soil/Land: Degradation of the riverbed, Changes in the slopes of the river channel, Erosion of riverbanks, Reduced ability of coastal zones to cope with storms and extreme weather events, Deterioration of soil conditions (in the coastal zone and transport routes).

Despite these negative impacts, we must recognize that construction is impossible without these processes. We are not yet at a level of development where we do not need every ton or kilogram of gravel, without which it is impossible to build schools, kindergartens, and hospitals that are the heart and soul of modern civilization. In life, we often have to make unpleasant decisions that we do not "enjoy," but are vitally important, and this is no exception.

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Vertical Greening - the future of "green construction"

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It is a well-known fact that the ecological situation in big cities and densely populated areas and neighborhoods is becoming more and more difficult every year. The intensive process of urbanization led to a sharp increase in car traffic on city streets. Residents of the modern city mostly see the flat and roofless planes of building facades, squares and streets and the right angles of intersection of these planes.

The gray color of monolithic concrete and asphalt predominates in the color solution of buildings and structures in the cities, while nature rewards us with a variety that is more pleasing to the eye.

The presence of vegetation cover in cities is necessary for creating comfortable living conditions. However, in reality, in construction, due to some subjective and objective reasons, the use of plants did not find wide spread.

In the present article, we will discuss examples of the use of "green construction" in modern construction, where one of the important places is the so-called Vertical greenery is occupied.

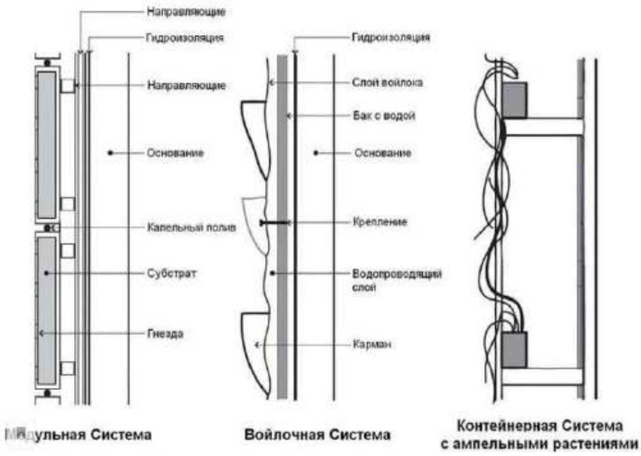
Vertical greening - this is a means of decorating vertical constructions and elements of buildings, including facades, side deaf walls, supporting walls or basement floors, in order to improve ecological comfort, create expressive facades and protect against unfavorable external factors.

It should be noted that the history of using vertical greenery on building facades goes back centuries. At that time, wild grapes, ivy and other creeping plants were used for vertical greening. A distinctive feature of these plants is their stems, with the help of which they attached themselves to the walls of the building and made it possible to arrange vertical greenery without additional support structures.

It was possible to arrange vertical planting without additional support structures. Along with the increase in the floors of the buildings, it became possible to arrange vertical greenery on the facades only by using additional structural elements. For high-rise buildings, there are 2 types of structural structures that are used to arrange vertical greenery - the so-called "Retaining structure"

(the plant is connected to the building with additional fasteners) and "living plants" (special containers with soil). Ropes, cables and light fastening nets of various materials are used as additional fasteners on the facades of buildings. In order to prevent damage to the structures under the influence of external factors, the appropriate building materials are selected in detail and the requirements for finishing are significantly increased.

Vertical greenery can be arranged on the entire surface of the facade wall of the building or placed as separate elements. Vertical greenery can be used on walls of various purposes. Among them - on load-bearing walls, supporting walls and boundary walls. Such a facade wall consists of a double surface, one of which is green. There are three variants of "vertical greening" arrangement systems - modular, felt (textile),



container.

It should be noted that, as we have learned from the international practice, the so-called Elements of "green construction". In the big cities of Europe and America, the facades of many buildings are decorated with living plants.

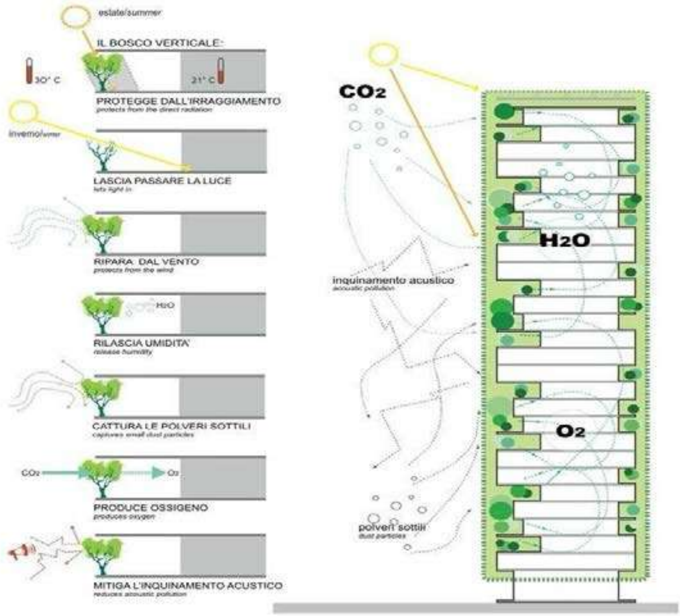
One of the best examples of the organic combination of ecology and style implemented under the auspices of "green construction" is in Italy, in the Porta Nuova district of the city of Milan in 2009-2014. Implemented (Arch. Stefano Boeri, Gianandrea Barreca and Giovanni La Varra) residential complex project called - "Vertical Forest" (Bosco Verticale). The complex consists of two 18- and 27-story tower buildings. 1600 trees, shrubs and grasses are planted on the facade of the buildings. The total area of vertically arranged greenery is more than 10,000 square meters, which is 7,000 square meters. meter is equivalent to horizontal greening and is 41% of the total building area. Social and shopping facilities are located on the first floors. Outside the complex, a green zone of intensive greenery has been planted.

The Polytechnic University of Milan was involved in the process of designing the complex, which carried out the selection of plant species, the calculation of the loads of the building structures and the stability test of the building structures. At the Polytechnic University of Milan, the first test of the impact of wind on facades with containers of trees and plants on a scale of 1:100 was also carried out.

At the next stage, the prototype of the container with plants was tested in the aerofoil in the wind speed of 190 km/h (52 m/s) at the Florida International University.

Despite the presence of an automatic system for watering plants located on the balconies of the building, it is necessary to provide their regulated service, which is not carried out by the residents of the complex, but by the relevant company. With the help of cranes, the staff brings necessary fertilizer for the plants several times a year, carries out repair and transplanting works.

Like everything else, the "vertical forest" has its pros and cons. It is considered positive that a special microclimate is created by means of it, the outer walls of the buildings are not overheated, the air is filtered and there are no small particles of dust characteristic of the urban environment. Diversity of plants helps to maintain optimal air humidity, absorption of dense particles or carbon dioxide and release of oxygen. Protects space from radiation pollution and noise.



BOSCO VERTICALE 01 foresees the perimetral construction on each floor of a sequence of containers of different sizes according to the needs ofaech plant: the selection of the plants and the definition of distribution and reuse of water with respect to the different microclimatic zones are based on the optmization of hidrcal resources.

In summer and during the warm period of the year, the leaves of the trees on the balconies create a pleasant light breeze and shade, which reduces the harmful effects of UV rays on the building materials. Compared to traditional facades, in the case of this type of "green facades", the consumption of electrical energy is reduced by 68%, which allows to achieve savings of 7.5% annually. The balconies are protected from the wind by means of trees.

As for the negative side, an important factor is the high ($2.8 billion) cost of the complex's construction and the increased (23%) electricity cost in the winter period, although the annual cost is still less than the economic cost in the summer period.

As a whole, it can be said that living conditions in multi-storey buildings have been significantly improved in this complex implemented under the auspices of "green construction", and these high-rise buildings with their constantly changing colorful facades are a special attraction for the city.

As the study of international examples of "green construction" has shown us, along with successful examples there are also negative examples. Such is the example of Qiyi City Forest Garden.

According to the authors' idea, the eight towers with trees and plants planted on the balconies should be the most "green" point of attraction of the city and should attract the attention of citizens to ecology. However, the number of people wishing to live in such buildings was not large (currently there are 10 families). In addition, the plants planted on the balconies of the buildings were not cared for. The plants grew on their own and became misshapen plants.

Thus, as the study of existing practices has shown us, in general, people respond positively to green facades of residential buildings and their use in urban development. At the same time, it is necessary to take care of plants by special services (application of fertilizers, pruning, disease control, etc.). It is also necessary to select plant species adapted to the local climate, which will be suitable for a specific region.

It is important that "green construction" projects, in addition to creating a comfortable microclimate for residents, allow buildings with their green facades to have a more expressive, individual look and add variety to the monotony of the gray city.

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Development of Technical Diagnostics and Monitoring in Control Systems of SCB Field Devices

Lasha khurtsilava, Bachelor Program student, Supervisor Merab Chaladze, Academic

Abstract: In my work, I would like to highlight the aspects of the development of technical diagnostics and monitoring systems for the condition of field devices for trains and lineups moving along the tracks, their and signaling centralization blocking (SCB), and I would like to consider how these systems should look in the near future.

The main direction of the work is the development of monitoring systems for rails, railway machine guns and telemechanics devices, control of the technical condition of military equipment and strategic facilities. In connection with the development of testing the condition of rails and couplings, the production of continuous video recording on the upper structural elements of the railway track. As a result, the logical development of the railway track video recording system and the identification of the normal state of its elements will occur.

Keywords: Railway automation and telemechanics; Track circuit; Axles count systems.

For the development of an automatic video measuring system by means of “mobile diagnostic" tools for monitoring the technical condition of the upper structure elements of railway tracks. The technical requirements for this device (TM) are a document that allows manufacturers to systematically approach the development of a video monitoring system and identify elements according to the list of dimensions of approved parameters:

- Rails-according to the presence of surface defects in addition to eliminating the depth of the rail;
- Edges- (size of the groove, determination of two or more zero grooves in a row, presence and magnitude of horizontal step differences on the working rods of the rails at the place of adhesion of the edges, condition of the underpinnings, presence and condition of the retaining bolts, condition of the relays, insulation (insulation and presence of insulating edges);
- Intermediate fastening (presence and condition of connecting jumpers);
- Treasures (sleepers) - dimensions, except for depth defects, respectively Epicurus, angle of displacement relative to the axis of the gauge;
- Ballast (presence and volume of vegetation);
- Saisre gadamuvans (separate pen tip from the frame, transducer curve ordinates, width of grooves and their purity, condition of inter-pen connecting traction).

Measuring defectoscope-development of special software (hereinafter-software) for the detection of combined irregularities for wagons, on which railway video cameras were previously installed. The result of the development of such software is the automatic recognition system of such elements as gaps in the adhesion between the rails, identification of missing bolts in the insulating edges (or simply in the adhesion of the rails), determination of the type of rails subsidence. Determine the type of inter-rail connecting sidings and their malfunctions. A new system is also being developed that will develop automatic recognition of the elements of the upper structure of the track.

This system will have a modern computing complex that will be able to process the stream of video information received from six wired cameras and automatically convey the information of malfunctions of the elements of the upper structure of the track found by video decryption.

As an example of automatic recognition of the groove between the rails and identification of the bolts holding the sidewalls of the bonded blades, presented in Fig. On 1.

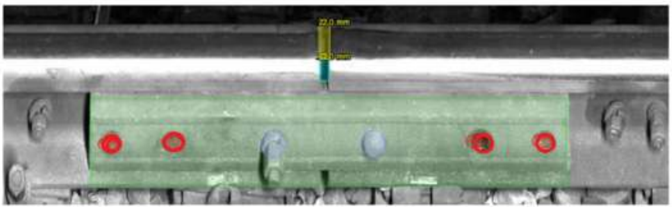

Fig.1 example of automatic recognition of the groove between rails and identification of lost (dropped) bolts in the bonded blades

A red oval sign on the face indicates the absence of a gill-shingle junction, while a Blue Oval sign on the contrary indicates the presence of a gill-shingle junction. At the same time, this program allows us to download only parameters of interest to the user, for example, violated values of elements that exceed deviations from the norms. Thus, it can be concluded that serious and responsible work is being carried out for track management in order for the controlling system to automatically recognize the shortcomings of the upper structural elements of the railway track. Currently, a list of examples for recognizing violations of the state of elements of railway automatics and telemechanics field devices has been formed:

1. Bearing adapters (fig.2):

Fig.2 Bearing adapters

- Bolts, clips, connecting the fundamental headset of the bearing converter to the corners and the binder bar.
- Presence of bolts, nuts, counter bolts;
- Bolts for attaching fundamental angles to rails (fig.3);
- Bearing electric drive fixing bolts;
- Bolts for attaching the inter-cuttings connector and control traction, the presence of wrenches and snags (fig.3);
- Measuring the thickness of the gasket between the Pens connecting and control traction earrings and arrow pens;

➢ During the pressure of the train, no more than 2 mm of the groove between the frame and the bonded Pen is present.

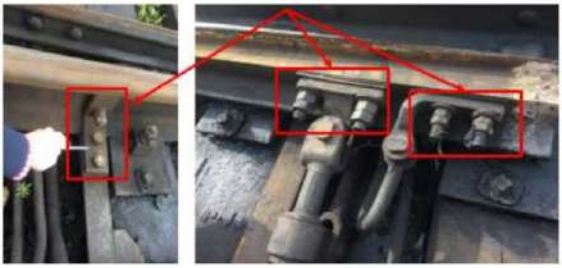

Fig.3 control the fastening of the bearing headset nodes

2. "3300 mm" length jumpers:

➢ Presence of two couplings;

➢ Their condition;

➢ Distance from track underpass;

➢ Presence of wrenches and counterscrews.

3. Couplers:

➢ Welded (fig.4);

➢ Control of existence and condition;

➢ Presence of a "1200 mm" gauge annealing coupler, condition control, presence of wrenches and counter-wrenches.

Fig.4-control of duplicated (welded) couplings

4. Dsrosel-transformer coupling splints (fig.5):

- Throttle transformers and rail boxes (Thermal Vision installation-measured the heating temperature of jumpers and couplers output from throttle transformers and rail boxes);
- Height and spacing of throttle transformers and rail boxes;
- presence of wrenches and countersinks with which the restraints are attached to the rails;
  - Distance away from track underpasses .

Fig.5. Throttle-transformer jumpers heating video control

5. Distance from the top of the rails, their bolts, mounts and bearings (**Fig.6**).

6. Grounding of traffic lights and reliability of fastening to these grounding rails.

7. Control of the bounding pole gauge.

8. Monitoring the condition of the foundation of dwarf traffic lights.

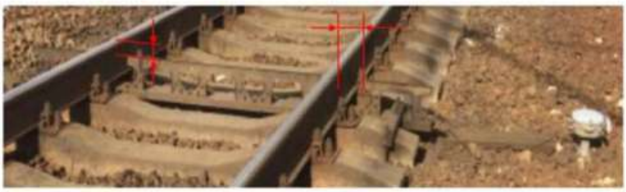

Fig.6 control of the flow rate during rolling stock

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Innovative Technologies in Soil Reinforcement

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Abstract: The goal of this scientific work is to discover innovative and improved ways to reinforce soil, focusing on state-of-the-art materials, methods, and technologies. It will provide a comprehensive overview of emerging trends, including the use of geosynthetics, biotechnical stabilization, chemical stabilization and hybrid systems as well.

Furthermore, this study will evaluate the environmental impact and sustainability of these innovative technologies, highlighting their potential to contribute to eco-friendly and resilient construction practices, while also providing estimate price ranges to get a better understanding of the methods. By examining case studies and practical applications, this paper seeks to provide valuable insights for researchers, engineers, and practitioners in the field of geotechnical engineering and civil engineering.

Keywords: Soil reinforcement, Geosynthetics, Biotechnical stabilization, Sustainable construction, Geotechnical engineering, Innovative materials, Geogrids.

Modern soil reinforcement techniques have evolved significantly to enhance soil strength, stability, reliability and overall performance. I will list the most widespread methods and describe when and where they are used:

1. Geosynthetics

Composite Geotextiles

Geotextiles are permeable fabrics used to separate, filter, reinforce, protect, or drain soil. Such products are manufactured on a textile equipment able to weave the PET (polyethylene terephthalate) yarns into a finished fabric. It can be the form of a typical woven textile or of a composite as combination of a filtering-separation nonwoven geotextile with a knitted one (Directional Oriented Structure geotextile). These materials are able to combine the reinforcement and the separation/filtration functions in one composite mostly used in soil stabilization or reinforcement applications. In most cases, these products are used on soft soil as the geogrid is most suitable for soils unprotected from the damaging effects of granular material.

Price Range: $0.50 to $2.00 per square meter, depending on the type and quality.

Multicomposites

Multicomposites are the latest and the most innovative development in the geosynthetics family. Drainage composite can, and not exclusively, be combined with other layers of grids, membrane, reinforced mats, naked mats or textured geogrids in a multitasking composite able to provide in one single layer the performances of many geosynthetic materials. Such composites are therefore able to provide relevant saving in the construction process (timing, costs, efficiency) while also lowering the environmental impact (for example by reducing CO_2 emissions).

Biaxial Geogrids

Biaxial geogrids are used mostly for reinforcement purposes in soil stabilization, retaining walls and slopes, this is due to the fact that their symmetric structure is able to provide the necessary strength and a confinement effect. The tensile strength and the geometry of these geogrids is normally symmetric with tensile strengths from 20 to 300 (or even more) kN/m;

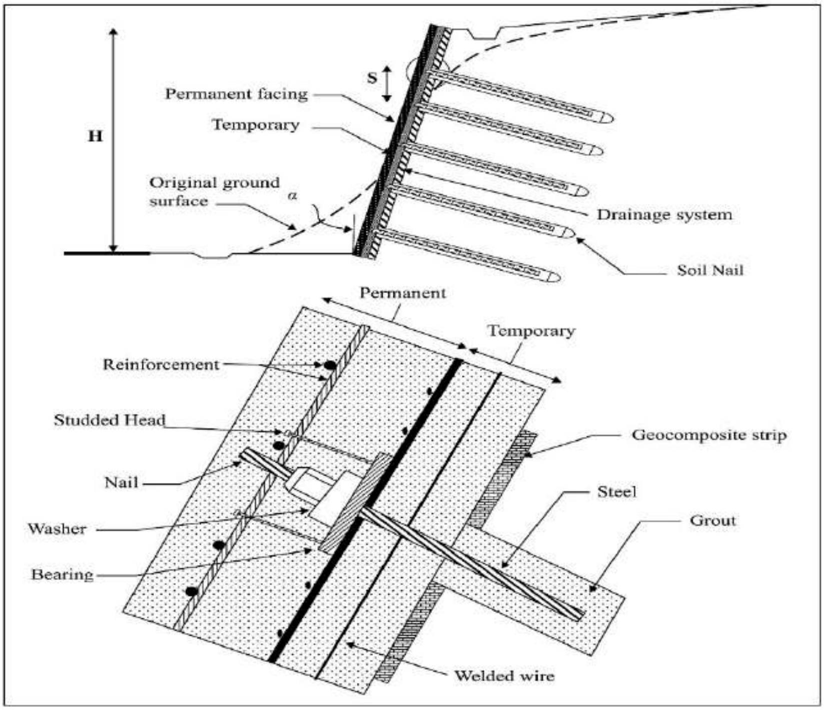
Price Range: $1.00 to $5.00 per square meter, varying with polymer type and grid size.

2. Soil Nailing

Soil nailing is an economical technique used to stabilize existing slopes and to construct retaining walls from the top down.

This soil reinforcement process uses steel bars which are drilled and grouted into the soil to create a composite mass similar to a gravity wall. A shotcrete facing is typically applied, though many options such as precast panels or “green” vegetated cells are available for permanent wall facings.

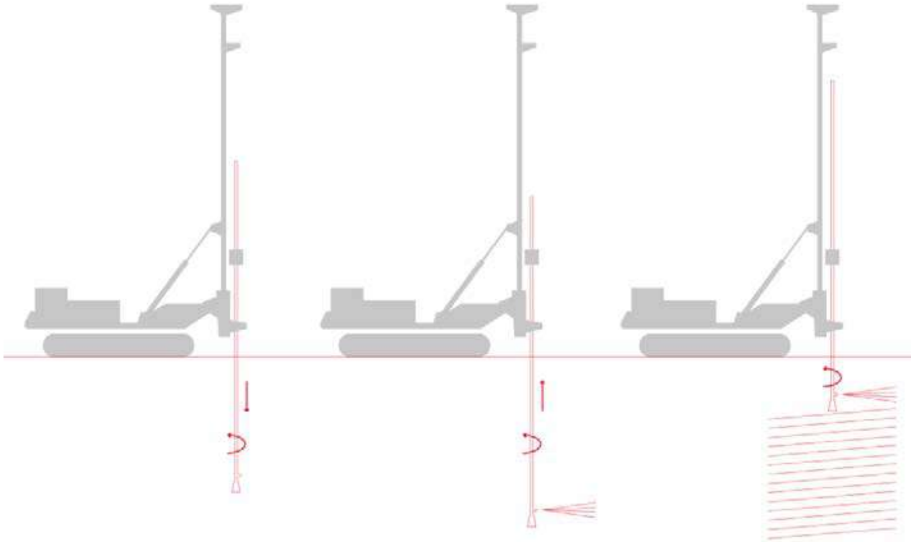
The Price Range is $100 to $300 per square meter of wall face, depending on project specifics and site conditions. Its first application was in 1972 Versailles, France, since then Soil nailing has become a well-established and cost effective practice around the world.



3. Jet Grouting

Jet grouting is a ground reinforcement technique. One or several jets of fluid with high kinetic energy are used to break apart and mix the ground with a liquid cement slurry so as to form a column of a homogeneous mass of high strength reinforced soil-cement material. Depending on the overall design and soil conditions, several methods of treatment have been developed (single or double curtain wall, secant columns walls, plugs, isolated columns, etc.) making jet grouting a flexible technique. It is used as a targeted treatment for a wide range of applications, such as: control and reduce settlement under structures, increase of bearing capacity, install retaining walls, underpin existing structures, reinforce soils with existing utilities lines and burred structures, operate in areas that are difficult to access.

Price Range: $200 to $600 per cubic meter, influenced by grout type, depth, and site conditions.



7. Chemical Stabilization

Chemical stabilizers, also known as soil binders or soil palliatives, provide temporary soil stabilization. They are readily applicable to the surface of the soil, can stabilize areas that cannot establish vegetation, and provide effective protection from wind and stormwater erosion. Categories of chemical stabilizers are as follows: water with surfactant, water-absorbing, organic non-petroleum, organic petroleum, synthetic polymer emulsion, concentrated liquid stabilizer and clay additive

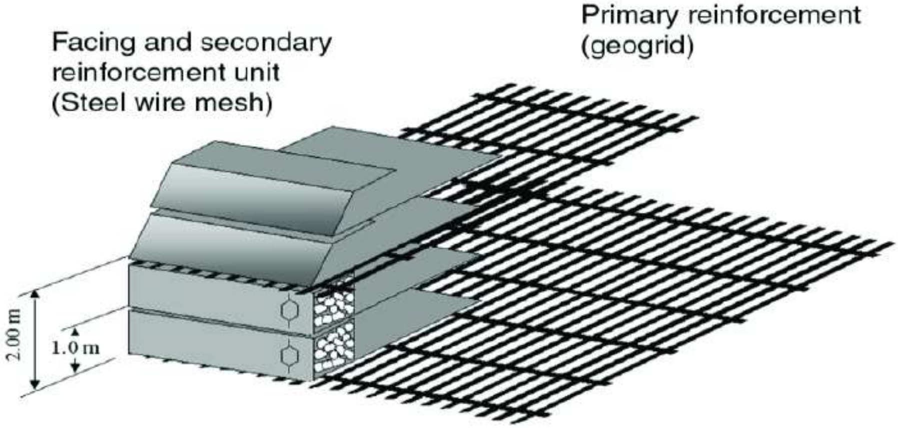
Price Range: $20 to $50 per ton of soil treated, depending on the chemical used and application rate.

Lime treated soil can develop long-term, permanent strength in reactive soils resulting in soil stabilization. According to the National Lime Association, a soil with at least 25% passing a 75 micron screen (clay) and having a plasticity index (PI) of 10 or greater are generally good candidates for lime stabilization. Lime treatment is almost always suitable for fine grained, moderate to high plasticity soils.

We can see site workers applying lime to stabilze the soil in the picture below.

11. Stone gabions

Double twisted wire mesh products have been widely used in the past 25 years as reinforcement materials for mechanically stabilized earth (MSE) structures. Metallic gabions have been used for more than 100 years for the construction of gravity type retaining structures in all environments and climates, very common in the mountainous areas of Georgia. They are basically rectangular boxes manufactured from hexagonal woven steel wire mesh laced together and filled with stones at the jobsite. Gabions have been used for a variety of application in sectors of infrastructure development as roads, railways and airports construction, landslide mitigation, riverbank construction and stabilization, erosion control on natural slopes and even architectural facades. The picture below shows a schematic view of a hybrid MSE structure, with gabion facing units at the bottom and wrap-around green facing units at the top; it can be noted that the primary reinforcing geogrids are always vertically spaced as a multiple of the height of the facing units



A noteworthy product in wire mesh developments is The Maccaferri, Terramesh® Family, which includes different facing options to build a Mechanically Stabilized Earth structures and Reinforced Soil Slopes (RSS). It consists of pre-assembled units of double twist wire mesh to be assembled when they reach the jobsite, making the installation much more efficient. The geogrid reinforcement, fascia and lid are all one continuous panel of mesh, requiring no cuts operations on site.

9. Biotechnical Stabilization

In case there are a lack of stones, or in remote areas where arranging a continuous supply of suitable stones for the filling operations of facing elements is difficult and expensive, or in case the design requires the reinforced slope to be fully integrated in the surrounding green environment, a valid alternative to stone gabions can be used and is a green vegetated facade. Typically structures such as retaining walls are considered to have a 60-year design life. However, using green walls can assure a longer design life because it uses geogrid which have been independently assessed and certified for use in structures with a design life of up to 120 years. These geogrids provide core stability for the walls. Green walls also allow the growth of vegetation and root systems which can provide long-term stability to the slope face. The Price Range: $1 to $10 per square meter, varying with plant species and site condition

Conclusions and the future for soil reinforcement

The choice of soil reinforcement method depends on various factors such as soil type, project requirements, environmental conditions, and budget. Each method has its own set of advantages and limitations, making it essential to do site investigations and engineering assessments to select the most appropriate and cost-effective solution.

The future of base foundations and soil mechanics will likely be the integration of cutting-edge technologies, sustainable practices, and innovative materials. Addressing current challenges, such as lowering costs and reducing carbon emissions, will become possible through collaboration, research, and development. It is essential to creating resilient and adaptive infrastructure capable of meeting the demands of a changing world, because soil reinforcement will be very relevant for many more years.

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Production of Carbon Fiber and Potentials for Its Use in Building Construction

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Abstract: Following paper describes manufacturing basics, implementation and development of carbon fibers, the ability of their use in construction. Presents data about types of reinforcement of building structures using carbon fibers. Examples of reinforcement of reinforced concrete, stone and wooden elements are given. An opinion was expressed on the introduction of external reinforcement technologies at construction sites in Georgia and the creation of a regulatory framework for the theoretical calculation of such structures.

Key words: carbon, carbon fiber, carbon tape, composite, polymer, concrete, building structure, external reinforcement.

1. Introduction

An analysis of the development of the modern construction industry clearly shows the effectiveness of using new composite building materials on construction sites. Products made using carbon, basalt, aramid, glass, boron composite fibers are distinguished by high strength, heat resistance, lightness, resistance to corrosion and aggressive environments, various electrical properties (from semiconductor to conductor) and other mechanical or chemical characteristics. which makes them very attractive, which makes them consumed in almost all sectors of the national economy, primarily in construction. One of these materials, the most interesting and promising, is carbon-polymer composite fiber.

1.1. Carbon

Carbon is a chemical element whose symbol is C; density - 1800-2100 kg/m3 (graphite 2267 kg/m3; diamond 3515 kg/m3); Sublimation (evaporation) temperature – 3642°C; Boiling point – 3506.85°C; The critical temperature is 3856.85°C. Refers to non-metals. Several of its allotropic forms are known - graphite, diamond and amorphous carbon. Diamond is known as a colorless, transparent and very cold substance, while graphite is a black, soft substance that leaves marks on paper. The largest sources of inorganic carbon are limestone, dolomite and carbon dioxide, although significant amounts are found in the organic layers of coal, oil and peat. Carbon is a chemical source in the production of plastics. With nitrogen it forms alkaloids (nitrogen-containing substances of plant origin that have alkaline properties) and, when combined with sulfur, produces antibiotics, amino acids and rubber products. Carbon was discovered a long time ago and was known to early civilizations in the form of soot and coal. Diamond in China as far back as AD. They were known before 2500 BC. e. The area of use of carbon and its compounds is not defined. Today, without carbon, the functioning of enterprises such as metallurgy, the chemical industry, the production of plastics, glass, building materials, light industry, the food industry, medicine, etc. is unthinkable.

1.2. Carbon Fiber

Carbon fiber (carbon) is a composite polymer material consisting of thin threads with a diameter of 3-15 microns (Fig. 1), which, in turn, consist of microscopic crystals formed from parallel (identically) located carbon atoms, which provides high strength to break. this material. Essentially, in carbon-polymer composite fiber, the threads act as a matrix, that is, carbon is obtained from carbon threads, which, in turn, are obtained from ultrafine carbon materials, and then carbon fiber is produced from them, which is widely used in the production of composite materials (Fig. 2, Fig. 3).

Fig. 1. Carbon Thread

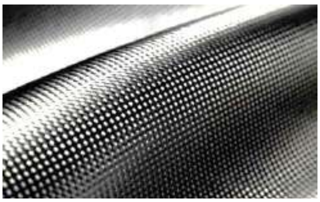

Fig. 2. Carbon Fiber

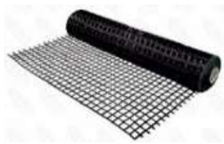

Fig. 3. Carbon Fiber Mesh

Carbon fiber has high tensile strength. Its strength exceeds that of steel, aluminum and titanium by 8-17 times, and its modulus of elasticity is 5-13 times.

Carbon fiber production began in the 1960s and quality gradually improved. Currently, the strength of carbon fibers even reaches 6000 MPa (for comparison: the strength of ordinary steel is 300 MPa, and high-strength heat-treated steel class 60C2A is 1570 MPa).

Depending on the processing conditions, carbon fibers can undergo carbonization (carbonization is the saturation of a solution or liquid with carbon dioxide) and graphitization (graphitization is the transformation of carbon into graphite). The heat treatment temperature for carbonized fibers is 900-2000°C, for fibers containing carbon - 80-99%. For graphite, these figures are: 3000°C and more than 99%).

To produce carbon fibers, only fibrous polymers are used that do not melt during heat treatment and provide high carbon content and mechanical properties in the final product. These polymers include: viscose, polyacrylonitrile chemical fibers, coal tar, hydrocellulose fibers and organic fibers derived from phenolic resin.

The technological process for producing carbon fibers includes the following stages: material preparation, oxidation, carbonization and graphitization.

The preparation of cellulose material involves the removal of moisture, inorganic impurities and organic substances (including lubricants), which is carried out using solvents and surfactants, after which drying is carried out for 15 hours at a temperature of 100°C.

Carbonation occurs at a higher temperature (900-1500°C). At this stage, chemical processes continue, as a result of which the waste is enriched with carbon, and graphitization is the formation (stratification) of graphite in iron-carbon alloys (cast iron, steel) at high temperatures (>2200°C).

An important stage in the production of carbon fibers is the extraction-spinning stage of converting cellulose fibers into carbon fibers, which significantly improves the elastic properties and strength of the fiber.

The strength and elastic modulus of carbon fibers are affected by heat treatment temperature. With increasing temperature, the elastic modulus monotonically increases, while the strength reaches a maximum up to a certain temperature, then begins to decrease (Fig. 4), which is explained by the fact that with increasing temperature of thermosetting carbon blacks, graphite contracts. Stalls become less defective, in particular, their sizes increase. This leads to shear stresses and fiber rupture.

Carbon fibers used to strengthen structural materials can be divided into two groups: high-modulus and high-strength.

The following materials are made from composite materials based on carbon fibers: three-layer panels, panels of aircraft carriers, wings of aero- and hydraulic turbines, parts of spacecraft and rockets, structures operating under conditions of strong heat, etc.

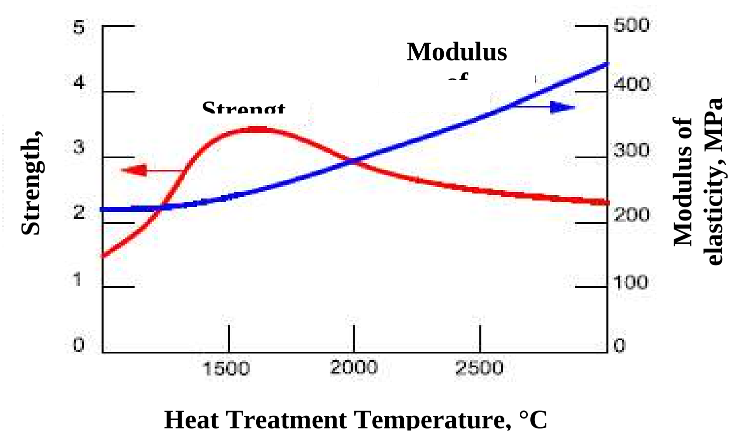

Fig. 4. Relation of the Strength and Modulus of Elasticity of Stretched Carbon Fibers on Heat Treatment on Temperature

An example of the successful use of polymer composite materials reinforced with carbon fibers is data from the world's most powerful aviation company, Boeing (USA), according to which carbon fiber plastics occupy the largest share in the design of the Boeing 787 aircraft (Table 1).

Table 1

	material	Mass fraction of material, %
1	Composite materials	50
2	Aluminum alloys	20
3	Titanium alloys	15

4	Steel	10
5	Other materials	5

It should be taken into account that carbon fibers, although not subject to corrosion, can cause electrochemical corrosion of steel when in contact with them, withstand high cyclic (periodic) loads, and stress relaxation and coefficient of thermal expansion are less than prestressed ropes used in concrete.

2. Research Area

2.1. Carbon tapes

Carbon tape (Figure 5) is a fabric in which the fibers are arranged in only one direction and is used as a filler in composites and as an effective means of structural reinforcement in reinforced concrete, masonry and timber structures. It practically does not increase the weight of the structure, increases the load-bearing capacity by 15-20%, does not require the use of concrete ingredients during the reconstruction process (i.e., it belongs to the group of finishing works), and repair work is carried out quickly.

Carbon fiber fabrics are recommended to be used to reinforce heavily damaged areas when operating loads on the structure change (Fig. 6).

Fig. 5. Carbon Fiber Tape

Fig. 6. Carbon Canvas

The work technology is as follows: the surface of the reinforced structure is cleaned, damaged areas are filled with plaster, a layer of primer is applied, and finally the tape is folded according to the design, sand is not allowed to enter., dust, water, oil, solvent or other substances on the tape. Do not bend or wrinkle the tape, which can lead to tearing of some of the fibers and a decrease in strength.

2.2. Reinforcement and Reconstruction of Reinforced Concrete Structures

The general requirements for strengthening and reconstruction of

reinforced concrete structures are as follows:

- Restoration and strengthening should be carried out after full-scale studies of the structure (building) and verification calculations;
- Condition of load-bearing structures, geometric dimensions, type of reinforcement, class and technical condition of reinforcement, concrete strength, amount of bending of the structure, location of

cracks and dimensions of openings, size of defects, location, operating loads and static diagram of construction work;

- Verification calculations of structures are carried out taking into account design materials, field surveys, actual dimensions of the structure and individual elements, as well as design deviations;
- When carrying out test calculations, defects and damage are taken into account, such as: reduction in strength, local damage and ruptures of concrete, bending of reinforcement, corrosion of reinforcement, failure of fastening and adhesion to concrete. the occurrence of cracks and opening sizes, etc.
- Verification calculations are carried out on the bearing capacity of the structure, deformations and crack formation;
- Based on verification calculations, the suitability of the structure for operation, the need for reinforcement, or its complete unsuitability are established;
- It is allowed not to carry out verification calculations to determine operability during the reconstruction of a structure if the displacements and width of cracks in existing structures do not exceed the permissible maximum permissible actual loads.
- The system of external reinforcement with composite material must ensure the inclusion of all components in the system and its joint operation with the structure being strengthened or restored;

- The concrete class of the existing reinforced structure should be: B15 – for bending elements and B10 – for compression elements;
- It is prohibited to restore a reinforced concrete structure with steel reinforcement damaged by corrosion without eliminating the causes;
- It is not recommended to restore and strengthen a bending structure if the height of the compressed zone of the reinforced element according to the test calculation exceeds the limit value according to building codes, standards or rules;
- For fire safety purposes, a protective layer of fire-resistant material is laid on the reinforced structure. Calculations for the base of the structure are carried out without taking into account external reinforcement.

In reinforced concrete structures, the reinforcement system with composites should be used when the actual compressive strength of concrete in the structure is at least 15 MPa. Carbon and basalt fiber composites are mainly used, which are characterized by high tensile and compressive strength, and the elastic modulus value is close to that of steel. For example, in Western countries today carbon composite tapes are produced with a tensile strength of 3500 MPa and an elastic modulus of 230-240 GPa, i.e., this material is approximately 8 times stronger and 5 times lighter than A500 class reinforcing steel.

Fig. 11.7. Eeinforced Concrete Coils and Columns
Reinforcement With Casing

In reinforced concrete structures, if the process of corrosion of existing reinforcement has already begun, then before external reinforcement with a composite it is necessary to carry out the following procedures: when the reinforcement is exposed, it is cleaned and treated with an anti-corrosion primer, then covered with a polymer-cement repair mortar, which ensures normal adhesion of the old concrete to the new; If the existing reinforcement is not exposed, then they resort to treating the concrete surface with a migration inhibitor, which will pass through the protective layer of concrete and protect the reinforcement from corrosion.

In practice, combined reinforcement of reinforced concrete structures with composite and steel sheathing (Fig. 11.7) or textile-composite tape (Fig. 11.8; Fig. 11.9) is quite common. For example, a reinforced concrete column is embedded in a steel casing and then covered with a layer of composite polymer, which helps the compressed steel sections (angles) work and also increases the earthquake resistance of the building. The composite tape prevents cracks from opening and protects the reinforcement from corrosion.

Fig. 11.8. Coils, Columns and Ceiling Reinforcement with Composite Tape

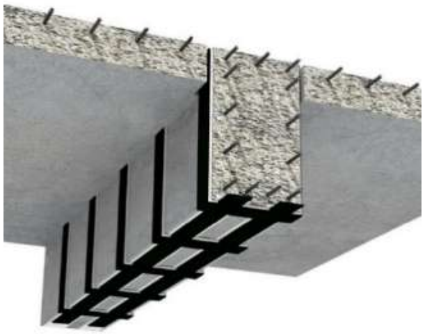

Fig. 11.9. Reinforcement of Reinforced Concrete Roofing Coil with Composite Ribbon

To restore the lost load-bearing capacity on the outer surface of reinforced concrete columns, composite materials reinforced with glass fiber, carbon, basalt or aramid fibers can be used. A flexural tape wound around a circular column limits deformation in the transverse direction and increases flexural rigidity. For reliable operation, the belt shell must fit tightly to the concrete, although the amount of clamping force is not critical.

Strengthening the roof is an important stage in the restoration and modernization of a building in disrepair. It ends on the top (Fig. 10) and bottom (Fig. 11) sides. It is considered the most effective reinforcement in areas of tensile stress on the bottom side. The main criterion for carrying out this type of work is the determination of real operational loads, on the basis of which a strengthening project is drawn up. Sometimes reinforcement is applied to a newly built object if it is planned to place heavy structures or machines on the roof that were not initially taken into account when drawing up the project.

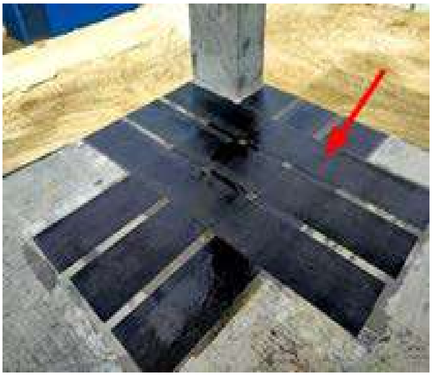

Fig. 10. Reinforcement of Reinforced Concrete from the Top Side with Carbon Fiber Tape

Fig. 11. Reinforcement of Rein-Forced Concrete Roofing from the Bottom with Carbon Fiber Tape

Reinforced concrete roofs have different configurations:

- Prefabricated – used in residential and civil buildings;
- Prefabricated – used in industrial buildings;
- Monolithic – universal roofing, which is used in all types of buildings.

- Carbon FibArm Tape and Carbon FibArm Grid are universal solutions for strengthening any tile. Depending on the type of tile, the following actions are performed:
- To strengthen a hollow reinforced concrete slab between floors, FibArm material is glued to the underside of the slab in the direction of the fibers with a certain slope. It can be single-layer or multi-layer, depending on what strength indicator is required;
- A monolithic slab is repaired in the same way, but the entire surface is covered with tape, which increases not only strength, but also seismic resistance;

When reinforcing reinforced concrete slabs, you should pay attention to openings and openings in the slab. For example, in a hollow slab, one or two holes with a diameter of up to 15 cm are allowed. If the number of holes is larger, then it is necessary to calculate the slab. The opening or hole in the slab should be additionally secured with fiberglass tape on both sides of the slab. In the case of a monolithic version, composite hangers are used parallel to the tape to strengthen the hole.

Examples of strengthening the load-bearing structures of a Mali reinforced concrete bridge building are shown in Fig. 13 - fig. 18th.

Fig. 12. Reinforcement of the Plate with Carbon Composite

Fig. 13. Reinforcement of the Structure of the Bridge with Carbon Composite Tape

Fig. 14. Reinforcement of Longitudinal Bearing Coils with Carbon Fiber Tape

Fig. 15. Reinforcement of the Tongitudinal Beams of the Road Bridge with Carbon Fiber Tape

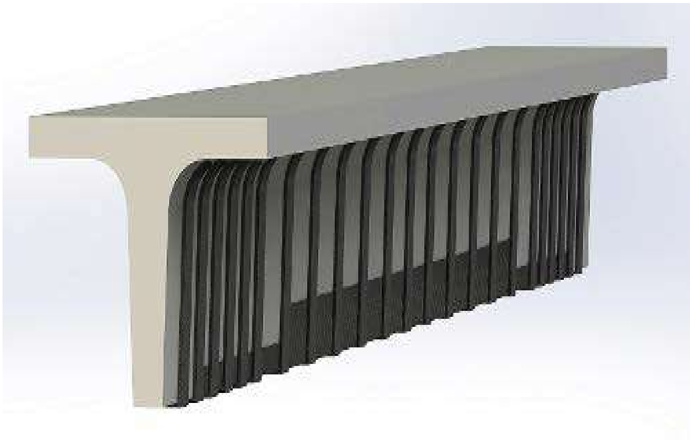

Fig. 18. The Structural Element of the Bridge Reinforcement with Carbon Fiber Tape ITECWRAP® BF1-016

Fig. 16. Reinforcement of the Bearing Coils of the Reinforced Concrete Bridge Structure with Carbon Fiber-Reinforced Plastic

Fig. 17. Reinforcement of the Middle Supports of the Reinforced Concrete Bridge with Carbon Fiber Tape FibArm

3. Conclusion

1. Interest have been raised in carbon fibers in the middle of the last century, which was associated with the development of the aviation and space industries. Carbon fiber is characterized by lightness, high tensile

strength, corrosion resistance, low thermal conductivity and very high heat resistance.

2. In modern conditions, carbon fiber materials, along with the aviation and mechanical engineering industries, are widely used in construction, which provides the gradual replacement of steel.

3. In the construction industry, the use of carbon fiber reinforced plastics, tapes, and reinforcement products in external reinforcement systems for reinforced concrete structures is very promising, which requires the presence of an appropriate regulatory framework and the development of a practical theory for calculation.

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Smart dams: Advancements and Applications

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Abstract: This article explores the advancements and applications of smart dams in modern engineering. It discusses the technologies used in smart dams, their functions in monitoring and managing water resources, energy production capabilities, and their role in environmental protection. Through case studies, the article highlights successful implementations of smart dams globally, while also addressing the challenges and future directions of this innovative field.

Introduction

Smart dams represent a significant advancement in modern engineering, offering improved water resource management, energy production, and environmental protection. This article delves into the technologies, functions, and importance of smart dams in today's world.

Technologies of Smart Dams

Smart dams incorporate various technologies to continuously monitor water levels, flow, and quality. These technologies enable real-time data collection and analysis, allowing operators to respond promptly and take appropriate measures.

Monitoring and Management

One of the core functionalities of smart dams is the ability to monitor and manage water resources effectively. Sensors installed in the dam infrastructure provide continuous data on various parameters such as water pressure, temperature, and chemical composition. This data is crucial for predicting potential issues and optimizing dam operations.

Energy Production

Smart dams also play a crucial role in energy production. By using advanced turbines and generators, they can efficiently convert water flow into electricity. Additionally, smart systems can adjust energy production based on demand, ensuring a steady supply of renewable energy.

Environmental Protection

Environmental protection is another critical aspect of smart dams. These dams are equipped with technologies that minimize their ecological impact. For instance, fish-friendly turbines and bypass systems are designed to allow aquatic life to pass through the dam safely. Moreover, smart monitoring systems help detect and mitigate pollution levels in the water.

Case Studies

Several smart dam projects worldwide exemplify the successful integration of these technologies. For example, the Hoover Dam in the United States has been upgraded with smart technologies that enhance its operational efficiency and environmental sustainability. Similarly, the Three Gorges Dam in China utilizes advanced monitoring systems to manage water levels and prevent flooding effectively.

Challenges and Future Directions

Despite their numerous benefits, smart dams face several challenges. High installation and maintenance costs, technological complexities, and potential cybersecurity threats are some of the hurdles that need to be addressed. However, ongoing research and development are paving the way for more resilient and cost-effective solutions.

Conclusion

Smart dams are a testament to the remarkable progress in engineering and technology. They offer a promising solution to some of the most pressing water management and environmental challenges. As technology continues to evolve, smart dams will undoubtedly play an even more vital role in ensuring sustainable water and energy resources for future generations.

Integration with Renewable Energy Sources

Smart dams are increasingly being integrated with other renewable energy sources such as solar and wind power. This hybrid approach not only maximizes energy production but also ensures a more stable and reliable energy supply. For instance, during periods of low water flow, solar panels installed on the dam surface can generate electricity, compensating for the reduced hydroelectric power generation. This integrated system helps in balancing energy demand and supply, making it a sustainable solution for the future.

Community and Economic Benefits

The construction and operation of smart dams bring significant benefits to local communities and economies. They create job opportunities, both during the construction phase and in the long-term maintenance and operation of the dam. Additionally, smart dams can provide recreational opportunities, such as boating, fishing, and tourism, which contribute to the local economy. By ensuring a stable water supply for irrigation and domestic use, smart dams also support agricultural productivity and improve the quality of life for surrounding communities.

Policy and Regulatory Considerations

The implementation of smart dam technologies requires supportive policies and regulatory frameworks. Governments and regulatory bodies need to establish standards for the design, construction, and operation of smart dams. These standards should address safety, environmental impact, and data management to ensure that smart dams operate efficiently and sustainably.

Moreover, policies that promote investment in smart dam technologies, such as tax incentives and subsidies, can accelerate the adoption of these innovations.

Future Prospects

The future of smart dams looks promising with ongoing advancements in technology and increasing awareness of sustainable water management practices. Innovations such as artificial intelligence and machine learning are being integrated into smart dam systems to enhance predictive maintenance, optimize operations, and improve decision-making processes. As these technologies continue to evolve, smart dams will become even more efficient, resilient, and capable of addressing the complex challenges of water resource management in the 21st century.

Conclusion

Smart dams symbolize a remarkable leap in engineering, addressing critical needs in water resource management, energy production, and environmental conservation. By integrating advanced technologies, these dams provide real-time monitoring and management capabilities, enhancing operational efficiency and safety. The ability to produce renewable energy while minimizing ecological impacts further underscores their importance in sustainable development. Despite challenges such as high costs and technological complexities, ongoing research and innovation promise to overcome these hurdles, paving the way for more resilient and cost-effective solutions. As smart dam technologies continue to evolve, they will play an increasingly vital role in securing water and energy resources, ensuring environmental protection, and improving the quality of life for communities worldwide. The future of smart dams holds immense potential for addressing global challenges, making them a cornerstone of sustainable infrastructure development.

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Hydro Insulation and Polyurethane

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Abstract: Hydro insulation is a crucial element in construction and building maintenance, aimed at preventing water infiltration and protecting structures from moisture damage. Effective hydro insulation techniques ensure the longevity and durability of buildings by minimizing the risks associated with water exposure. One of the materials commonly used for hydro insulation is polyurethane (PU). This versatile class of polymers is created through the reaction of isocyanates and polyols, resulting in a wide range of chemical structures and properties. Polyurethanes are particularly valued in hydro insulation applications due to their excellent water resistance, flexibility, and durability.

Keywords: Hydro insulation, polyurethane

Introduction

Since their introduction in 1937 by Otto Bayer, polyurethanes have evolved into essential materials in various industries. Their adaptability allows for tailored solutions in applications such as flexible and rigid foams, coatings, and adhesives. In the context of hydro insulation, polyurethane provides an effective barrier against moisture, making it a popular choice for both residential and commercial building projects.

Main part

In 2007, global consumption of polyurethane raw materials surpassed 12 million metric tons, with an average annual growth rate of approximately 5%. Projections indicated that revenues from polyurethane were expected to reach around US$75 billion by 2022, highlighting the material's significance across various industries.

One of the types of polyurethane ოს hybrid. Hybrid Polyurea (Masterseal 811) is a two-component (PTA - gray in color, PTB - colorless) waterproofing material, which is used for: residential houses, industrial buildings, commercial properties, garages, basements, roofs, and terraces, for both interior and exterior façade waterproofing.

The material is characterized by: penetrability and durability, maintaining its properties at -45°C as well as under the influence of ultraviolet rays from the sun. It can be easily applied to surfaces using a spraying machine, which is why it is considered one of the leading materials in terms of waterproofing. It is noteworthy that it penetrates deeply into the insulating material and stands out for its effectiveness.

Masterseal 811 can be applied to both concrete surfaces (industrial concrete) and metal structures and wood (although it is not as effective and durable as on concrete).

Before use, the weather forecast should be checked to avoid rain, fog, humidity, and strong wind. The use of the material is not recommended under such weather conditions. For the best results, it is preferable to use the material at 5-35°C. The moisture content in the concrete should not exceed 5%, while the air humidity should be less than 85%.

After arranging the waterproofing, its strength should be at least 1.5 N/mm² (which is checked with a device), and its thickness should be no less than 2 - 2.5 mm.

Nearby objects should be protected, whether they are cars or machinery. This can be done with a special cover or large polyethylene bags.

Conclusion

Polyurethane is a versatile and durable finish that offers excellent protection and aesthetic benefits for a wide range of projects. Whether you are refinishing a floor, protecting a piece of furniture, or tackling an outdoor project, understanding the types of polyurethane, their applications, and best practices for use will help you achieve professional results.

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