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GEORGIAN TECHNICAL UNIVERSITY STUDENT CONFERENCE ON INNOVATIVE TECHNOLOGIES IN ENGINEERING

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Evaluation of the Impact of Defects and Damages of Load bearing Structures

Vakhtang Abashidze (PhD program student), Supervisor: Professor Malkhaz Tsikarishvili, Georgian Technical University

Abstract: In the article are analyzed the technical conditions of buildings load-bearing structures, their description, and categories of technical condition according to characteristic defects and damages, as well as based on the examples and data discussed in the article, the calculations presented in them, a quantitative and qualitative assessment of the influence of defects characteristic of load-bearing structures of a building is carried out, on its reliability.

Research and analysis of the most common defects and damage to buildings have shown that significant defects and damage can reduce the strength and stability of the structure, which during the construction and operation of the building can render the load-bearing structure of the building inoperable. . The percentages of defects and damage, while maintaining a general trend, change over the years, especially in recent years, the number of defects and damage has increased, and safety factors have decreased.

Key words: load-bearing structures, defects and damages, reliability, impact, evaluation.

Introduction

Significant defects and damages would reduce the strength and stability of the structure. For example, a defect reducing the strength of the structure by 25% or more is critical and represents a danger both at installation stage and at operation of the structure, and corresponds to the disabled state of the structure. Defects and damages are reducing the carrying capacity of the structure by more than 35% correspond to the accident state of the structure.

Main Part

Qualitative evaluation of defects and damages

The impact of defects in structures is evaluated according to the categories [2] considered in the structures reliability methodology. Based on the presence of a defect and its impact on the reliability of the structure, five categories of the technical condition of structures are established (Table 1).

Table 1. Categories of technical condition of structures

Description of technical state	Relative reliability, $y=\gamma/\gamma_0$	Ultimate safety factor, γ_0
1.Serviceable state of structures. The requirements of current standards and	1 and more	1,75 and more

design documentation are met. There are no deviations from the project or norms. There is no need for repair work.		
2. Serviceable state of structures. The load-bearing capacity of the structures is ensured, the norms of deformability and durability may be violated, although normal operating conditions are ensured. It is necessary to eliminate the identified defects.	0,95	1,66
3. Structures are in limited serviceable state. Existing defects lead to a decrease in the load-bearing capacity of individual structures. Defects must be eliminated for normal operation.	0,85	1,66
4. Inactive state of structures. Existing significant defects testify to the instability of structures for operation. Overhaul with reinforcing of structures is required. Before carrying out reinforcement, it is necessary to limit the active loads. Operation is possible only after repair and reinforcement.	0,75	1,31

5. Accident state of emergency. The existing defects testify to the possible collapse of the structures. It is necessary to immediately unload the structures and arrange temporary anchorages, poles, supports, fences of the dangerous zone. Repairs are mainly carried out by replacing damaged structures	0,65	1,31 or less

Table notes. The ultimate reliability (safety) factor γ_0 characterizes the safety factor of the structure strength that is defined as the ratio of the breaking force in the structure, compliance of the design construction norms P^{des}, with the force acting at the stage of operation P, i.e. $\gamma_0 = P^{des}/P$. The value y characterizes the ratio of the breaking force P^{act} of the structure under consideration with defects to the force acting on the operation stage, i.e. $\gamma = P^{act}/ P$.

The most dangerous are the defects in the construction or manufacturing of the structures of the columns, girders, beams, and trusses, and the damages that occurred at the operation. In the case of columns, this firstly is related to their demolition usually is instantaneous, and on the other hand the demolition of columns leads to the demolition of other structures located above them. The structures of trusses are the most susceptible to defects, because they have, on the one hand, a low safety factor, on the other hand, they contain a large number of rods and units, the failure or damage of all of thar would lead to the demolition of the structure.

Defects and damages that have not been eliminated, lead to the demolition of structures or their damage that are expressed in cracks propagation or the appearance of additional cracks, increased deformations, reduction of service life due to corrosion, destruction of materials, increased humidity of walls and premises, vibrations, etc.

Individual defects or damages of one structure have an impact on the reliability of other structures supported on it.

With the aging of materials and the accumulation of various types of damages in structures, dangerous accident processes are developing.

At evaluation of the technical start, the detected defects or damages should be analyzed and determined how critical these defects and damages are.

Minor defects in the structure, or even the total amount of damage, affect the quality of the construction.

At investigating accidents, the question that usually arises is: Which defect or damage was the main cause of the accident?

A failure would occur due to a single large defect or damage, characteristic of the strength of materials or the natural dispersion of loads, or the simultaneous presence of several average, random defects at construction.

Let's analyze this issue from the standpoint of probability.

For simplicity and visualization, let's take the normative assurance of the quality of materials, manufacturing and loads that is equal to $p_{\text{cons}} = p_{\text{oper}} = 0.99$.

Then, the failure values of will be $q_{\text{des}} = q_{\text{cons}} = q_{\text{oper}} = 1 - 0{,}99 = 0{,}01 = 1{,}10^{-2}$.

The probability of collapse in the presence of a large defect at the construction process that will lead the collapse of building structure will be $Q = q_{\text{des}} + q_{\text{cons}} + q_{\text{oper}} = 1{,}10^{-2} + 1{,}10^{-2} + 1{,}10^{-2} = 3{,}10^{-2}$ that indicates on the probability of an accident (from 100 buildings 3 of them should be demolished).

The probability of collapsing at the simultaneous occurrence of average or minor defects at construction $Q = q_{\text{საპრ}} \cdot q_{\text{მშენ}} \cdot q_{\text{ექს}} = 1{,}10^{-2} \cdot 1{,}10^{-2} \cdot 1{,}10^{-2} = 3{,}10^{-6}$, i.e. the value is very small, smaller, than in the first case.

From above mentioned, we would conclude that large accidental defects and damages caused by gross errors are the most dangerous, since the simultaneous unfavorable coincidence of average and small accidental defects and damages is less expected.

In the case of a combination of moderate systematic defects and damages, the combination of that will result in a decrease in the strength of the structure (for example, the cross-sections of the structures are simultaneously reduced and the design loads are increased at construction), then this will result in an emergency situation for which $Q \approx 1$ (Fig. 1; 2; 3; 4).

Fig. 1. Construction with defect

Fig. 2. Construction with defect

Fig. 3. Construction with defect

Fig. 4. Construction with defect

Let’s consider the building, in the presence of defects and the possibility of an accident from an engineering point of view.

Even with one structure in accident conditions, the probability of a building failure is high. The collapse of an structure in accident condition would lead to the complete collapse of other structures and buildings. In this case, it is necessary to immediately unload the structure in accident condition, arrange safety crippling or supports under it, fencing the dangerous zone for people.

In the presence of a number of structures in accident conditions in the building, the probability of an accident increases even more. In this case, the operation or construction of the building would be completely stopped. The presence of people is not allowed in the building. Strengthening of structures in accident conditions is usually carried out by replacing them with new structures or, in the case of a significant number of structures in accident conditions, by constructing a new building.

In the presence of individual or several structures in out of service condition, it is necessary to reduce the loads acting on them and carry out overhaul repairs to reinforce them and restore their original quality. If the structure is in accident conditions with the loss of bearing capacity, the building should be considered as being in accident conditions and immediate measures should be carried out to unload and reinforce the structures in accident conditions.

Quantification of impact of defects and damages

Let's evaluate the impact of defects and damages in structures on reducing their strength and stability on concrete examples of calculations taken from practice. We have one example in the paper.

20 cm thick monolithic reinforced concrete slabs of flooring are supported on monolithic reinforced concrete columns. According to the project, the slabs are made of B25 grade concrete, reinforced with upper and lower meshes of 10...28 mm diameter rods with A-III grade steel rods with pitch of 10 cm.

Due survey of the coverings, the following defects of structures were revealed:

- The concrete strength of the flooring slabs is reduced compared to the project. In some areas, the concrete grade was B20, instead of B25 that represents the danger of crumpling the flooring slabs with the columns;

- The diameters of the lower mesh reinforcement in separate areas are reduced, compared to the project. instead of 16 mm, a 12 mm diameter reinforcement bars are installed;

- In some places, the thickness of the concrete protective layer is reduced to 10 mm, instead of 25 mm according to the project (Fig. 5; 6; 7; 8);

Fig. 5. Local open r/c floor slab (outlined in red)

Fig. 6. Measuring of r/c floor slab protective layer thickness (outlined in red)

Fig. 7. Determination of r/c slab concrete strength

Fig. 8. In red line is indicated the horizontal plane, in yellow line is indicated deflection

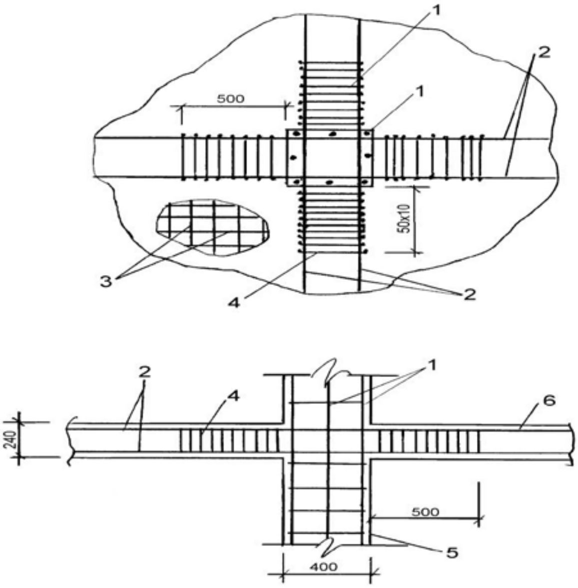

Fig. 9. Structure of monolithic beamless covering: 1 - longitudinal reinforcement of the column: 2 - additional reinforcement in the slab under the column; 3 - slab upper and lower reinforcement meshes with a rod diameter of 100 mm (conditionally not shown on the section); 4 - clamps with a diameter of 8 mm and pitch of 50 mm; 5 - a column with a section of 40x40 cm; 6 – floor slab.

The cracks are propagating to a depth of 4 mm and had a direction mainly along the reinforcement. Cracks appeared due to deficiencies in concrete care during construction: excessive hardening of the lower layers of concrete, reduction of the thickness of the concrete protective layer, removal of the formwork when the concrete was insufficiently strong. These cracks do not affect the load-bearing capacity of the structures but can lead to a reduction in the fatigue strength of the structures (Fig. 10; 11).

Fig. 10. Cracks in beamless monolithic r/c floor slab (outlined in red)

Fig. 11. Cracks in beamless monolithic r/c floor slab (outlined in red)

Let's evaluate the impact of the most dangerous defect on the floor slab, the reduction of concrete strength, as a result of which (due to crumpling) the floor slab may collapse.

The force of the design crumpling from the load on the roof N=69 tm.

The actual grade of slab concrete is B20, R_{bt} = 8.16 kgf/cm^2. Double clamps 8 mm diameter, A-III grade, with pitch of 10 cm. The cross-section of the c[amp is 0.503 cm^2. Slab thickness h=20 cm, working height h_0 =20 - 4=16 cm.

Column cross-section is 40x40 cm, b = 40+2+16 =58 cm.

The average perimeter of the c crumpling u_m = 4(58+40)/2=196 cm.

$(b - b_k)/2$= (58-40)/2=9 cm.

The number of clamps in the perimeter of the crumpling is nx = 2·4·20/5 =32 items.

$\Sigma A_{sw} = 32 \cdot 0{,}503 = 16$ cm^2.

$F_{cw} = 1750 \cdot \Sigma A_{sw} = 1750 \cdot 16 = 28\ 000$ kg.

Slab load bearing capability on on crumpling

$[N] = R_{bt} \cdot u_m \cdot h_0 + 0{,}8F_{cw} = 8{,}16 \cdot 196 \cdot 16 + 0{,}8 \cdot 28\ 000 = 47989$ kgf = 47.9 tm < N = 48 tm, i.e. the carrying capability is not ensured, reinforcement is required.

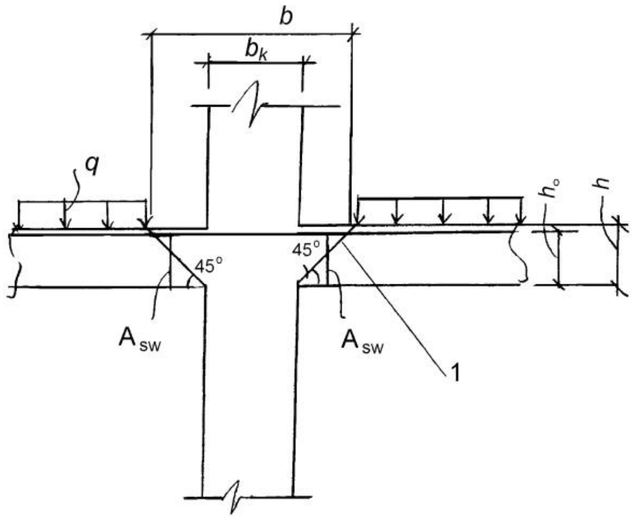

Fig. 12. For the analysis of the crumpling of the floor slab:

1 - crumpling pyramid

Taking into account the defects revealed at study, it was recommended to reinforce the slabs against the crumpling of the concrete in the areas of reduced strength by arranging steel capitals on the columns. The cracks in the slabs due to the settling of concrete should be repaired using the epoxy resin. With a reduced number of reinforcements compared to the project, it was recommended to stick reinforcing GRCM tapes on epoxy resin in the areas of the slabs.

When assessing the relative reliability of structures with defects and damages, it was accepted that the design of the structure is carried out in accordance with the applicable load, norms and does not have an excessive reserve of strength. The presence of a defect in the structure leads to an overload from the design loads and a decrease in the relative reliability of the structure. The category of relative reliability and technical state of structures was evaluated according to Table 2.

The results of the calculations of the influence of defects on the technical condition of construction structures are presented in Table 9. in 2.

Table 2. summary table of impact of characteristics defects of structure on its reliability according to the analysis data

Structure	Defect	**Over-stress, %**	**relative reliability $y = \gamma / \gamma_0$**	**Defect value at in**

				inactive status
1	2	3	4	5
1. Reinforced concrete slab	Reduction of the protective layer thickness of reinforced concrete slab from 3.5 cm to 1.5 cm	38	0,72	3,3 sm
2. Reinforced concrete column	Reduction of reinforced concrete column concrete strength by one grade (24% strength reduction)	17	0,85	27%
3. Steel column	20% corrosion of metal profile thickness	28	0,78	21%
4. Roofing steel beam	20% corrosion of metal profile thickness	15	0,87	23%
5. Beams supporting on brickwork	Absence of support pads (in	110	0,47	32%

	support area reduced by 52%)			
6. 5 story frame building flooring and roofing structures	Exceed by 15% of loads on separate areas oif roofings and coverings	In slabs and beams by 15%	Slabs and beams 0,87	Slabs and beams - 25%
7. Reinforced concrete frame building floor beamless slab	Reduction of concrete strength by two classes of non-reinforced concrete slabs for inter-floor roofing of r/c frame building	35	0,85	30%

Conclusion

The study and analysis of the most common defects and damages in buildings showed that significant defects and damages would reduce the strength and stability of the structure that during the construction and operation of the building can lead the load bearing structure of the building to an inactive status. According to the examples considered in the paper, the technical state of the building's load-bearing structures were described and the technical condition categories were determined according to their characteristic defects and damage.

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Road Construction in Georgia in the 19th Century and Before the Establishment of the Soviet System

Irakli Aladashvili (Bachelor program student), Supervisor: Professor Konstantine Mchedlishvili, Georgian Technical University

Abstract: Road construction plays a dual role in a country's development as well as in its defense. Well-planned and executed road infrastructure is essential for promoting economic growth and improving access to vital services. Also, well-designed and maintained roads help protect the country and mobilize strategic infrastructure during emergency situations. It also helps to move military personnel quickly and easily.

Key Words: Road construction, Georgian military road, Railway network, Ioseb Andronikashvili, Tunnel

After the abolition of the Kingdom of Georgia and its accession to Russia in the form of Tbilisi and Kutaisi governorates, political and economic life began to be regulated, which created better conditions for the development and improvement of the road network.

First of all, the so-called the military road of Georgia, which connected the North Caucasus with the South Caucasus. Russia at that time was lagging behind advanced European countries and Romania-Turkey in terms of road development. In the Russian Empire of 1830, there were two highways with stone pavement. The construction of the Georgian military road began in 1803-1805 and the Moscow-Petersburg highway, the construction of which began in 1817. The best specialists in road construction in Europe at that time were the French. In 1791, the world's first specialized road school (Corps of Bridges and Bridges) was founded in Paris, which was transformed into the High School of Roads and Bridges in 1797 at the initiative of Napoleon. Graduated specialists who worked in Georgia as well. The contingent of workers was filled with local peasants. Military units, brought from the war in the North Caucasus to rest, also worked on road construction.

Roads of military significance were built by the work of soldiers: Georgian military road (Tbilisi-Vladikavkaz); Imereti military road (Tbilisi-Kutaisi-Poti); Zekar military road (Kutaisi-Abastumani); Military Road of Abkhazia (Sukhumi-Tsebelda-Klukhori). From Tbilisi to Suram, from Zestaon to Marana (the confluence of Tskheniskali near Rion).

On the Surami-Zestaon section, the roads passed through the valleys of Chkhrimela and Dzirula. Due to marshy areas near Poti, passengers and cargo were transported by flat-bottomed boats from village Marani to Rion. In 1830, General Paskevich asked for 250,000 manats to improve the roads in the South Caucasus, 66,000 manats were needed from Acre to Armenia due to the war with Iran, 22,000 manats for the roads of Kartli and Imereti, 3750 manats for Samegrelo, 12,000 manats for the military road of Georgia, etc.

The amount allocated for the development of the road work of the crown princes M. Vorontsov (1845-1854) and A. Baryatinsky (1856-1862) increased significantly and exceeded millions.

1858-1899 was spent: Ossetian military road (Kutaisi-Mamison) - 609 thousand man. Poti-Kutaisi-Tbilisi-Yerevan-Julfa-1.9 million people. After joining Batumi District in 1878-90 Spent: Batumi-Ardagan, Batumi-Akhaltsikhe - 1.2 million man. New pass section Mtskheta-Kobi 1857-60. - 1 million man. Novorossiysk-Sukhum 1890-1901 10.5 million people.

In the Caucasus, the so-called VIII road district, which is not less than 100,000 per month. was financed. 1900-1914 Much of the funding came in the form of tolls from roads. In 1860, moving an empty cart - 5 cap, loaded cart - 10 cap, livestock - 3 cap, man - 2 cap, cattle - 4 cap, sheep - 1 cap.

Tbilisi was at the end of the 20th century. The customs point "Moscow Checkpoint". The distance between the customs points was 40-60 km. Taxes were increasing all the time.

Since the 1880s, road funding has declined sharply, as a large portion of capital investment has been spent on the railway network. In 1855, there were 1,000 km of railways in the Russian Empire, in 1900, 60,000 km.

Nevertheless, highways with a strategic direction in Western Ukraine, Poland and the South Caucasus received more attention. In

1857-64, the agricultural district-Mletha-Kobi was built. The head of the construction was Boleslav Statkovsky, a prominent road engineer working in the Caucasus, the main supervisor was the famous poet, General Grigol Orbeliani. B. Statovsky from 1847 to 1898 Before his death, he worked in Georgia and made his way from an engineer to the head of the VIII road district, he published many scientific works on the fight against snow avalanches and the climatology of the Caucasus.

Engineer Mikheil Garsevanishvili was a well-known traffic figure. He lived from 1830 to 1855. He built a 500-km road in the Caucasus. In 1883, he was appointed the rector of the St. Petersburg Institute of Three-Way Roads and headed it until his death in 1902. The main area of his scientific interest was the sustainability of soil erosion.

Georgian engineer Kaikhosro Bagration-Mukhraneli has a great merit in the construction of roads and bridges in Georgia. (1789-1855) under his project and under the direct supervision of Taigo Vorontsov, currently the Saarbrucken Bridge in Tbilisi.

Ioseb Andronikashvili (1855-1940) is very much credited with the development of road affairs in Georgia. Roads in Kakheti were built with his projects and guidance, which are still excellent examples of matching the track with the landscape (eg Sighnaghi-Anaga, Sighnaghi-Tsnori). His contribution is great in finding financial funds for the design and construction of the Kakheti railway. Along with that, he was a well-known patron and cultural worker of Georgian theater and one of the founders of Tbilisi Conservatory. He was the governor of the Department of Motorways at the Polytechnic Institute. The author of the first traffic manuals and terminological dictionaries in the Georgian language. Head of the Traffic Department of Georgia 1935-1940.

The German geologist, Academician Germanebych (1806-1886) played a major role in the study of road conditions in the Caucasus. Since 1854, he worked as a mining engineer in the Caucasus. In 1869, an extraordinary commission with 10 members was created to regulate road affairs in the Caucasus. G. Abikh, B. Statkovski, M. Garsevanishvili were also present.

The Commission divided the roads of the Caucasus Road District into 4 categories:

Category I: Military road of Georgia; Imereti military road (Tilisi-Kutaisi-Sukhumi); Akhaltsikhe military road (Surami-Borjomi-Akhaltsikhe); Ossetian military road (Kutaisi-Mamison); Tbilisi-Red Bridge (part of the Tbilisi-Yerevan Road); Orpiri-Ozurgeti.

II category: Tbilisi-Manglisi-Tsalka-Akhalkalaki, 180 km long.

III category: Tbilisi-Gombori-Telavi; Treadmill; Telavi-Akhmeta-Tianeti; Zemo Imereti (Kutaisi-Jvari)

Category IV: local, national roads.

In 1970, Germane Abikh was asked by the Division of the Crown Prince of the Caucasus to give his opinion on the obstacles in the construction of the Tbilisi-Gombori-Telavi road. G. Abikhi's opinions are still relevant for the road network of Georgia. In his opinion, the main obstacle to the development of the road network of Georgia is the inconsistency of the routing with the geological conditions. In his opinion, due to strong landslides and weak rocks in the Gombor Pass, there will be constant obstacles in the operation of the roads. It is better to build the road on the northern side of the Gombor ridge, where there are strong rocks. As we can see, the recommendations of G. Abikh 150 years ago have not been fulfilled to this day. Accordingly, we have difficulties in Gombor and especially the highway. on E60 in Dzirula valley.

The road network of Georgia by 1912 was 4840 versi roads, of which approx. 3700 versi, 1140 versi ground. In the same period, the total length of the road network in the Russian Empire was 3 million km. 30,000 km. That is, 1%, and in Georgia, 76% of the roads were used, but the indicators of road operation and maintenance were lower than in Europe.

Technical norms were not followed when designing the roads, road works were not mechanized. Nevertheless, the Caucasian Road District (кавказский округ путей сообшения) was the best in the empire in terms of the number of highly qualified specialists. It had a research laboratory equipped with European-made tools, the best technical library in the Caucasus, where road construction literature in Russian and other foreign languages was collected.

The Soviet government gave this laboratory and library to the newly formed Polytechnic Institute.

In the second half of the 19th century, remarkable objects were built in the history of road construction in Georgia:

The Georgian military road was built since 1803. At the end of the 19th century, it was the most well-equipped and safe road in the Russian Empire in the most difficult mining conditions. It had anti-avalanche galleries, stone arched bridges and retaining walls built with the advanced constructions of that time. They started using water wells. Effective anti-landslide and drainage measures were implemented near Akhal Athos. The construction of monolithic reinforced concrete bridges and embankment structures began. In 1849-1853, he built a stone arch bridge (today's Saarbrücken Bridge) in Tbilisi under the project and guidance of the famous Georgian bridge engineer Kaikhosro Bagration. 32 in length M. The thickness in Klite is 1.52 m.. This bridge, together with the bridge designed by the Italian Giovanni Scudieri (today's "dry bridge") through Orbelianti Island (today's Mother Tongue Garden) connected the intensively constructed left and right bank areas of Tbilisi.

In 1810, Engineer-Colonel Greenberg was appointed as the instigator of complex works in the Caucasus Road District. He was the first to use the term "Georgian military road" and it was noted that to connect Tergi and Aragvi valleys, it is better to organize an underground passage between S. Kobi and S. Kaishauri. This was the first A suggestion about the need for a tunnel. In 1856, engineer B. Statkovsky drew up a project for the reconstruction of the military road, according to which the track passing through S. Kaishauri was rejected, and the road passed from Kushsheti to Mleti on the right bank of Aragvi. Aragvi was crossed by a stone bridge near S. Mletha and climbed the slopes of the left bank by arranging eight zigzags in a relatively confined area and reached the cross pass at an altitude of 2395 meters above sea level. Then the road also zigzags down the Bidar valley to the Tergi valley near S. Kob.

The project envisaged 5569 m. A long tunnel was cut under Mount Sadzeli, but the complexity and cost of construction forced the management to replace the tunnel option with much cheaper avalanche protection structures.

Subsequently, the issue of the tunnel was repeatedly raised. In 1980, a technical and economic feasibility study was made by "Tbilgzaprojekt" (engineer A. Gorozia) on the arrangement of the southern portal 2 km from the Mleti bridge and the construction of an 8.1 km tunnel to Koba. Later, this decision was changed and from 2020 The Transcaucasian road tunnel of Kobi-Tskeri (Khada river gorge) with a length of 9.6 km to S. Kvesheti and 16 km Sigridze access road is being built.

Georgia became a constituent part of the Russian Empire in the 19th century. Compared to European countries, Russia had an insufficient and low-quality road network, which was caused by the empire's cultural and economic backwardness, as well as its large territory. Due to the strategic importance of the South Caucasus, for the implementation of imperial goals, Russia paid much more attention to the territory of the South Caucasus and Georgia compared to other governorates. A small but very important part of the staff consisted of Georgian engineers who had received professional education in Russia and Europe. K. Bagrationi, M. Gasviani, I. Andronikashvili, N. Kvezereli and others. Under their leadership and direct participation, the Georgian State School of Surveyors-Engineers was established, which carried out highway projects in the most difficult conditions all over the world and on the territory of the USSR.

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Evaluation of the combined Transport Terminals of Georgia

Tamar Arjevanidze (PhD program student), Supervisor: Professor Goderdzi Tkeshelashvili, Georgian Technical University

Abstract: The article presents the presentation of the model of new service, intermodal, contrailer shipments in the railway transport system of Georgia. Determination of its value in the railway system of Georgia. The current condition of railway stations and terminals is discussed in the study. Modern technologies of combined transportation for the railway sector of Georgia have been evaluated. The article identifies investment opportunities: through the reconstruction of existing stations and terminals and the construction of a new terminal. Economic analysis makes it possible to make informed and conscious decisions when launching a new sustainable mode of transport. The obstacles considered in the research can become a hindrance in the implementation of contrailer shipments. Such as tunnels, the strength of curves and tracks, volume.

Key words: Intermodal shipments, type of combined transport, contrailer, railway.

Introduction

The main task of the railway transport of Georgia was to fully and timely satisfy the needs of the country's economy and population in transportation. The current state of the market and national economy, which is characterized by an imbalance in the financial system, with a decrease in production and investment in basic industries, together with the previous goal, requires the provision of transportation services and a fundamentally new, competitive transportation service to customers. Over the last decades, the share of intermodal shipments in the transport system of Georgia has increased significantly. Be it container, sea, vehicle or truck types of transportation.

It is important for the economy of Georgia to develop the transportation of combined technology as a green, ecological type of transport, since the mentioned model will allow the transport market to more fully adapt to the new global system of supplying goods and services. Multimodal transport has the ability to flexibly respond to changes in market conditions.

In general, just like any activity, transport activities related to innovation and its implementation necessarily require improvement of organizational mechanisms and capital investment, for this, it is necessary to make a comprehensive economic assessment, to develop special approaches, especially if the market conditions are highly competitive.

Main part

Contrailer transportation is a type of intermodal transportation where a loaded trailer or trailer/body (empty or loaded) is placed in a specially equipped station by means of a transfer platform on the railway tracks, where it continues its way through the railway to the destination station, and the further journey is completed by land vehicle. Both qualitative and quantitative methods of technology have been used to assess the feasibility of such shipments. For this purpose, we identified 3 main tested criteria: technical, technological and economic.

In the technical criteria, we discussed the technical parameters of the load units of the rolling stock and selected the means acceptable for the rolling stock of the train of the Georgian Railway.

The technological criteria include the parameters of the technical means of horizontal loading terminal processing on 4 models (Modalohr, Cargobeamer, Megaswing, Cargospeed) and the economic criteria determine the average cost of investment equipment for the selected stations and terminals.

Qualitative methods are used:

Literary works, information and reports, analysis describing the transport market of the region.

Due to its geographical location, Georgia is in a complex relief transport system, among which railway transport is no exception, and therefore, when transporting large cargoes, we take into account the capacity and volumes of tunnels, curves and tracks. Cargo size is a particularly sensitive issue for contrailer shipments. The "International Agreement on Railway Freight Traffic" (SMGS) was developed by the Railway Cooperation Organization OSJD, including for countries that must meet zonal requirements in terms of gauges. That's why the

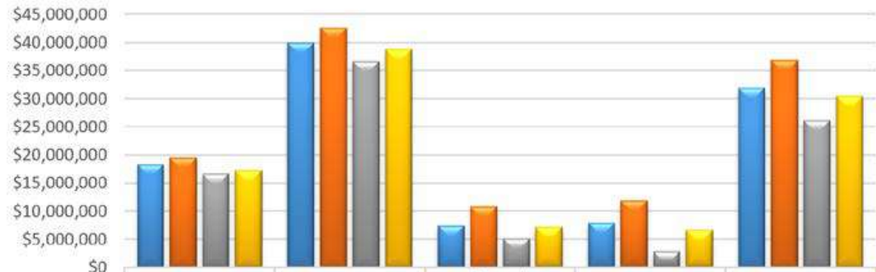
"Technical Conditions for Cargo Placement and Fixing" have been developed, according to which the 12th chapter of the first volume is devoted to the loading conditions of counter-truck shipments and it is established that for counter-truck shipments, it is necessary to take into account 2 important parameters, the height and width of the loaded cargo, the maximum data of which is height 5 3 m, and the width - 3.4 m.

To calculate the area of each module for research, we also need the parameters of the semi-trailers themselves, which means the length and width of the semi-trailers, and we also take into account the weight of the load to determine the number of components and the height depending on the requirements of complex terrain (tunnels, bridges, curves). The data of the wagons also differ according to the models, so we take the maximum lengths of the mentioned wagons, taking into account the length of the semi-trailers. for example; The maximum weight of the trailer for the Modulohr module is 13.7 m; For Cargobeamer - 14.2 m; 16.3 m for Cargospeed and 14.7 m for Megaswing. As for the height, the height of the semi-trailers starts from 2.3 m and the maximum is 4 meters, although in the main form there are trailers with a height of 2.7 m. Which requires the presence of appropriate drawings on the road of Georgia due to the difficult terrain to determine the dimensions of the cargo. Based on the parameters of individual stations, the number of carriages in the train was calculated.

In addition, it is necessary to take into account the possibility of performing parallel operations according to modules, which requires the presence of several similar technologies at the terminal and their number when the wagon is loaded with this technology. Besides Megaswing, other modules require the presence of a special similar technology terminal at the point of destination, and Megaswing with its independent system does not require the presence of an automated system at the receiving point. Therefore, other than Megaswing, the terminal arrangement model needs at least 2 terminal systems to function.

We use the weighted average cost of capital (WACC) to calculate today's cash flow.

It should be noted that there are risks associated with the cash flow forecast, so we are making a 15-year forecast, taking into account the operational period of the new equipment. Among the above-mentioned horizontal loading technologies, the Megaswing module receives the most value for the Poti and Ankli stations, since it contains less capital costs, and does not require the reconstruction of the stations. It has parametric indicators that meet the technical manufacturing difficulties and as a result of the calculation has the highest current monetary value compared to other technologies.



	ბათუმი	ფოთი	თბილისი საკვ.	რუსთავი	ანაკლია
Modalohr	$18,326,000	$39,976,000	$7,398,000	$7,919,000	$31,846,000
Megaswing	$19,525,000	$42,611,000	$10,818,000	$11,855,000	$36,878,000
CargoBeamer	$16,682,000	$36,657,000	$5,115,000	$2,884,000	$26,149,000
Cargospeed	$17,247,000	$38,695,000	$7,093,000	$6,547,000	$30,500,000

Conclusion

Our goal was to describe, compare and evaluate the presented modern technologies based on the operational and technological analysis for the implementation of counter-trailer transportation in terms of space and investment costs of the transportation facility. Each implemented technology is a unique complex with its own advantages and disadvantages, such as scale, flexibility, processing time and costs. The study highlighted2 investment opportunities, when the development of terminal operations is possible by completing the infrastructure of existing terminals, i.e. reconstruction, and the second option, when the construction of a new terminal is required, for example, in case of a potential breakdown.

As a result of the study, it was revealed that the Kargobeamer and Megaswing systems are wagon-based technologies that require minor modifications to the terminal infrastructure for Batumi, Poti, Tbilisi

Sakvandzo and Rustvai stations, while the Anaklia station requires constructio

On the basis of the economic analysis, we concluded that the cost of the mentioned project for Poti and Anakli with a horizontal load module for Megaswing is valuable and gives the basis for equipping the terminals for the mentioned stations to carry out counter-trailer shipments.

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Urban Construction and Engineering-Geological Issues in the City of Tbilisi

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Abstract: In the contemporary era, there is a burgeoning intensity of activities related to the construction and reconstruction of small towns. Consequently, urban planning issues, particularly their interconnection with geology, assume paramount significance, with a specific emphasis on engineering geology. The geological aspects of land utilization for urban development play a crucial role, requiring an exhaustive exploration and consideration of influential factors such as hydrogeological conditions, soil physical and mechanical properties, geodynamic processes, geological structure, and tectonics, among others. A thorough understanding of the geological structure of a designated construction area is imperative for rational planning. This becomes even more essential in urban development scenarios where there is a growing necessity to utilize less favorable areas for construction, both in the development of new structures and the retrofitting of existing buildings to address potential causes of deformations. Typically, these issues are intricately linked to the research and assessment of soil characteristics.

This article centers on the engineering-geological and hydrogeological discussions in the city of Tbilisi, using the example of a

planned construction project on a st. university. The research facility, situated in Tbilisi, exemplifies a nearly horizontal construction site characterized by a square layout with a slight southward inclination. The intended development involves a multifunctional, high-rise, four-block building.

Engineering-geological studies were conducted with the objective of delineating the characteristics specified in the technical assignment for the buildings and determining the foundational conditions based on acquired data. Drilling operations were executed using the mechanical-column method, Kearney, with continuous extraction, ensuring parallel layers for visual description and sampling.

The study area is situated within the geomorphological context of the Small Caucasus Tertiary folding mountain zone, characterized by ridges and massifs with deeply divided erosive relief. The research area, located in the eastern part of the Trialeti ridge, specifically in Saburtalo, is positioned at the end of a depression.

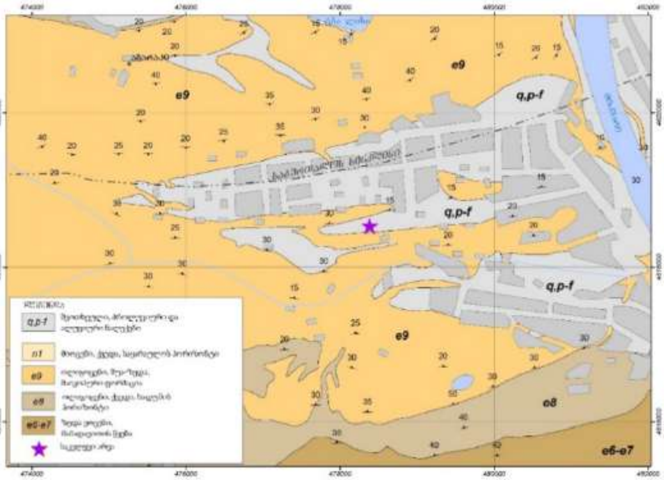

Fig 1. Location of research area on the map of east Adjara-Trialeti Geological map

The construction site, situated in the Saburtalo syncline on the southern flank, rests upon Quaternary sediments. The predominant rocks in the area consist of Oligocene-Submiocene terrigenous turbidites, exhibiting lithologically depleted thin layers of alternating sandstones and argillites.

Fig.2 Outcrop of surrounding teritory of research area. Oligocene-lower miocene Terrigenous turbidites

In accordance with the hydrogeological map of Georgia, the territory falls within the fold-fault zone of Adjara-Trialeti, forming part of the hydrogeological district of the water pressure system. The water distribution area is characterized by fissured and napralu-karst waters, with weak water richness and a low degree of mineralization.

The construction site is stratified into four layers: Bulk soil (Layer #1), dark brown loamy mass with tabs; Loam (Layer #2), dark brown with chert and chert tabs; Sandstones and argillites (Layer #3), a sequence of thin-layered, badly worn, cracked, and disintegrated to loamy soil; and Sandstones with argillite interlayers (Layer #4), grayish-blue and of small strength.

Furthermore, water was identified in the soil at varying depths, revealing a layer of saturated soil in the lower part of the trench. The moisture content of the soil exhibits variations in relation to Portland cement, whereas it remains consistent concerning Sulphate Resistant Cement (SRC). Periodic evaluations of the performance of the reinforced concrete structure in subaqueous conditions indicate cost-effectiveness under constant submersion conditions and average efficiency during periodic submersion.

The culmination of soil and laboratory analyses identified three geotechnical-geological elements in both subaqueous and adjacent regions of the construction site. Recommendations for geotechnical measures, particularly focused on subaqueous conservation, have been articulated. Specifically, the proposal suggests the implementation of geotechnical-protective measures, including the utilization of erosion-resistant materials such as gabions and the installation of slope protection structures like retaining walls or their synergistic deployment, in a phased manner.

The project engineering of these geotechnical-protective measures was spearheaded by the geotechnical specialist and executed by the construction organization. However, the emergence of an underwater landslide induced by soil erosion posed a critical challenge during the construction phase. Consequently, additional geotechnical-protective measures were deemed imperative to preempt potential damage to the infrastructure and ensure the stability of the project objectives. This underscores the pivotal significance of ongoing geotechnical-protective measures, tailored to adapt to the dynamic conditions of soil erosion and evolving project requirements.

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Hazardous Slope Slip Surface and Depression Curve Equations

Valeri Bliadze (PhD program student), Supervisor: Professor Tariel Kvitsiani

Abstract. In order to investigate the problems of static stability and instability of slopes, the equation of hazardous slip surface (line) of a slope is derived. Using this equation, the location of the center of curvature $C(x_c, z_c)$ and its radius R at any fixed point of the hazardous slip line, as well as the length ℓ of hazardous slip line arc of the landslide prism and the volume of the prism can be found analytically. Finally, the static stability coefficient of the slope will be calculated by means of the retention and shear forces acting on the section (block) under consideration.

To determine the position of the groundwater depression curve, a differential equation is obtained, the solution of which gives the groundwater level fluctuation values. The equation of the theoretical depression line and auxiliary plots are obtained to plot the depression curve based on a single borehole.

When determining the slope shear resistance coefficient, the slope is conditionally divided into sections along the vertical. To calculate the specified values of the retention and share forces acting on these sections, a pore pressure coefficient r_u is introduced, which is determined by the location of the line of depression. The given

coefficient r_u allows determining the target component of gravity and hydrodynamic pressures.

Key words: Slope, hazardous slip surface, depression line, porosity coefficient, stability coefficient.

Introduction

In the practice of hydraulic engineering, transportation and civil construction, one of the important tasks is to examine the static stability of natural and artificial slopes and to predict the occurrence of soil mass talus and landslide phenomena.

The purpose of the static slope stability analysis is to determine the shear reserve coefficient of potentially hazardous slip surface of the collapsed mass. To determine the reserve coefficient, it is necessary to determine the shape and location of the potentially hazardous slip surface and to determine the position of the groundwater table or depression curve. Otherwise, it is not possible to determine the shear reserve coefficient [1,2].

In homogeneous massifs, in the upper part of the slip surface of the landslide at a distance of ℓ meters horizontally from the slope crest edge A, a vertical plane (crack) will appear as a result of tensile stresses (Fig. 1), the height of which is $BL = H_{90}$. This height is determined by the following theoretical dependence [1,3]:

$$H_{90} = \frac{2K}{\gamma} \operatorname{ctg}(45° - \frac{\varphi}{2}), \tag{1}$$

Where: γ is the specific weight of the ground, N/cm^3; $\underline{K}$ is the adherence; and φ is the angle of internal friction, degree. Thereafter, a plane inclined at an angle μ=45^0- φ/2 to the vertical below the continuation of the hazardous slip vertical plane H_{90} – a linear LM section is formed (Fig. 1). Then the collapsed mass moves along the curvilinear surface MO, which intersects the cylindrical surface of the slope at an angle μ=45^0- φ/2, or descends into the base of the slope (at φ<13^0).

The hazardous slip surface of the slope collapsed mass must be plotted in the following order: first, the width (ℓ) of possible prism collapse on the upper platform is determined, which is given by the following formula [1,4]:

$$1= \frac{2H\left[1-ctg\alpha\cdot tg\left(\frac{\alpha+\phi}{2}\right)\right]-2H_{90}}{ctg\left(45°-\frac{\phi}{2}\right)+tg\left(\frac{\alpha+\phi}{2}\right)}, \tag{2}$$

Where: β is the angle of slope inclination to the horizon (c=tgβ); φ is the angle of internal friction, degree; H is the slope height, m; and H_{90} (m) is determined by formula (1).

Main Part

Let us consider the case when the slope massif is a homogeneous soil. In such a case, when the slope massif destructs, the slip triangle mass slides over some curvilinear surface, and to describe it analytically, we solve the following problem:

Problem 1. A uniform rock slope is given on the coordinate plane Oxz. The slope prism is bounded from above by AB=ℓ section of line $z = H$, by section $BD = H_{90}$ of vertical line $x = d$ from the right (d=Hctgα+ℓ), by OA section of line $g(x)=cx$ from the left (c=tgα), and by hazardous slip line $z=z(x)$ from below. Besides, homogeneous loose rock soil is characterized by: the angle of internal friction (φ), adherence (K) and volumetric weight (γ). Let us define the functional dependence potentially describing the hazardous slip surface of the prismatic massif of the ground slope $z = z(x) = z(x, K, \varphi, \gamma, \alpha, \mu, a, H, H_{90})$ (Fig. 1).

To solve the set problem, let us represent the functional dependence $z = z(x) = z(x, K, \varphi, \gamma, \alpha, \mu, a, H, H_{90})$ as a polynomial of the third degree:

$$z = z(x) = A_0 + A_1 x + A_2 x^2 + A_3 x^3, \tag{3}$$

Where: A_0, A_1, A_2 and A_3 are unknown coefficients. It is clear that to find four unknown values, it is necessary to use four conditions: partially geometric, as well as those conditions, the definition of which is based on the peculiarities of loose soil properties.

Substituting the obtained values of the coefficients determined using the four conditions into equation (3), we will obtain:

$$z = z(x) = tg(\alpha - \mu) \cdot x + \frac{ctg\mu + (3x_d - 1) \cdot tg(\alpha - \mu) + 3(H_{90} - H)}{(2 - 3x_d)x_d} x^2 + \\ + \frac{ctg\mu + (2x_d - 1) \cdot tg(\alpha - \mu) + 2(H_{90} - H)}{(3 - 2x_d)x_d^2} x^3, \tag{4}$$

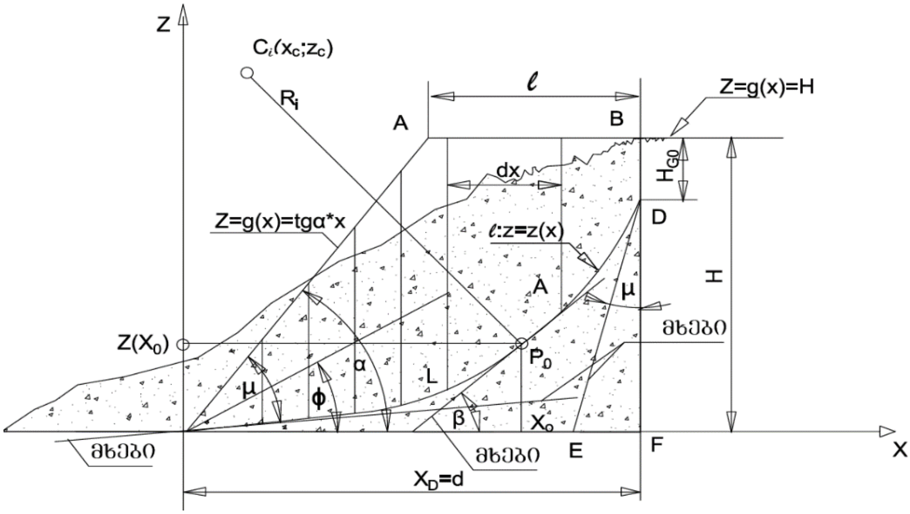


Fig. 1. Calculation plan of hazardous slip surface

Where: $x_d = Hctg\alpha + a$ (m), $\mu = 45^0 - \varphi/2$, φ is the angle of internal friction of rocks; α is the slope angle of inclination to the horizon; x and z are current coordinates of lines; ℓ is determined from formula (2), and H_{90} determined by formula (1).

The obtained functional dependence (4) describes a potentially hazardous slip surface of homogeneous lose ground slope massif of mountain rocks.

Slope stability is usually estimated by the ratio of the sum of the moments of retention forces to the center of curvature $C(x_c, z_c)$ of hazardous slip line $z=z(x)$ to the sum of the moments of shear forces to the same point $C(x_c, z_c)$. This ratio is called the shear resistance reserve coefficient [3.4]:

$$K^{\text{ძვ}}\left(P_0\right)=\lim_{\varepsilon\to 0}\sum_{i=1}^{m_1}F_{i,\varepsilon}^{-}\cdot r_{i,\varepsilon}^{-}/\lim_{\varepsilon\to 0}\sum_{i=1}^{m_2}F_{i,\varepsilon}^{+}\cdot r_{i,\varepsilon}^{+}\geq 1. \tag{5}$$

Where: $F_{i,\varepsilon}^{-}$ და $r_{i,\varepsilon}^{-}$, $i=1,\ldots,m_1$; $F_{i,\varepsilon}^{+}$ and $r_{i,\varepsilon}^{+}$, $i=1,\ldots,m_2$ are retention and shear forces acting on the site $\ell\left(P_o,\varepsilon\right)$ and their tangents, respectively.

Obviously, in any sufficiently small ε area of a fixed point $P_0(x_0, z(x_0))$ of line $\ell: z=z(x)$, $0\leq x\leq d$ with infinitely small high-order precision, this line is its circumference of curvature with the locations of its center $C(x_c, z_c)$ and radius R given by the following formulas of mathematical analysis [7] (see Fig. 1):

$$x_c=x_0-\frac{z'(x_0)(1+x'^2(x_0))}{z''(x_0)},\quad z_c=z(x_0)+\frac{1+z'^2(x_0)}{z''(x_0)},$$

$$R=\frac{(1+z'^2(x_0))^{3/2}}{|\,z''(x_0)\,|} \tag{6}$$

Thereafter, we can use the shear stability coefficient formula (5) for slope collapse according to the point P_0 on the small area $\ell(P_0,\varepsilon)$ of the line ℓ.

According to the statistics, most landslides are caused by the impact of filtration waters. So studying the movement of filtration waters and considering reliable structures on it is one of the main issues in planning [6,7,8]. Therefore, in order to accurately calculate the shear resistance reserve coefficient, let us consider the case where pore pressures are available, i.e. where groundwaters are present. In this case, it is desirable to determine the pore pressure in advance by means of the predicted depression surface in the case of established filtration. In order to take into account, the influence of pore pressure in the calculation of slope stability, a ground state parameter is used, which is called the pore pressure coefficient and is denoted by the symbol r_u [2,6].

The pore pressure coefficient is expressed as the ratio of the total pore pressure to the total pressure caused by the soil above the surface of the depression, that is, the ratio of the total force caused by the water and directed upward to the total force caused by the weight of the soil above the depression and directed in the opposite direction.

The porosity coefficient can be determined by the following formula:

$$r_u = \frac{V_1 \gamma}{V \gamma_{\text{გ}}}, \tag{7}$$

Where: V_1 is the volume of the collapsed submerged prism; γ is the specific gravity of water; V is the total volume of the slip triangle; γ_G is the specific weight of the soil. Since the specific gravity of water is approximately half the specific gravity of the soil, the approximate value of pore pressure coefficient is calculated by the following formula:

$$r_u = \frac{abdea\_Area}{2abcdea\_Area},$$

or

$$r_u = \frac{S_1}{2S}, \tag{8}$$

Where: S_1 is the area of the collapsed submerged prism; S is the total area of the slip triangle (Fig. 2).

If the shape and location of the hazardous slip surface and curvilinear depression are known, the pore pressure coefficient can be determined using formulas (7) or (8).

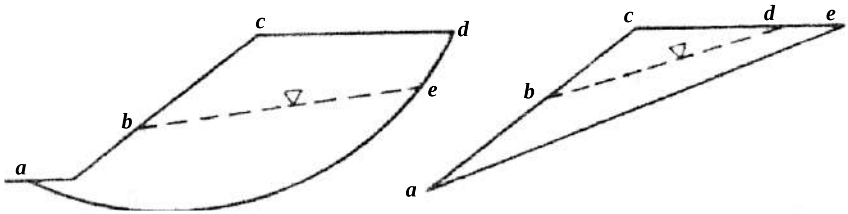


Fig. 2. Plans to calculate pore pressure

Thus, in the presence of groundwaters, the value of the porosity coefficient determined by formula (7) or (8) should be used in all calculations by simplified methods. For this purpose, we enter expression $(1-r_u)$ as a product into the corresponding formulas. Figure 3 shows a schematic of one of the excised blocks and the external and internal forces acting on it, where the normal force in the presence of groundwaters is equal to: N= (1- r_u) G cos β.L

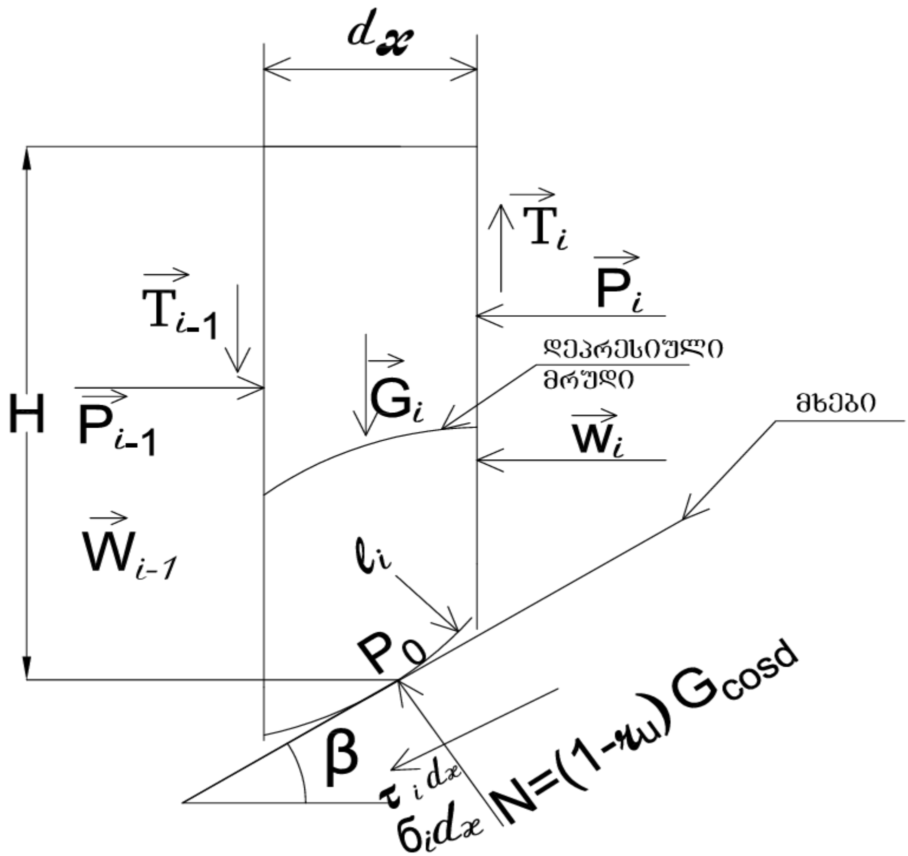


Fig. 3. Plan to calculate shear resistance reserve coefficient

So, it is necessary to determine the location of groundwater and its level fluctuations, leaking sites, surfaces of wet plots, groundwater pressures, and aquifers. For this purpose let us consider the following problem.

Problem 2. A slope of homogeneous mountain rocks is given, resting on a rocky base inclined at an angle α to the horizon. Let us compile a differential equation of groundwater current movement in the body of the slope, which will be satisfied by the depression line equation. Let us

take as initial conditions the entry point $M(x, y)$ of the depression line into the hazardous slip prismatic massif, where $x = d,\ y = h$ (Fig. 4). Consider a slope composed of homogeneous mountain rocks, which rests upon an impermeable rocky base inclined at an angle α to the horizon. Figure 4 shows a slope of homogeneous mountain rocks forming an S:1 gradient (ratio of horizontal to vertical projections). Without a drainage system, the slope gradient should be less steep, not more than 1.5:1. In such a case, Dupuis assumption that the hydraulic gradient at each vertical point maintains a constant value and is equal to the ratio $\frac{dy}{dx}$ is valid for groundwater flow. Filtration in the soil of the slope can be expressed by Darcy's law [2]:

$$q = k(y - xtg\alpha)\frac{dy}{dx}, \tag{9}$$

Where: q is the specific discharge of groundwater runoff; k is the filtration coefficient; α is the gradient angle of the base; x and y are the current depression line coordinates.

The specific discharge of the filtration flow at outflow point M_2 is equal to [2] :

$$q = \frac{ka(1 - S\,\mathrm{tg}\,\alpha)}{S}, \tag{10}$$

Where: α is the ordinate of the outflow point (Fig. 3).

Equating the right-hand sides of equations (9) and (10), we obtain:

$$\frac{dy}{dx} = \frac{a(1 - S \cdot tg\alpha)}{Sy - S \cdot tg\alpha \cdot x}. \tag{11}$$

After simple transformations, equation (11) can be rewritten as follows

$$\frac{dx}{dy}+\frac{Stg\alpha}{a(1-Stg\alpha)}\cdot x=\frac{S}{a(1-Stg\alpha)}\cdot y, \qquad (12)$$

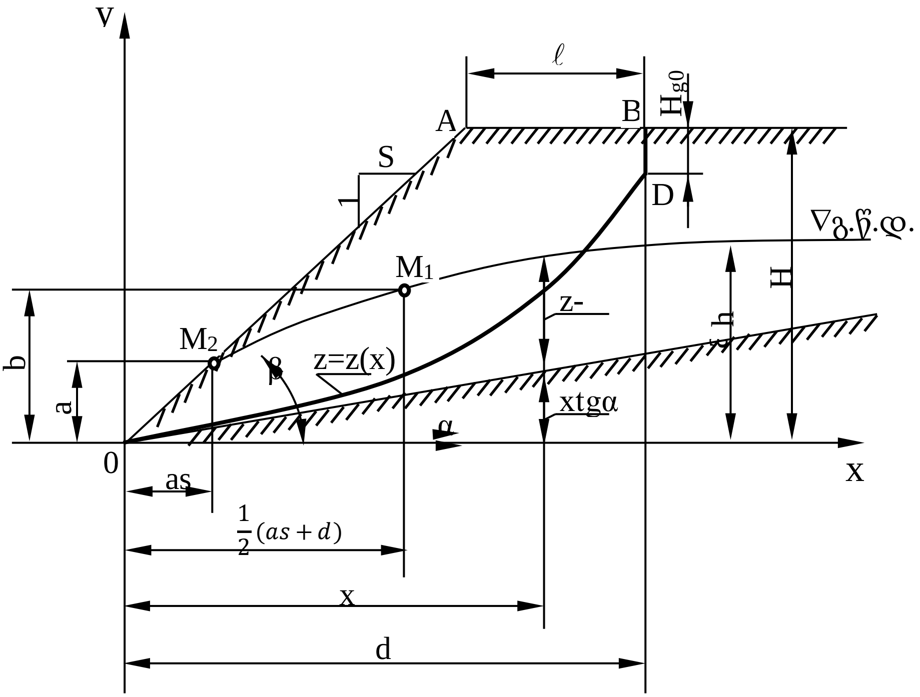


Fig. 4. Calculation plan of depression line in the presence of groundwater

(12) is a differential equation of filtration flow motion. It is a linear differential equation of the first series, integrating which we obtain the following functional expression:

$$x=e^{-\frac{Stg\alpha}{a(1-Stg\alpha)}y}\left[ctg\alpha\cdot e^{\frac{Stg\alpha}{a(1-Stg\alpha)}y}+C\right], \qquad (13)$$

Where: C is any constant of integration. It is assumed that the theoretical depression line starts at a point $M(d;h)$, i.e. only one depression point is known, which is the point of entry of the filtering flow into the prismatic mass of the hazardous slip. So, to determine constant C, we substitute initial conditions $x = d,\ y = h$ into (13) and then solve the resulting equation with respect to y. Thus, we will obtain:

$$C = (d - ctg\alpha)e^{\frac{Shtg\alpha}{a(1-Stg\alpha)}}. \tag{14}$$

$$y = \frac{a(1-Stg\alpha)}{Stg\alpha}\ln\left|\frac{d - ctg\alpha}{x - ctg\alpha}\right| + h \tag{15}$$

Equation (15) is the equation of the depression line passing through point $M(d;h)$. Obviously, to construct the depression line it is necessary to determine the coordinates of at least two more points located on it. Let us choose outflow point M_2 and middle point M_1 as such points (see Fig. 4).

Note. The abscissa d of the inflow point $M(d;h)$ is determined by the geometric parameters of the slope and soil characteristics. In particular, $d = Htg\beta + l$, as for the ordinate h of the point $M(d;h)$, by the moment considered, it is determined through the well (see Fig. 4).

Let us assume that the coordinates of the outflow point M_2 are: $x = aS$ and $y = a$ (Fig. 4). Then, substituting the coordinate pair (x, y) into equation (15), we obtain the following dependence:

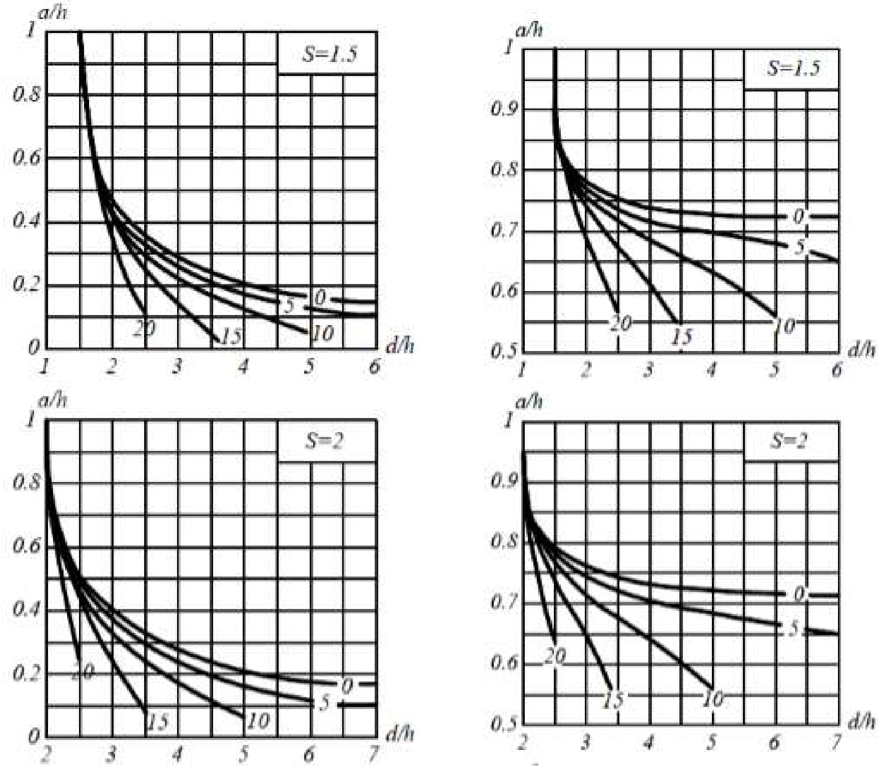
$$a = \frac{a(1-Stg\alpha)}{Stg\alpha}\ln\left|\frac{d - ctg\alpha}{aS - ctg\alpha}\right| + h. \tag{16}$$

To solve $\varphi(a) = 0$ type equation (16) with respect to α, it is necessary to use a numerical method. To do this, let us measure the values of a/h and d/h on the vertical and horizontal axes of the coordinate system, respectively. The values of α are taken from the interval $\alpha \in [0, 20^0]$ with a specific spacing. For different values of slope geometric parameters and soil characteristics, the results of solving equation (16) numerically are presented as graphs in Figure 5, a.

Then, we assume that the coordinates of the midpoint M_1 are equal to: $x = \frac{1}{2}(as + d)$ and $y = b$. Then, by substituting the coordinate pair (x, y) into equation (16), we obtain:

$$b = \frac{a(1 - Stg\alpha)}{Stg\alpha}\left(\frac{d - ctg\alpha}{\frac{1}{2}(aS + d) - ctg\alpha}\right) + h. \qquad (17)$$

Now, when solving equation (17) with respect to b, we take into account that the values of a are obtained from equation (16), and the results of the solution by numerical method are presented as graphs in Figure 5, b. Thus, if we have three points of the depression surface, namely, the starting, the middle and the outflow, we can draw a line representing the theoretical depression curve based on these points. Since the actual depression curve should be perpendicular to the upper gradient and the tangent of the lower gradient, the theoretical line should be drawn according to these boundary conditions [2,7,8].



a) б)

Fig. 4. a. Graphs to determine outflow points; b) Graphs to determine the middle point (the numbers on the curves denote the natural slope angles α from the interval)

Note that if the base of the slope is horizontal, i.e. α=0, the solution we obtained coincides with the results given in the literature.

Conclusion

The obtained functional dependence (4) can be used to analytically find the location of the center of curvature $C(x_c, z_c)$ and its radius R at any fixed point of the hazardous slip line; The arc length ℓ of the hazardous slip line, the prism volume and, finally, the static shear resistance reserve coefficient of the slope in the considered area can be found by the formula (5).

The equation of the theoretical depression line and auxiliary graphs allowing to construct the depression curve through one well are obtained.

To calculate the specified values of retention and shear forces acting on the slope sections, the pore pressure coefficient r_u is introduced, which is determined by the location of the depression line.

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Peculiarities of Designing Combined Constructions in Buildings

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Abstract: Taking into account the complex construction scheme and operating conditions, one of the means of optimal design and reliable solution is to design buildings with combined constructions, which ensures: the shortest possible terms of project development and production; to create roofs of any type and shape; construction time as short as possible; the possibility of placement on any foundation; Reliability and durability in seismic impact.

The article discusses the problems that hinder the design and construction of this type of buildings in Georgia, as well as the development of construction practices in general, and require immediate research and solutions.

Key words: contemporary construction, optimal design, metal, reconstruction, high, Sports complex, trusses.

Introduction

In contemporary construction practice, some knowledge-sharing forms in the field of sustainable construction are notably powerful and unique. It is characterized not only by its distinctive design but also by its involvement in various types of projects' implementation-neutralization, followed by optimal project development in construction.

Integrated construction projects involve the structural decisions of sustainable construction and play a vital role in the joint operation of concrete and steel constructions, aligning with current trends and shaping the architectural landscape.

It is noteworthy that limestone construction elements are not primarily used in low-class concrete constructions. In the case of objects of the fourth and fifth classes of construction, the utilization of reinforced concrete and limestone in combined construction projects is frequent, addressing various project tasks for reinforced concrete and limestone.

Main Part:

The legal document regulating construction activities in Georgia, determining the framework for architectural and construction activities, is the Construction Code. The normative documents and regulations related to construction activities systematically used in design, construction, and exploitation create a basis for scientific, project, and analytical work.

The projects of building-normative documents and complexes, construction and reconstruction, or technical renovation, face challenges due to the lack of synchronization with the construction norms and regulations. The use of construction norms and regulations before their full implementation remains a significant issue. Their study and analysis become crucial for creating a comprehensive normative base.

Currently, in Georgia, both national and international construction regulations are in force. The analysis and study of European codes are essential for understanding the requirements imposed by European norms on technical projects, geopolitical situations, and many other factors influencing the use of European normative documentation. Therefore, the analysis and research should be conducted with respect to European codes and the normative documentation of partner countries before creating a Georgian normative base.

Sustainable construction is mainly focused on the use of reinforced concrete and limestone constructions. Architectural projects in major cities and metropolises are oriented towards high, technologically advanced sustainable construction. In such cases, architects explore the comprehensive utilization of reinforced concrete and limestone constructions during various types of construction works. The study of different types of construction works contributes to understanding the most important and valuable aspects of their implementation.

For the synchronization of normative bases in Georgia with European analogs, it is necessary to conduct a comprehensive analysis and research, considering the specific conditions of local regulations and specifications.

In Georgia, it is possible to consider the Batumi New Sports Complex as a unique combined facility (see Fig.1).

Fig.1. Batumi New Sports Complex

The majority of the structural constructions of the sports complex are made of reinforced concrete; however, the roof structure is constructed with lightweight forms of 70 meters in length, which are commonly used as roofing material. This structural decision resulted in the overall reduction of the building mass, leading to a decrease in the load transferred to the foundation, contributing to optimal construction for stability and efficient exploitation conditions. This optimal decision in construction aimed to ensure timely completion, reducing labor-intensive processes. In the case that the roofing material of the sports complex had been constructed with reinforced concrete structures as initially planned, as indicated by the comprehensive study, it would have required additional, complex technical solutions, as well as 2-3 times more labor and construction time.

Conclusion:

The combined construction and project-based structures of integrated sports facilities, which have complex construction schemes, provide the best opportunity for increased capacity, sustainability, and optimal project outcomes.

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Overview and analysis of Poti Port development reconstruction-expansion

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Abstract: In the paper, a review and analysis of the reconstruction-expansion of Poti Port development was conducted, which showed that numerous and multifaceted studies are conducted to solve the problem of seaport development within the framework of spatial-territorial and economic limitations, and foreign experience is widely used and adapted. The problem remains acute for each seaport, in our case the Poti Port, as an object that has common sets of individual properties, requirements and limitations regarding development. The need to solve the problem on a scientific basis and the lack of recommendations for the development of port reconstruction-expansion technology and organization methods taking into account local conditions and the establishment of logistics service systems for the developing port determined the relevance of the dissertation research topic, and the direction and content of the research is pre-determined by the acute need for typical models of organization and logistics services for the sea port, by developing optimal reconstruction technology, construction solutions and organizational methods to protect the sustainability of buildings and compliance with modern safety requirements.

Key words: Port, expansion, reconstruction, logistics, development.

Introduction

The development of the world market, international industrial relations and foreign trade led to a dynamic increase in the volume of cargo flows, the services of which are widely included in large transport hubs, including the sea Poti Port, as the main part of the world base transport system and transport infrastructure.

Recently, due to the increase in cargo shipping flows and volumes, the role of seaports, which they traditionally play in the transport system of a certain area or country, is changing.

The existing ports, including the Poti Port, are turning from coordination transport hubs into logistics distribution centers, the territorial and spatial possibilities for their development have been exhausted. Now this problem is becoming more acute for Georgia, because the state of most of the country's sea ports does not meet the growing volume of cargo transported in the ports. Along with the above-mentioned problem, the tightening of customer requirements regarding the quality and complexity of logistics services in seaports, the submission of cargo by sea transport and seaport processing, increasingly aggravates the situation with the determination of directions and the search for resources for the development of ports, using the most adapted surrounding areas and the developed infrastructure of the seaport.

Studying the condition of the areas and facilities surrounding the Poti Port allows us to conclude that there are various options for developing the port's capabilities, with limited resources involved in solving the problem. Existing theoretical and methodological studies, development and methods, organizational and economic problems on this issue do not take into account the peculiarities of the development of seaports, conditions and trends for the development of ports, as well as the needs of clients who have high demands on the conditions and forms of logistics services for processing goods in ports.

Main part

The structure of the port consists of a breakwater protection mole, an entrance channel and a berth. Each of these infrastructural units needs to work properly for the efficient operation of the port and smooth receipt of cargo.

To achieve the goal, the following tasks must be solved:

- to determine the role of sea ports in the development of the transport and logistics system of Georgia and to evaluate the impact of the development of ports and their infrastructure on the volume of foreign trade;
- systematization of types of ports in the evolutionary-historical development of the seaport work organization and determination of the need to develop a classification of seaports;
- to study the factors determining the direction of development, the methods and models of organizing the development of sea ports, to determine the necessity of developing a classification of

factors affecting the choice of the direction of port development;

– Development of technological processes of port expansion-reconstruction, X-block manufacturing technology and organization of process.

In general, when designing a port, the interrelationship between capital investments, cargo flow and objective factors is evaluated, which is shown in Figure 1.

The high level of risk, in our understanding, should reflect the high degree of adaptation of the port's existing capabilities and technologies to the conditions of changes in the structure and volume of cargo traffic for the production of services. This level of risk corresponds to the type of seaport in which it is easy to change specialization due to uniform equipment and high adaptability in the use of shipping equipment, terminal equipment and port areas.

[The volume of capital investments] [Reporting cargo flow] **[Level 2]** **[Subjective factors]** [State of maritime transport and transport infrastructure] [Existing and prospective technologies of cargo transportation and processing] [Labor resources]	**[Level 1]** **[Objective factors]** [Development of the economy of the country, region, partner countries] [Consumption level] [Geographical conditions] [Existing cargo flows] **[Port development projects]**

Figure 1. Two-level accounting system of factors affecting the

formation of port restructuring/development project.

A low degree of adaptation predetermines specialization for a strictly defined structure of the cargo flow, in which the limits of the flow filling of the volume of each type of cargo are established and, therefore, the design of production capabilities and technologies of services, logistics services and infrastructure should be carried out only for strictly defined cargo volume and direction. We recognize such types of port adaptation as inflexible and in some cases organizationally and economically impossible.

Using the existing statistical database, the methods of probability theory and the "three sigma" rule for problem solving on the organization and variability of cargo flows in Poti seaport, we calculated the empirical scale of permissible risk (Table 1) in the restructuring of cargo flows or the development of the seaport, which can be used to make decisions about flexible specialization according to the structure of cargo traffic in the port.

Table 1

Probability of an adverse outcome (risk value)	Naming risk intervals
0,0-0,1	Minimal risk
0,1-0,3	Little risk
0,3 - 0,4	Medium risk
0,4 - 0,6	High risk
0,6-0,8	Critical risk
0,8-1,0	Catastrophic risk

Taking into account the methods and models of organizing the development of the seaport proposed by us, we propose to add several stages to the algorithm described in the traditional methods, which allows us to take into account possible directions of development that depend on the model and not on the volume of new construction. In the presented algorithm, the part that is most important for this research is highlighted and, considering the theoretical and methodological messages, distinguishes the approach from similar approaches of other scientists and researchers.

1. During the construction of a specialized port, it will be necessary to assess the consequences of changes in cargo traffic for the main port and to design the commissioning of the specialized port capacities. The flow of specialized cargo "separated" from the main one will be completely or largely redirected to the specialized port, which predetermines the need to assess the possible excess of transshipment capacities in the main port and plan their use to serve other cargo flows.

At the same time, it should be noted that according to preliminary calculations, the model of the main port development organization and the creation of a specialized port as a complement to the main one will be a more capital-intensive option than the development organization model with the allocation of an additional holding port.

In general, the assessment of the economic efficiency of port development models requires consideration of characteristics, specification and calculations based not only on traditional methods, but also on the assessment of the influence of various factors, taking into account the reliability of the forecast of cargo movement in terms of volume, nomenclature and direction, and the use of a conceptual scheme of the source of investment financing.

The practice of economic relations shows that the service component in modern conditions allows any company focused on serving a large number of customers to develop dynamically, and the sea port as a multifunctional object of the transport and logistics system of the region is no exception.

In our research, the service will be understood as a set of services provided for cargo transportation and processing, as well as a set of additional services that will depend on the type of port and its specialization.

Taking into account the peculiarities of the organization of logistics services in the sea port, we came to the conclusion that it is necessary to develop our own classification of logistics services, because the classification given in the sources available to us does not fully reflect the peculiarities of various logistics service objects.

The analysis of the most important service parameters allowed us to establish additional classification features that affect the construction system of the seaport. At the same time, the type of port and its specialization in terms of cargo transportation with a selected level of risk became crucial.

In our opinion, the criteria for choosing the preferred option for designing a specialized or holding port should be adopted as follows: The ratio of port capacity to the one-time volume of cargo flow, the duration of processing of a given volume of cargo flow, the cost/quality ratio of processing services.

We present a conceptual model of organizing an efficient logistics service in a third-generation seaport, which is presented in Figure 2.

In this case, the algorithm of forming a constructive system in the port can be briefly presented as a sequence of mandatory interactions:

- Determining the general configuration of the design changes at the main and additional port areas with the lowest total costs;
- Evaluation of the level of customer service and the projected capabilities of the logistics service system;
- Ensuring minimum overall costs in all locations that require reorganization;
- Analysis of the sensitivity of the project to the increase in the level of service, the volume of the cargo flow or its changes, the direction of the cargo flow and the costs directly related to the creation of additional income;
- Determining the threshold level of the main facilities.

[The main port] [Regional logistics center] [Infrastructure] [Logistics service departments]	**[Customers]** Logistic operators Logistics providers	**[Filling port]** [Infrastructure] [Logistics service departments]
a) Logistics service model in developing development projects as a holding port		
[The main port] [Regional logistics center] [Infrastructure] Logistic operators Logistics providers	**[Customers]**	**[Filling port]** [Infrastructure] Logistic operators Logistics providers
b) Logistics service model in the development of development projects as a specialized port ______________ - Material flows --------------- - Information flows		

Figure 2. Conceptual model of organizing efficient logistics services in the third generation sea port

The technological process of the reconstruction of Molo and the organizational structure of the implementation of the reconstruction, which is successfully completed at the stage of the reconstruction of the Poti Port, as well as the technology of strengthening and restoring the retaining wall, are elaborated. The obtained results will be successfully used for the next expansion.

Technology of making X-blocks

The technology of making X-blocks in its content consists of several important stages: 1. Planning-arrangement of industrial area and warehouse area;

2. Preparation of production methodology;

3. Mold making;

4. Preparation of concrete mix-design;

5. Product production process;

6. Quality control and management;

7. Product warehouse and its management;

8. Logistics of product delivery.

The planning and arrangement of the industrial site and warehouse site has a great importance on the amount of capital expenditure. The cost of the final product (block X) is largely determined by the area on which we carry out the production and storage process. The production methodology includes the solution of a number of issues and also plays an important role in the price and quality of the final product. The methodology includes the selection of the type of mold (vertical or horizontal molds), planning of the concrete pouring process, selection of tools, selection of mold lubricant, number of workers, maintenance of concrete during the curing process, formation and creation of a safe working environment for workers. Concrete mix design should be prepared according to international standards EN-206-1 and BS 8500. The mix-design must meet the following requirements: concrete class C25/30, high strength concrete is not recommended, it must be resistant to aggressive environment (sea water), and the water-cement ratio must be determined depending on the climatic conditions of the production area. The cement must be selected according to the resistance to sea water as required by the standard EN 197-1. Inert materials must meet the requirements of EN-12620 standard.

The production process of the products should be carried out in accordance with the pre-prepared methodology. The process should be managed by a production engineer and skilled labor under the supervision of a quality control officer. Quality control includes: concrete mixture consistency control, vibration control, concrete temperature control in the mold, visual inspection of finished products, geometric dimensions of finished products, concrete shrinkage test, detection of the number and size of cracks, preparation and implementation of methodology for repairing damaged surfaces. After the formation process, the products are assembled. An important challenge is the area to be stored, the selection of the type of equipment for placing the products in the warehouse and sending the finished products from the warehouse. Delivery of finished products depending on the dimensions and weight of the products (3 m^3 volume, 7.5 tons) to the construction site requires the selection of appropriate equipment for the safe movement of cargo, the selection of equipment for loading the products and fastening of the products to the transport vehicle.

Conclusion

Research of all the above-mentioned processes and preparation of a complete technological cycle and implementation in production will allow us to develop the reconstruction-expansion of the Poti Port with the right technological and organizational solutions.

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Enhancing Wastewater Treatment Efficiency: The Promise of Aerobic Granular Sludge Technology (AGST)

Giorgi Chkhaidze (Bachelor program student), Supervisor: Associate Professor Zaal Tsinadze, Georgian Technical University

Abstract: Wastewater treatment is vital for environmental and public health, but traditional methods like activated sludge systems have drawbacks. Aerobic Granular Sludge Technology (AGST) offers a promising alternative by forming dense microbial granules that improve settling, nutrient removal, and energy efficiency. AGST has diverse applications, from municipal to industrial wastewater treatment, and is even suitable for decentralized systems. Challenges such as granule stability and scalability exist, but ongoing research aims to overcome them. Recently introduced in Georgia, AGST shows potential for enhancing water treatment globally, emphasizing collaboration for sustainable solutions. In conclusion, AGST presents a significant advancement in wastewater treatment, poised to contribute to cleaner water and healthier communities worldwide.

Key Words: Water; Aerobic Granular Sludge Technology; AGST; Conventional methods; Advantages; Granules; Nutrient removal; Energy consumption; Challenges; Future directions; Kvareli, Georgia, water treatment plant;

Introduction

Wastewater treatment is a critical process for preserving environmental health and safeguarding public well-being. Conventional methods, such as activated sludge systems, have long been employed for this purpose. However, the limitations of these systems, including their large footprint, high energy consumption, and inefficiencies in nutrient removal, have spurred the search for alternative approaches. Aerobic Granular Sludge Technology (AGST) has emerged as a promising solution to address these challenges.

AGST represents a paradigm shift in wastewater treatment, leveraging the natural tendency of microorganisms to form dense granules under aerobic conditions. These granules, composed of a diverse microbial community, offer several advantages over conventional flocs, including higher settling rates, improved nutrient removal capabilities, and reduced energy requirements. This article explores the principles, applications, and benefits of AGST in wastewater treatment.

Principles of Aerobic Granular Sludge Technology

AGST relies on the formation and manipulation of aerobic granules, which are dense aggregates of microorganisms that develop under specific environmental conditions. Unlike conventional activated sludge flocs, which are dispersed and flocculent, aerobic granules exhibit a compact structure with well-defined microbial zones. This unique morphology enhances the performance of the treatment system in several ways:

1. Enhanced Settling Characteristics: The dense structure of aerobic granules allows for rapid settling in sedimentation tanks, facilitating the separation of treated water from biomass. This results in a more efficient solid-liquid separation process and reduces the footprint of the treatment plant.

2. Improved Nutrient Removal: Aerobic granules harbor diverse microbial populations capable of metabolizing organic matter and removing nutrients such as nitrogen and phosphorus from wastewater. The spatial organization of microorganisms within the granules promotes synergistic interactions and enhances nutrient removal efficiency.

3. Reduced Energy Consumption: The compact nature of aerobic granules promotes efficient oxygen diffusion, minimizing the energy required for aeration. This translates to lower operational costs and reduced environmental impact compared to conventional activated sludge systems.

Applications of Aerobic Granular Sludge Technology

AGST has been successfully applied in various wastewater treatment scenarios, including municipal wastewater treatment plants, industrial effluent treatment, and decentralized systems. Its versatility and adaptability make it suitable for a wide range of applications, from small-scale decentralized facilities to large centralized treatment plants. Key applications of AGST include:

1. Municipal Wastewater Treatment: AGST offers municipalities a cost-effective solution for treating domestic wastewater while meeting stringent effluent quality standards. Its compact design and efficient nutrient removal capabilities make it ideal for urban environments with limited space and resources.

2. Industrial Effluent Treatment: Many industries produce wastewater with complex compositions and high pollutant loads. AGST can effectively treat industrial effluents, including those containing organic compounds, heavy metals, and nutrients, making it a valuable tool for sustainable industrial wastewater management.

3. Decentralized Wastewater Treatment: In remote or rural areas lacking access to centralized treatment infrastructure, decentralized wastewater treatment systems powered by AGST can provide reliable and efficient sanitation solutions. These systems offer flexibility, scalability, and resilience to local conditions, making them well-suited for off-grid communities and resource-constrained settings.

Technological scheme

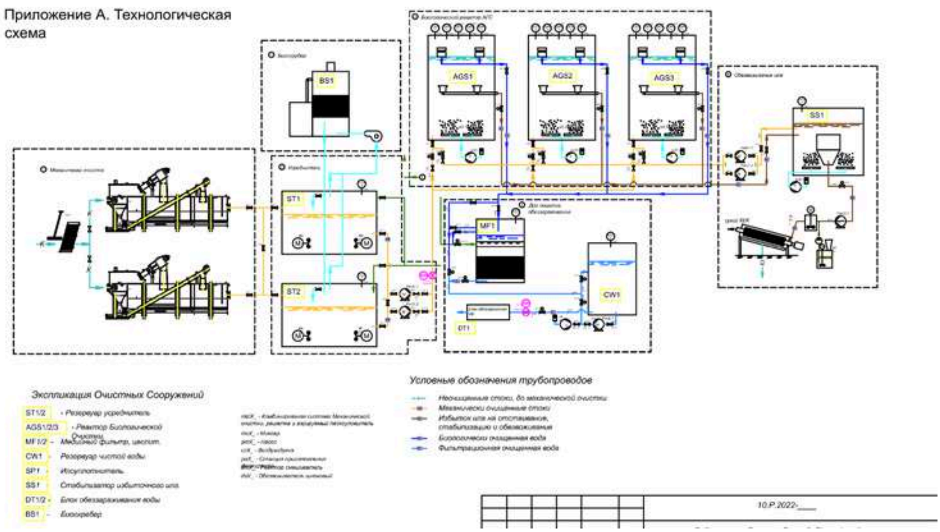

Table 1 pollution rate

Indicators	UNIT	Average indicators
Biochemical oxygen consumption/demand	$MgO_2/\ dm^3$	300
Chemical oxygen consumption/demand	$MgO_2/\ dm^3$	600
suspended solids	$Mg/\ dm^3$	350
ammonia	$Mg/\ dm^3$	40
Ntot secular nitrogen	$Mg/\ dm^3$	55
pH		6.8
P tot (total phosphorus)	$Mg/\ dm^3$	9

Table 2 Quality of treated wastewater

Indicators	UNIT	Indicators after cleaning with aerobic granular (granulated) sludge	Indicators after cleaning and filtration with aerobic granular (granulated) sludge
Biochemical consumption/requirement of	$MgO_2/\ dm^3$	<15	<5

oxygen			
Chemical oxygen consumption/demand	MgO_2/dm^3	<80	<50
suspended solids	Mg/dm^3	<15	<5
ammonia	Mg/dm^3	<0.8	<0.5
Ntot total nitrogen	Mg/dm^3	<10	<8
P tot (total phosphorus)	Mg/dm^3	<0.5	<0.5

Challenges and Future Directions

While AGST holds great promise for improving wastewater treatment efficiency, it is not without challenges. Granule stability, operational optimization, and susceptibility to shock loads are among the key issues that researchers and practitioners continue to address. Furthermore, the scalability and cost-effectiveness of AGST in large-scale applications require further investigation.

Granule Stability: One of the primary challenges in AGST is maintaining the stability of aerobic granules over extended periods. Granule disintegration or washout can occur due to fluctuations in operational parameters, such as organic loading rates, hydraulic retention times, and dissolved oxygen levels. Strategies to enhance granule stability include optimizing feeding regimes, controlling filamentous growth, and promoting microbial diversity within the granules.

Operational Optimization: Achieving optimal performance in AGST requires careful control and monitoring of various operational parameters, including aeration rates, mixing intensity, and nutrient concentrations. Process modeling and simulation tools can aid in optimizing these parameters to maximize treatment efficiency while minimizing energy consumption and operational costs.

Susceptibility to Shock Loads: AGST systems may be vulnerable to shock loads caused by sudden changes in wastewater composition or flow rates. These shocks can disrupt the microbial community structure within the granules and compromise treatment performance. Strategies to mitigate the effects of shock loads include implementing buffer tanks, optimizing process control strategies, and enhancing the resilience of the microbial community through bioaugmentation or pre-acclimation.

Scalability and Cost-effectiveness: While AGST has demonstrated success at the laboratory and pilot scales, scaling up to full commercial applications presents unique challenges. Factors such as capital costs, land availability, and regulatory requirements must be carefully considered when designing large-scale AGST facilities. Collaborative research efforts between academia, industry, and government agencies are needed to address these challenges and optimize the cost-effectiveness of AGST in real-world applications.

Future Directions: Despite the challenges, AGST continues to attract significant interest and investment from the wastewater treatment community. Ongoing research efforts focus on advancing fundamental understanding of granule formation dynamics, developing innovative process control strategies, and exploring novel reactor configurations and operational schemes. Additionally, the integration of AGST with other emerging technologies, such as membrane bioreactors, anaerobic digestion, and resource recovery, holds promise for further enhancing the sustainability and resilience of wastewater treatment systems.

AGST in Georgia

AGST technology has recently made its debut in Georgia, marking a significant advancement in the country's wastewater treatment infrastructure. The technology is set to be implemented for the first time in the Kvareli water treatment plant project, a venture commissioned by the United Water Supply Company (UWSC) of Georgia. Spearheaded by the collaboration between Invest Group and Eco Hub, this initiative underscores a commitment to leveraging innovative solutions for sustainable water management. By introducing AGST into the Kvareli project, Georgia aims to enhance treatment efficiency, reduce environmental impact, and ensure the provision of safe and clean water to its citizens. This landmark project not only showcases the potential of AGST on a global scale but also exemplifies the power of collaboration in driving positive change in water resource management.

Conclusion

Aerobic Granular Sludge Technology represents a significant advancement in wastewater treatment, offering numerous advantages over conventional activated sludge systems. Its compact design, enhanced nutrient removal capabilities, and reduced energy consumption make it a compelling option for municipalities, industries, and decentralized applications. As research and development efforts continue to refine and optimize AGST, its role in sustainable wastewater management is expected to expand, contributing to cleaner waterways and healthier communities worldwide.

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The Influence of Creep Deformations Developed in Reinforced Concrete Roofs on the Static Performance of the Structure

Vano Chkhikvishvili (PhD student), Supervisors: Professor Maya Chanturia and David Vardiashvili, Georgian Technical University

Abstract: long-span is a construction whose length (span) exceeds 6 meters. The material with which this construction is made can be metal, reinforced concrete and wood. The most common large-span constructions are beams, coils, frames, arches, roofing tiles. The advantage of such constructions is a large space free from columns and an unobstructed area, which is then freely used by the owners of the building, it is also necessary for covered sports fields. In large-span constructions, especially those that are built using universal technology, it is important to develop long-term deformations - creep deformations. Their development has a significant impact on post-construction static performance.

Key words: creep, large-scale, static work, aging;

Introduction

Large structures include both single-walled and solid-walled arches, enclosures, vaults, etc. In concrete, as a composite material, during the long-term action of the load (without increasing them), creep deformations develop, which cause the forces induced in the structure to increase by 50-70%, which may turn out to be disastrous for the structure.

Main Part

Creep deformation is one of the types of plastic deformation. It develops during the long-term action of the load. The development of concrete creep deformation is especially important in combined constructions and constructions built with universal technology, which work with a different static scheme at the time of installation, and with a different static scheme at the time of operation. In statically uncertain reinforced concrete constructions, especially in constructions built with universal technology, such as the construction calculated by me, the forces, stresses and the magnitude of the deformation itself are important as a result of the development of creep deformation, the instantaneous or elastic values of which are given below by calculation and observation in the already built construction. The characteristic amount of concrete creep deformation is an experimentally determined amount with possible deviations. The deviations may be so large that they cause the loss of stability of the structure. As the research results showed, creep and temperature have a significant influence on the force distribution in statically uncertain structures, which must be taken into provided for the calculations. Cyclic changes in temperature cause short-term changes in stress and displacement, which add up to long-term changes. As the flexibility of the structural elements increases, creep begins to play a dominant role. The agreement of the theory with the experimental is satisfactory if the load and temperatures are constant in a cyclic manner. In many cases, creep deformation can be calculated in a single step based on ductile stage analogies.

S.D. Diggler proposes a simplified method of accounting for the creep of prestressed reinforced concrete using an "aging coefficient" that allows the calculation of stresses and strains in a quasi-elastic analysis framework. The main advantage of the method is that with its help, the location of prestressed reinforcement in several layers can be taken into account, as well as the calculation of combined concrete-monolithic constructions is discussed in detail. Further possible generalization conditions of the described procedure for more complex structures or loads are discussed.

Stress distribution caused by concrete creep in statically uncertain prestressed coils was experimentally investigated. The method of calculation of three-pole coils for different load options and with the height of the support device at different levels is described. Measured concrete stresses, displacements and local deformations reveal that the effect of the primary difference in height of the coil support decreases rapidly with the duration of direct transverse loads. The obtained experimental data are compared with the results of using normative reporting procedures. Estimates of loads during creep of concrete under constant load and variable creep conditions are given.[1]

V. Lomke developed a methodology for designing reinforced concrete piers, where the creepability and seating of construction elements are taken into account, in which the determination of the load and moments in the body of the pier in different periods of time is considered. Creep calculations are made based on “aging theory”. The creep differential equation is solved. Based on the calculation, structures with concrete and steel elements are designed. Spanish scientist L. Murkia's research describes the methods of calculating the creep in compressed rods, the methods of determining the boundary conditions of the internal force factors acting on the body elements of the compressed-bent column separated from the frame, the limit load conditions on the compressed thin rod are determined taking into account the effective second order.

The work describes the procedure for the influence of creep under non-centric compression of a concrete rod and indicates the limitations of using the approximate calculation formula. A new calculation formula is presented that reflects the eccentricity delay in relation to the duration of the compressive load and the changes in concrete creep. S.V. Bondarenko and O.B. In the work of Tutberidze, the problems of the strength of building constructions in the conditions of creep are discussed. The purpose of this task is to create and research the methodology of calculation of building constructions under the conditions of a variable static scheme. Exact and practical methods of calculation considering linear and indirect deformation are proposed.

In the framework of the theory of deformation of a cracked reinforced concrete coil, A.F. Yaromenko and A.I. Melnik developed a method by which such constructions as coil-wall problems are solved by the theory of creep. These calculations take into account the peculiarity of concrete creep during biaxial loading, the indirectness of creep deformation, the increase in concrete strength over time, and other special features of reinforced concrete at different stages close to collapse.

E.N. Sherbakov and V.L. Khasin developed mathematically rigorous and accurate methods for calculating reinforced concrete elements, the analytical images obtained taking into account the linear creep of concrete allow us to reduce the solution of the problem to the calculation of the stress damping coefficient in a reinforced concrete element with joint reinforcement (independently of the prerequisites of the theory of creep and the type of the kernel of the integral equation).[2]

In their own works, the calculation methodology of reinforced concrete structures for long-term loading is provided, taking into account the indirect connection of tension and deformations, which allows to solve complex engineering problems with relatively simple algebraic operations in a compressed form (form). The presented method generalizes previously obtained strict mathematical solutions, which responds to the actual conditions of operation of reinforced concrete structures.

The following linear theories are used to describe the influence of concrete creep on the stress-deformed state of concrete and reinforced concrete: the theory of inheritance of elasticity (viscous-elastic body theory), a modified version of the theory of aging (simplified theory of viscous-elastic body) and the theory of inheritance of aging (viscous-elastic body theory) .[3]

The heredity-elasticity theory is based on the following basic premises:

1. Concrete is considered as a homogeneous isotropic material;

2. There is a direct relationship between instantaneous deformation and stress;

3. There is a linear relationship between creep deformation and stresses;

4. It is assumed that the principle of addition applies to the creep deformation: the total deformation under variable loading can be found as the sum of the creep deformations obtained by adding the stress.

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A Study of the Concentration of E. coli Contamination of the Surface Waters of the Adjara Region

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The article is completed with the support of the Shota Rustaveli National Science Foundation of Georgia (SRNSFG). Project no. PDF 22-2127

Abstract: The problem of water pollution is becoming more and more urgent for the whole world. Unfortunately, Georgia is not an exception, where water sources, although numerous, have a small flow rate and a significant part of them are polluted. Unlike pollution from industrial wastewater treatment plants, which comes from many diffuse sources, biological pollution is caused by the movement of precipitation or snowmelt onto and into soil. As the runoff moves, it collects and transports natural and anthropogenic pollutants and deposits them in rivers, groundwater, or lakes. Particular attention should be paid to the biological pollution of water sources, which occurs as a result of leaching or washing away of sources of anthropogenic biological pollution by rain and melting water. Once in the aquatic environment, under favorable conditions, pathogenic organisms are able to multiply rapidly, creating a threat to the environment. Pollution of water sources is the main cause of water quality problems. The impact of source water pollutants on specific waters varies and cannot always be fully assessed.

However, we know that these pollutants have harmful effects on drinking water supplies, recreation, fisheries and wildlife. That is why it is necessary to find the source of biological water pollution in order to develop an effective method for its elimination.

Key words: Water source, Region of Adjara, Water pollution, E. coli, laboratory analysis.

Introduction

Pollution of water as the most important need for life is one of the most important problems facing the world in the third millennium. Despite the implemented measures, improvement of wastewater treatment methods, the issue remains relevant. One of the most common forms of pollution is biological pollution, which is directly related to the entry of pathogenic microorganisms, bacteria, viruses and protozoa into water [1; 8; 10].

Wastewater is one of the main sources of pollution [2]. It should be noted that not only technical and human faecal matter, but also cattle faecal matter pollutes the environment no less. Bacterial contamination is characterized by the number of coli-titer, that is, the volume of water in milliliters that contains E. coli. These types of pollutants are most commonly found in household and wastewater from factories, laundries and hospitals.

The aim of the mentioned research is to identify the sources of surface water pollution and characterize their possible consequences.

Main Part

Organic compounds and microorganisms can enter both surface and groundwater, causing serious damage to ecosystems. First of all, the threat is created by the pathogens of infections and diseases that negatively affect the health of people and animals (Table 1). At worst, they can cause completely irreversible consequences [3].

Table 1. Possible threats caused by water pollution

the source of the disease	Human	Human industrial activity	An animal	Environment
causing the disease	Bacteria, viruses, parasites	Chemicals, fertilizers	Bacteria, viruses, parasites	Chemical inorganic substances
Pathology	Infectious diseases	Chemical poisoning, nitrate poisoning	Infectious diseases	chemical poisoning

For the current stage, in 144 out of 341 water sources studied in Adjara, higher than acceptable concentration of E. coli was found (Table 2).

Petroleum oils cause the greatest damage to water in open sources because they are extremely persistent pollutants and can also spread over long distances. The most dangerous are the lighter fractions, which actually completely stop gas exchange between water and the atmosphere and form a shell. Within a country, pollution by such substances can be local or regional [4; 7].

In the presence of high levels of bacterial contamination, it is enough to wet hands or food to initiate the poisoning process [9].

Standard methods are used to determine pollutants of biological origin. Among the most common, the membrane filtration method stands out as the simplest, most accurate and economical. The sample taken within the research is passed through a membrane filter under aseptic conditions. The diameter of the pores should not exceed 0.8 μm. If the sample contains microorganisms and bacteria, they will remain on the filter. The filter itself is placed in a Petri dish on a nutrient medium [6].

This is followed by an incubation period at about 37 degrees Celsius. In most cases, 24 hours is enough for a reaction. At the same time, it was proven that for more accurate detection of microorganisms, it is better to use cellulose ethers as filter material. To facilitate colony counting, a grid is applied to the filters. At the same time, depending on the purpose, they can be produced in white or black. The first is intended for bacteria, the second for yeast and molds [5; 6].

Table 2. Share of E. coli pollution in studied rivers of Adjara [8]

Municipality	Number of polluted sources	Number of unpolluted sources	Total
Kobuleti	40	34	74
Khelvachauri	17	52	69
Kedah	17	45	62
Shuakhevi	19	43	62
Khulo	23	23	46
Bowl	144	197	341

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Such studies can be carried out in high-standard laboratories, which will allow us to know the exact location of E. coli-contaminated rivers at this stage.

Conclusion

1. Remedial measures should be implemented immediately after river pollution. These measures vary depending on the type of pollutant. One of these measures is mechanical cleaning. For this purpose, disposal of solid waste discharged into rivers is carried out using containment and collection devices/devices.

2. Another most common practice is phytoremediation. Some species of plants are used to effectively remove heavy metals from polluted rivers. For example, Eichhornia crassipes (water lily) is used to absorb cadmium and copper. Similarly, the symbiosis of blue-green algae Azolla-anabena and Azolaii is used for bioremediation of rivers polluted with arsenic and other metalloids [10].

3. Some bacterial species and some fungal derivatives are used to break down pollutants in rivers (biodegradation). Bacteria of the species Acintobacter, Pseudomonas, Imycobacter destroy alkanes, monoaromatic and polyaromatic substances, respectively.

4. Taking into account the existing modern technologies, the study of the state of water sources and the development of recommendations for wastewater treatment should be continued.

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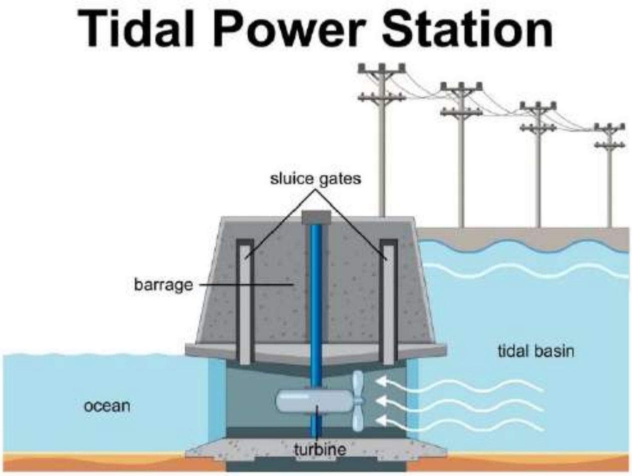
Harnessing the Power of the Seas and Oceans

Gvantsa Davitaia (Bachelor program student), Supervisor: PhD Grigol Kheladze, Georgian Technical University

Tidal Energy

Sea waves, which manifest themselves in regular rises and falls in sea level, are the result of the tidal forces of the Moon and the Sun. This is how tides are generated in the world's oceans. The highest known tide is found off the coast of Nova Scotia in the USA. The water there rises as much as 20 meters. The course of tidal forces and thus tides is only apparently regular. During lunar days (i.e. for 24 h 50 min and 30 s) the same place is twice changed by low tide and twice by high tide. In a certain period, there is a so-called deaf tide. There is also a one-day tide. When building tidal power stations, it is necessary to take into account all the peculiarities of a particular place and all the irregularities it entails.



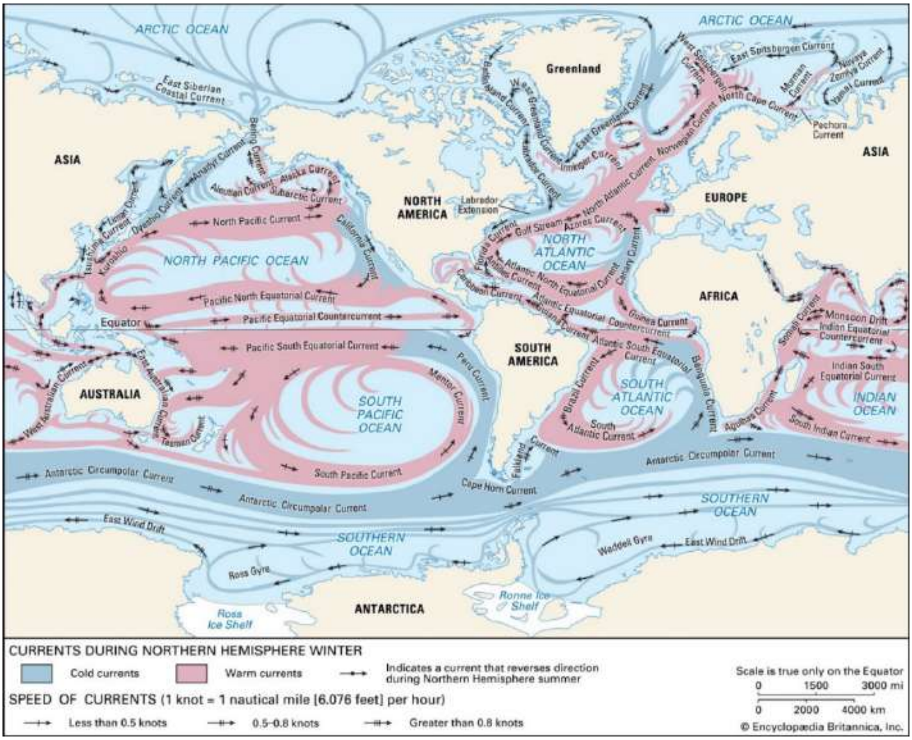
The oldest tidal power station is the English hydro station on the River Dee in Chester with a capacity of 635 kV. A truly modern tidal power station did not start operating until 1966. It is a French tidal power station in Brittany, at the mouth of the Rance River. In this area, the average tidal height is 8.4 meters. The reservoir above the power station uses the morphological shape of the river channel and has an area of 22 km2. In addition, the tidal water for the turbines is also enhanced by the inflow of the river. The power plant has a capacity of 240 MW. It is equipped with 24 reversible turbines, so it utilizes both tides and ebb tides. The power plant at the mouth of the Rance River operates 2,250 hours per year and produces 540 million kWh of electricity. In 1984, the first generator of a tidal power plant with tidal heights of up to 15.8 m was started up in the Annapolis Basin in Canada. The DC turbine rotor with four blades has a diameter of 7.6 m and a capacity of 17.8 MW. Serious disadvantage of tidal power plants is that their operating times often do not coincide with the energy peak of electricity supply systems. Another disadvantage is that the locations suitable for the construction of these power plants are often quite far from where the energy produced is consumed. Losses on long-distance lines are then so significant that construction is impractical. Nevertheless, tidal energy is a promising source of energy for future utilization. Thus, between 7.2 and 11.8 trillion MJ of electricity could be generated annually. Thus, tidal energy could play an important role in the future.

Surf Energy

The character of sea waves changes significantly when they reach shallow water. When waves hit the sea floor, their length and height change. It increases and the crests of the waves break. The force of the surf during big storms is incredible. For example, in France, surf waves through boulders weighing up to 3.5 tons over a 7-meter-high stone breakwater and moved a 65-ton concrete block a distance of 20 meters. High surf power is still very little used, also because there are no large cities or large industrial plants in areas of high surf. In Japan, a vertical shaft water turbine suitable for both directions of water flow has been built. Its blades independently open about half of their circumference to the side against the water flow. The resulting imbalance creates torque. Four-bladed turbines have a diameter of up to 700 mm and a height of up to 150 mm.

Energy of Marine Currents

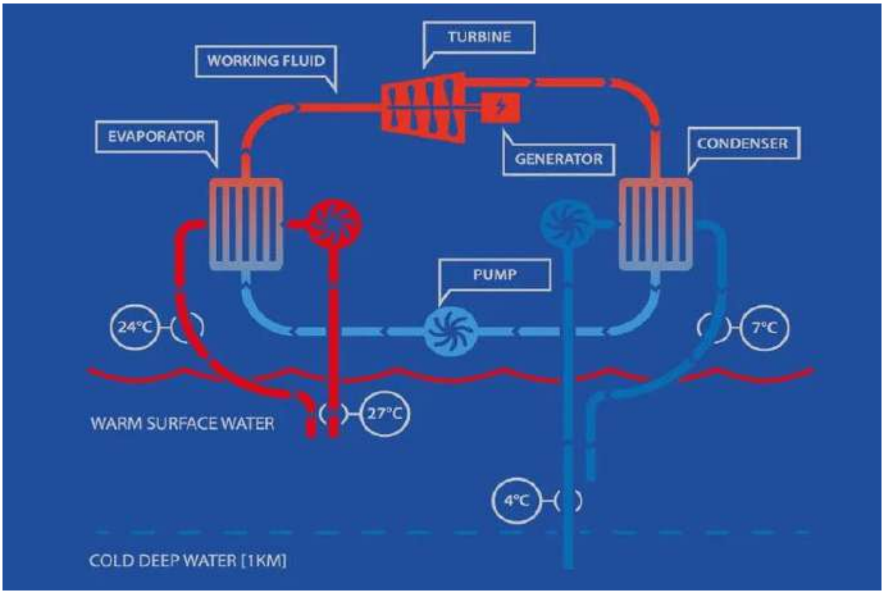
Ocean currents result from differential heating of the sea surface by the sun. For some currents, different salinity, water density, seabed topography and the rotation of the Earth also contribute to their formation. Sea currents are relatively constant and always flow in the same direction.



The most famous sea current is the Gulf Stream. Its speed reaches 3.2 km/h at the bottom and 8 km/h at the surface between Florida and Cape Heteras. One thousandth of its energy could power 35 percent of Florida. Other currents are, for example, the California Current or the Humboldt Current. Although ocean currents are slower than wind, they carry much more energy because of the density of the water. The USA, Japan and China are thinking about utilizing sea currents. Different types of turbines are being developed, which resemble a classic wind farm in their principle. However, they move more slowly, so fish can pass through them without problems. One of the projects envisages the use of large turbines with a diameter of about 170 meters, with two impeller blades, which will rotate at a speed of 1 revolution per minute. The turbines would be anchored by steel cables to heavy anchors at a depth of 30 to 130 meters from the surface. Their mutual distance would be 100 meters of culverts for the passage of large ships. However, all projects that utilize ocean currents are highly risky. The Gulf Stream could slow down, and the possible catastrophic consequences are difficult to predict. Frenchman Morion proposes sinking huge disks into the sea floor that would rotate with the sea current. The turbine would have a diameter of more than 100 meters. He proposes to place these power plants on the coasts of France, Japan and the Pyrenees. A test project has been conducted off the southern coast of Sicily. There is considerable global interest in this project also because it does not threaten the stability of currents and does not involve environmental risks. In the US, there was once an idea that it would be possible to dig through the Florida peninsula and turn the Gulf Stream northward along the US coast while fully utilizing its energy. A favorable climate would move from Europe to America, wouldn't it? Gulf Stream

Thermal energy from the sea (OTEC)

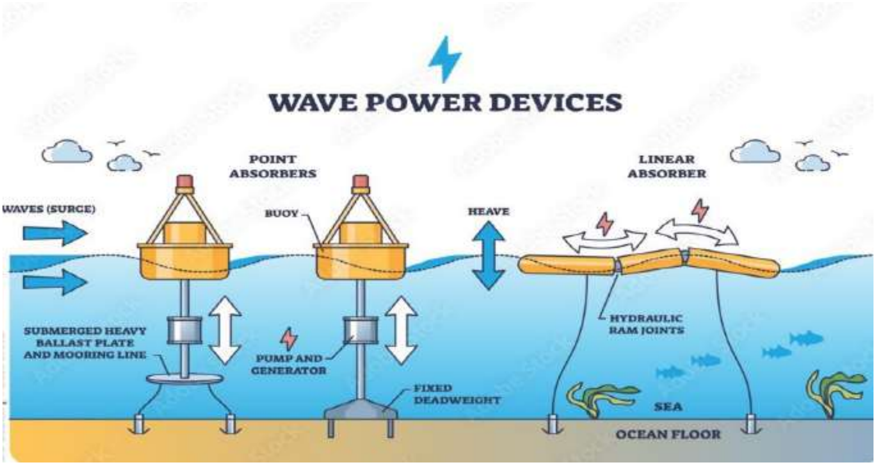
The first proposal to use temperature differences in the ocean to generate electricity was in Verne's 1870 novel Twenty Thousand Miles Under the Sea. It was not until 1930 that the first power plant using thermal energy from the sea (22 kW) was built in Cuba by the Frenchman Georges Claude.



The world's oceans contain a huge amount of thermal energy. Utilizing the temperature difference between the upper and lower layers of water is one way to generate electricity from the oceans. There are open and closed cycle ocean thermal energy conversion systems. A closed Rankine cycle uses a heat-exchange medium (e.g., ammonia) that vaporizes the surface water temperature, the resulting vapor drives a low-pressure turbine, and cooler seawater condenses the medium again. Open cycles use seawater as the working fluid, which is vaporized by lowering the pressure. After passing through the turbine and condensing, the water is desalinated and becomes potable. A special Arctic variant of such a system utilizes the difference between the warm water temperature under the ice of 2 °C and the cold air temperature of up to 50 °C.

Energy of sea waves

The entire mass of the world's seas is in constant motion not only on the surface but also at considerable depths. Vertical motion of water particles changes the sea level, horizontal motion is the cause of formation of both local and oceanic current systems. The most important movement of water particles on the surface of oceans and seas are waves, which have different origins. Waves caused by wind, tidal action of the Moon and the Sun, waves in front of the mouths of large rivers, catastrophic tsunami waves resulting from underwater earthquakes. It is estimated that the energy generated by waves in all the world's oceans reaches a value of 342 billion MJ. However, so far this resource has been very little utilized. However the first steps towards the practical use of sea waves have already been made. The development of power plants using sea waves is mainly taking place in countries such as Japan, UK, Ireland, Norway and Denmark. Various prototype propulsion systems have been produced worldwide: moving buoys, level buffers, blowers and converters using flexible membranes. It has been estimated that each high seas wave off the UK coast continuously for a year has a power output of 50 to 80 kWh per meter of its length. One of many solutions is the proposal to use three section pontoons. These would be fixed to the bottom and lie on the sea level surface. The motion of the waves would be transmitted to the water engine. Another way of utilizing waves has been proposed in Japan. Kalimai power plant looks like a tanker 80 meters long and 12 meters wide. Sea waves compress the air in the chambers of the station and drive 3 turbines with 200 kW generators.



The power station modified in this way is multi-purpose as it acts as a breakwater in front of the harbor and in front of fish farms. Experiments have been conducted off the coast of Hawaii with mini power plants placed in sea buoys.

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Study of Deviations from the Applicable Norms of Buildings Acceptable for Operation

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Abstract: The article presents the results of the research conducted in the field of construction, taking into account the current norms. The conditions that construction companies should take into account have been determined.

Key words: commissioning, valid norms, resolutions, deviation from the norm, permissible deviations, unacceptable deviations.

Introduction

Building occupancy, also known as building occupancy, refers to the phase of a building's life cycle where it is in active use after completion of construction. This phase includes all activities related to the management, maintenance, operation and use of the building to ensure its continued functionality, safety, efficiency and comfort for the occupants. It requires collaboration between building owners, facility managers, residents and other stakeholders to effectively manage the complex and dynamic nature of building operations.

Main Part

Building operations involve a number of tasks and considerations, including:

1. Occupancy and Use: Buildings are occupied and used for their intended purpose, be it residential, commercial, industrial or institutional.

2. Maintenance and Repairs: Regular maintenance works are carried out to maintain the condition of the building, prevent deterioration and solve any problems that arise. This includes routine inspections, cleaning, repairs and replacement of building components and systems.

3. Operation of building systems: Buildings have various systems and equipment that require operation and management, such as HVAC (heating, ventilation and air conditioning), lighting, plumbing, electrical, fire protection and security systems. Proper operation and maintenance of these systems is essential for passenger comfort, safety and energy efficiency.

4. Safety and Compliance: Adherence to building codes, applicable norms/regulations and safety standards is critical to ensure the safety of occupants and legal compliance of the building during the operation phase.

5. Energy efficiency and sustainability: Improving energy efficiency and sustainability can include implementing energy saving measures, using renewable energy sources, optimizing building performance and reducing environmental impact during building operation.

6. Occupant/staff comfort and satisfaction: Building performance includes occupant/staff comfort, satisfaction and well-being, such as

indoor air quality, temperature control, lighting levels, noise abatement and amenities.

Overall, the building operations phase is about managing and maintaining the built environment to meet the needs of occupants, ensure safety and compliance, optimize performance and maximize the life of the building while minimizing operating costs and environmental impact. The article deals with the fourth point, which includes compliance with the applicable regulations.

In Georgia, at the time of commissioning, several basic technical-normative documents should be taken into account, such as:

- • Law of Georgia - Code of Spatial Planning, Architectural and Construction Activities of Georgia
- • Resolution of the Government of Georgia No. 255 (2019) - on the procedure and conditions for issuing a construction permit and putting the building into operation
- • Resolution of the Government of Georgia No. 57 (2009) - on the procedure for issuing construction permits and permit conditions
- Regulation of building safety rules approved by the Government of Georgia Resolution No. 41

Let's move on to the main deviations often repeated during the commissioning of buildings:

- improvement of the territory;
- Size, number, location and visual of openings;

- Facade cladding of the building;
- Arrangement of air-conditioners and exhaust fans on the facades;
- Change of the geometric dimensions (main dimensions) of the building;
- Constructive changes;
- Change of premises;
- Ignoring solutions requested for disabled persons;
- Violations of fire and accessibility requirements.

Conclusion

Based on the results of the studies, it was determined that the percentage of deviations for second-class buildings is as follows:

• Improvement of the territory - 95%

• Dimensions, number, location and visuals of openings - 70%

• Facade cladding of the building - 45%

• Arrangement of air conditioners and exhaust fans on the facades - 97%

• Change in the geometric dimensions (main dimensions) of the building - 6%

• Structural changes - 3%

• Area change - 6%

• Ignoring solutions requested for disabled persons - 2%

Violations of fire and accessibility requirements - 2%

For buildings of the third class:

• Improvement of the territory - 94%

• Dimensions, number, location and visuals of openings - 66%

• Facade cladding of the building - 47%

• Arrangement of air conditioners and exhaust fans on the facades - 95%

• Change in the geometric dimensions (main dimensions) of the building - 4%

• Structural changes - 8%

• Area change - 4%

• Ignoring solutions requested for disabled people - 13%

• Violations of fire and accessibility requirements - 11%

For buildings of the fourth class:

• Improvement of the territory - 91%

• Dimensions, number, location and appearance of openings - 9%

• Facade cladding of the building - 11%

• Arrangement of air conditioners and exhaust fans on the facades - 98%

• Change in the geometric dimensions (main dimensions) of the building - 72%

• Structural changes - 24%

• Space change - 72%

• Ignoring solutions requested for disabled people - 18%

• Violations of fire and accessibility requirements - 6%

The main causes of deviations

• Scarce information about the applicable regulations.

• Hiring non-professional personnel for project implementation.

• Environmental conditions (implementation of necessary changes during the construction process,

• Arbitrary action, etc.)

Damage caused by deviations

• Failure to put it into operation;

• Financial;

• time;

• (image in the case of construction companies).

It is advisable to follow the applicable norms during the construction process so that companies can avoid damages caused by deviations.

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Mass-spectrometric Method of Measurement of Isotopic Content of Nitrogen in Organic Compounds

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Abstract: Nitrogen-15 isotope-modified compounds are widely used in medicine, pharmacology, agriculture and various fields of science and their nomenclature is gradually increasing. Their widespread use depends on the availability of inexpensive and simple isotope analysis methods. The present article is an attempt to determine the nitrogen-15 isotope content directly in organic compounds without their conversion.

The general principle of possibility of determination of the isotopes of nitrogen directly in organic compounds is proposed. Based on the study of mass-spectra of Carbamide Carbonyldiamide, isocyanic acid and nitrobenzene the mass peaks are selected, by which it is possible to determine the atomic fraction of the isotopes of nitrogen. The respective formulas are proposed.

Key words: Atomic fraction, isotope ,nitrogen, molecular ions, mass spectrometer, mass spectrum, monoisotopic forms, Carbamide Carbonyldiamide (Urea), Isocyanic acid, Nitrobenzene, Isotope analysis, isotope-modified compound, Nitrogen center, monoisotopic form, two different nitrogen centers,

Introduction

Compounds labeled with stable isotopes of light elements are widely used in various fields of science. At the same time, their applicable scope is gradually expanding. Use of these compounds allows solving problems that could not be solved without their use. The increase in the use of stable isotopes was due to the increase in the nomenclature of these compounds. At the same time, the number of isotopically labeled compounds increases day by day.

The use of labeled compounds, to a large extent, depends on the existence of accurate, reliable, express and inexpensive methods of determining the atomic fraction of the labeled element in them. Until recently, these compounds are being converted into compounds "convenient" for mass spectrometric analysis. Compounds labeled with isotopes of nitrogen are being transformed into molecular nitrogen or nitrogen oxide (1). But meantime a relatively large amount of expensive organic compounds is consumed; the conversion process is added that reduces rapidness and accuracy. During the conversion process, it is possible to distort the true value of the isotopic concentration not only by the atmospheric nitrogen, but also by nitrogen-containing impurities existing in the compound. In some cases, conversion is impossible due to the small quantity of synthesized compounds.

We have proposed general mass spectrometric methods for the determination of isotopic content of hydrogen (2), carbon (3), oxygen (4) and boron (5), directly in the organic compounds to be analyzed.

Experimental

This paper discusses the mass spectrometric method of determining the isotopic content of nitrogen.

The fragmentation of organic compounds during ionization by electron bombardment is the main difficulty in determining the isotopic content of nitrogen in them, because the monoisotopic forms of molecular and various types of fragmentary ions with equal mass-to-charge ratio are registered as a single mass peak. It should also be noted that the protonated, molecular, and fragmentary ions may occur due to the secondary processes taking place in the ionization chamber. The formation of isobaric fragments is mainly due to hydrogen abstraction, protonation, or hydrogen migration processes. The mass spectra of synthesized organic compounds and the mechanisms of their fragmentation are known. There are spectra banks of these compounds, but the use of these spectra for isotopic analysis requires additional study because small probabilistic processes that are not considered in the study of spectra, make it impossible to process the isotopic content of the elements directly in these compounds.

To address this superposition, we have proposed a mathematical model for solving a problem. We derive a system of equations. At this point, we take into account that bond breaking is equally probable for different isotopes of elements, and that the magnitude of the ionic currents is proportional to the isotopic concentration of the elements in it. When compiling the system, we consider only the number of nitrogen and hydrogen atoms in the compound. The presence of isotopes of other elements does not change the form of the system of equations. They are accounted for by the natural distribution through numerical coefficients for a given specific compound.

The general system of equations for calculation of atomic fractions of nitrogen isotopes in organic compounds, uniformly isotopically modified for every nitrogen center, has the following form:

$$\begin{cases} I_{M-p} = K\alpha_0(1-x)^n \\ I_{M-p+1} = K[\alpha_1(1-x)^n + n\alpha_0(1-x)^{n-1}X] \\ I_{M-p+2} = K\left[\alpha_2(1-x)^n + n\alpha_1(1-x)^{n-1}X + \frac{n(n-1)}{2}\alpha_0(1-x)^{n-2}X^2\right] \\ \cdots\cdots\cdots\cdots\cdots\cdots \\ I_{M+p} = K[\alpha_p(1-x)^n + n\alpha_{p-1}(1-x)^{n-1}X + \cdots + \alpha_{p-n}X^n] \\ I_{M+p+1} = K\left[n\alpha_p(1-x)^{n-1}\cdot X + \frac{n\cdot n-1}{2}\alpha_{p-1}(1-x)^{n-2}\cdot X^2 + \cdots + \alpha_{p-n+1}X^n\right] \\ \cdots\cdots\cdots\cdots\cdots\cdots \\ I_{M+p+n} = K\alpha_p X^n \end{cases}$$

(1)

where x-is the atomic fraction of nitrogen-15, I_{M-p}, I_{M-p+1}.... I_{M+p+n} are the intensities of those peaks, which m/z=M-p; p-n+1…. I_{M+p+n}; M is the mass of ion, z - charge, k - is the coefficient of proportionality between probability of origination of various types of ions and their intensities;

α_0, α_1, ... α_p are the probabilities of origination of ions with the given gross-formula, n- is the number of nitrogen atoms, p- the number of hydrogen atoms.

The system of equations consists of p+2 unknown quantities. We choose various equations according to the value of atomic fraction of the isotope nitrogen-15. If the atomic fraction of the isotope nitrogen-15 is less than 50%, we choose the first p+2 equations. In such case the system of equations is reduced to the equation:

$$(-1)^{p+1}\frac{(n+p)!}{(p+1)!(n-1)!} I_{M-p}Y^{p+1}+(-1)^{p}\cdot\frac{(p+n-1)!}{p!(n-2)!} I_{M-p+1}Y^{p}+(-1)^{p-1}\cdot\frac{(p+n-2)!}{(p-1)!(n-3)!}$$
$$\cdot I_{M+2}Y^{p-1}+\ldots.+(-1)nI_{M+p}Y+I_{M+p+1}=0 \qquad (2)$$

where,

$$Y=\frac{{}^{15}X}{{}^{14}X} \qquad (3)$$

is the ratio of values of atomic fractions of the isotopes nitrogen-15 and nitrogen-14.

The atomic fraction of the isotope nitrogen-15 in percent is calculated by the formula:

$$X_{15}\%=\frac{Y}{Y+1}\% \qquad (4)$$

If the atomic fraction of the isotope nitrogen-15 is more than 50%, then we take the last m+2 equations; then the system of equations is reduced to the equation:

$$(-1)^{p+1}\frac{(p+n)!}{(p+1)!(n-1)!}\cdot I_{M+p+n}Y_1^{p+1}+(-1)^p\frac{(p+n-1)!}{p!(n-2)!}\cdot I_{M+p+n-1}Y_1^{p}+(-1)^{p-1}\frac{(p+n-2)!}{(p-1)!(n-3)!}\cdot I_{M+p+n-2}Y_1^{p-1}+\ldots\ldots+(-1)nI_{M+p}Y_1+I_{M+p-1}=0$$
(5)

Where

$$Y_1=\frac{^{14}X}{^{15}X}$$

is the ratio of values of atomic fractions of the isotopes nitrogen-14 and nitrogen-15. The atomic fraction of the isotope nitrogen-15 in this case is calculated by the formula:

$$X=\frac{1}{1+Y_1} \qquad (6)$$

If an organic compound is isotopically modified only by one isotope center, then the system is written in the form:

$$\begin{cases} I_{M-p} = K\alpha_0(1-x) \\ I_{M-p+1} = K[\alpha_1(1-x)+\alpha_0 x] \\ I_{M-p+2} = K[\alpha_2(1-x)+\alpha_1 x] \\ ----------------- \\ I_M = K\left[\alpha_p(1-x)+k\alpha_{p-1}x\right] \\ I_{M+1} = K\alpha_p x \end{cases} \qquad (7)$$

In this case the system of equations is reduced to the equation:

$$(-1)^{p+1}I_{M-p}\ Y^{p+1}+(-1)^p\ I_{M-p+1}\ Y^p+(-1)^{p-1}I_{M-p+2}\ Y^{p-1}+.\ \ .\ \ .+(-1)I_MY+I_{M+1}=0$$
(8)

In the case, if a compound is isotopically modified by not one, but several centers, the system of equations will take the

for

$$I_{M-p} = K\alpha_0(1-x)^q$$
$$I_{M-p+1} = K[\alpha_1(1-x)^q + \alpha_0 q(1-x)^{q-1}X]$$
$$I_{M-p+1} = K\left[\alpha_2(1-x)^q + \alpha_1 q(1-x)^{q-1}X + \alpha_0\frac{q(q-1)}{2}(1-x)^{q-2}X^2\right]$$
$$- -$$
$$I_M = K[\alpha_p(1-x)^q + \alpha_{p-1}q(1-x)^{q-1}X + \cdots + \alpha_{p-q}X^q] \qquad (9)$$
$$I_{M+1} = K\left[\alpha_p(1-x)^{q-1}X + \alpha_{p-1}\frac{q(q-1)}{2}(1-x)^{q-2}X^2 + \cdots + \alpha_{p-q+1}X^2\right]$$
$$- -$$
$$I_{M+q-1} = K[\alpha_{p-q}(1-X)X^{q-1} + \alpha_{p-1}X^q]$$
$$I_{M+q} = K\alpha_p X^q$$

here q is the quantity of isotopically modified nitrogen centers that is reduced to the equation:

$$(-1)^{p+1}\frac{(p+q)!}{(p+1)!(q-1)!}I_{M-p}Y^{p+1}+(-1)^{p}\frac{(p+q-1)!}{p!(q-2)!}I_{M-p+1}Y^{p}+(-1)^{p-1}\frac{(p+q-2)!}{(p-1)!(q-3)!}\cdot I_{M-p+2}Y^{p-1}+\ldots\ldots+(-1)q\, I_M Y+ I_{M+1}=0$$
(10)

The value of the isotope nitrogen-15 in the non-modified centers is taken into account by means of numerical coefficients, according to a natural distribution.

The given equations allow to determine the atomic fractions of nitrogen isotopes, directly in an organic compound. However in each specific case it is necessary to study the mass spectrum of the compound and determine the processes that are to be taken into account during formation of the system of equations. For stable molecules abstraction of two or more hydrogenes is less probable process, so it is not necessary to take them into consideration. In this case in the system of equations the number of equations and the unknown quantities decrease, respectively the degree of equation decreases. It is also necessary to take into account the process of protonation in polar molecules, at determination of the isotope content, while in non-polar molecules it is of such low probability that the damage caused by the process is one order less than the measuring inaccuracy.

For the given specific compound, using this mathematical model it is possible to determine content of nitrogen isotopes even on fragmentary ions that increases the accuracy and reliability of the method.

Results and Discussion

Based on the aforesaid methods of determination of atomic fractions of nitrogen isotopes directly in Carbamide Carbonyldiamide, Isocyanic acid and Nitrobenzene have been proposed. The mass spectrum of Carbamide Carbonyldiamide, recorded on the mass spectrometer МИ-1201, is given on Fig. 1.

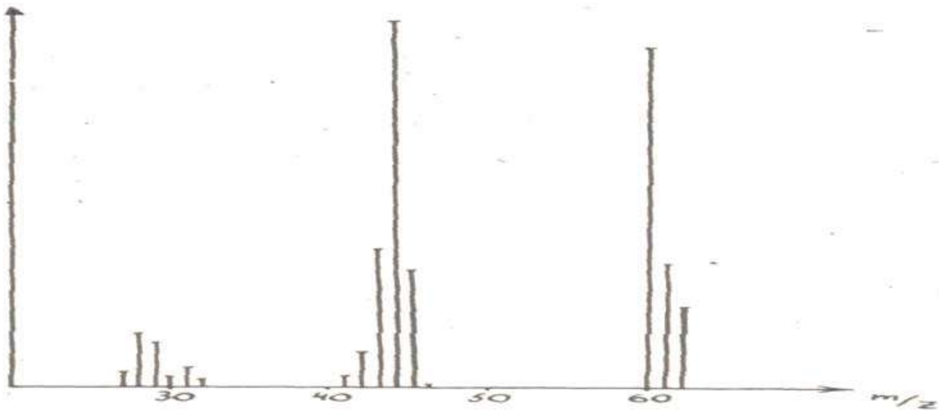

Fig. 1. The mass spectrum of Carbamide Carbonyldiamide

As is well known, the positive charge on the ion obtained by electron bombardment of Carbamide Carbonyldiamide is predominantly observed on one of the amino groups. This determines the form of the spectrum. The maximum in the spectrum is the molecular ion with m / z = 60. Fragmentation of the molecular ion by the abstraction of hydrogen will be virtually unnoticed. The mass peak 16, i.e. the peak, corresponding to the ionic current NH_2^+, is intensive. The mass peak m/z = 44, i.e. the peak corresponding to the ionic current $(NH2\text{-}CO)^+$ is also intensive. It is unlikely that a positive charge will be localized on the oxygen atom, so m / z = 28 (ionic current CO^+) is of much lower intensity. Based on the spectrum analysis, we have a nitrogen element on the following mass peaks, m / z = 60 (molecular), m/z = 44 (fragmentary ions $(NH2\text{-}CO)^+$) and m/z = 16 $(NH2)^+$. Nevertheless, on the mass peak m / z = 44 the background superposition of the ions $C0_2^+$ is probable, as well as the superposition of some substances in the analyzed sample that increases the error. A background superposition occurs on the mass peak m/z=16, which is obtained by fragmentation of carbon dioxide, molecular oxygen, and water. Therefore, we use only molecular ions to determine the atomic fraction of nitrogen isotopes.

The molecule of Carbamide Carbonyldiamide is symmetric in respect to amino groups, therefore the nitrogen isotopes are uniformly distributed in both nitrogen centers.

The atomic fraction of the isotope nitrogen-15 in percent is expressed by the formula:

$$X^{15}N\ \% = \frac{1}{1+2\,\frac{I_{60}}{I_{61-0.01217}\ I_{60}}} \cdot 100\% \qquad (11)$$

whereas

$$X^{14}N\ \% = \frac{2\,\frac{I_{60}}{I_{61-0.01217}}}{1+2\frac{I_{60}}{I_{61-0.01217}I_{60}}} \cdot 100\% \qquad (12)$$

where I_{60}, I_{61} are the intensities of the peaks of mass numbers m/z=60, 61; $X^{15}N$ and $X^{14}N$ are the atomic fractions of the isotopes nitrogen-15 and nitrogen-14. The numeric coefficient takes into account the natural distribution of heavy isotopes of carbon, oxygen and hydrogen in the molecule. Using this approach we have conducted the isotope analysis of the samples, in which the atomic fractions of the isotope nitrogen-15 was 20,0%; 56,1% and 61,7%. The results of measurements carried out directly in the sample of urea were 20,2%; 56,0% and 61,7%, i.e. within the accuracy of measurements agree with the data of certificate.

The mass spectrum of Isocyanic acid, recorded on the isotope mass spectrometer МИ-1201В, is given on Fig. 2.

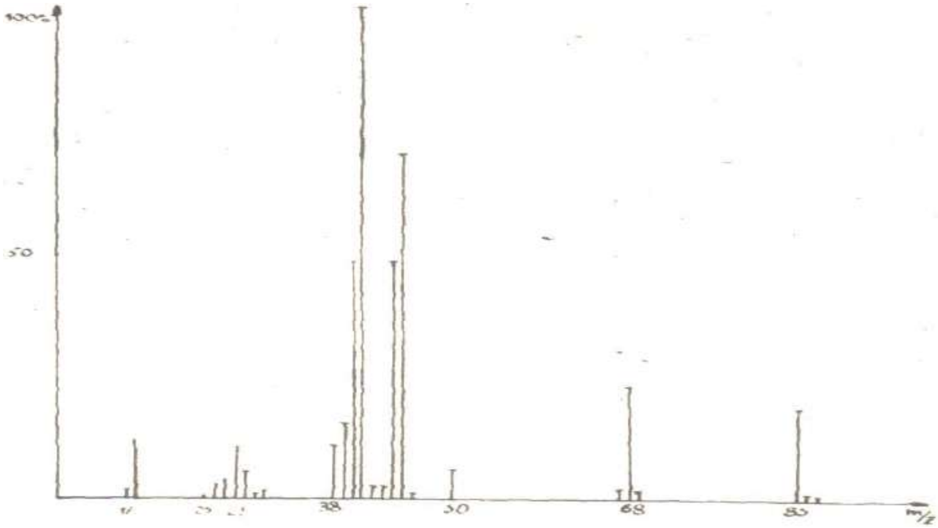

Fig. 2. The mass spectrum of Isocyanic acid

The molecular peak in the spectrum is sufficiently intensive and amounts to 18% of the maximal peak. The maximal peak of the spectrum is m/z=41 that is obtained by localization of charge on the atom, followed by hydrogen migration on amino group and elimination of carbon dioxide, i.e. the ionic fragment $(CH_2{=}C{=}NH)^+$ is formed. The peak with the mass number m/z=68, i.e. the ionic fragment $(M\text{-}OH)^+$, is also intensive in the spectrum, where the abstraction of oxygen atom occurs with low probability after migration of hydrogen. Abstraction of hydrogen atoms from molecular ions was not registered in the spectrum, but the ion-molecular reaction is observed, during which the hydrogen atom addition, or protonation and formation of $(M+H)^+$ takes place. Despite the low probability of the process, it is important to take it into account, if the atomic fraction of the isotope nitrogen-15 is less than 2%. From the maximal peak with the mass number m/z=41, from this fragmentary ion the atoms of hydrogen are intensively abstracted, as a result for determination of the atomic fraction of nitrogen-15 by these mass peaks it is necessary to solve the high order equations that is undesirable.

Proceeding from the aforesaid, the atomic fraction of the nitrogen isotopes must be determined by means of the intensities of the ionic currents of the ions M^+ and $(M\text{-}OH)^+$.

At determination of the atomic fraction of the isotope nitrogen-15 by the peaks of ions $(M\text{-}OH)^+$ the low probable process must be taken into account - elimination of water and fragmentation by abstraction of oxygen. By taking into consideration these processes, the system of equations will be reduced to the cubic equation of the following form:

$$I_{67}Y^3-(I_{68}-0{,}03443I_{67})Y^2+(I_{69}-0{,}03443I_{68}-0{,}00127I_{68})Y-(I_{70}-0{,}03443I_{69}-0{,}00116I_{68}-0{,}00012I_{67})=0 \quad (13)$$

where

$$Y={}^{15}X/{}^{14}X \quad (14)$$

whereas the fraction of nitrogen-15 and nitrogen-14 is calculated by the formula:

$$X^{15}N\ \% = \frac{Y}{Y+1} \cdot 100\% \qquad (15)$$

$$X^{14}N\ \% = \frac{1}{Y+1} \cdot 100\% \qquad (16)$$

A determination of atomic fraction of the isotope nitrogen-15 by means of molecular ions is far easier, if $X^{15}N\% > 5\%$, then

$$X^{15}N\ \% = \frac{1}{1+\frac{I_{85}}{I_{86}-0.03480\, I_{85}}} \cdot 100\% \qquad (17)$$

whereas

$$X^{14}N\ \% = \frac{\frac{I_{85}}{I_{86}-0.03480 I_{85}}}{1+\frac{I_{85}}{I_{86}-0.03480\, I_{85}}} \cdot 100\% \qquad (18)$$

whereas, when $X^{15}N\ \% < 3\%$, then the protonation process is to be taken into account. The system of equations will be reduced to the equation:

$$I_{85}Y^2 - 2(I_{86} - 0{,}03477 I_{85})Y + (I_{87} - 0{,}03492 I_{86} - 0{,}00325 I_{85}) = 0 \qquad (19)$$

The conducted measurements have demonstrated that the process of evaporation of the sample is unstable, as a result the accuracy of the measurement is rather low. Therefore tungsten powder is to be added to the sample in proportion 1:1. It slows and stabilizes the evaporation process. After that the spectrum is stable and the accuracy of measurement significantly increases.

The measurement has been carried out on the sample, in which the atomic fraction of the isotope nitrogen-15 according to the certificate was 69,8%.

The mass spectrum of Nitrobenzene is sufficiently specific, the mass spectrum , recorded on the isotope mass spectrometer is given on the Fig. 3. The maximal peak of the mass spectrum is (M-46), which m/z=47, i.e. the ion $(C_6H_7)^+$, from which the fragmentary ions of the spectrum are obtained. Only the sufficiently intensive molecular ion contains nitrogen.

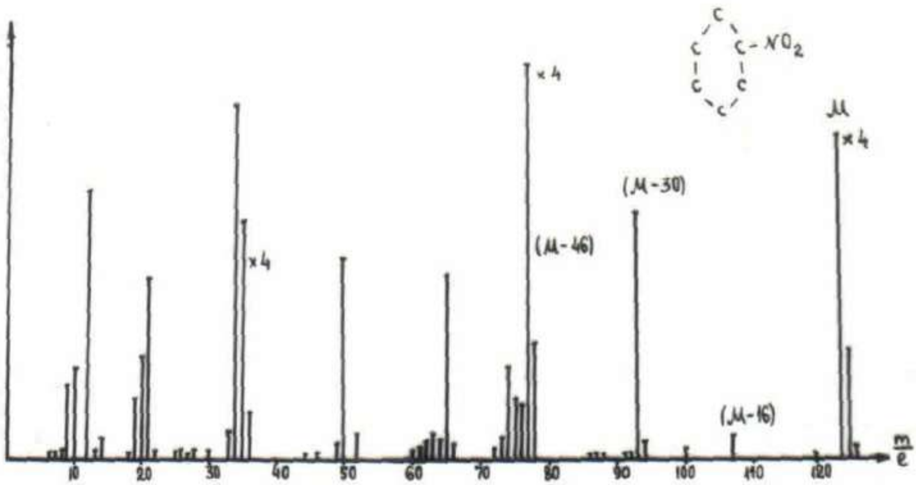

Fig. 3. The mass spectrum of Nitrobenzene

Proceeding from the aforesaid, the atomic fraction of nitrogen isotopes in Nitrobenzene is determined by the formula:

$$X^{15}N\ \% = \frac{1}{1+\frac{I_{123}}{I_{124-0.06871\,I_{123}}}} \cdot 100\%$$

(20)

$$X^{14}N\ \% = \frac{\frac{I_{123}}{I_{124-0.06871\,I_{123}}}}{1+\frac{I_{123}}{I_{124-0.06871\,I_{123}}}} \cdot 100\%$$

(21)

The atomic fractions of the isotope nitrogen-15 has been measured by this method in the samples, in which according to the certificate, it was 64,5% and 89,5%, that corresponds to the results of the measurement 64,6% and 89,6%.

Conclusions

The given methods meet requirements to the isotope analysis and are successfully used for determination of the atomic fraction of nitrogen in Carbamide Carbonyldiamide, Isocyanic acid and Nitrobenzene isotopically modified by nitrogen.

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Hazards Present in Construction Organization Projects

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Abstract: The document outlines the results of the analysis conducted on projects of construction organizations. It identifies discrepancies, challenges, and obstacles encountered in projects undertaken by construction organizations. It specifies the regulatory requirements set forth by construction companies.

Key Words: Construction company, Urban Planning, Architectural, and Construction Code of Georgia.

Construction is one of the most significant sectors of the economy, defining the country's development level. Individuals employed in the construction sector are involved in work in environments where various complex technological processes are carried out using various machinery and equipment and manual labor. Today, active efforts are underway in Georgia for new construction and existing dilapidated, dysfunctional structures' demolition, reconstruction, and renovation. According to the data of the National Statistics Office of Georgia, the number of employed individuals in construction at the end of 2023 was 66,500, which is approximately 10,000 less compared to 2017. The value of the produced construction is 3.4 billion GEL. According to the Urban Planning, Architectural, and Construction Code of Georgia, construction represents a set of activities that encompass the organization of activities related to the preparation, implementation, reconstruction, demolition (demolition, dismantling), conservation, and procurement.

In order to obtain a construction permit, the relevant documents submitted to the Mayor's Office of Tbilisi include documents related to the preparation of a construction organization project (PMP). The construction organization project is an integral part of the construction project, which contains detailed provisions for construction organization implementation. Specifically, the construction organization project should include:

- A cover letter, the name and address of the object;
- A bar chart with the following information:
    - Description of the organization and preparation of construction activities and relevant work organization;
    - Description of the sequence, stages, and duration of these regulations;
    - In case of existence, the visibility of closed work, inspection, and test activities, which should be performed during the construction process;
    - Description of safety assurance methods and inspection activities.

- A construction site plan (land plot plan, construction site plan, project building and demolition work site plan, construction equipment movement scheme, and locations for temporary construction and demolition (deconstruction) work);
- A calendar schedule of construction, indicating the sequence, stages, and duration of these regulations:
    - For Grade II construction - minimum 3 and maximum 5 stages;
    - For Grade III construction - minimum 5 and maximum 10 stages;
    - For Grade IV construction - minimum 10 stages.

In the construction organization project, in case of necessity, additional information should be provided: a) The preparation of the land plot and public land for construction on the ground or for public use, including optimization of the optimal term and time; b) Special inspections of construction and demolition operations, which ensure the correctness of their implementation or not hinder their correctness/correctness.

The document is used - during new construction, reconstruction, demolition, conservation, and/or procurement, and is common for everyone, according to the Code, is one - "Construction Organization Project." The construction organization project must be detailed and must contain the necessary information to facilitate the implementation of construction work.

The priority order and stages of the construction process are determined by the construction organization project. The construction organization project should specify the two-row:
Section "

a) I Row – Preparatory Work for Construction": Section "

b) II Row – Main Construction Activities": The preparatory work for construction is carried out in two stages, and in the case of ground surface alterations, it consists of three stages:

- Preparatory work includes activities related to the preparation of construction sites, among them, the division of demolished or other existing structures and the preparation of construction site access roads, soil protection measures, and communication of subsurface engineering communications;
- Investigation of the ground on the construction site and fixing the main axes;
- In case of ground surface alterations, after changing the ground surface, investigation of the ground on the construction site and fixing the main axes.

Preparatory work includes organized events both outside and inside the construction area, which must be completed in accordance with the documents of construction implementation.

The main construction activities of the preparation and construction of the building's foundation are divided into the following stages:

- Groundwork activities for foundation construction;
- Groundwork activities for foundation basement construction;
- Groundwork activities for foundation superstructure construction;
- Main structural system construction from ground zero marking;
- Construction and dismantling of foundation formwork;
- Construction of non-structural elements;
- Local civil engineering-technical network construction;
- Installation of technological equipment;
- Construction of external works;
- Excavation works for foundation clearance.

In the last two years, we have studied the project of organizing the construction of 45 objects. It is evident from the pictures presented in the article that work processes do not correspond to the prescribed records of the construction organization project. It is stipulated in the project that a three-stage foundation division should be carried out from top to bottom. Initially, the third floor should be divided, then the second floor, and so on.

The results of the inspections revealed the following discrepancies and inconsistencies:

1. The project organization does not fully comply with the requirements outlined in №255 (Regulation on the issuance of construction permits and exploitation of construction works), regarding the provision of complete information.
2. Project names determined during inspections do not correspond to the regulations outlined in the Code of Urban Planning, Architectural, and Construction Activities of Georgia.
3. There is no identified information (graphically) regarding the specific location for the supply of construction equipment and building materials on the construction site.
4. Graphically identified temporary construction site organization locations are missing.
5. Identified records of completed construction, inspection, and testing activities are missing.
6. Methods and procedures for ensuring safety, determined by central information mostly derived from Russian Federation regulations, which are largely incompatible with Georgia's legal framework and international agreements to which Georgia is a party. Until the adoption of relevant technical regulations regarding the regulation of technical activities in the construction sphere in Georgia, the norms and regulations in

force in Georgia concerning construction and technical activities until 1992 and international agreements to which Georgia is a party, which are not contrary to Georgian legislation and international agreements, shall apply. Despite this, the projects include normative acts, analogs of which have been developed and implemented in Georgia.

7. Authors of construction organization projects demonstrate a lack of knowledge of Georgian laws, codes, and technical regulations.
8. The initiation of construction/demolition processes in project organization projects deviates from established methods and procedures.

The identified discrepancies may lead to different levels of degradation of health and safety for workers and other persons - minor, moderate, and severe. Fatal consequences are also possible. Properly and comprehensively organized construction in project organization projects ensures the safe implementation of construction activities (preparation, new construction, reconstruction, demolition, conservation, and production). It is important that the authors of construction organization projects familiarize themselves with the following regulations in Georgia:

1. №255 "Regulation on the issuance of construction permits and exploitation of construction works";

2. The Georgian Law "Code of Urban Planning, Architectural, and Construction Activities";
3. Organic Law "On Labor Safety";
4. Minister's Order №01-15 / N "On the assessment of risks in the workplace";
5. Technical Regulation "On the safety of construction work at height";
6. Technical Regulation "On the safety of work and the safe operation of equipment for work at height";
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Analysis of Statistical Data in relation to the Environmental Friendliness of Commercial Fuels in Use in Georgia

Eter Gelashvili (PhD program student), Supervisor: Professor Jumber Iosebidze, Georgian Technical University

Abstract: The article discusses the statistical data of cars in Georgia, the composition of toxic components of their exhaust and their impact on the ambient air, human health, global warming, motor fuels and the steps taken by the state to correct the situation. Topics of research are defined.

Main Part

Georgia, which received the status of a candidate for EU membership, shares European culture, history and values. Among the values, care for environmental protection is the most important, one of the aspects of which is the improvement of ambient air quality.

It is established that on the environment Harmful influence makes natural and man-made factors. Man-made Among the factors in terms of harmful impact on the environment, road transport is on the first place. It affects the environment locally and globally. Related to the latter is "global warming", which causes catastrophic climate change and poses a great threat to the existence of humanity.

Most of the chemical pollution of the environment comes from exhaust gases of internal combustion engines. The content of harmful substances in the exhaust of internal combustion engines is directly related to the environmental friendliness of the used fuels.

Theoretically, during the complete combustion of fuel, as a result of the interaction of carbon and hydrogen contained in the fuel with oxygen in the air, carbon dioxide and water vapor are produced. In practice, due to the processes taking place in the engine cylinders, the actual composition of exhaust gases is very complex and includes more than 200 components, a significant part of which is toxic [a].

The main harmful components in the exhaust gases are: carbon monoxide (CO), carbon dioxide (CO_2), Hydrocarbons (CmHn), nitrogen oxidizers (NO_X), soot (smoke) etc.

The increase in the amount of harmful substances emitted by automobiles is a potential risk factor for morbidity, disability and mortality. In 2016 alone, air pollution caused 6845 deaths in Georgia [b]. According to the Ombudsman's report, more than 120 million GEL was spent from the state budget in 2016 for the treatment of diseases caused by individual pollutants (NO_2, SO_2, CO, O_3, PM10 and PM2.5). According to the World Bank's 2020 report, the economic value of the health burden of atmospheric and indoor air pollution in Georgia is estimated at 560 million USD [c].

The Euro 5 standard of vehicle exhaust emission has been introduced in Georgia in 2024. Parallel to this, the fuel quality control also continues. Control of vehicle emissions on the roads has begun;

Also, to combat the harmful practice of removing catalysts from cars, the export of catalysts was banned.

In Georgia, 8 new automatic air quality monitoring stations of modern standards are operating, which provide a continuous possibility of air quality control. Also, in order to strengthen the monitoring of atmospheric air pollution, the National Environment Agency has been carrying out indicator measurements since 2015, within the framework of which, the content of nitrogen dioxide, ozone and benzene in the air is determined in 25 cities of Georgia [d].

Based on the above, it is important to implement long-term, result-oriented measures to reduce atmospheric air pollution in Georgia. Top priority is identification of risks and research of methods of mitigating them.

According to the latest data of the National Statistics Service, in 2017 there were 1228123 cars in Georgia, and at the end of 2023 - 1647629 [e].

Along with the increase of the motor park, the level of harmful effects of motor transport on the environment increases intensively. For example, if at the beginning of the 70s, scientists and hygienists determined the share of pollution introduced into the atmosphere by road transport to be equal to 13% of total on average, now it has exceeded 50% and continues to grow. As for cities and industrial centers, the share of their atmospheric air pollution by vehicle emissions exceeds 70%, which creates a serious environmental problem [a].

If we take into account the fact that the age of vehicles in Georgia is one of the highest among European countries, for example, more than 83% of registered cars are over 10 years old, and there are only 70661 vehicles under 5 years old in the country - less than 5% of the total number, it is becoming more important to take care of the environmental protection of motor fuels [f].

Motor fuel is imported into Georgia from 5 countries: Romania, Bulgaria, Russia, Turkmenistan and Kazakhstan. The data from 2017-2023 National Statistics Agency (see table) shows how small the share of safer (gas powered cars, electric cars and others) vehicles is.

Table

Distribution of light vehicles in Georgia according to the fuel used

type of fuel	Number of cars
gasoline	676851
diesel	322407
gasoline-gas	160906
Hybrid	129273
electric	4369
gas	1283
the rest of	352540

As can be seen from the table, according to the type of fuel, the largest number of gasoline-powered vehicles are registered in Georgia - 41.1%, followed by diesel fuel (19.6%) and LPG/NG powered vehicles (9.8%).

By the end of 2022, the number of electric cars registered in the country amounted to 3.3 thousand, which shows a 37.5% increase compared to the figures of 2021. According to geostat, by the end of 2022, 67% of electric cars will be collected in Tbilisi [g].

Despite the expected increase in the number of electric cars (which, due to their small number, cannot yet affect the health of the ambient air), in the near future the percentage of cars running on petroleum-derived fuels will remain very high. Therefore, the amount of vehicle emissions (including toxic components) and the corresponding danger will be large.

Thus, the following research must be conducted, to understand the ecological characteristics and ways of improving the main fuels used in Georgia – gasoline and diesel.

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2023-03-01

Analysis of Methods of Diagnosis and Control of the Electrical Equipment and Electrical Installations of Power Substations

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Abstract: It is substantiated in the work that increasing the efficiency of the operation of the electrical equipment and electrical installations of power substations can be achieved by the complex diagnostic parameter of the tangent of the angle of dielectric losses as a method of diagnosing the technical condition and forming a forecast of the residual resource, as well as a method of managing their operation modes.

Key words: Electrical Installations, operation modes, power substations, dielectric losses

According to experts, the peak of the development of domestic electrical systems comes in the years 1950-1970. Today, a significant part of the equipment has been in use for more than 50 years, and during this time, they have already exhausted their resources. In addition, under the conditions of limited funding, it is impossible to simultaneously remove all obsolete and physically worn-out equipment from the operation and replace them with high-tech modern analogs. For this reason, starting from 1990, the rates of reconstruction and modernization of existing electrical installations and construction of new facilities of electrical network complexes have been significantly reduced. As a result, the material and technical base has aged considerably.

To solve the given scientific task, based on economic needs, exploitation, repair service, and renovation of outdated electrical equipment and electrotechnical equipment are considered as a priority direction of the development of the electric power complex. For this, it is necessary not only to take care of accidents but also to determine the remaining resources of the equipment for planning its replacement and repair. The paper aims to substantiate the tangent of the angle of dielectric losses as a complex parameter for the formation of diagnostics and forecasting of the residual resource of the electrical equipment and electrical installations of power substations.

One of the main factors affecting the formation of the residual resource of the electrical equipment and electrical installations of power substations is the wear and tear of their current-carrying parts.

The current-carrying parts of the electrical equipment wear out, influenced by four factors: thermal, electrical, mechanical, and environmental conditions. As the temperature increases, the mechanical strength and heat transfer coefficient decrease. The structure weakens during thermal expansion. Internal thermomechanical stresses are generated, especially large in tightly connected insulation systems, which differ significantly in thermal expansion coefficients. In the process of wear, its decomposition products can accumulate in the insulation of conductive parts, leading to gas bubbles and conductive impurities that reduce its breakdown voltage. The voltage level of the device determines the electrical impact on current-carrying parts. The most significant influence on wear is caused by commutation and ambient overvoltages, which lead to uneven distribution along the current-carrying parts and can cause them to break. The uneven voltage distribution is typical for the windings of electrical equipment fed from the frequency converter by rotation-module modulation. The operating conditions of the electrical equipment deteriorate due to atmospheric influences, namely humidity, harmful chemical impurities, and ambient temperature. The moisture in the insulation of current-carrying parts reduces its mechanical strength, enhances the ionization process, and accelerates its chemical aging.

The mechanical impact is manifested as a result of the device's vibration. During the passage of alternating current in its windings, alternating electrodynamic forces and centrifugal forces are produced in the moving parts. At the same time, the mechanical forces that act on the current-carrying parts of the electrical device in emergency modes (usually in short-circuit modes) can be hundreds of times greater than the forces operating in normal modes.

As a result of this impact, the insulation of the current-carrying part can be broken, and high electrical potentials can be detected on the parts of the electrical equipment that are not under voltage under normal conditions. Correcting this type of wear and tear usually requires a major overhaul of the electrical equipment and installations.

All four factors of wear and tear cannot be considered separately. For example, the mechanical wear of current-carrying parts is strongly influenced by the current density, temperature, and humidity of the environment; the Electrical wear of insulation is influenced by mechanical factors (vibration, thermomechanical forces, abrasive wear) [1].

Thus, to evaluate the residual resource formation, a complex diagnostic parameter is needed, which will allow us to consider all the factors mentioned above.

Consider the dielectric loss angle tangent as such a parameter. Dielectric losses are the energy that is dissipated in the insulating material under the influence of an external electric field.

The dielectric loss angle and the dielectric loss angle tangent usually characterize the ability of a dielectric to dissipate energy in an electric field. During the test, the dielectric is considered as the dielectric of a capacitor, which has a capacitance and an angle δ, which fills the angle of shift between current and voltage in the capacitive circuit up to 90^0. This angle is called the dielectric loss angle.

During an alternating voltage, a current flows through the insulation, which precedes the applied voltage by an angle δ less than

90^0 by an angle φ. (Fig. 1), which is due to the presence of active impedance.

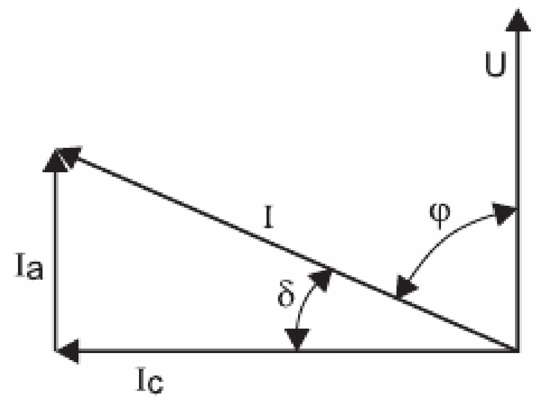

Fig. 1. Vector diagram of the current passing through the dielectric with losses:
U - voltage on the dielectric; *I* - complete current passing through the dielectric; *Ia*, *Ic* - respectively, full power active and capacitive compilers; *φ* - phase shift angle between the voltage applied to the dielectric and the entire current; δ- angle of shift between entire current and its capacitive compiler.

The ratio of active compiler *Ia* to its capacitive compiler *Ic* is called the dielectric loss angle tangent and is expressed in percent.

$$tg_\delta = \frac{I_a}{I_c} X\ 100\ \%$$

In an ideal dielectric, i.e., in a dielectric without losses, the angle δ=0 and, therefore, $tg_\delta=0$. Wetting of the insulation and other defects cause an increase in the dielectric loss current of the active compiler and tg_δ. Since, at this time, the current's active compiler increases faster than the capacitive compiler, the indicator tg_δ reflects the change in the state of the insulation and the losses in it. With a small amount of insulation, we can notice the development of local and concentrated defects [2].

The dielectric loss angle tangent tg_δ increase can be explained as follows: the aging products by dissociation into ions, form new charge carriers or form colloidally charged particles. An increase in the concentration of charge carriers corresponds to an increase in the electrical insulation conductivity of current-carrying parts, i.e., to the increase of tg_δ. tg_δ, as a parameter that characterizes the degree of aging, has the following features:

- high sensitivity to the current physicochemical condition of electrical insulation of current-carrying parts;
- During the aging of electrical insulation of current-carrying parts, a peculiar positive feedback loop is created: the greater tg_δ and the temperature of the electrical insulation, accordingly, the faster the insulation aging rate is, and in turn, the higher tg_δ increases.

Since tg_δ is a calculated parameter and depends on temperature, to extend the life of electrical equipment and electrical installations, it is necessary to control the parameters of the power supply system, as well as the temperature of the working environment. The temperature of the working environment of the power substations consists of the sum of the heat released by the electrical equipment and the temperature of the environment and is a distributed parameter.

Thus, during the cooling regulation of the substation, it should be considered a facility with distributed parameters.

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Challenges of IV Technological Revolution

Natia Gochashvili (PhD student), Supervisor: Professor Khmaladze Konstantine, Georgian Technical University

Abstract: World-renowned scientists, experts, and research centres are emphasizing the emergence of new challenges and opportunities on an unprecedented scale, intricately linked to the ongoing process of the fourth industrial revolution. This transformative phase is a crossroads in industrial revolutions, or it may have already commenced, heralding significant global changes. Anticipated changes extend to the mutation of occupations and jobs, driven by the pervasive influence of artificial intelligence. The trajectory of this shift is exponential, underscoring the urgency for acquiring new skills. As Industry 4.0 unfolds, it becomes clear that humanity cannot evade the transformative impact it will bring to various aspects of life, work, and society.

The concept of the Fourth Industrial Revolution refers to the evolution of manufacturing in an increasingly digital world. Automated management, speed of processes, "smart systems", internet of things (IOT), 3D printing, big data analysis, these advances already exist in today's reality, the process is growing and irreversible. The purpose of the concept is to make use of digital production and also to eliminate its shortcomings.

Key words: industrial revolution, artificial intelligence, workforce, cyber security, internet of things.

Introduction

Industry 4.0, which is also referred to as the 4th technological revolution, is one of the most relevant topics and challenges in the world today, which has already changed the lives of many people and will bring many more changes.

The term "Industrial Revolution" refers to the most important turning points in the history of mankind, which established a new way of life.

The foundation of the industrial revolution was laid in England, which started with the cotton textile industry. Textile factories appeared in England, which worked on steam machines, machine building gave an impetus to the development of the mining industry, the development of the railway. **The first industrial revolution** took place around 1760-1840. **The second industrial revolution** lasted from the 70s of the 19th century to the 20s of the 20th century. It is characterized by the development of the railway system, iron and steel processing, machinery production, telegraph use, paper production, oil production and refining. Through the electrification of factories, it became possible to move to mass production.[1] **The third industrial revolution** began in the 60s-70s of the 20th century. [7]

What is Industry 4.0?

Industrial Development The industrial sector is undergoing major changes due to the rapid development of technology. New technologies have had a tangible impact on the activities and organizational structure of entrepreneurs, such as services, production, control, design and workforce. The fourth phase of the world industrial revolution involves the interconnection of devices with systems.

Industry 4.0 is defined as the name of the latest trends in data exchange and automation in production technologies, such as the Internet of Things, cyber-physical systems, cognitive computing, cloud computing and the construction of intelligent factories. Cyber-physical systems are at the heart of this revolutionary technology. [8]

Industry 4.0 enables manufacturers to be customer-centric, breaking traditional industrial frameworks. The main challenge is to meet the new needs of customers who are becoming more demanding.

What are the benefits of Industry 4.0?

Adaptation of productive tools to the needs of the population; improvement of raw material and energy consumption; production flexibility; increasing speed and responsiveness; vehicle stability; optimization of human resources; Strengthening the processing industry by improving material and energy resources. Industry 4.0 and the Internet of Things are making machines autonomous and mobile. [2]

Professor Klaus Schwab, chairman and founder of the World Economic Forum, who is always interested in global issues, offers an interesting study in his book "The Fourth Industrial Revolution". Schwab calls on the country's leaders to "build together a future that works for everyone, by putting people first, by empowering them, and by constantly reminding them that all these new technologies are first and foremost tools made by people for people." [3]

There are several myths about the fourth industrial revolution. According to one, it is not able to influence on such a scale that past revolutions were able to do. Technological revolution always takes time. It is too early to claim that the synthesis of the human genome and synthetic biology is more important than driving a car or traveling by air. The second myth is that the process will go smoothly. It is absurd to think that the wealth created by the fourth industrial revolution will make the poor richer, that the laid-off workforce will find an alternative job where they will have a good salary. All the benefits of change are expected to be concentrated in the hands of already successful and high-budget companies and individuals, further reducing the prospects for equality. According to the next myth, with smart robots and artificial intelligence redistributing the goods of the economy, all jobs will be done by machines, everything will be secured, and people will have more free time. Schwab says: “The changes are so great that, from the perspective of human history, there has never been a more hopeful or potentially dangerous time. It excites me that decision-makers often think in a traditional, linear way and are surrounded by thinking about the power of innovation to influence our future." [4]

Challenges of Industry 4.0

The main challenges of the implementation of Industry 4.0 are security, workforce compatibility with technology standards. In this case, manufacturers should not save money in training the workforce.

The first and foremost challenge is ensuring data security. For many businesses, there is a constant threat of cybercrime involving customer data. Use of data: Another challenge of Industry 4.0 is to use information and data and make informed decisions. [8]

One of the challenges in implementing Industry 4.0 is retraining current staff and attracting talent. It is important for manufacturers to hire people with high technical function roles, robotics specialists, IT specialists, cyber security specialists. The success of Industry 4.0 depends on employees who must actively use new technologies.

What technologies does Industry 4.0 include? Edge Computing, Sensor Networks, Data Analysis Software. While manufacturers often use 3D printing, they can also use digital twins to test changes to production lines and factory layouts in computerized models before they are implemented.[5]

Conclusion

Today, humanity is facing the biggest change that will fundamentally change our lives. Within Industry 4.0, several technologies are coming together and blurring the lines between the biological, digital, and physical realms, which are evolving at an exponential rate. Although we do not know in the end how life and processes will go, it is clear that we must effectively respond to new challenges with joint forces, as government agencies, academic and civil groups, public and private sectors. Every country's industry will change, transforming governance, management and production systems.

The use of artificial intelligence is already part of our reality. Visible examples of this are: unmanned vehicles, virtual assistants, drones. In the field of artificial intelligence, it is an impressive process to create a new medicine through a program, which is possible through computer power and databases. Determining cultural trends, which is possible through an algorithm. Symbiotic products are created by the digital and biological worlds working together. [6]

In the end, it is humans who control technological development and outcomes, and we must take advantage of these opportunities and lead the industrial revolution as we see fit.

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Green Construction

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Abstract: this passage emphasizes the key relationship between architectural advancement, sustainability, and the urgency of addressing climate change. It highlights the role of green buildings in lessening environmental damage by using resources efficiently, adopting renewable energy, and reducing waste. Green buildings strive to elevate construction practices and environmental stewardship through sustainable materials and renewable energy sources. It also points out the importance of evaluating buildings' full life cycle to cut resource use and environmental effects. Despite the possible upfront costs, the long-term benefits and savings from green technologies make them practical options for tackling climate change.

Keywords: Green construction, new environmentally friendly materials, ecology

Green construction

The emergence of new building structures, architectural forms and construction methods has always been directly related to the creation of new building materials. New, more sophisticated properties of materials allow us to use them not as a substitute for traditional materials, but as a means of increasing the quality of construction, which are characterized by high physical-mechanical and artistic decorative properties.

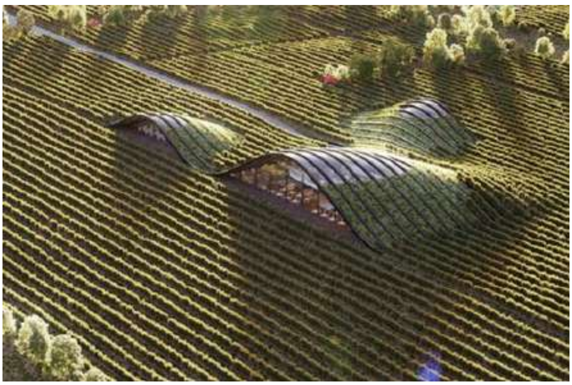
Progressive climate change is the biggest challenge for humanity. It is necessary to take measures to reduce the climatic impact on ecology. Green buildings have a significant impact on environmental conditions. Its concept refers to buildings that are designed, constructed and operated to use natural resources efficiently. Green buildings use renewable energy sources such as wind, sun or soil. Those buildings generate the energy they need, have wastewater recovery systems, make the most of daylight for lighting, and have effective thermal insulation. There are a number of features that can make a building "green" - these are:

- Use of renewable energy, such as solar energy;
- Pollution and waste reduction measures, reuse and recycling;
- efficient use of energy, water and other resources;
- Use of non-toxic, ethical and sustainable materials;
- consideration of the environment in construction, design and operation;
- Design that adapts to a changing environment;
- Considering the life of the population in design, construction and operation.

Any building, be it a home, office, school, hospital, community center or any other building can be considered as a green building provided it includes the features above mentioned.

The main thing is to achieve the high quality of the building with the least possible costs and the least impact on the environment, together with the high consumption rate, and keep it as long as possible. A building must be optimized throughout its entire life cycle, starting with design, construction, operation and finally dismantling. The consumption of energy and resources should be minimized, which should reduce the burden on the environment.

"Shilda Winery" is an excellent example of green construction and architecture from Georgia. The building is located directly in the vineyard and it is almost impossible to notice it from above. The thermal mass of the soil is used to cool the building, and the largest part of the facade is directed to the north to avoid direct sunlight and reduce energy loss. The tasting center of "Shilda Winery" is located in Kvareli.



This wooden tower, whose architect is Chris Precht, is located in Toronto and is used for residential purposes. The building is built with environmentally friendly materials, and special importance is attached to wood - both in decor and in living conditions. The terraces are arranged in such a way that it is possible to arrange a green cover on the balconies, naturally, at such a time, the plants that the specialists choose are very important, and among many factors, their compatibility with the construction and sustainability of the building is especially important.

Urban and vertical gardens are starting to appear all over the world, because the United Nations predicts that 68% of the world's population will live in cities by 2050, therefore, the population concentration will increase, and the number of buildings and structures is expected to decrease at the expense of green, natural cover. That is why they are a challenge to modern architecture.

Synthesis has become - what green architecture implies should be ecological, green, comfortable, and compact at the same time.

This unusual building was built in Singapore in the last century. This building, built in 1994, can be said to be surrounded by greenery.

Then, for example, we can cite a building built on 747 square meters in Guatemala, which is built entirely with recyclable materials. The main concept of the building is based on the complete preservation of the green cover in the area and the maximum functional use of the spaces between them.

It is worth noting the building of the "Meama" coffee factory, the construction of which began in March 2017 and was completed in

September 2018. The building is distinguished by the most complex geometric constructions and folded concrete walls, which speaks of its architectural uniqueness. However, there is nothing more outstanding in Meama coffee factory than the so-called. "Green roofing", because for the first time in Georgia, the roof of the building is completely covered with ecologically clean and natural vegetation. It is also worth noting the fact that the exterior of the coffee factory echoes its interior. In three different atriums located inside the building, different varieties of trees are planted, which, when seen, completely neutralize and erase the ideas people have about standard factories. In addition, it is interesting that the coffee factory rests on 10-meter concrete columns cast in one piece, like the Palace of Kronos. Another thing that sets the coffee factory apart from all the other buildings is its architectural complexity, which can be clearly seen in the photos.

Most green buildings are no more than 4% more expensive than conventional buildings, and in the near future, the use of green technologies will become the most effective means of reducing construction costs. Green buildings are a viable solution to reduce environmental impact. Green buildings are a necessary and promising solution to the environmental challenges caused by global climate change.

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About the length of the towing rope of the curvilinear contour suspended at different marks

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Abstract: The article is about the calculation of the length of the curvilinear shaped towing rope, suspended at different marks. For this purpose, the research was held on the bridge, when its span is: L=50 m, L=100 m and L=200 m with different Sag and swing. According to the research results, lengths of the curves were compared, and the expression was modified with its second member multiplied to K-coefficient. With the modified formula parabolic curves were constructed, and the value of K-coefficient determined.

Key Words: SuspensionBridge, Sag, CableBridge, ArcBridge, ParabolicCurve

Main Part

Modern transport and civil engineering mostly uses cable-stayed systems (suspension and cable bridges, Ropeway, cable roof structures etc.) whose main Carrying construction is steel wire. In those construction wire is straight or curvilinear shaped. Its shape depends on the magnitude of tensile forces and deformation conducted in it. Tensile and deformation measurement in curvilinear shaped steel wire belong to non-linear equation and even little error in initial values May not reflect the real stress state of the structure. (Fig.1)

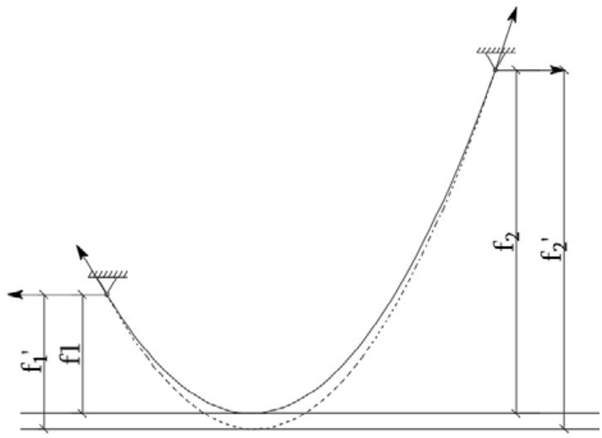


Fig.1

As known, the rope hanging freely on the same level takes the shape of square parabola, due to its own weight. Two initial parameters are required to obtain its coordinates:lengh of the span (l) and the sag (f) (Fig.2)

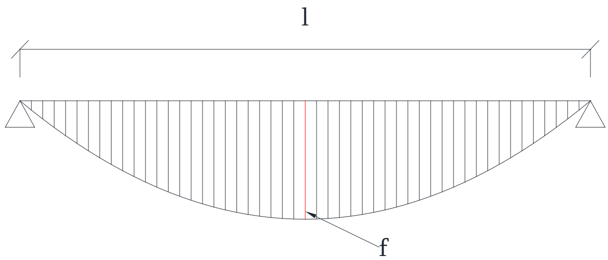


Fig. 2 Parabola shaped curve- square parabola

By given initial parameters it is possible to calculate the length of parabolic curve and the tensile and deformation forces.

The Rope hanging freely on the different magnitude also takes the curvilinear shape by its own weight (pic.2). Its ordinates can be obtained by plotting from the ordinates of the corresponding parabola of a rope freely suspended on two equal magnitude marks:

$y^* = x\tan\beta - y$ (1)

Where: β-is angle of inclination between supports, in degrees;
y-ordinate of initial parabolic curve;

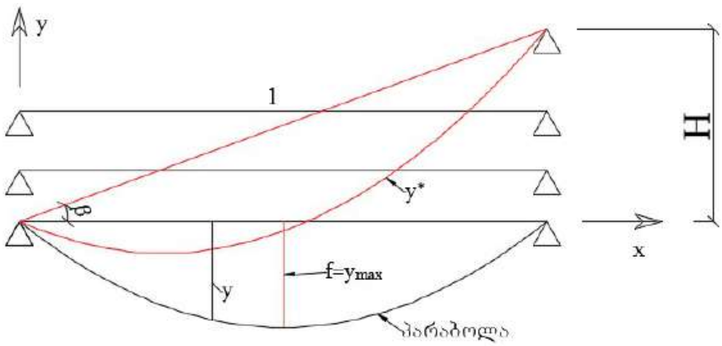


Fig.3

The comparison of the lengths of curves shows that, (Fig.3) the length of the curve obtained by above given expression is longer than initial length of curve (ropes on the same magnitude). This situation changes characteristics of the steel wire and gives Results different from reality. The research was held on the paraboli with the span: 50, 100 and 200 meters, with different Sag and swing.

Below is a table of corresponding curve lengths of ropes suspended at different points when L=50, L=100 and L=200

Length of the curves							
Swing, degrees	0°	10°	20°	30°	40°	50°	60°
Sag F, meter							
10	54.91	55.51	57.46				
20	66.68	67.09	68.43	71.07	75.87		
30	81.75	82.05	83.03	84.95	88.5	95.29	
40	98.51	98.72	99.47	100.97	103.74	109.04	
50	116.16	116.34	116.95	118.17	120.04	124.04	134.3

Table.1 Lengths of a curve with a 50-meter span

Length of the curves							
Swing, degrees	0°	10°	20°	30°	40°	50°	60°
Sag F, meter							
10	102.6	104.04					
20	109.82	111.03	114.93				
30	120.43	121.43	124.65	130.95			
40	133.36	134.19	136.87	142.14	151.75		
50	147.89	148.58	150.85	155.32	163.50		

Table.2 Lengths of a curve with a 100-meter span

Length of the curves							
Swing, degrees	0°	10°	20°	30°	40°	50°	60°
Sag F, meter							
10	201.32						
20	205.2	208.07					
30	211.41	214.07					
40	219.64	222.06	229.85				
50	229.55	231.74	238.84				

Table.3 Lengths of a curve with a 200-meter span

Shown on the tables 1-3, the lenghts of the curves are far from its initial length and Varies between 1.22-14.21 %.

The task is to develop a method of reducing the length of the curve, suspended at different points, to the length of the initial curve.

The solution of the provided problem is provided by modifying of the formula (1), multiplying its second member by the coefficient K (k < 1.0). The modified formula will look like:

$$y^{*} = x \tan\beta - \mathrm{k}y \qquad (2)$$

The research was performed using the modified formula, considering different magnitudes of the tilt angle on the initial parabolic curve with different initial parameters and the curve obtained by modifying it.

To solve this problem, the computer program "Autocad" was used, which gives opportunity, after construction corresponding ordinates of the span, we can easily get the length of parabolic curve. To minimize the error, the ordinates were calculated with 1-meter increments.

The research was performed on the lengths of the curves with the span of 50, 100 and 200 meters, with different sag and swing.

The K-coefficient was calculated using the gradual approximation method. Coefficient is different for all parameters of the curve, depending on the length of the mallet, the height of the hook arrow and the swing.

The tables below show the lengths of the curves obtained by the modified formula depending on the variation of the length of the span, the angle of inclination and the magnitude of the Sag.

Length of the curves							
Swing, degrees	0°	10°	20°	30°	40°	50°	60°
Sag F, meter							
10	54.91	54.91 K=0.93	54.93 K=0.63				
20	66.68	66.68 K=0.985	66.67 K=0.932	66.68 K=0.809	66.69 K=0.38		
30	81.75	81.76 K=0.994	81.76 K=0.973	81.77 K=0.929	81.77 K=0.836	81.75 K=0.515	
40	98.51	98.51 K=0.997	98.52 K=0.986	98.51 K=0.963	98.67 K=0.918	98.88 K=0.817	
50	116.16	116.16 K=0.998	116.15 K=0.991	116.42 K=0.977	116.16 K=0.95	116.15 K=0.889	116.16 k=0.729

Table.4 The lengths of the modified curves of the 50-meter span

Length of the curves							
Swing, degrees	0°	10°	20°	30°	40°	50°	60°
Sag F, meter							
10	102.6	102.61 K=0.65					
20	109.82	109.82 K=0.93	109.82 K=0.625				
30	120.43	120.41 K=0.971	120.42 K=0.867	120.41 K=0.56			
40	133.36	133.37 K=0.985	133.35 K=0.94	133.36 K=0.82	133.35 K=0.36		
50	147.89	147.89 K=0.99	147.88 K=0.955	147.88 K=0.88	147.89 K=0.725		

Table.5 The lengths of the modified curves of the 100-meter span

Length of the curves							
Swing, degrees	0	10	20	30	40	50	60
Sag F, meter							
10	201.32						
20	205.2	205.21 K=0.65					
30	211.41	211.42 K=0.867					
40	219.64	219.63 K=0.92	219.64 K=0.628				
50	229.55	229.52 K=0.957	229.53 K=0.71				

Table.6 The lengths of the modified curves of the 200-meter span

The Results was satisfying. The modified formula allows to obtain a parabolic curve of initial length, in some cases inaccuracy is one hundredth of a percent, Therefore in engineering calculations, we can ignore the difference.

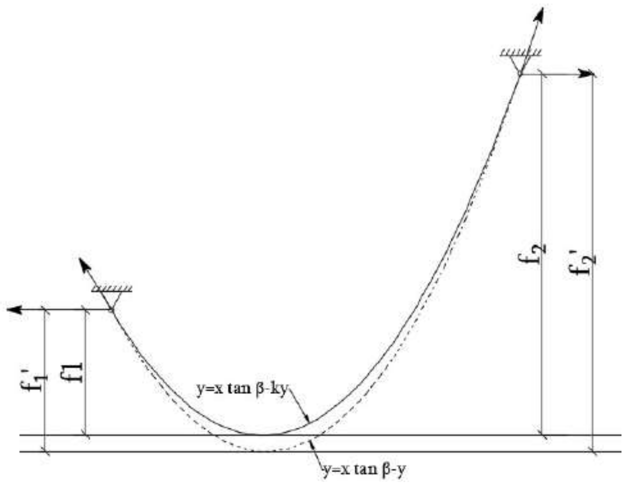
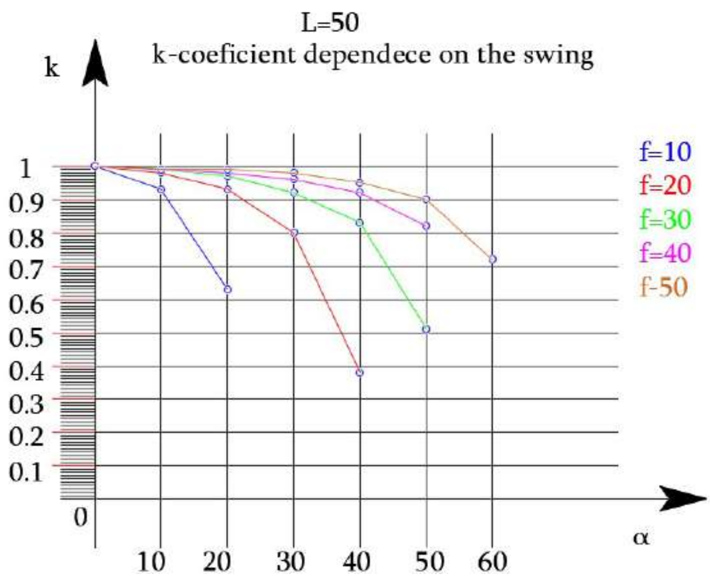
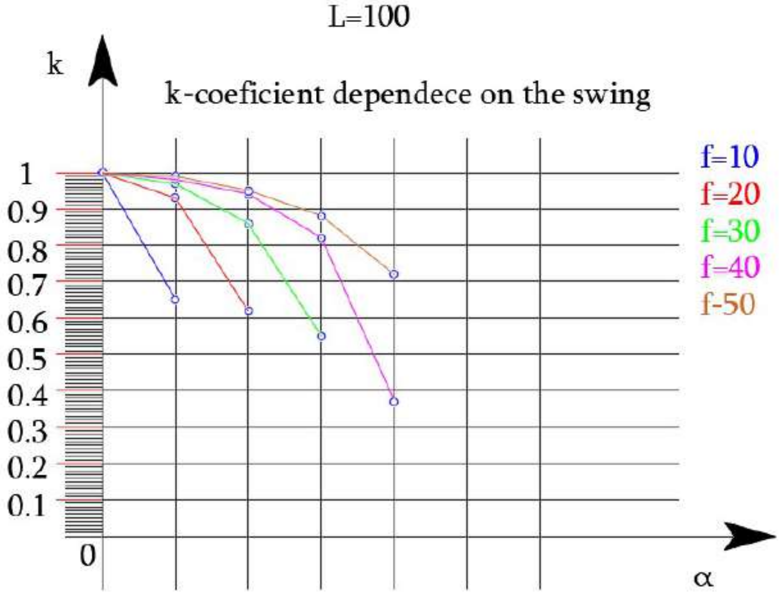


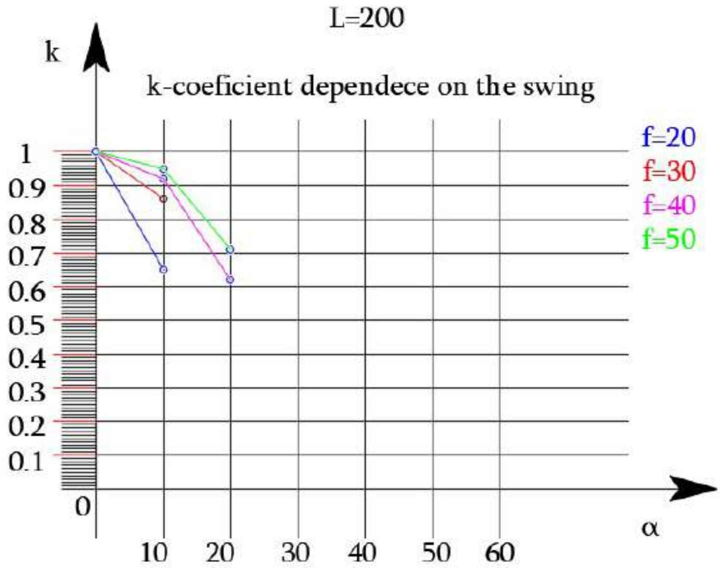
Fig.4 difference between length, calculated with the initial and modified expressions

According to the results, The graph, K-coefficient dependence on the swing, depending on the span, was drawn.

For the bridge span of 50 meters K-coefficient varies between 0.37 and 1, for 100 meters of span between 0.36-1 and for 200 meters of span between- 0.6-1.




L=100
k
k-coeficient dependece on the swing
f=10
f=20
f=30
f=40
f-50
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
α


L=200
k
k-coeficient dependece on the swing
f=20
f=30
f=40
f=50
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
α
10
20
30
40
50
60

1. In the case of the examined curves, the K-coefficient considered for each curve is individual and changes in different intervals between 0.38-1 depending on the length of the span and the Sag.
2. Initial length of the curve can be obtained using modified formula
3. According to the K-coefficient change graphs, it is possible to determine the value of the K-coefficient for another desired curve within the parameters of the curve used in the study (span length, Sag, tilt angle).

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Characterization of the Georgian Reservoir Fund

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Abstract: According to the analysis of the research, it is determined that the reservoir systems of Georgia should be considered simultaneously: as a unique product - water storage. An object that significantly changes the initial properties of water, a source of energy and a water accumulator for hydroelectric power plants, an aquaria used for fishing water transport, a loser of territory (flooding, silting, reclamation of banks), an object that makes significant changes in a nature and river valleys, lakes and in confluent areas.

Key Words: water storage, aquaria, water transport, confluent areas

Of the many types of human activity, scalability and importance, only two directions are distinguished: multi-purpose assimilation of new territories and the transformation of river systems using hydrotechnical structures. These processes are carried out extensively on all continents for the purpose of reclamation, hydropower, sailing, water supply, etc. It is already recognized that such structures are the leverage by which the hydrosphere is transformed in the appropriate direction of modern problems. Among the mentioned buildings, the most widely used reservoir, i.e. one hydrotechnical structure that can be distributed in time and space.

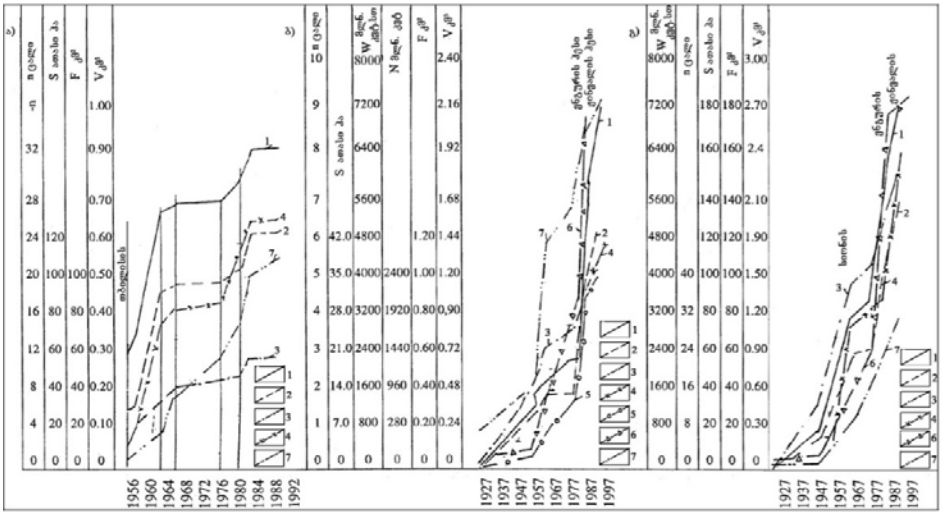
The watershed is created and operated by man's hands, although it is still a component element of nature, is part of it and is governed by the laws of nature. An individual feature of the reservoir is the high dynamics of development. This is the result of being artificially managed and its adjustment type, location, morphometry and other characteristics are determined in the design process. In turn, the reservoir also affects the environment, and this process is a function of its characteristics, more specifically, on its morphometry, vertical and latitudeal mtgomarreness. From the initial period of the creation of reservoirs, the formation of hydrological, hydrophysical-hydrochemical and biological systems in them begins. In 1862, the first reservoir – Jandar was created in Georgia, and its new networks were merged only in 1957. The modern stage of the creation of reservoirs in Georgia began after the end of World War II (1945).

Jandar Reservoir

The beginning of intensive construction of large reservoir complex hydrosystems is marked by the commissioning of Tbilisi (1952), Shaori (1954), Tkibuli (1956), Gumati (1958) and a number of other reservoirs, among which such large reservoirs as Sioni (1964), Khrami (1966), Jvari (Enguri) (1976), Zhinvali (1985) and others should be noted.

Development dynamics of the Georgian Reservoir Fund:

a) irrigation b) Energy c) General Fund



On the territory of Georgia (F = 69.7 ვ∂^{2}) there are 26060 rivers. For hydropower purposes, up to 320 rivers can be used, they have a significant drop in height. The potential capacity of Georgian rivers is 18.2 million. kW. Which corresponds to 60 billion. Sq hour per year. 75% of the territory of Georgia is in the mountain and foothill zone, it is distinguished by the diversity of natural landscape and climatic zones and complex terrain, which leads to the rational of water supply. Use, distribution and layout of reservoir systems.

At present, a total of 32 reservoirs (in volume 1 million) operate on the territory of Georgia. ∂^{3}more than that). Among them – 24 reservoirs in eastern Georgia, and 8 reservoirs in western Georgia (Table 1.); Total in the lowland zone (∔ < 400,0 m) _ 7, in the foothill zone (∔< 400,0800 m) _ 14, in the mountainous zone (∔ < 800,01200 m) _ 5, and in the mountainous zone (∔ > 1200 ÷ m) _÷ reservoir.

Table 1

Classification of reservoirs of Eastern Georgia according to depth					
N^{o}	Name of the reservoir	Depth, H, m		Morphometric index H/F· 10^{-3}	Volume increase at a depth of 1 m $V_{complete}$/H, million m^3
		H_{max}	H_{min}		
Deep (H=100, 40 m					
1	Jinwal	98,0	50,0	0,22	5,30
2	Algeti	72,5	28,2	0,35	0,89
3	Sioni	68,6	31,4	0,086	4,73
4	Zonkari	62,0	29,0	0,60	0,64
5	Tbilisi	45,0	26,2	0,12	6,84
6	Narekvavi	40,3	18,8	0,60	0,16
medium depth (H = 100÷40 m)					
7	Xrami	25,0	9,3	0,0057	12,48
8	Teletwyali	25,0	12,0	1,030	0,06
9	Zahesi	23,0	14,0	0,007	0,52
10	Tavwyaro	22,4	6,5	0,165	0,04

11	Lapiani	20,0	12,0	0,048	0,17
shallow (H=20÷10 m)					
12	Kushisxevi	18,0	7,0	0,075	0,22
13	Pantiani	15,0	10,0	0,16	0,36
14	Kranchisxevi	14,0	8,0	0,24	0,09
15	Dmanisi	11,5	5,6	0,016	0,95
16	Nadarbazevi	11,0	7,0	0,025	0,74
17	Cxenisis-wa	10,5	5,9	0,12	0,14
18	Walis	10,0	6,0	0,10	0,17
Shallow depth (H < 10 m)					
19	Marabda	8,0	4,0	0,070	0,15
20	Mtisz"iri	7,2	3,7	0,017	0,46
21	Jandara	7,0	4,6	0,0017	7,42
22	Oqtomberi	8,5	4,2	0,077	0,21
23	Kumisi	4,7	2,0	0,0007	2,34
24	Zresi	3,8	1,8	0,0006	0,54

Classification of reservoirs of Western Georgia according to depth

№	Name of the reservoir	Depth, H, m		Morphometric index H/F· 10^{-3}	Volume increase at a depth of 1 m $V_{complete}$/H, million m^3
		H_{max}	H_{min}		

1	3	4	5	6	7
Very deep (H > 100÷40 m)					
1	Jvari	230,0	115,0	0,98	4,74
deep (H = 100÷40 m)					
2	Lajanuri	67,8	36,0	0,93	0,35
3	Gali	52,0	26,0	0,086	2,78
Medium depth (H = 100÷40 m)					
4	Tyibuli	32,0	16,0	0,0042	5,25
5	Gumati	30,0	17,0	0,12	1,30
6	Kuxi	19,4	6,3	0,13	0,10
7	Shaori	12,3	6,8	0,035	5,77
Shallow depth (H < 10 m)					
8	Varcxisi	8,0	4,0	0,03	1,83

The relevance of building reservoirs in Georgia in the mountain and foothills regions, as well as in Switzerland, is due to: significant water resources and high energy potential; With higher rates of efficiency of their use, low negative impact on their environment, enrichment of natural landscapes, increase in recreation and number of tourists, increase in the productivity of irrigated lands.

Based on the analysis of the studies, it is established that for the regulation of river water, the reduction of environmental impact and the flooding of lands, which is due to the significant volume and depth of mountain reservoirs – the most effective are mountain and foothill reservoirs. In Georgia, it is possible to build a number of mountain and foothill reservoirs in the near future.

The cessation of the construction of reservoirs in Georgia, which was caused by individual groups of trending negative populations (in the middle of the last century) led to Georgia's economic and ecological breakthroughs. Fortunately, it is currently starting to build a number of reservoirs – e.g. Nenskra ($V_{სრ}$=176.0 million $მ^3$) and others.

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Composite Materials in Construction

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Abstract: Following article introduces the development process of composite materials, compatibility of their use in construction as structural elements, gives perspectives of potential development, describes common types of reinforcement and specifics their place in the construction process. In the research, basalt fiber reinforced composite materials are featured with the development process of modern structural components. Research is based on Georgian made basalt composite materials, presenting their perspectives in modern civil engineering.

Key Words: Fiber-Reinforced Polymer, FRP, Basalt Fiber-Reinforced Polymer, BFRP, Composite Materials, Polymers, Reinforcements, Concrete, CFRP, GFRP, AFRP.

Introduction

From the ancient times, builders, artisans, engineers and manufacturers started to develop composites of a wider array of materials for more sophisticated applications.

About 1200 AD, Mongols invented the first composite bows made from a combination of wood, bamboo, bone, cattle tendons, horns, bamboo and silk bonded with natural pine resin. These small, powerful, extremely accurate bows were the most feared.

From the 1870's through the 1890's, a chemical revolution changed composite development. New synthetic resins were 2 transformed from a liquid to solid state in a cross-linked molecular structure using a process known as polymerization. Early synthetic resins included celluloid, melamine and Bakelite. weapons on earth until the 14th century invention of effective firearms.

In the early 1900's, chemical advances drove the development of plastics. Materials such as vinyl, polystyrene, phenolic and polyester were created and reinforcement was needed to provide strength and rigidity.

Recognized as the most important decade in the composites industry, the 1930s saw the development of resins still used today. In 1935, Owens Corning introduced the first glass fiber and launched the fiber reinforced polymer (FRP) industry. In 1936, unsaturated polyester resins were patented. Because of their curing properties, unsaturated polyester resins are the dominant choice for resins in manufacturing today. In 1938, other higher performance resin systems like epoxies also became available. By 1947, a fully composite body automobile was prototyped and tested, leading to the development of the 1953 Corvette. Fiberglass preforms impregnated with resin and molded in matched metal dies were used to build this classic car. The advent of the automobile age gave rise to several new methods for molding.

Two methods, compression molding of sheet molding compound (SMC) and bulk molding compound (BMC), emerged as the dominant forms of molding for the automotive and other industries. In 1961, the first carbon fiber was patented and several years later, became commercially available. Carbon fibers improved thermoset part stiffness to weight ratios, for use in even more applications such as aerospace, automotive, sporting goods, and consumer goods.

In the 1960's, the marine market was the largest consumer of composite materials. Over the next twenty years, the composite materials market advanced. New ultra-high molecular weight polyethylene joined other advanced fibers used in breakthroughs in aerospace components, structural and personal armor, sporting equipment, medical devices and other applications.

By the mid 1990's, composite materials became more common in mainstream manufacturing and construction. As a cost-effective replacement to traditional materials like metal and engineered thermoplastics, thermoset composites were common components within the appliance, construction, electrical and transportation industries.

Today, composites research attracts grants from governments, manufacturers and universities. These investments allow innovation to accelerate. Specialized companies, such as aerospace composite companies, will find a place in the industry. Two applications that continue to experience innovative growth are airplane composite materials and composite sheets for marine use.

Other materials such as environmentally-friendly resins incorporating recycled plastics and bio-based polymers meet the demand for stronger, lighter and environmentally friendly products. Looking ahead, still to be developed fibers and resins will create even more applications for everyday and specialized use.

General Terms for Modern Composite Materials

Composites are materials consisting of two or more chemically distinct constituents on a macro-scale, having a distinct interface separating them, and with properties which cannot be obtained by any constituent working individually [1]. There are two categories of constituent materials: matrix and reinforcement. The reinforcement imparts its special mechanical and physical properties to enhance the matrix properties. Due to the wide variety of matrix and reinforcement materials available, the design potentials are incredible.

Composites are simply a combination of two or more constituent materials with different physical or chemical properties. When combined, they produce a material with characteristics different from their original properties. The two main components within a composite are the matrix and fiber. The matrix is the base material while the fiber is what reinforces the material. On top of the fiber reinforcements and matrix, composites can also include core materials, fillers, additives and surface finishes to provide unique performance attributes.

Fiber-Reinforced Polymer – FRP is a composite made from a polymer matrix that is reinforced with an engineered, man-made or natural fiber. This combination of plastic and reinforcement fiber can produce some of the strongest, most versatile materials (for their weight) ever developed by technology (see Fig.1).

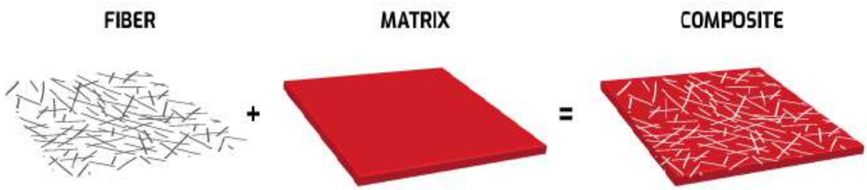

Fig. 1. Fiber-Reinforced Polymer Composite (FRP)

The fiber in a FRP composite includes materials like glass, carbon, aramid, basalt or natural fibers. These fibers reinforce the material and provide strength and stiffness to the composite. The matrix includes materials like polyester, epoxy, vinyl ester and polyurethane which acts as a glue to hold the fibers together and protects the fibers from damage. Due to its strong yet flexible properties, FRP can replace materials like wood, aluminum, granite and even steel. The true term for a fiber reinforced polymer matrix composite is FRP. However, modifiers have been used to identify a specific fiber within that composite.

Depending on the type of fiber, FRP name modifications can include Glass (GFRP), Carbon Fiber (CFRP) and Aramid (AFRP).

The matrix is a material component of the composite which in this case is a Resin material. Resins, used in FRP composites, are either thermoset or thermoplastic. Thermoset resins are used to make most composites. They're converted from a liquid to a solid through a process called polymerization, or cross-linking. When used to produce finished goods, thermosetting resins are "cured" by the use of a catalyst, heat or a combination of the two. Once cured, solid thermoset resins cannot be converted back to their original liquid form. Common thermosets are polyester, vinyl ester, epoxy, and polyurethane. Thermoplastic resins, on the other hand, are not cross-linked and, so, can be melted, formed, re-melted and re-formed [2]. Thermoplastic resins are characterized by materials such as ABS, polyethylene, polystyrene, and polycarbonate.

Additives - there are many different additives that are used to modify and enhance resin properties that become a part of the matrix. These additives include: Thixotropes, pigments & colorants, fire retardants, suppressants, UV inhibitors & Stabilizers, conductive additives, and release agents.

Closed Molding - raw materials (fibers and resins) cure inside a two-sided mold or within a vacuum bag. Typically, automated and require special equipment, so they're mainly used in large plants that produce huge volumes of material.

Composite - a material made from two or more different materials that, when combined, are stronger than those individual materials by themselves.

Core - Core material is sandwiched between fiber reinforced laminate skins to significantly increase stiffness and flexural strength while reducing warpage of flat surfaces. Core materials include Balsa, Cross-linked PVC Foam, Thermoplastic Foam, Polyurethane Foam, Syntactic foam, linear PVC Foam, honeycomb, PMI foam, fiber reinforced core and core fabrics (laminate bulkers).

DCPD RIM - a process for quickly, efficiently creating large parts using dicyclopentadiene resin and reaction injection molding. It utilizes a closed mold and a low-moisture, low-oxygen environment.

Dicyclopentadiene (DCPD) - DCPD resin is characterized by its low viscosity and its resistance to heat, impact, and corrosive chemicals when compared to thermoplastic resins used in standard injection molding. This allows the resulting product to be large, strong, and lightweight.

Fiber - a component of a composite that reinforces the material. Provides strength and stiffness. Made of glass, carbon, aramid, basalt or natural fibers.

Fiber-Reinforced Polymer composite (FRP) - a composite made from a polymer matrix that is reinforced with an engineered, man-made or natural fiber or other reinforcing material.

Fillers - least expensive of major ingredients of a composite and help reduce the cost of composites. Can improve mechanical properties including fire and smoke performance by reducing organic content in composite laminates. Fillers include Calcium carbonate, Kaolin, Alumina trihydrate, and calcium sulfate.

Long Fiber Injection - a process in which polyurethane resin and chopped fiberglass are sprayed into an open mold. Low compression pressure is then used to create complex parts in a variety of sizes allowing for formed geometry on both sides of the parts [3].

Matrix - a component of a composite. protects and transfers load between fibers.

Open Molding - raw materials (resins and fiber reinforcements) are exposed to air as they cure or harden. Open molding utilizes different processes, including hand lay-up, spray-up, casting, and filament winding.

Reinforcements - the material of fibers that help reinforce the composite. Available in reinforcement fibers and reinforcement forms.

Reinforcement Fibers - the different types of fibers that help reinforce the composite. Include Glass, Carbon, aramid (polyaramids), or new fibers.

Reinforcement Forms - forms serve a wide range of processes and end-product requirements. Materials supplied as reinforcement include roving, milled fiber, chopped strands, continuous, chopped or thermoformable mat.

Reinforced Reaction Injection Molding - a process in which two or more reactive resins are metered and impingement-mixed under high pressure to form a thermosetting polymer, injected into a mold, and then cured. A popular process with a number of advantages including faster cycle times, low labor, low mold clamping pressure and low scrap rate.

Resins - the material of a matrix. Acts as a glue to hold the fibers together and protect fibers from damage. Includes polyester, epoxy, vinyl ester, polyurethane or other.

Surface finishes - used mostly for UV protection, corrosion resistance and aesthetics. Can be molded in process or secondarily applied coatings. Examples include gel coat, surface veils, adhesives, ultraviolet protection, and both In-mold and post-mold painting.

FRP Materials in Structural Engineering

FRP materials in structural engineering are treated as additional reinforcement, the only difference is the initial strains that are present in the concrete and reinforcement, due to the dead load at the time of applying the FRP.

Due to their high tensile strength and low weight (compared to the conventional materials, and in particular steel), FRPs have become an important structural material for use in the construction industry as internal or more frequently external reinforcement. Other significant advantages of FRPs over steel are the ease of handling and application, the lack of requirement for heavy lifting, the minimal labor required for their installation, as well as their high resistance against corrosion, and their low thermal conductivity. Moreover, due to their exceptional formability, FRP systems provide flexibility to the practitioners and can be applied on any flat, curved or geometrically irregular surface [4].

The use of FRP materials in civil engineering has increased steadily after their first appearance, four decades ago. Although FRP systems have significant potential for various civil engineering applications even in new construction, they are mostly employed in the retrofit and rehabilitation of existing reinforced concrete structures of various types, such as buildings, bridges, marine structures and tunnels. The role of FRPs in strengthening is growing at an extremely rapid pace, owing mainly to the ease and speed of construction, and their application without significant disturbance to the functionality of the building. As a result, externally bonded FRP reinforcement has become nowadays one of the most important and most frequently used methods for enhancing the strength, energy dissipation, and stiffness characteristics of poorly detailed members.

The initial developments of the FRP-strengthening techniques took place in Germany and Switzerland, where mainly the flexural strengthening of reinforced concrete members with externally epoxy-bonded FRP laminates has been thoroughly studied. Gradually, it was recognized worldwide that FRP materials can be used in a series of ways for upgrading existing members. In particular, the invention of FRP sheets (wraps) led to a series of applications that provide flexural, axial, and shear strength enhancement, especially under seismic loads, but also increased deformation capacity, confinement and ductility. Gradually wrapping with FRP sheets has become one of the preferred methods in seismic retrofitting projects.

FRP materials in retrofit (sheets/wraps, laminates, and less often strings and bars) are mainly used as a replacement for steel reinforcement, both longitudinal and transverse, in lightly reinforced members (which are very common in older construction), so as to increase their flexural and/or shear capacity.

The fibers are the main load carrying element of the composite [5]. The combination with the epoxy matrix results in a high-strength material with linear elastic behavior until failure without a yielding plateau. The complete description of the load bearing curve of the composite is provided by the modulus of elasticity and the tensile strength of the composite fibers plus matrix material (or alternatively the maximum tensile strain). The material of the fibers usually has a tensile strength much higher than steel and is employed to mainly undertake tension, while the resins are employed to transfer and distribute these tensile stresses from the fibers to the existing member. The interface between the FRP composite and the existing member significantly affects the performance of the method, and the loss of bond between them is one of the most common failure modes. It should be noted that the strengthening of structural members with FRPs, while considerably increasing their strength, does not change their stiffness, and has no effect on the stiffness distribution of the entire structure.

The properties of the composite materials are mainly determined by the mechanical properties of the fibers.

The FRP systems are divided into carbon (CFRP), glass (GFRP), aramid (AFRP), and basalt (BFRP) systems.

Carbon Fiber Reinforced Polymers (CFRP) - Carbon fiber reinforced polymers have the best mechanical properties amongst other FRP composites, and have the more favorable price to properties ratio. The carbon fibers have high strength and higher modulus of elasticity with respect to the other fiber materials, which make it more appropriate for the shear strengthening of RC members. As a result, they are the most widely used FRP systems, and all the main FRP providers offer a large variety of carbon-based sheets and laminates, in terms of size and weight.

Glass Fiber Reinforced Polymers (GFRP) - Glass fibers have relatively lower cost with respect to the other types of FRPs, and they are the second (after carbon) most commonly used material in the construction industry. They come in three different types: First type E, which is the most common type. It has relatively low strength and modulus of elasticity, and its main drawbacks are that it has low humidity and alkaline resistance, Second type AR with increased alkaline resistance, but low strength and elasticity, and Third type S with high strength and elasticity modulus. Glass is more suitable for increasing the confinement of RC members, and it can also be used for flexural enhancement. Because of its low modulus, glass is seldom used for the shear capacity increase. The GFRP rebars are the most popular among other FRP rebar types, due to the combination of relatively low cost with environmental resistance.

Aramid Fiber Reinforced Polymers (AFRP) - These fibers have high static and impact strengths, which is why they are often used for the wrapping of bridge piers, where there is high danger of car crashes. Nevertheless, their use is limited by reduced long-term strength (stress rupture) as well as high sensitivity to UV radiation. Another drawback of aramid fibers is that they are difficult to cut and process.

Basalt Fiber Reinforced Polymers (BFRP) - Such fibers have excellent resistance to high temperatures, possess high tensile strength, as well as good durability. Other advantages are high resistance to acids, superior electro-magnetic properties, resistance to corrosion, resistance to radiation and UV light and good resistance to vibration. All the same, basalt FRPs are seldom used in practical applications. In terms of mechanical properties and production complexity, basalt (BFRP) and aramid (AFRP) bars are somewhere in the middle, but they are seldom used in practice.

Conclusion for Basalt Fiber-Reinforced Polymers (BFRPs)

A basalt FRP bar is a composite material consisting of rigid polymer resin bounding unidirectional basalt fibers. Basalt fibers are produced by melting queried and crushed natural volcanic basalt rocks at a temperature of nearly 1400 °C [6]. The molten rock is extruded through small nozzles to produce continuous filaments of basalt fibers ranging in diameter from 13 to 20 μm. A critical process in the manufacturing of fibers, in general, is known as fiber sizing. Sizing involves the application of a thin layer of mainly organic material known as the size to the surface of the fiber. Most importantly, the short-term and long-term performance of FRP bars is critically influenced by the optimization of the fiber sizing as well as the fiber–matrix interface [7]. The fiber sizing film consists of a film former and a coupling agent. The film protects, lubricates, and holds the fibers together while ensuring their separation when the fibers come in contact with the resin. The coupling agent, typically an alkoxysilane compound, serves to bond the fibers to the matrix resin [8]. However, the composition and process of applying the fiber size layer vary significantly amongst manufacturers, resulting in variations in properties of FRP bars made of the same type of fiber and sometimes the same resin type.

The resulting composite material, consisting of polymeric resin and fibers, offers numerous favorable properties, including, but not limited to, high tensile strength, with applications in building new structures, such as FRP reinforcing bars, or retrofitting/strengthening deficient existing structures using FRP sheets and/or strips [9].

BFRP bars are commonly manufactured through the pultrusion process, which involves pulling the continuous fibers through a die that is circular in cross-section and contains resin. The FRP bars are formed once the resin cures (thermosets) in the die. The amount of basalt fiber in BFRP bars is not standardized, but the fiber content most frequently reported in the literature falls in the range 75% to 90% [10][11]. Automated wet-layup is another method to manufacture BFRP bars that reportedly offers the same degree of variation in mechanical properties as the pultrusion process [12]. As the resin has much lower strength compared to the fibers, the tensile strength and stiffness of BFRP bars varies depending on the overall volume of fibers to volume of FRP. Vinyl ester and isophthalic polyester are common types of resin matrix used to manufacture BFRP. FRP bars are more sensitive to fire than steel bars. However, because the FRP bars are embedded in concrete, they do not contribute to fire severity nor toxicity. Nonetheless, FRP-reinforced concrete elements have lower resistance to fire compared to steel-reinforced concrete elements [13]. More importantly, at temperatures close to the glass transition temperature of the polymer, Tg, mechanical properties of the polymer deteriorate, and its ability to transfer stresses between the fiber and the surrounding concrete decreases [14]. The structural implication is the degrading of the bond strength between FRP bars and concrete. Glass transition temperatures for most resins used to manufacture FRP reinforced bars range from 93 °C to 120 °C.

BFRP bars may be 2.3 times stronger or more, in terms of ultimate strength (fu), than traditional steel reinforcing. However, the modulus of elasticity of traditional steel may be 3.5 times or greater than BFRP. BFRP elastic moduli varying from 44.5 to 71 MPa were reported in the literature [11][15][16], depending on resin type, manufacturer, and sometimes bar diameter. Unlike traditional carbon steel, FRP bars do not exhibit yielding, as shown in Figure 1. Tensile strength reported in the literature varied from 1100 to 1565 [11][15][16]. These wide ranges of values for the tensile strength and modulus of elasticity were reported for BFRP produced by different manufacturers, which not only reflect variation in the properties of resin but also manufacturing. Nonetheless, variability in moduli and strength were reported in BFRP bars produced by the same manufacturer, although with less dispersion. In comparison, due the homogeneity of steel, the modulus of elasticity of and tensile strength can largely be assumed to be constant for all practical purposes.

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By the Residents of the Pilot Village Ledzadzame of Senaki Municipality Results of Chemical Research of Well Waters Used for Drinking (January 2024)

Giorgi Jojua (Bachelor program student), Supervisor: Associate Professor Shorena Kupreishvili, Georgian Technical University

Abstract:In the article, in order to monitor the chemical composition of water in January 2024, 6 water samples were taken from the household plots of the pilot village of Ledzadzame, Senaki municipality. Laboratory studies were carried out in the laboratory of the Institute of Water Management named after Tsotne Mirtskhulava of the Technical University of Georgia. During the conducted research, it was found that the well water is significantly polluted from a chemical point of view, and a case of iron pollution was also recorded. The research results were compared with the drinking water regulations.

Key words: chemical composition, iron pollution, sanitary-hygienic, water pipes

Water resources are an essential part of our natural environment. Together with other main factors, they form natural complexes and determine the ecological and social development of this or that region. Supplying the country's population with quality drinking water remains an unsolved problem. To date, the sanitary-hygienic and technical condition of, individual wells, natural springs, and small-capacity rural type water pipes is unsatisfactory, drinking water is not chlorinated, or this process is broken. Added to the above is the intensive pollution of water supply sources, especially surface ones, by many factors, due to which most of the rural population cannot get drinking water of standard quality [1, 2].

Recently, against the background of the intensive development of agriculture in Georgia, the problem of ground water pollution has become urgent, because the population is using fertilizers and poisonous chemicals uncontrollably on agricultural fields. The most dangerous pollutants of the biosphere are nitrogenous fertilizers: sodium fertilizer, potassium fertilizer, ammonium fertilizer, urea, ammonium sulfate. Nitrate forms of the above-mentioned fertilizers, which are characterized by high solubility and mobility, therefore easily get into groundwater are especially polluting the environment [3,4].

Based on the above, there is intense pollution of groundwater with various substances (nitrite, nitrate, pesticides), which is the cause of the occurrence and spread of many acute diseases (kidney failure, cardiovascular diseases, diseases of the respiratory organs and urinary systems, etc.) [5].

Water from the well-used for drinking is also polluted by the population from the stalls of goods set up in the vicinity of the well, uninsulated latrines and sewage systems.

The mentioned problem is particularly acute for the rural population of the Kolkheti plain, because so far, due to the lack of water supply systems, often the only source of drinking water is well water, which is mainly cut in layers 2-30 meters deep, and their quality is permanently checked - hydromonitoring (permanent regime observation of the ground (on the amount and formation of water resources. Also, the degree and extent of pollution is unknown) is not carried out due to lack of funds, therefore, it is not determined what measures (management mechanisms) need to be implemented in order to completely prevent or substantially limit the polluting factors of well waters, which is why the mentioned At present, the well water used for drinking by the rural population in the region is unsafe.

In the pilot village of Senaki Municipality, Ledzadzame, in the first stage, we will monitor the sources of pollution in the months of January, March, May, July, September, December, and in the second stage, we will develop mechanisms for effective management of well water quality.

In order to determine the chemical composition of water, in January 2024, a water sample was taken at a different location - one water sample from the territory of the public school in the village of Ledzadzame, Senaki municipality, which is ground water and is used by students for drinking.

Photo 1, 2, 3, 4. Taking water samples from the well.

Also water samples of 5 wells (Tamaz Jojua, Kakha Dzadzamia, Romani Jojua. Mamuka Abshilava I, II homesteads) rural water products to determine chemical pollution characteristics of hot well water for drinking. The chemical analysis of drinking water was carried out at the

Tsotne Mirtskhulava Water Management Institute of the Technical University of Georgia by means of a mobile chemical laboratory (CEL).

Photo 5,6,7,8. Laboratory studies at the Institute of Aquaculture named after Tsotne Mirtskhulava of the Technical University of Georgia

Table 1.

Results of chemical analysis of the well water used for drinking by the inhabitants of the pilot village Ledzadzam of Senaki Municipality.

sampling place	depth (m)	**PH**	nitrite mg/l	Nitrate mg/l	phosphate mg/l	iron mg/l
Sample #1. (Water of the public school of Ledzadzame Village, Senaki Municipality)	5	7.2	0,022	0.54	3.89	0.072
Sample #2. (Tamaz Jojua homestead well water)	7	6.89	0.15	1.22	4.2	0.065
Sample #3. (water from the well of the homestead plot of Kakha Dzadzamia)	6	6.9	0.1	3.66	5.1	0.012
Sample #4. (water from the well of Roman Jojua's homestead)	7	7.05	0.013	1.22	5.01	0.062
Sample #5 (Mamuka Abshilava homestead well water 1.)	7	7.01	0.029	4.55	3.1	0.012

Sample #6 (Water of Mamuka Abshilava's homestead well 2.)	7	7.05	0.11	2.22	2.89	0.23

(January 2024)

According to the research results, according to our analytical analysis, the content of nitrite from mg/l - 0.15 mg/l, nitrate - from 0.54 to 6.5 mg/l, the total amount of phosphates - 1.018-5, Up to 1 mg/l, the results are compared with the technical registration of drinking water of Georgia, according to which the phosphate content in some cases exceeds the permissible concentration limit. In the course of the field work, several colored waters were observed, due to which iron was also determined in the waters of the selected wells. According to the results, the iron content exceeds the maximum allowable concentration. Because all well water equipment for drinking, results and processing, also use bottled drinking water temperature storage according to the sanitary-hygienic equipment used, according to which the nitrite content should not exceed 0.005 mg/l. Of the 5 test wells we selected, the nitrite content in 5 is greater than 0.005mg/L. The above creative indicators can be used to confirm that drinkers need a permanent system to confirm the suitability of their drinks. Also, preparation of the necessary design for neutralization of the centers of pollution, then plants for the pollution of well waters.

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Solar Power Station in Enguri Reservoir

Giorgi Kapanadze (PhD program student), Supervisor: Professor Aleksandre Bagration-Davitashvili

Abstract: Building a solar power plant in the Enguri Reservoir isn't a big deal from an engineering standpoint. But, making sure it runs safely is crucial because of possible accidents. The Enguri river valley is narrow, so it's not as big of a worry as in other places globally. Unlike the Hapcheon Dam, we've got more space here, even if there's not much water. The reservoir covers 925 km², holding 790 million m³ of water. We think it's better to have fewer panels and build a thin concrete storage for them. We can pull them out of the water easily with a rope and store them for as long as we need.

Keywords: Enguri DAM, Khudoni DAM, Solar panels, Hydraulic model

Construction and Hydraulic Model

The plan is to:

Keep the station safe during timber transportation so it doesn't slow down.

Stop the panels from moving on icy tivtiva by putting them on a precast concrete structure. The average annual temperature is 14°.

Make sure the solar station is covered against landslides, floods, and other issues.

Have a backup plan even after the Khudoni dam is built.

The Enguri Cascade took years to build, while the Khudonghesi faced delays. The model helps plan safety procedures for the solar plant if something goes wrong.

The model checks if it's safe to put solar panels in the cross-reservoir and what blocks would be best. A concrete cover at the water level would keep panels safe on the shore.

Study Area

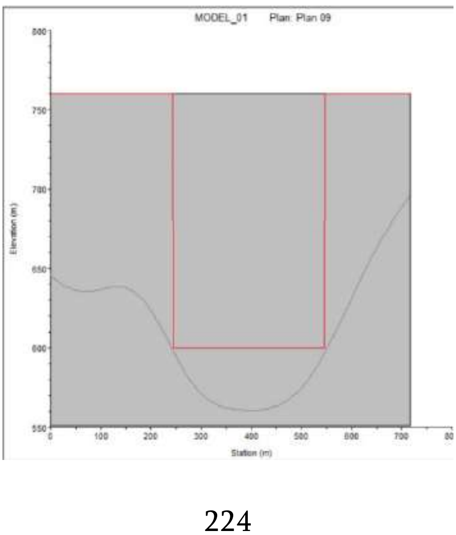
Both Enguri and Khudoni dams are in the Samegrelo-Zemo Svaneti region with mountains (600 to 900 meters high). People live there, and there are trees and landslide spots. We used topographic material to study the area before it got flooded.

The model covers 145.6055 km².

Cross reservoir: 11.491 km².

Khudoni reservoir: 3.7991 km².

Khudon Parameters for Collapse Analysis

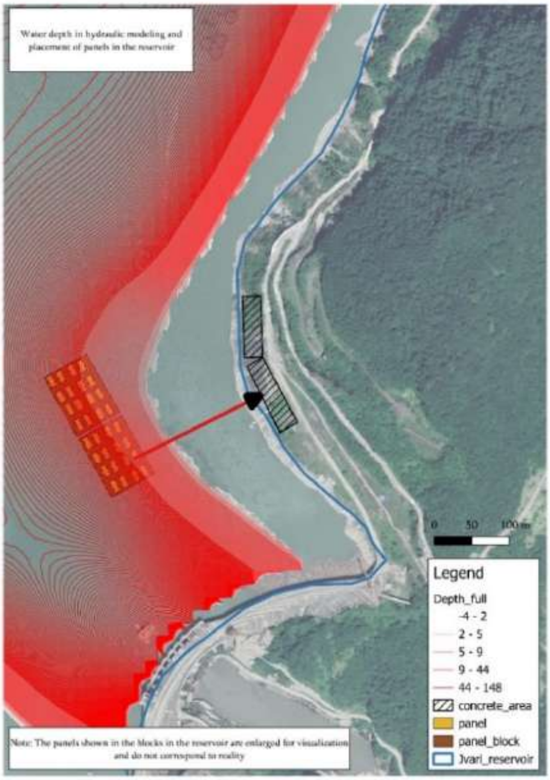


Concrete arched dam height: 200.5 m. Top length: 522 m; Top width: 6.02 m; Base width: 31.7 m. Reservoir volume at normal flooding (702 m): 364.5 million m³. Mirror area: 5.28 km². Dead volume at 640 m: 140 million m³; Useful volume: 224.5 million m³; Flooded area: 528 ha.

Hydraulic Model and Unsteady Flow Analysis

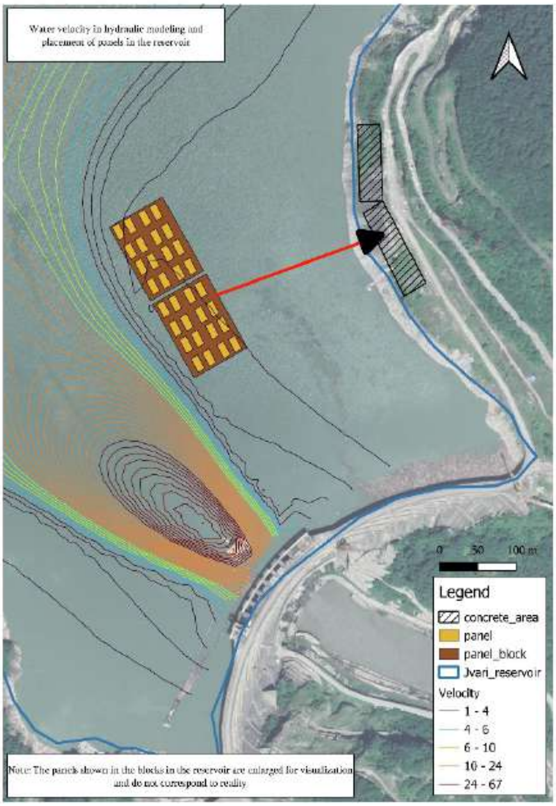
Enguri and Khudoni dams need to be modeled accurately, starting from the lowest point, to get good results.

We studied the flow every 0.1 seconds with a 30-second gap. We got maps and detailed results every hour. We looked at the riverbed in small details for accuracy.



Resalt

The most water shock, 31 m^3/s, happens at the Enguri dam 30 minutes after Khudon gets damaged. During this time, we can easily remove panels from the pre-made construction. About 2000 panels on a ~4000 sq. m. concrete cover, designed like blocks, keep the solar power station safe on the shore.



Adding more concrete and responding quickly makes the model close to reality. We need good data and software for the small details.

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Entrance to the Port

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Abstract: Ports are vital hubs in global transportation networks that move various types of cargo and passengers between countries and regions. A port's hydrotechnical facility is an inlet that ensures the safe movement of ships of various sizes and types in many different types of environmental conditions.

Key words: ports, entrances to the port, duration of ships' entry period, duration of the ship's exit period, gate, shore.

In the technical sense, the entrance to the port is a set of elements of the port, which ensures the safe entry and exit of ships in the port. These elements are the inlet gate, the inlet channel section adjacent to the gate, and the inlet ramp.

An inlet gate is a break between containment structures or an opening between the shore and the containment structure.

For merchant ships, it is enough to arrange one entrance to the port, but two (even three) entrances can be made for large ports along the shore.

When the port has 2 gates, it is advisable to use one only for entry, and the other for exit (in case of unfavorable meteorological conditions, it is advisable to use the entrance that is more convenient at the given moment). At the same time, we should remember that the arrangement of several entrances to the port worsens the wave regime in the water and in some cases helps to increase the intensity of its flooding.

Port throughput is the number of ships that can enter and leave the port in a certain period of time (usually a month). The number of ships which can enter or leave the port n_e in a certain period of time (usually one month) - calculated by the formula:

$$n_e = \frac{8640 \cdot k_e \cdot K_{dmc}}{t_1 + t_2} \quad (1)$$

where 8640 is the number of hours per year;

k_e - coefficient of use of the entrance in time;

k_{dmc}- the coefficient considering the interruption of the duration of entry and exit of ships (depending on meteorological conditions);

t_1 and t_2- the time of entry and exit of ships (in minutes), depending on the conditions of continuous operation of the entrance, the coefficient k_e was obtained within 0.45÷0.55.

The coefficient of entrance use k_e takes into account the water supply of the ship.

A lower value of k_e is obtained for large-tonnage ships.

It is recommended to determine the k_{dmc} coefficient based on the data of the natural mode of the area of the port to be designed, which cause delays in the entry-exit process as a result of storms and storms. The values of k_{dmc} are different for different sea basins. For the Black Sea, the k_{dmc} coefficient is equal to 0.9 in the I and IV quarters, and in the II and III quarters of the year - the coefficient is equal to 0.95.

$t_1$and t_2, respectively, the duration of the ship's entry and exit periods (calculated according to the specific conditions of the port to be designed and the water of the ship). The length of the inlet fairway varies from 20 to 50 minutes. Longer (3.6-5.4 km) fairways obviously need more time.

The length of the entrance is selected based on the requirement to ensure the ease of entry and exit of ships during storms and the minimum possibility of storm water entering.

Large ships enter port with the help of tugs and often with a pilot on board. In this case, the wind speed and the permissible wave height are determined by the operation of the tugboat and the ability of the pilot to transfer from the boat to the ship (before entering the port).

The entry reference length B_e, m (during one-way movement of ships) must always be at least $0{,}8l_b$ (l_b is the longest length of reference ships, m)

The value of B_e can be determined by the formula:

$$B_e = B_{\text{sh}} + \frac{V_D}{V_{\text{sh}}} l + V_{\text{sh}}\ t \sin\beta + \Delta B \qquad (2)$$

where B_{sh} is the width of the reference ship;

V_D - the speed of the ship being carried away by the drift caused by currents and waves, m/s

V_{sh} - speed of the ship at entry, m/s

l - ship wandering time, sec (taken as equal to 60 sec)

β- angle of wandering, degrees (varies from 3 to 10 degrees and depends on wind power and wave height);

ΔB-width stock, m (taken to avoid touching the ship's restraining structures and the slope of the channel, ΔB/B_g is taken from 0.5 to 2)

The ship's drift speed V_D is calculated by the formula:

$$V_D = V_t + V_w \qquad (3)$$

where V_t is the speed of the steering blades of the diametrical plane of the ship, m/s

V_w- controlled wind drift speed of the same plane, m/s.

Values of V_t are obtained by referring to hydrological data near the port entrance;

V_w- values are obtained according to the windiness of the district and the characteristics of the reporting ship;

The value of the wandering angle β is obtained by the dependence of the wave height and the wind strength.

The gate width of the existing ports varies widely in Harglen - from several tens to several hundred meters. It is 250 meters for Batumi, 180 meters for Poti, 330 meters for Norovosiisk, 275 meters for Odessa, 130 meters for Dunkirk, etc.

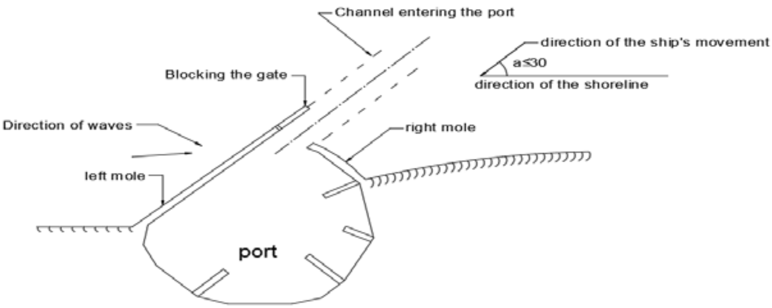
In large tidal ports, the width of the gates should be checked against the tidal currents so that their velocities do not exceed the allowable velocities for specific soils, so as not to cause soil washing.

Usually, the entrance is located in the deepest part of the aquarium, farthest from the shore. The direction of the inlet axis, as well as its length, should be selected in such a way that the navigational requirements are met and the minimum amount of sediment entering the water body is ensured.

When approaching the gate of the port, the axis of movement of the ship should have as small an angle as possible with the direction of the prevailing winds and waves, because otherwise the danger of the ship colliding with the surrounding structures is very high.

However, it should be taken into account that it is difficult to control the ship in the direction of the axis of the entrance and the direction of the wave.

The condition of protection of the aquaria from waves requires that the beam of the waves in the direction of the ship sets the greatest possible angle with the beam, which in practice is equal to 30÷35 degrees.



Pic. 1. Port entrance, gate, and its

Block implementation scheme.

If the width of the entrance cannot protect the water area of the port from waves, they resort to blocking the entrance (see pic. 1). The length of the barrier, the effectiveness of protection against water waves and the operating conditions of the inlet are tested on a hydraulic model.

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Road Construction in Ancient Rome

Salome Kekishvili (Bachelor program student), Supervisor: Professor Konstantine Mtchedlishvili, Georgian Technical University

Abstract. The paper discusses the road network of the ancient era, in particular, Rome as a node of roads at that time. The construction techniques of Roman road building, tracing and construction methods, tools used in road forming of the ancient era are presented. The building of roads was carried out in accordance with natural conditions. It was believed that massive construction of transport tunnels was started by the Romans. Tunnels and bridges were an important part of the Roman road network. In Rome, the movement of goods and passengers was highly developed. The creation of concrete is also connected with its name.

Key words. Road network of the ancient era. Construction of road clothing. Tunnels and bridges. Aqueducts.

Introduction

The ancient road network was stretched from the British Isles to Eastern Europe. The ancient network was created and developed step by step, according to the joining of the surrounding territories. Roads on the territory of Italy were of great economic importance, that is why the improvement and development of the road network was one of the main tasks of the Romans. Till today the state's road network has been a powerful tool for managing political and economic processes. This was also well understood in Rome, where road construction reached a very high level of development.

Main part

Two documents give an idea of ancient roads: the table of road stations compiled by the emperor Marcus Aurelius (160-180 BC) and the map of the road network compiled in 90 AD, on which 300 main roads are schematically depicted. Rome was a junction of roads leading from individual provinces and other countries. Roads were built from time to time to connect neighboring areas. Along with military operations, Roman legionnaires also performed road works. The army-built roads before the start of the war, converting the paths leading to the war zone into paved roads. Italian roads were of great economic importance, and they were well maintained. For example, the Via Appia, which is still preserved in fragments. Its total length is 162 km. It was covered with stone slabs. Roman road clothing consisted mainly of four layers. An example of a typical construction is as follows: the lower layer - two rows of large stones stacked on a lime solution. The next layer - stones the size of a fist, above it a concrete layer of stones the size of walnuts, the top layer - a mixture of sand and gravel or stone slabs.

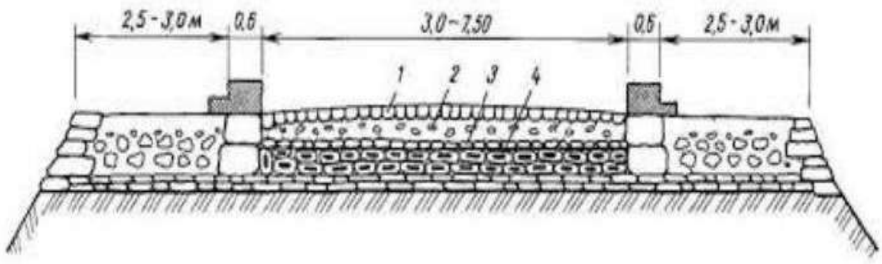

Fig.1

1-paved or cemented gravel; 2-stones the size of walnuts; 3-stones the size of a fist; 4 - double layer of stone slabs.

As a rule, the streets of the city were paved with stone slabs. Channels covered with stone slabs - "cloaca" - were arranged under the pavements. Water used for household purposes, rainwater runoff from the road parts of the street flowed into it from the buildings. The cities of Rome were abundantly supplied with water, and the used water flowed like a river in large-cut cloacas. Building cloacas was a necessary requirement of urban planning.

The thickness of the road surface of Roman roads reached 1 m. It is likely that the original road surface construction needed repair after a dozen years. During this period, the clay accumulated on the surface of the carriageway was not removed from the ground layer and the next layer was built on it. Often the Romans placed cobblestones directly on the compacted clay soil and filled the gaps with large stones.

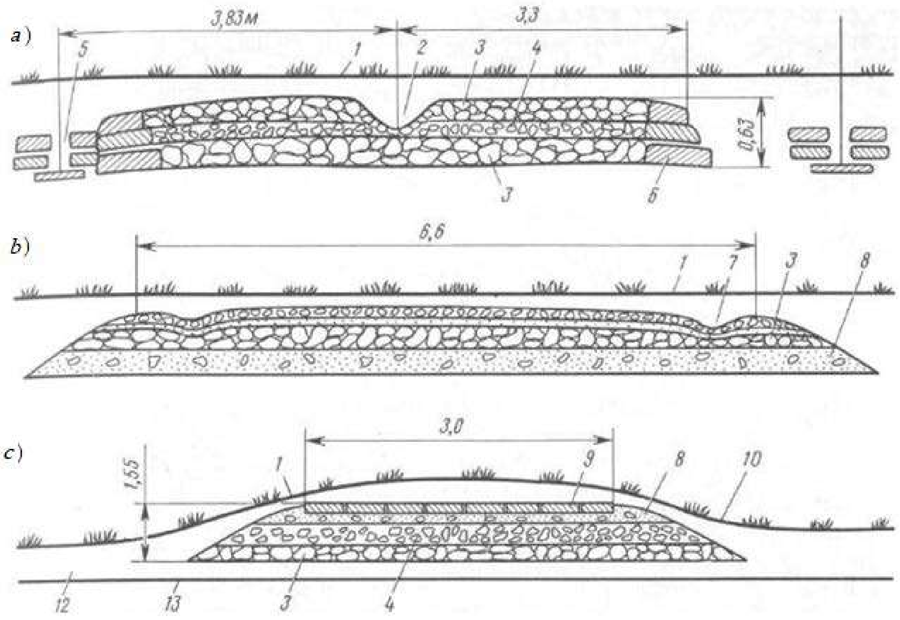

Fig.2
Cross-sections of Roman roads that were covered with dirt due to neglect

The main roads of the Romans were long straight stretches of paved plain and hilly terrain. Straight sections were combined with small bend angles. The deviation of the 40-50 km long sections from the airline did not exceed 1.5 km. The track deviated from the air line to climb the side of negative landforms, swamps and rock massive. Roads on the slopes of the mountains were divided by a half-cut arrangement. In most cases, the transverse slope of the slope was corrected with 1.2-1.5 m high stone retaining walls, at the bottom of which a mixture of peat and loamy soil was poured and compacted.

In mountainous areas, tunnels were used to shorten the length of the road. Their length rarely exceeded 40-50 m. There were exceptions, for example, the 700m long tunnel on the Naples-Puzzoli road. The Roman road network crossed many rivers. In most cases, the background was arranged. Rarely, stone slabs were arranged on the bottom of the river. 2,000 stone bridges were laid on the 90,000 km of highways belonging to ancient Rome. The first stone bridge was built on the Tibros River in 142 BC. There were 9 stone bridges in Rome, 6 of which are still functioning today. Most of the bridges on the Roman roads collapsed in the Middle Ages due to neglect. The Romans did not have the technique of removing water from a cauldron and did not know how to use long piles. They used no more than 2 m long piles. The thickness of the piers was 0.3-0.5 of the length of the bridge span, rarely 0.2. Thick massive piers reduced the live cross-section of the bridge, so sometimes a hole for water was made in the pier. The length of arched mallets rarely exceeded 5.5 m. That's why they used scaffolds of simple construction and relatively weak stone for construction - Travertine.

The invention of concrete significantly elevated the art of Roman construction. Roman concrete was made at the construction site from lime, pozzolan, baked powdered clay and volcanic ash.

Rome had a highly developed cargo and passenger transportation system. Back in the period of the Roman Republic, a system of moving mail and carriages on the roads was created. There were stations located every 23-28 km on the main roads. Officials were provided with overnight accommodation, meals, mail carriers - with horses. Couriers covered at least 180 km per day. Blacksmiths, veterinarians, merchants, winemakers, and wheelwrights lived in the places of overnight stay. Later, these settlements turned into large European cities, for example: Cologne, Budapest, Prague.

Conclusion

Based on the above discussion, we can conclude that the ancient Roman Empire played a major role in the development of ancient road construction. Sophisticated road construction methods made it possible to unite territories more quickly and strengthen the Roman Empire. The developed construction system made everyday life comfortable and convenient. The surviving sources about the ancient road network show that communication and information exchange became easier with the help of well-organized and well-maintained roads. The Roman Empire reached the peak of development in the field of road construction. The success of the Roman Empire in building statehood was directly related to the quantitative and qualitative indicators of the road network. The experience of the Roman Empire remains an example for modern countries.

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Advantages of the Information Model

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Abstract: The article "Using information models" discusses the advantages of using BIM (Building Information Model) technologies. The cost incurred for its implementation is high, but justified. The use of this technology connects a powerful industrial network: business and project development team; Introduces us to the need to use cloud. One example is discussed, when it is easy to make changes to the project according to the customer's wishes.

Key words: BIM, information model, Revit , the cloud.

The information model simplifies the relationship with the customer, makes it easier to make corrections to the project and calculate costs. In addition to the visual side, the information model includes a lot of information: First of all, information about the material used, also about the price of the material and the total cost of the project. Changes to any details or invoices in the project are automatically reflected in the price table. The use of this technology connects a powerful industrial network: the business and the team of project developers. Construction is a highly collaborative process. From drawing up the project to the construction of the building, the construction company must ensure continuous communication between the participating groups (architects, constructors, designers, engineers). The use of BIM technologies best provides this connection. Each group member is reluctant to use this technology and store material in the "cloud", allowing everyone to use each other's data. The cloud can be used both with a computer and with mobile devices, therefore, we have access to the project both in the office and on the construction site or any other place. The cloud allows people to work remotely, which has become very relevant especially after the covid pandemic. The use of BIM technologies ensures collaboration and a seamless flow of information from design and planning to construction. Cloud computing is virtual storage that stores our applications, files and data and allows us to securely access it when needed. By using BIM technologies, it is possible to correct errors in time and avoid unnecessary costs. Both the project team and the client are sure of the project's smoothness and, therefore, the safety of the construction and less costs. For example, the customer wants to increase the area of the room at the expense of reducing the area of the balcony. The program Revit allows us to create interconnected objects. For example, a layer of wooden surface or ceramic tile is attached to the floor tile (Fig. 1.), and to the wall surface - a layer of plaster, thermal insulation, facing material or wallpaper (Fig. 2.). The program allows to move the given wall (1) in the desired direction (Fig. 3). At this time, the area of the ceramic tile laid on the balcony automatically "divided" the wall and reduced its area. The area of the wooden floor of the room was also automatically divided by the wall and its area increased (Fig. 4). The measurements shown in Figure 4 show that we moved the wall to the side of the balcony by one meter (by 1000 mm) and the dimensions of the balcony and the floor of the room changed automatically. We have given one example out of many that the information model is distinguished by.

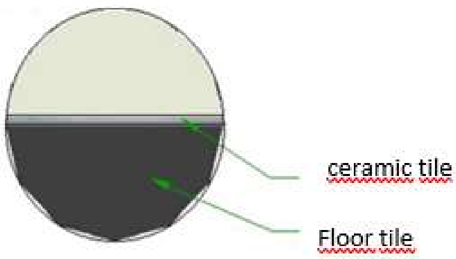

Fig. 1

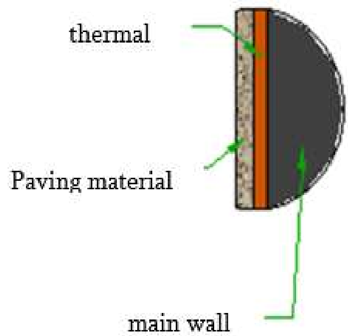

Fig. 2

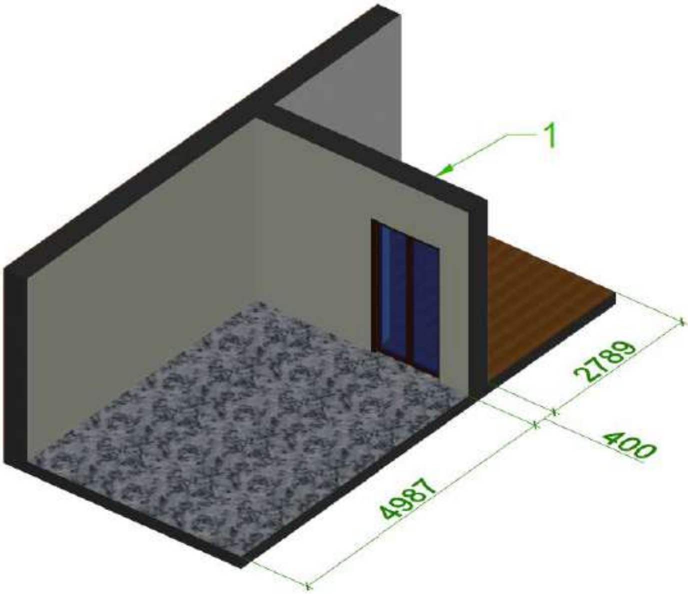

Fig 3

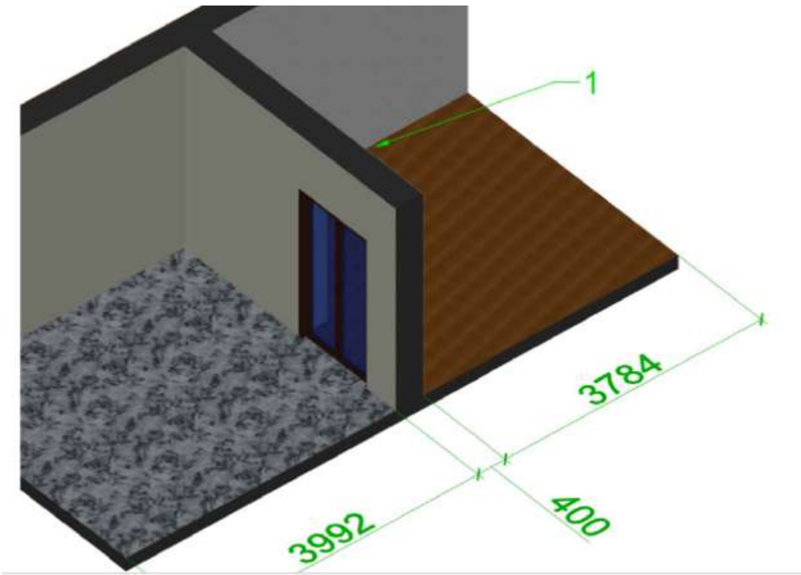

Fig. 4

Conclusion

The article discusses the advantages of creating and using an information model in construction. Here is one example out of many that proves the advantage of using an information model.

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Determination of the Optimal Variant of the Construction Scheme of High-Rise Buildings Under the Influence of Dynamic Loads

Giorgi Khachidze (PhD student), Supervisor: Professor Maya Chanturia, Georgian Technical University

Abstract: high-rise buildings belong to first-class buildings in terms of reliability and responsibility. Their design and construction are closely related to the development of economic and scientific technologies. The level of design of such types of buildings is very high in the leading countries of the world at this stage. In this regard, Georgia is not behind other countries. High-rise buildings are being built intensively in our big cities. Since our country is located in a seismically active region, ensuring the seismic stability of these buildings is one of the most important issues.

Key words: high-rise, buildings, dampers, hysteresis damper, seismicity.

Introduction

The design of high-rise buildings, regardless of their intended purpose, requires consideration of various design aspects, construction constructions and work production. Based on the practice of the advanced countries of the world, reinforced concrete, metal, composite materials and combinations of the above materials are mainly used in such structures. High-rise buildings require special consideration because, unlike conventional buildings, the impact of wind and seismic increases, especially in a seismic region like Georgia.

Main Part

A high-rise building is a building whose functional use is impossible without an elevator. There are different definitions according to which a building may belong to the high-rise category:

1. Any construction whose height may have a serious impact on emergency evacuation;
2. In the United States of America, the National Fire Protection Association defines buildings of 7 or more stories or more than 23 meters high;
3. Buildings with more than 4 floors or a height of 15 to 18 meters are considered tall buildings according to Indian construction norms;
4. In Georgia, buildings with 10 to 100 or more floors are called high-rise buildings, where all the accounting schemes, concepts, definitions and construction solutions related to high-rise construction should be taken into account (Fig. 1).

Fig. 1

In this paper, the calculation of the high-rise building on wind load is generally reviewed, the selection of the scheme according to the nature and influence of its impact, to determine the effect of the dynamic effect on the total wind load, and after that to determine the influence of the wind itself. In addition, the paper will show the calculation of the high-rise building on seismic loads with different types of damping systems and the selection of the type of high-rise building according to the nature of their work. A high-rise building with a multi-story frame-connection system will be selected as a research object (Fig. 2)..

The structural scheme must be selected to withstand gravity and horizontal forces, both permanent and temporary. These forces depend on the size and shape of the building, as well as the geographical location of the building. Their possible maximum values should be determined before designing. The construction systems of a high-rise building consist of a lower and an upper system. The superstructure is the part of the system above the ground. The substructure is located below the ground and usually consists of foundations, beams, trusses and coils in the ground, which are located below the lowest floor of the building and the basement. It is between the underground part and the above-ground parts that seismic suppression systems are arranged.

Fig. 2

The most dangerous for high-rise buildings are wind load and earthquake [1], the effect of which increases depending on the height of the building. The designer must be sure that the building will not overturn in case of strong winds or earthquakes, and at the same time its swaying will not cause physical or emotional discomfort to people. All this has a significant impact on the construction of the carrier system, as well as the total cost of construction. An important factor to consider during acceptable design is the material selection of the structural systems – be it concrete, steel or composite material, which will have a significant impact on the overall cost of the building. The calculation planned in the study, taking into account the effects of pulsating and seismic loads, such as damping systems, ensures the minimization of all the factors listed above [2]. These systems are of many types, there are more than a hundred types of dampers. Their selection depends on the nature of the earthquake.

Among these systems, the following types of dampers are most often used:

1. Viscous damper systems;
2. systems with dry friction damper;
3. Systems with an element capable of plastic deformation.

Conclusion

The research and methodology presented in the paper will contribute to the development of high-rise building construction in Georgia by providing more stability and reliability against the effects of dynamic loads.

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The Main Areas of Labor Market Transformation in the General Concept of Economic Development

Dimitri kiknadze, Natia Gochashvili (PhD program students),
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Abstract: In the current landscape marked by the interdependence of diverse communities, institutions, and social groups, there is an imperative to delineate the pivotal directions for the development and transformation of the labor market. Globalization processes intricately link modern societies in networks, reshaping social interactions, interrelations, and the very fabric of social institutions.

The realities of contemporary economic development necessitate viewing the labor market as a non-conventional system of contracts between buyers and sellers of labor services. This dynamic system plays a crucial role in determining the level of prices and orchestrating the optimal distribution of labor services. Encompassing a broad spectrum of labor relations and individuals engaged in it, the labor market serves as the primary conduit through which the majority of the working population secures both income and enduring employment.

Key words: labor market, transformation, institutionalism, workforce, economic development, labor market price, salary, competition, labor resources.

Introduction

The modern labor market is legitimately the main link of the national and global economy, within which labor resources with creative potential, competitiveness and personal brand are formed and carry out the daily evolution of modern society. Changes and events in the economic, political or social spheres, in one way or another, affect the country's labor market.

The development of market relations is accompanied by the emergence of institutions acting on behalf of employees, which express and protect their interests. Trade unions are the most massive organization of workers. The labor market relations system consists of three main components:

1. Relations between employees and employers.
2. Relations between labor market actors and their representatives.
3. Relations between the actors of the labor market and the state.

The structural elements of the labor market are: demand for labor; labor supply; the price of labor, which is reflected in the salary; cost of labor; competition.

It can be said with full certainty that the modern labor market, as a result of long-term transformations, is today represented as a system of socio-economic institutions that ensures the involvement of workers in social production and determines its institutional character. This type of system includes: trade unions, associations or unions of entrepreneurs, labor legislation, individual and collective agreements, state policy in the field of labor and employment, through which market relations between labor market entities are implemented.

It should be noted that the labor market is considered from the perspective of an open and competitive system, the formation of which is subject to the traditional law of labor supply and demand, while depending on innovative factors.

A modern feature of the formation and development of labor market institutions is that labor market relations are not reduced only by the operation of the market mechanism, but require consideration of the institutional characteristics of its functioning. Institutions have an organized influence on supply and demand in the labor market, and trends in modern economic development make it possible to determine the institutional characteristics of the labor market. The social structure of modern society is formed, as a rule, against the backdrop of a decrease in demand for some workers and an increase in demand for others. The transition to a high-tech economic model has led to problems that did not exist during the first industrial revolution. The rapidly declining knowledge, skills and abilities of the workforce no longer match today's demands.

New technologies demand both the growth of professional knowledge and their systematic updating from the subjects of labor relations. This situation determines the development of the continuous education system. Studies show that many professions will become a thing of the past, for example, legal adviser, notary, pharmacist, analyst, broker/realtor, secretary, municipal employee, logistician, bank teller, journalist, diagnostician, system administrator, watchman, miner, truck driver, traffic police inspector Packer, Cook, Handyman, Tailor/Shoe Maker, Taxi Driver. Some professions are completely replaced by artificial intelligence, which competes even with highly qualified specialists. Considering the similarities in the development of all the economies of the developed countries, as well as their social spheres, the employment policies in these countries are different, which ultimately led to the formation of different labor models. The existing diversity can be divided into two types: the external labor market and the internal labor market. As a rule, the external labor market implies some labor mobility, which is possible between companies. On the other hand, the internal market is based on the movement of personnel within the enterprise.

The trends observed in the framework of economic development and leading to the reduction of working hours create a new form of labor market called "flexible labor market". As Adam Smith said, "The less government involvement in the economy, the better for the economy itself." According to his position, the market system has the ability to self-regulate, which is based on the so-called "invisible hand", namely, personal interest driven by the desire for profit. However, J.M. Keynes's theory has been subjected to strong criticism as well as significant modification. In particular, the researcher disputed the fact that within the framework of perfect competition there are adaptation mechanisms that lead to equilibrium, including under conditions of full employment. Keynes, advocating active government intervention in labor relations, noted that it was wages that provided the necessary balance of national income. Although involuntary unemployment remains due to insufficient demand for labor.

Methodological support of the labor resources management mechanism, taking into account the proposed aspects, includes adapted and actively used methods that are perfectly used in practice and systematically improve the quality of the labor resources management system.

Changes are observed in the qualitative characteristics of labor resources in the region. Today, management of labor resources is carried out in the form of a "soft model" of regulation, which is based on the potential of the labor market, but does not purposefully form an object. The "soft model" operates exclusively within the framework of the existing object, strengthening some and weakening others, while realizing itself in several forms - conscious and spontaneous, respectively.

A high level of employment of the population should be ensured by creating new jobs and not by maintaining excess staff. Achieving high, structurally rational, economically efficient and socially justified employment is a structural element of the economic recovery mechanism of many countries. This process can be stimulated by market relations, as well as targeted economic policy measures at all levels. So, if the problem of employment in developed countries is usually solved separately, then our country needs a thorough transformation of the entire economy. This goal can be realized by financial stabilization and solving social problems. In particular, there is a need for efficiency in the interaction between employees and employers.

It should also be taken into account that the state's ability to create new jobs is significantly less than that of private capital. However, this fact does not diminish the role of the state, which acts as a guarantor of the population's employment.

To solve these problems, it is necessary not only to provide resources based on economic growth, but also to systematically develop effective legislation aimed at changing the public's attitude to the problem in question.

The conditions of labor relations that arise within the production process are reflected in all areas of human life and imply a special character of regulation based on the priority of the individual's personality. By analysing the constitutional norms, we can come to the conclusion that the protection of the rights of labor and entrepreneurial activity is equal. Accordingly, the labor legislation should take into account the rules of equality and mutual consideration of the rights and interests of the parties.

If there is no effective government policy, self-regulatory processes begin to form, aimed at survival by any means, for example, employment in the shadow economy.

Conclusion

In the context of the economy of our country, the experience of industrialized countries, including in the field of large-scale labor market policy, is of particular importance. This policy is a set of measures aimed at regulating the labor market, promoting all subjects of labor relations and training programs. As we have already mentioned, the analysis of foreign experience will make it possible to use similar development models in Georgia.

The labor market is influenced by various subjects of labor relations, namely: trade unions, government bodies, as well as employers.

It is quite natural that today it is inappropriate to focus on a certain segment of the market, since a certain segment cannot reflect the situation in the labor market as a whole. On the other hand, the state policy that is implemented in the labor market will be effective only if it is implemented in a differentiated way for each segment.

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Frames as Construction Elements and Methods for Solving Them

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Abstract: Constructions such as the frame are very often used in construction and design. Any frame and its stem, as its constituent elements, get some load on its head. Therefore, calculating the necessary strength of the stem and the tension of each of them during a given load, one of the most important factors in preparation for construction. To make them subsequently used, to calculate the optimal values of the transverse areas of the stem.

The work considers the possibility of using the method of non-linear mathematical programming to calculate the optimal, according to the criterion of weight, the values of the parameters of a symmetrical three-tire frame. The proposed method allows you to choose the area of the transverse sections of the frame rods so that their weight would be minimal, with given loads and restrictions imposed on the area of the rods.

The work also considers the effect of changing the angle of inclination of the edge rods to the abscissa axis on the structure and values of the optimal parameters of the frame. To find the global minimum of target functions, a random search method is used. A set of

programs for finding numerical values of the optimal parameters of the frames has also been developed.

Key words: symmetrical three-tire frames; optimal sections; random search extremum; Non-linear mathematical programmed.

1. Formulation of the problem

Let there be a three-chain frame (Fig. 1). The purpose of the design is to choose the areas of the transverse sections of individual stems b_1, b_2 and b_3 (variable design) so that the weight ψ of frame would be minimal and the restrictions are satisfied. Similar tasks have been seen to see [1].

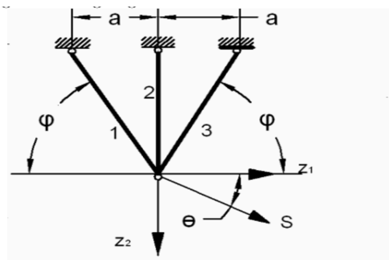


Fig.1.1

Thus, the target function is the weight of the frame and has the form:

$$\psi = p.a.(b_1 + b_{2.} \sin\varphi + b_3)/\cos\varphi,$$

(1.1)

here p - is the specific gravity of the material from which the frame is made. φ and θ corresponding angles of inclination.

Horizontal z_1 and vertical z_2 - displacements of the common node. For these designs, the equilibrium equation of the frame has the following face:

$$K(p).z - S = 0 \qquad (1.2)$$

K (b) is a positively defined stiffness matrix; S is the load vector.

The voltage in each rod is obtained by calculating the deformation depending on the displacement of the node and the application of the Law of the Hook

$$\sigma_1 = \frac{E(z_1 + z_2)}{2.a}, \qquad \sigma_2 = \frac{Ez_2}{a}, \qquad \sigma_3 = \frac{E(z_2 - z_1)}{2.a},$$

(1.3)

Here E is the module of Jung. With the help of permissible stresses separate $\sigma_i, i = 1,2,3$ for each rod, the restrictions on the voltage will take the view:

$$\psi_1 = E|z_1 + z_2| / 2.a - \sigma_1^0 \leq 0$$

(1.4)

$$\psi_2 = E|z_2| / a - \sigma_2^0 \leq 0,$$

(1.5)

$$\psi_3 = E|z_2 - z_1| / 2a - \sigma_3^0 \leq 0.$$

(1.6)

To impose restrictions on stability, it is necessary to set of the dependence of the moment of inertia on of the cross section for each rod. Quite common to applications is the dependence of the type

$l = \beta.b^2$, where b is the cross section and β is a dimensionless constant. A similar dependence is obtained if you fix the shape of the cross section. Stability restrictions have the form:

$$\psi_4 = -E(z_1 + z_2)/2a - \pi^2 E\beta b_1 .\cos^2\varphi/(a \ \sin^2\varphi) \leq 0,$$

(1.7)

$$\psi_5 = -Ez_2/a - \pi^2 E\beta b_2^2/a^2 \leq 0$$

(1.8)

$$\psi_6 = -E(z_2 + z_1)/2.a - \pi^2 E\beta b_3^2 \cos^2\varphi/2.a^2 \leq 0 \leq 0.$$

(1.9)

Displacement restrictions can be formulated in the form:

$$\psi_7 = |z_1| - z_1^0 \leq 0,$$

(1.10)

$$\psi_8 = |z_2| - z_2^0 \leq 0$$

(1.11)

where z_1^0 and z_2^0 specified upper boundaries for z_1 and z_2 correspondingly

Lastly requires that the areas of stem intersection meet the conditions (1.12), which minimize weight (1.30) and satisfy limited:

where $b_1^{'}, b_1^{''} b_2^{'}, b_2^{''}$ and $b_3^{'}, b_3^{''}$ the top and bottom borders of the search parameters are, respectively.

Thus, the design task can be considered as the task of choosing variables by projecting b_1, b_2 and b_3,which minimize weight (1.1) and satisfy restrictions (1.3) and (1.3-1.12).

To solve the equation (1.2), it is possible to imagine to K(b) in the following form:

$$k(p)=\begin{bmatrix}(Eb_1.\cos^2\varphi/l_1+Eb_3.\cos^2\varphi/l_3) & (Eb_1.\sin\varphi.\cos\varphi/l_1-Eb_3.\sin\varphi.\cos\varphi/l_3)\\ (Eb_1.\cos\varphi.\sin\varphi-Eb_3.\cos\varphi.\sin\varphi/l_3) & (Eb_1.\sin^2\varphi/l_1+Eb_2/l_2+Eb_3.\sin^2\varphi/l_3)\end{bmatrix}$$

Where the lengths of the elements ℓ_1 and ℓ_2 of the frame are, respectively, the E-Jung module.

$$k(p)=\begin{bmatrix}(Eb_1.\cos^2\varphi/l_1+Eb_3.\cos^2\varphi/l_3) & (Eb_1.\sin\varphi.\cos\varphi/l_1-Eb_3.\sin\varphi.\cos\varphi/l_3)\\ (Eb_1.\cos\varphi.\sin\varphi-Eb_3.\cos\varphi.\sin\varphi/l_3) & (Eb_1.\sin^2\varphi/l_1+Eb_2/l_2+Eb_3.\sin^2\varphi/l_3)\end{bmatrix}$$

(1.13)

In general, when designing a computer program, for a type of framework, in particular, because the frame stem forms rectangular triangles where a-is cathets ℓ_1 and $\ell_3$hypogenous, we can use the following dependence:

$$l_1=\frac{a}{\cos\varphi},\qquad l_2=a.tg\varphi,\qquad l_3=\frac{a}{\cos\varphi}.$$

(1,14)

Insert the General Function (1.13) in Function (1.2) in the formula of addiction will give us an image that has the following face:

$$\begin{bmatrix} (Eb_1.\cos^2\varphi/\ell_1+Eb_3.\cos^2\varphi/\ell_3) & (Eb_1.\sin\varphi.\cos\varphi/\ell_1-Eb_3.\sin\varphi.\cos\varphi/\ell_3) \\ (Eb_1.\cos\varphi.\sin\varphi/\ell_1-Eb_3.\cos\varphi.\sin\varphi/\ell_3) & (Eb_1.\sin^2\varphi/\ell_1+Eb_2/l_2+Eb_3.\sin^2\varphi/\ell_3) \end{bmatrix} . \begin{bmatrix} z_1 \\ z_2 \end{bmatrix} = \begin{bmatrix} s_1 \\ s_2 \end{bmatrix},$$

(1.15)

where $s_1 = s.\cos\theta$ and $s_2 = s.\sin\theta$.

Write the system of the latest equations recorded as a system of ordinary equations, it will have the following face:

$$(Eb_1.\cos^2\varphi/\ell_1+Eb_3.\cos^2\varphi/\ell_3)z_1+(Eb_1\sin\varphi.\cos\varphi/\ell_1-Eb_3.\sin\varphi.\cos\varphi/\ell_3).z_2 = s.\cos\varphi$$
$$(Eb_1.\cos\varphi.\sin\varphi/\ell_1-Eb_3.\cos\varphi.\sin\varphi/\ell_3).z_1+(Eb_1.\sin^2\varphi./\ell_1-Eb_2/\ell_2+Eb_3.\sin^2/\ell_3).z_2 = s.\sin\varphi$$

(1.16)

Remove the obtained system using the Kramer rule. The system determinant will have a face:

$$\Delta = \begin{vmatrix} (Eb_1.\cos^2\varphi/\ell_1+Eb_3.\cos^2\varphi/\ell_3) & (Eb_1.\sin\varphi.\cos\varphi/\ell_1-Eb_3.\sin\varphi.\cos\varphi/\ell_3) \\ (Eb_1.\cos\varphi.\sin\varphi/\ell_1+Eb_3.\cos\varphi.\sin\varphi/\ell_3) & (Eb_1.\sin^2\varphi/\ell_1+Eb_2/\ell_2-Eb_3.\sin^2\varphi./\ell_3) \end{vmatrix}$$

(1.17).

$$z_1 = \frac{\Delta_1}{\Delta}, \qquad z_2 = \frac{\Delta_2}{\Delta},$$

(1.18) where

$$\Delta_1 = \begin{vmatrix} s.\cos\theta & (Eb_1.\sin\varphi.\cos\varphi/\ell_1-Eb_2.\sin\varphi.\cos\varphi/\ell_3) \\ s.\sin\theta & (Eb_1.\sin^2\varphi./\ell_1+Eb_2/\ell_2-Eb_3.\sin\varphi^2/\ell_3) \end{vmatrix} \qquad (1.19)$$

and

$$\Delta_2 = \begin{vmatrix} (Eb_1.\cos^2\varphi/\ell_1+Eb_3.\cos^2\varphi/\ell_3) & s.\cos\theta \\ (Eb_1.\cos\varphi.\sin\varphi/\ell_1-Eb_3.\cos\varphi.\sin\varphi/\ell_3) & s.\sin\theta \end{vmatrix} \qquad (1.20)$$

$$\Delta=\sin^2\varphi.\cos^2\varphi\left[(\frac{b_1}{\ell_1}+\frac{b_3}{\ell_3})(\frac{b_1}{\ell_1}+\frac{b_2}{\ell_2\sin^2\varphi}+\frac{b_3}{\ell_3})-(\frac{b_1}{\ell_1}-\frac{b_3}{\ell_3})\right]=$$
$$=\frac{r^2p^2}{a^2}\left[(b_1+b_3)(b_1+\frac{b_2}{r^3}+b_3)-(b_1-b_3)^2\right] \quad (1.22)$$

$$\Delta_1=s_{1.}\cos\theta(\frac{b_1}{\ell_1}\sin^2\varphi+\frac{b_2}{\ell_2}+\frac{b_3}{\ell_3}.\sin^2\varphi)-s_1.\sin\theta(\frac{b_1}{\ell_1}\sin\varphi.\cos\varphi-\frac{b_3}{\ell_3}\sin\varphi.\cos\varphi)=$$
$$=\frac{s_1}{a}[v(b_{1.}.p.r^2+b_2.\frac{p}{r}+b_3.p.r^2)-q.(b_1.r.p^2-b_3.r.p^2)]$$

(1.23)

$$\Delta_2=(\frac{b_1}{\ell_1}\cos^2\varphi+\frac{b_3}{l_3}\cos^2\varphi).s_1.\sin\theta-s_1.\cos\theta.(\frac{b_1}{\ell_1}\cos\varphi.\sin\varphi+\frac{b_3}{\ell_3}\cos\varphi.\sin\varphi)=$$
$$\frac{s_1}{a}[p^3.q(b_1+b_3)-p^2v.r(b_1-b_3)]=\frac{s_1}{a}p^2[p.q(b_1+b_3)-v.r(b_1-b_3)]$$

(1.24)

Calculate the following numerical example,

when $\varphi=45^\circ$, $a=10$, $\ell_1=l_3=a/\sin\varphi$, $l_2=a/tg\varphi$, $\theta=45°$.
To do this, we need to make algorithm and then solve it using the program VB

2. Task Solve Algorithm

To solve the task, we use the random search algorithm of global extremum [2].

Below is the task solution method.

1.All the initial data required for the method of work are defined in advance.

-Number of independent variables-N;

-Number of limits-M;

-Bottom and upper boundaries of search parameters;

-Number of static trials- S;

-D_{min} - The value of the number (the most possible number as possible).

2. The cycle of static tests will begin.

3. The random numbers generator cyclically produces random numbers, which are then formed, using a special algorithm as search parameters.

4. Calculated by determinant formula (1.17) and will be checked on a condition Det <>0.

If it is satisfied, the system of equations will be solved. However, the meaning of all restrictions is calculated.

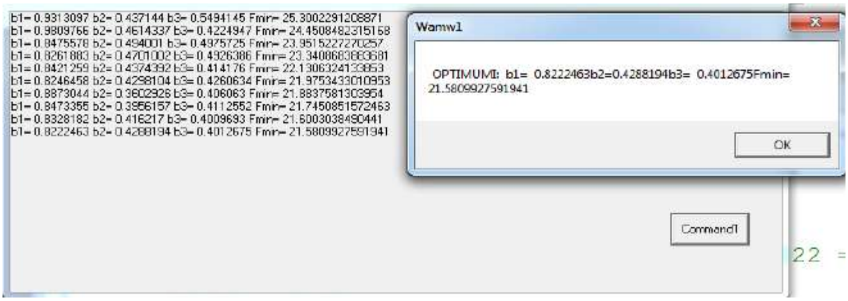
5. z_1 and z_2 considering the values, the limitations required by the condition will be cyclically checked. If all conditions are satisfied at the same time, then the management will be transferred to the performance of paragraph 6. If one of the restrictions is discarded, the program will be returned to the performance of paragraph 2.

6. The current value of the purpose function (1.1) is calculated and the condition shall be checked $\psi <= D_{\min}$. If this condition is fulfilled, then the value of the $D_{\min}$-the values of the search parameters will be saved (with it will be saved parameters) to use in case of

recurrence of the next cycle. Otherwise, that is $\psi > D_{\min}$, when the program returns to paragraph 2.

The above process is repeated until the number of static trials carried out is greater than S. The final results of the program's work will be values b_1, b_2, b_3 that give the function a minimum value.

The results of the program are given below:



3. Conclusion

The work considers the possibility of using the method of non-linear mathematical programming to calculate the optimal, according to the criterion of weight, the values of the parameters of a symmetrical three-tire frame. The proposed method allows you to choose the area of the cross -sections of the frame in such a way that their weight would be minimal, with the specified loads and restrictions imposed on the area of the rods.

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Means of Minimizing Physical Hazards of Workers at Height

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Professors Nana Razmadze, Nino Ratiani,

Abstract. This article considers the main dangers of working at height, highlights additional threats, discusses mandatory and safe use of rails and harness systems, recommendations and design solutions.

Key words: danger, risk, safety harness system, rail systems, safety nets.

Thousands of people are employed in the construction field in the countries with both, advanced and developing economies. It is characterized with: constantly changing operations at construction sites; extended chain of contracts, where the relationship between the contractors, sub-contractors and self-employed individuals is hard to ascertain; various jobs concurrently performed by various companies; majority of operations accompanied by high level of risk. Therefore, this is a priority sector for the labour inspectors across the world.

Safety of Working at Height

Construction works and the process of technical maintenance is oftentimes accompanied with the cases of workers falling from height. The consequences of such accidents are often severe. That is why the provision of high-quality protective equipment is so important. In practice, this translates into the supply and use of proper equipment. Globally, 40 per cent of construction site accidents resulting in severe injuries are caused by fall from height. Accidents at height have the highest mortality rate than any other job. On October 27, 2017 the Government of Georgia approved

Resolution No.477 on “the Approval of the Technical Regulations of Safety Requirements for Working at Height”.

It is necessary to follow the hierarchy of measures to prevent falling while working at height. Such measures include:

- Avoid working at height, if possible
- Working platform of proper design equipped with guard boards and guard rails preventing items from falling;
- The use of a hanging mechanism in the event of short-period and inconvenient work;
- Use of individual protective equipment (safety harness) preventing fall during inconvenient works;
- Use of fall arrest equipment (safety nets);

Majority of the works at height can often be performed on the ground either entirely or partially, at least, thus eliminating the danger of falling form height.

Working on or near fragile surfaces is a serious problem while working at height. Working on the roof, especially if it’s pitched, is especially dangerous and requires special risk assessment and working method planned prior to the commencement of works. Special dangers include:

- Fragile roofing material, including those that deteriorate and become brittle over time and due to extensive sun exposure;
- Protruding edges/borders;
- Dangerous accesses;
- Fall from stairs, roof ledges or beams.

Proper means of access should be made available, such as:

- Scaffolding, ladders;
- Proper barriers, guard rails;
- Appropriate warning signs that indicate to the use of individual protective equipment and the workplace risks;

Weather conditions are important for ensuring safety of persons working at height. Everything goes fine while working during favorable weather conditions, but situation may change drastically in the following events:

- Wind, when it is hard to stand upright and easy to lose balance;
- Crane operations, when balancing the load is complicated.

Employers can apply various methods for preventing their employees from working at height. This approach can be broken down into three-level hierarchy:

- Prevent working at height
- Prevent falls of workers at height;
- Mitigate the impact of falling from height on workers, should it occur.

Adequate and appropriate measures are required to minimize all risks of working at height that may cause injuries e.g. use of guardrails).

Requirements for the installation and operation of guardrails

Guardrails must be made of solid material. Vertical supports must be installed at every 50 cm interval. Horizontal rails are installed in three stages:

The lowest rail must be at least 10 cm high to prevent the falling of construction materials and waste. The middle rail must be installed 50-60 cm above the floor level and the top rail – 90-110 cm (Fig.1.).

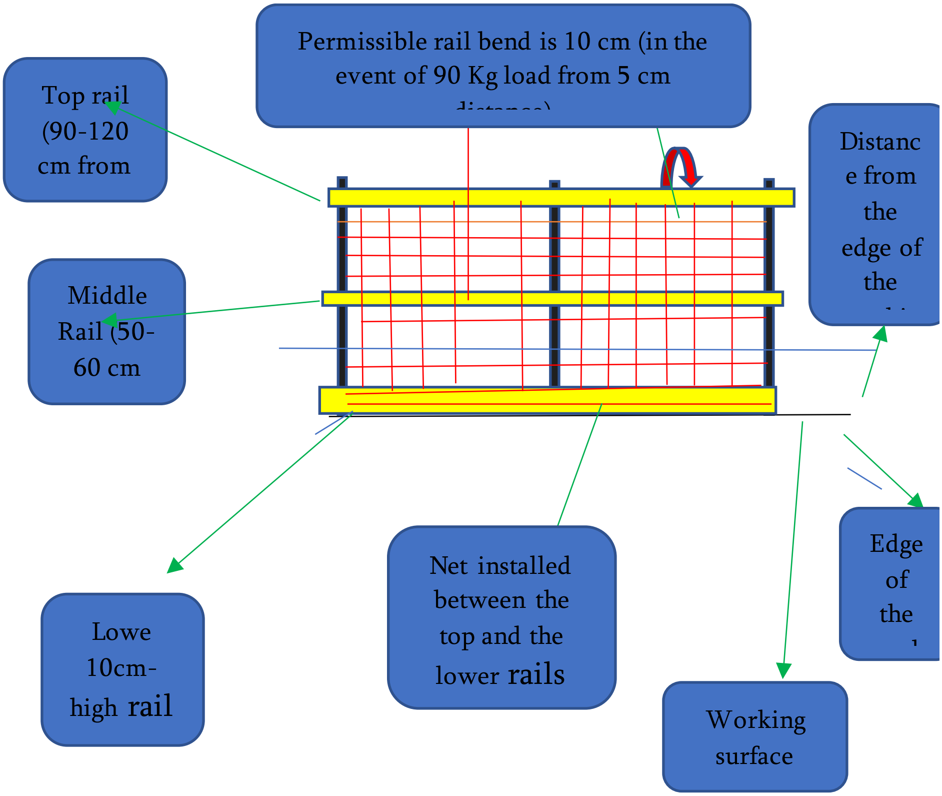

Fig. 1. Guardrail Schematic Drawing

Guardrail Installation

Several types of guardrails are currently available at the market. But due to construction process specifics, fast and simple installation of the rails is important for the builders. We have several practical experiences, and we are pursuing the following method: at least 18 cm-tchick reinforcements are used as guardrail supports and planks are attached to them with iron clamps (Image 1). The use of these clamps saves the welder's expense and tome of making the rails.

Image 1. *Guardrail plank clamp and reinforcement support*

Pollination Works

Workers must be protected from falling during pollination works. Currently the absolute majority of employees working on pollination in Georgia are under the danger of falling from height. Lifeline is installed along the perimeter of the structure, but that's not enough. Therefore, we designed and began the use of the special fall arrest equipment (Image 1). This product ensures the safe work of the employee and prevents their injury. Support square pipe is installed on the beam and the worker is tied with the special fall arresting equipment with the operating radius of 10 m.

 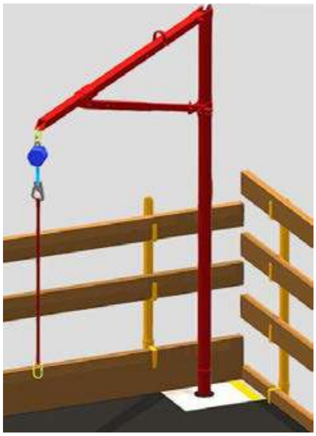

Image 2. *Working at height using guardrails and fall arrest equipment*

Safety Nets

Safety nets should be installed no more than 9m from the work platform. Therefore, during the construction of a multi-story building, it is moved along with the increase of building height. Net mounting posts are installed every 4m. while the net shall be extended from the edge of the building at a distance of 4m. its main purpose is to protect the employees from fallen construction materials. Upon installation the net should be tested on dropping 180 Kg load from at least 1 m elevation (Image 3).

Image 3. *Typical example of a safety net*

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Our aim is to have all construction sites install a new safety net, which includes a railing and a safety net together. This net will reduce the cost of a guardrail and the time of its installation. The structure consists of aluminum pipes and requires 2 workers for installation.

Image 4. *Combined design solution of a construction net and railing*

Nowadays, only a small number of construction companies comply with all labor safety requirements when working at height. There are several reasons for this:

1. Lack of qualified labour safety specialists;
2. Not including the labor safety costs during the preparation of the tender documents;
3. Not planning the works to be performed and no risk assessment.

Fall Arrest Personal Protective Equipment

Personal protective equipment against falling from height is a valuable means of protecting workers. Based on the demands, they should meet the following safety criteria:

1. PPE should be factory-made;
2. They must be visually inspected for damages after each use. In the event of detecting damage, they should be immediately replaced;
3. Operational requirements provided in the technical specifications should be followed.

Fig.2. *Personal Protective Equipment*

"Double strap with shock absorber" can be used at a height, the falling distance of which is at least 4.75 m (the strap hook should be attached above the head level); Upon falling from the shock absorber height the chute opens at 200 Kg load and the fall impact is minimized.

Conclusion

This article covers general and specific matters pertaining to the safety of working on height.

Thousands of people are employed in the construction field in the countries with both, advanced and developing economies. It is characterized with: constantly changing operations at construction sites; extended chain of contracts, where the relationship between the contractors, sub-contractors and self-employed individuals is hard to ascertain; various jobs concurrently performed by various companies; majority of operations accompanied by high level of risk. Therefore, this is a priority sector for the labour inspectors across the world.

Proper and relevant measures are required to prevent any possible risk to the maximum degree when work is performed at height and damage can be caused (e.g.: the use of protective rails).

Personal protective equipment for working at height must provide for arresting the falling employee at 1.8m height above the ground surface. Body harness, other equipment and components should be used for the employee safety protection only. Their use for lifting/handling other materials is prohibited.

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High Pressure Cylinders

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Abstract: The use of gas fuel in road transport is justified both from an economic and ecological point of view. For the use of gas fuel, it is necessary to develop technologies for the production of high-pressure cylinders. There is no production of cylinders in Georgia, although work on the creation of such technologies was underway. The article describes the processes of development of the mentioned technologies. Technologies for the production of metal cylinders as well as polymer composite cylinders are discussed. In the case of polymer cylinders, we use basalt fiber produced in Georgia as reinforcement fiber.

Introduction

In order to create common standards for the development of constructions and manufacturing technologies of high-pressure cylinders for motor transport, the first steps were taken with the document developed by the United Nations "Agreement on Adoption of Common Technical Regulations for Wheeled Vehicles" (14.03.01).

According to this document, a high-pressure cylinder can be made by any method from steel, aluminum or non-metallic materials and have any construction that corresponds to the operating conditions.

When designing the cylinders, the main determining parameters are the working pressure of natural gas of 20 MPa and the maximum filling pressure of 26 MPa. According to the mentioned agreement, CNG (compressed natural gas) cylinders are divided into the following four types:

1. CNG -1 metal cylinder;
2. CNG -2 cylinders with a metal body, reinforced with resin-impregnated fiber thread on the cylindrical surface;
3. CNG -3 cylinder with a metal body, reinforced with resin-impregnated fiber thread on the entire surface (full winding);
4. CNG -4 cylinder with a non-metallic (for example, polyethylene) body, reinforced with resin-impregnated fiber thread on the entire surface (full winding);

Metal cylinders

It was planned to utilize the production of metal cylinders in Georgia. In particular, an experimental factory was built in the town of Vaziani. At the proposal of the International Oil Corporation of Georgia, on May 6, 2005, an agreement was signed with "Georgian International Oil Corporation", "Manufacturing Union" and "Georgian Oil Pipelines Company" (participants in the listed order) on joint activities, on the establishment of partnership "NEW GEORGIAN TECHNOLOGY".

According to this agreement, a partnership was created without creating a legal entity. The purpose of the newly created company was to create a high pressure metal cylinder plant for natural gas. After signing the contract, the repair work started. Natural Gas High Pressure Metals Enterprise has taken important measures in the production area to organize the release production of compressed gas high pressure cylinders for automobiles.

Natural gas-powered vehicles are one of the most environmentally friendly forms of transportation, as they reduce CO_2 consumption by 25% compared to diesel or gasoline-powered vehicles [1]. The emission rate is reduced by 6-8 times. The use of diesel and gas hybrid vehicles improves the environment by 20% compared to diesel-only vehicles. Natural gas consumption is 45-50% cheaper than gasoline. In order to improve the environmental situation, many European countries already apply tax incentives for consumers who use gas as fuel [2].

The metal cylinder manufacturing plant is located in Vaziani, Gardabani district, on the Kakheti highway, 25 km from the city. The total area of the factory is 3000 sq.m. A modern infrastructure has been created in the area, with two access roads to the highway and a railway track on the side. The founding director of the factory was Professor Geno Susferidze.

The metal cylinder manufacturing technology that will be used in this factory is as follows. Cylinders are being manufactured in the so-called From seamless rolled pipes. They are cut to size by plasma cutting, after which their end is heated through an inductor and rolled on a special device (Fig. 1). On one side of the tube, a gas loading neck is made, and on the other side, the bottom of the cylinder (Fig. 2).

Fig. 1. Tube deformation device.

Fig. 2. Deformation at the end of the pipe.

The technological operations include the heating furnaces necessary for tempering the cylinders (Fig. 3.) and the cooling tank, which is filled with water or oil (Fig. 4).

According to the technology, a screw for a gas loading nozzle and a tap is cut in the neck of the cylinder using a special milling operation. After that, the cylinder is finished, painted and the tap connector is screwed using sealing grease. Fig. 5 shows the final appearance of the metal cylinder.

Fig. 3. Stoves for heating cylinders.

Fig. 4. Cooling the cylinders in the tank for hardening.

Fig. 5. Metal automotive gas cylinder.

Polymer-composite cylinders

To make polymer-composite cylinders, we first prepare a polyethylene liner and then wrap it around a fiber thread impregnated with a binding material, for example, polyester.

To make a polyethylene liner, the so-called liner is first pressed. lids. For this, we have made pressure molds that will be mounted on a vertical press [3]. A container for melting polyethylene powder rises above the mold. The powder is melted by an electric heater, and under the pressure of a pressure piston, the molten polyethylene flows into the mold and fills it. As a result, we get polyethylene caps.

To get a polyethylene liner, we will weld polyethylene caps on both ends of the polyethylene pipe cut to size. The welding process is carried out using a special welding machine, which is equipped with the so-called with an iron. Through the latter, we close the torets with a polyethylene tube and cap and press them together.

In the end, we prepare polyethylene liners (Fig. 6.), on which we will further wrap fiber thread impregnated with binding resin. In our case, we use basalt fiber produced in Georgia [4].

The construction material of the balloon, under pressure, is stretched in two mutually directed directions. A wall element bounded by two equally spaced longitudinal and transverse sections is subjected to transverse σ_y and longitudinal σ_x stresses calculated by the following formulas:

$$\boldsymbol{\sigma_y = \frac{P \times d}{2H}} \tag{1}$$

$$\boldsymbol{\sigma_x = \frac{P \times d}{4H}} \tag{2}$$

The technology of making polymer reinforced cylinders consists of two parts. The first is the production of a polyethylene liner, and the second is the winding of fiber thread soaked in polyester on the liner; as a result, a polymer composite balloon is made (Fig. 7). Formulas (1) and (2) are used to determine the length of the winding fiber.

Fig. 6. Polyethylene liners.

Fig. 7. Polymer composite cylinder

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Enguri Hydroelectric Dam Georgian Engineering Masterpiece

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Abstract: The Enguri Hydroelectric Dam stands as a Georgian engineering marvel, situated on the Enguri River in Tsalenjikha, Georgia. Rising to 271.5 meters, it claims the title of the world's second highest concrete arch dam. Construction commenced in 1961, fulfilling Soviet ambitions for hydroelectric power. Operational since 1978, its completion in 1987 solidified its status. Overcoming challenges, including a state of dilapidation in 1994, it underwent extensive repairs funded by international support. With 20 turbines generating 1,320 MW, it contributes significantly to Georgia's energy supply. Despite environmental considerations and ongoing rehabilitation efforts, the Enguri Dam remains a testament to Georgian engineering prowess and national energy independence.

Key words: Hydroelectric Power, Concrete arch dam, Construction, Energy supply, Rehabilitation

The **Enguri Dam** is a hydroelectric dam on the Enguri River in Tsalenjikha, Georgia. Currently, it is the world's second highest concrete arch dam, with a height of 271.5 metres (891 ft). It is located north of the town of Jvari. It is part of the Enguri hydroelectric power station (HES) which is partially located in Abkhazia.

History

Soviet First Secretary Nikita Khrushchev initially proposed a major dam and hydroelectric power scheme on the Bzyb River as his favorite resort was located near the mouth of the river at Pitsunda. However, his experts informed him that a dam built on the Bzyb River would have had catastrophic effects in causing beach erosion at Pitsunda, so in the end the dam was built on the Enguri River instead, where the impact upon the coastline was assessed to be considerably less pronounced.

Construction of the Enguri dam began in 1961. The dam became temporarily operational in 1978, and was completed in 1987. In 1994, the dam was inspected by engineers of Hydro-Québec, who found that the dam was "in a rare state of dilapidation". In 1999, the European Commission granted €9.4 million to Georgia for urgent repairs at the

Enguri HES, including replacing the stoplog at the arch dam on the Georgian side and, refurbishing one of the five generators of the power station at the Abkhaz side. In total, €116 million loans were granted by the EBRD, the European Union, the Japanese Government, KfW and Government of Georgia. In 2011 the European Investment Bank (EIB) loaned €20 million in order to complete the rehabilitation of the Enguri hydropower plant and to ensure safe water evacuation towards the Black Sea at the Vardnili hydropower cascade.

In the early 1980's, a series of radio relays were built to connect the Enguri Dam with the Hudoni Dam, which was under construction. The relays were in remote territory with no access to electricity, and thus were powered with a series of eight radioisotope thermoelectric generators (RTGs). However, the Hudoni dam's construction was stopped as Georgian independence from the Soviet Union drew near. The stations and their RTGs were abandoned and eventually dismantled. The RTG's became lost at this time. Two were rediscovered in 1998, leading to no injuries. Two more were found in 1999, and again led to no injuries or significant radiation exposure. Two more were rediscovered in 2001, which led to the Lia radiological accident. The other two sources remain unaccounted for.

Technical features

Distribution of the Enguri HES facilities in Abkhazia and Georgia proper.

The Enguri hydroelectric power station (HES) is a cascade of hydroelectric facilities including, in addition to the dam - diversion installation of the Enguri HES proper, the near-dam installation of the Perepad HES-1 and three similar channel installations of the Perepad HESs-2, -3, and -4 located on the tailrace emptying into the Black Sea. While the arch dam is located on the Georgian controlled territory in Upper Svanetia, the power station is located in the Gali District of breakaway Abkhazia. Enguri HES has 20 turbines with a nominal capacity of 66 MW each, resulting in a total capacity of 1,320 MW. Its average annual capacity is 3.8 TWh, which is approximately 46% of the total electricity supply in Georgia as of 2007. According to the 1992 agreement Abkhazia gets 40% and the rest of Georgia gets 60%, however in the late 2010s the Abkhazian consumption increased significantly driven in part by bitcoin mining.

The facility's arched dam, located at the town of Jvari, was inscribed in the list of cultural heritage of Georgia in 2015.

The Activity

The legal form of the Enguri Hydropower Plant is a limited liability company. The founding partner is the state represented by the Ministry of Economics and Sustainable Development of Georgia. Accordingly, the share of the state in the capital of Enguri LTD is 100%.

The main activity of the Enguri Hydropower Plant is the production and realization of electricity. Currently, the plant operates reliably and properly. Its contribution to the country’s power supply is more than 35%. In the 41 years of its existence, the Enguri Hydropower plant has generated more than 120 billion kWh of electricity. In 2015, by the decree of the Government of Georgia, the Enguri HPP arch dam was awarded the status of a cultural heritage monument.

Enguri HPP is a guarantee for Georgia's energy independence. We can say without any doubt, that the Georgian power system can not function without Enguri HPP and if it does, only with high costs. It is worth to mention, that the Enguri HPP is a unique construction and the same size Hydropower plant can not be built in the future. The main reason for this is the lack of appropriate physical-geographical conditions.

The Enguri HPP has a special state significance along with the weighty energy importance. This is the only place, where Georgians and Abkhazians work together as the importance of the joint operation of the plant is well understood by both sides. Obviously, the Enguri HPP is the basis of the country's energy potential. On its steadfastness and full work is based the country's energy system and the degree of energy independence.

Environmental Impact

The original phases of the project were categorised B/1 and Phase V of the Enguri HPP - Climate Resilience Upgrade is now categorised B (2014). The rehabilitation of components of the Enguri hydropower scheme (namely Vardnilli 2, 3 and 4) is anticipated to be associated with environmental or social impacts that can be readily identified and addressed. Environmental and social (E&S) due diligence for this phase of the rehabilitation of the Enguri hydropower scheme will be undertaken both internally and with the support of external consultants. The main E&S risks or issues that are to be assessed during the due diligence are: (i) the occupational health and safety risks associated with the rehabilitation of Vardnilli 2, 3 and 4 powerhouses, (ii) the potential for key biodiversity features and social dependencies to have established since the Vardinilli scheme has been out of commission, (iii) the contextual risks triggered by the fact that works will need to be implemented on both sides of the administrative boundary line, and, (iv) the management of contractors undertaking the rehabilitation works. This approach remains consistent with the previous phases of the project, however, a new environmental and social action plan (ESAP) will be developed for this component of the project as it is sufficiently discrete from the previous phases, and will be agreed with Engurhesi, in order to address the identified E&S risks. This section of the PSD will be updated following the completion of the ESDD.

History of construction of Engur HPP

The great publicist and public figure Niko Nikoladze first started thinking about the use of Georgia's rich hydroelectric resources. For this purpose, he even sent his son from St. Petersburg to conduct a professional analysis of the rivers of Georgia.

Invited by Niko Nikoladze, the famous St. Petersburg engineers Fyodor Ropp and Boris Bakhmetev chose Enguri for the construction of the hydroelectric power station on his advice. Due to reasons related to the high cost of construction, the First World War and the hesitation of the invited investors, the attempt to invest money for this issue ended in vain. Niko Nikoladze spent 20 years fighting for the use of Enguri's hydro resources, but the implementation of his idea turned out to be impossible at that time.

In 1913-1914, Italian specialists expressed an opinion about setting up a small-capacity hydroelectric power station on Enguri, but this project was not implemented either.

In 1926-1927, a scheme was worked out, according to which 13 hydroelectric power plants with a total capacity of 233 megawatts were to be built on the Enguri River, from the village of Valkhori to Anaklia, which also remained unimplemented.

Only in 1930, a longitudinal profile was built from the village of Lakhamuli to Jvari, as a result of which the effective areas providing energy power were identified.

The first steps to realize the construction of a hydroelectric power station on the Enguri River were taken in the second half of the 50s of the 20th century, based on the decision of the Government of Georgia. The Georgian department of "Hydroproject" of the USSR started work on the exploration and design-cost accounting documentation of the Enguri hydroelectric power station.

In 1954, the Energy Institute of the Georgian Academy of Sciences worked out a scheme for the construction of a cascade of hydroelectric power stations on Enguri. According to this scheme, the guaranteed capacity for the winter period was only 200 megawatts, which was considered a shortcoming of the project.

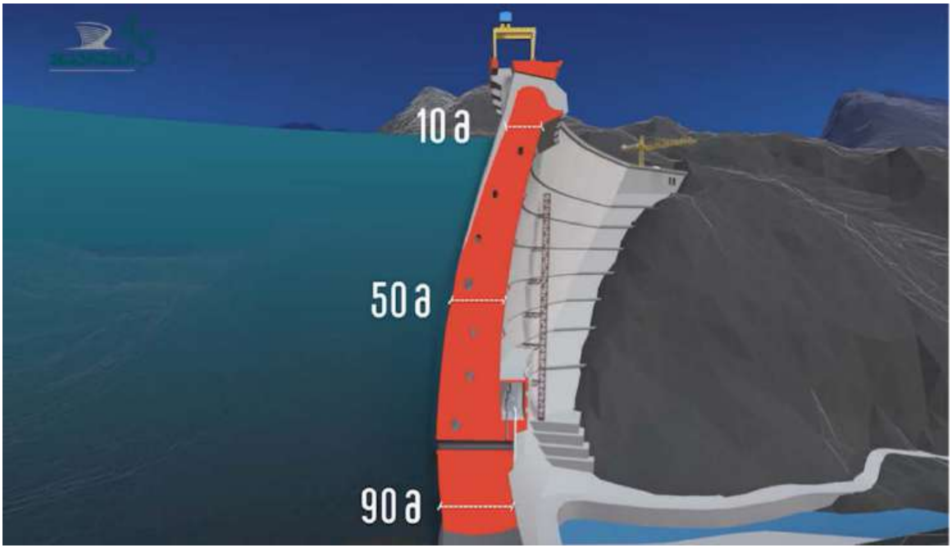
In 1960, "Hydroprojekt" worked out a scheme for using the Enguri River for energy purposes. Finally, the whole project of Engurhesi was created in 1965-1970, and the construction started in 1961.

The construction of Engur HPP was the implementation of the most daring idea in the history of Georgian technical thinking. This idea provided for the construction of the most complex complex of unique technical and engineering facilities, which many specialists looked at with suspicion. In order to justify and approve the project, it was necessary to overcome the greatest resistance. Skeptics considered this type of construction a fantastic idea and a utopia. The optimists were scared by the scale of the construction and the difficulty of the terrain, the supporters of the idea were worried by the grandeur of the future arched dam and the problem of seismic stability of the place.

In the first half of 1955, a complex expedition conducted hydropower and engineering-geological investigations of the natural conditions of the valleys of Enguri and its tributaries. A hydrogeological research expedition consisting of 50 people walked the steep slopes of the Svaneti mountains, the rocky beds of Enguri and its tributaries. Their main goal was to carry out soil-climatic and geological-topographical works. The research revealed that the unevenness of the terrain, the risk of earthquake resistance, and the variety of ground and soil required a special, unconventional approach to electrical construction.

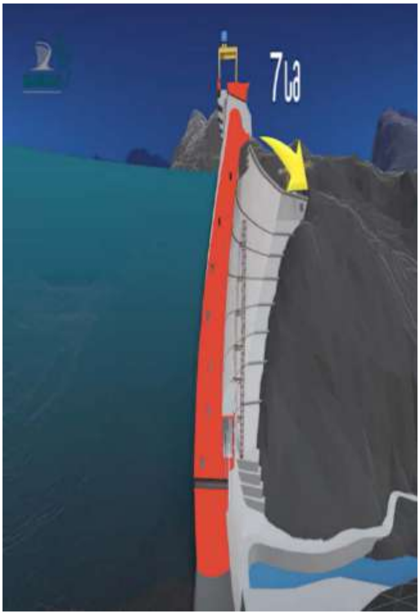
Arch dam

Many delegations of foreign countries have visited the Engurhesi complex at different times. Among them were professional hydrologists who came from the USA, France, Italy, England, etc. to see Engurhesi. The members of the delegation were surprised and could not hide their excitement because of the grand scale of the construction.



The dam has the shape of a sky arch and is curved like an arc. Engineers called its shape a double-arched curve, since the convex part of the sphere is directed upwards towards the reservoir, and the bottom and shoulders are attached to the walls. Such a shape increases the resistance force to prevent the flow of water. The supporting part is saddle-shaped and is separated from the arched dam by a perimeter seam. The height of the saddle is 15-20 meters from the slope, 60 meters in the lower part of the valley.

Sometimes it is also called alive, because it deforms by 7 centimeters during the seasonal rise and fall of water, which is a great finding for an engineer.



Rehabilitation

In 1997, in order to study the condition of the Enguri hydroelectric power station and to determine the scope and priorities of the necessary rehabilitation works, the study and analysis of the structures of the Enguri HPP was started. In 1998-1999, a large-scale project for the rehabilitation of the Enguri hydroelectric power station was developed. According to the plan, during the 3-month stoppage of the station, the rehabilitation of the Enguri dam and the urgent-emergency safety works of the pressure tunnel were carried out. Within the framework of the project, all units were rehabilitated, as a result of which Engurhes reached its design capacity of 1300 MW.

At the initial stage of Enguri HPP rehabilitation, a new support shield of Enguri dam was manufactured and installed. At the same time, rehabilitation works of electromechanical and hydromechanical devices were carried out at Vardnilhesi I. Rehabilitation/construction works of Vardnili dam, sluice structures and main channel were carried out.

In order to ensure the reliable and smooth operation of the Engur HPP, the fourth phase of rehabilitation is planned for 2018-2022. Within the mentioned initiative, construction-rehabilitation, monitoring, hydro-mechanical and electro-mechanical works are planned.

In conclusion I want to say that, The Enguri hydroelectric station is the largest and most spectacular construction in the history of Georgia. Such a structure belongs to a unique type of construction. Its construction included difficult tasks and problems, although the

Georgian construction and engineering departments played an important role in its construction. Despite the existence of many problems and large costs, today in Transcaucasia there is the largest arch dam in the world for decades. This reflects the level of Georgian engineering qualification in the world of engineering.

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New Generation Building Materials

Davit Maisuradze (Master program student), Supervisor: Professor Tamar Esadze-Gegeshidze, Georgian Technical University

Abstract: The article discusses the role of modern technologies and innovative materials in revolutionizing the construction industry, focusing on sustainability and energy efficiency. It introduces smart materials, such as Simprolite polystyrene-concrete and self-healing concrete, which enhance building performance and environmental impact. Also highlighted are thermobiometal and light-emitting cement, which adapt to environmental changes and offer sustainable lighting solutions, respectively. Advancements like smart bricks and photoelectric glass integrate functionality with aesthetic appeal, contributing to energy generation and efficiency.

The text emphasizes the importance of smart insulation materials, like phase change materials, in reducing heating and cooling demands. Examples from Germany, including the R128 House and the BIQ House, illustrate the country's commitment to energy-efficient, sustainable building practices, showcasing innovative designs like the KfW Westarkade's dynamic facade for optimized energy use. These developments underline a global shift towards environmentally friendly construction through cutting-edge technologies and materials.

Key Words: Sustainability, energy efficiency, innovative materials.

Modern technologies and new approaches to work have penetrated practically all areas, and construction is no exception. This field has consistently offered progressive solutions to improving living and working conditions, as well as addressing the world's most significant challenge: climate change.

Accelerating the pace of scientific and technical progress in the field of building materials production is an urgent task. This involves the introduction of new technologies and promising materials. Smart materials represent the latest technological breakthrough in the material science industry.

These are effective materials that respond to changes in the climate. They are:

- Sensitive to the environment
- Capable of responding to harsh environments
- Sustainable
- Easily installed

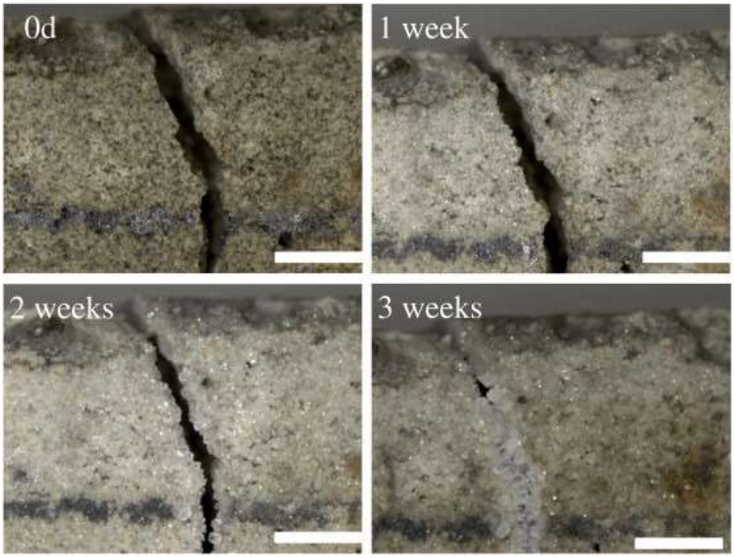
Smart materials represent the future of construction. These materials need to be efficient and exert a positive impact on the environment.

Significant emphasis should be placed on adopting energy-efficient practices and utilizing renewable energy sources, contributing to the improvement of the country's ecological conditions towards a healthy and sustainable future. Energy efficiency involves the efficient use of local heating and energy resources, the integration of innovative technologies, and the practical application of energy-saving measures.

A new, unique material for energy-efficient buildings has emerged: Simprolite polystyrene-concrete. Simprolite is a patented mixture consisting of expanded polystyrene granules, Portland cement, and special additives. It stands out as the lightest among lightweight concretes, boasting the best thermal insulation performance. The use of Simprolit blocks significantly reduces the load on a building's structural elements, leading to smaller dimensions, fewer reinforcements, and a reduction in all other elements that directly influence the cost of construction. Remarkably, Simprolite polystyrene-concrete is the only material in the polystyrene class that is non-combustible, effectively addressing fire safety concerns. Its properties include frost resistance, environmental friendliness, moisture resistance, fire resistance, sound insulation, and fire resistance. These characteristics make it highly versatile for widespread use.

A novel material, self-healing concrete (also known as bioconcrete), has been developed. Concrete, despite being the most widely used construction material, is prone to cracking. Researchers in the Netherlands have developed a type of concrete capable of self-repairing these cracks. Incorporated into the concrete are microgranules that, upon cracking, release a glue-like epoxy resin that aids in the repair process. This innovative type of concrete holds potential for use in streets and sidewalks, offering a solution to the longstanding issue of concrete durability and maintenance.

- It is energy-efficient.
- It features self-healing of cracks.
- It is a sustainable material option.
- It is durable.



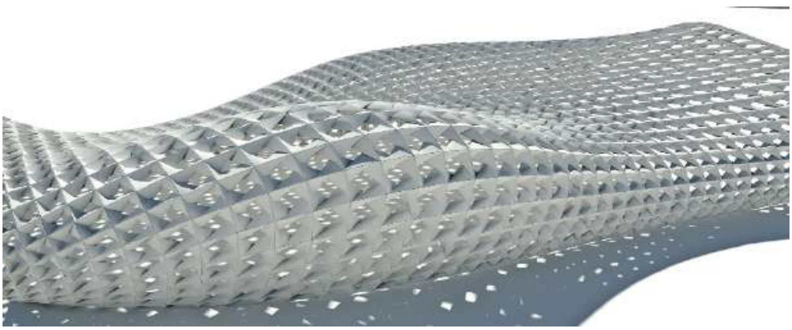
Thermobiometal - a metal that "breathes." This smart material responds to temperature and climate conditions, capable of creating shaded spaces and altering its shape. Upon heating, the material curls, and when cooled, it flattens, demonstrating its:

- Self-reactive nature

- Efficiency and durability

- Lightness and ease of handling

An innovative application of thermobiometal is the Bloom installation, designed by architect Doris Sung. Located at the Materials and Applications Gallery in Los Angeles, Bloom is constructed from 14,000 thermobiometal components that bend in response to heat. This sensitivity enables the structure to form shadows, showcasing the material's unique capabilities.



Light-emitting cement is an innovative material designed to emit light. During the day, it absorbs natural light and glows at night, thanks to a microstructure that captures solar energy. A notable application of this material is in Eindhoven, where a bike path, reminiscent of a maglite, utilizes light-emitting cement. This cement also incorporates phosphorus, enhancing its luminescent properties. This path not only illuminates the way for cyclists and pedestrians after sunset but also showcases a sustainable approach to lighting public spaces.

Smart brick represents another leap forward in building materials, merging cutting-edge technology with the traditional appeal of brickwork to offer modern functionality. It provides a unique blend of aesthetics and utility with several variants tailored for different construction needs:

- Solar bricks equipped with building-integrated photovoltaics (BIPV) generate electricity, offering a sustainable energy solution for buildings.
- Bricks featuring moisture and sound insulation systems enhance the durability and comfort of structures, ensuring a superior living environment.

- Bricks with built-in sensors that monitor environmental conditions, maintaining optimal indoor temperature and humidity levels, thus contributing to the building's smart management and energy efficiency.

Photoelectric glass is a groundbreaking technology in the pursuit of eco-friendly energy sources. This innovative photovoltaic glass transforms sunlight into electricity, diverging from traditional solar panels that require specific mounting spaces. Instead, it can be seamlessly integrated into building facades, windows, and other architectural elements, making every surface an efficient energy generator. One of the key benefits of photovoltaic glass is its aesthetic compatibility with architectural designs. Unlike the bulky appearance of conventional solar panels, which can detract from a building's visual appeal, photovoltaic glass maintains transparency or semi-transparency. This feature allows natural light to permeate while simultaneously generating solar energy, providing a dual-purpose solution that upholds energy efficiency without sacrificing the building's aesthetic integrity.

With the global push towards environmental sustainability, the construction industry is on the hunt for innovative ways to slash energy consumption. Smart insulation materials are emerging as a key player in this quest. Among these, phase change materials (PCM) stand out for their remarkable ability to absorb, store, and release thermal energy during phase transitions. Smart PCM-based insulation is a game-changer, offering significant reductions in heating and cooling demands by maintaining stable indoor temperatures. As the outside temperature increases, the PCM absorbs excess heat, preventing the interior from becoming uncomfortably warm. Conversely, in cooler conditions, it releases stored heat, keeping the indoor environment pleasantly warm without heavy reliance on conventional heating systems.

The integration of smart building materials extends beyond insulation, permeating residential construction and offering homeowners energy-efficient, technologically sophisticated living environments. Innovations include smart windows that dynamically adjust their transparency in response to sunlight, and self-regulating heating systems that optimize comfort and sustainability.

The commercial sector is not lagging behind in adopting smart building materials, leveraging them to enhance energy efficiency, lower operational costs, and foster sustainability. From smart lighting systems that adjust based on occupancy and natural light levels to sustainable facades that improve thermal performance, and intelligent systems that streamline building operations, these materials are revolutionizing the efficiency of commercial buildings, paving the way for a more sustainable and cost-effective future in construction.

Germany's dedication to energy efficiency in building practices is evident through its innovative designs and technologies that aim to reduce energy consumption and environmental impact. Among the notable examples of such commitment is the R128 House in Stuttgart, often referred to as an Active House. Designed by Werner Sobek, the R128 House stands as a testament to energy-efficient architecture, setting a benchmark for net-zero energy buildings. This house distinguishes itself by producing more energy than it consumes, thanks to a combination of photovoltaic panels, superior insulation, and the incorporation of passive solar design principles. These features work in tandem to drastically reduce the house's energy demand while optimizing the generation of renewable energy, showcasing a forward-thinking approach to sustainable living.

2. The BIQ House, situated in the HafenCity district of Hamburg, marks a groundbreaking achievement in sustainable architecture as the world's first building equipped with a bioreactor facade. This pioneering project,

realized through the collaboration of Splitterwerk Architects and Arup, features a facade that houses bioreactors filled with microalgae. These microalgae serve a dual purpose: they produce biomass and generate renewable energy via photosynthesis. This innovative system not only offers effective shading but also plays a significant role in carbon dioxide capture, contributing to the reduction of the building's carbon footprint. Furthermore, it generates renewable heat energy, thereby enhancing the building's energy efficiency. The BIQ House exemplifies a novel approach to building design, integrating living systems into the fabric of the structure to achieve sustainability and energy independence.

3. The KfW Westarkade in Frankfurt stands as a paradigm of energy efficiency in the commercial office building sector. Designed by the architectural firm Sauerbruch Hutton, this building is distinguished by its innovative, dynamic double-layer facade. This smart facade is engineered to automatically adjust, optimizing daylight use and natural ventilation, significantly reducing the reliance on artificial lighting and

air conditioning while simultaneously minimizing solar heat gain. Furthermore, the building incorporates a suite of sustainable features that enhance its energy efficiency, including highly efficient HVAC (Heating, Ventilation, and Air Conditioning) systems, energy-efficient lighting solutions, and the integration of renewable energy sources. Together, these elements synergize to lower the building's overall energy consumption and carbon footprint, positioning the KfW Westarkade as a leading example of sustainable office design and a beacon of environmental responsibility in the commercial sector.

These and many other examples highlight Germany's leadership in the design and construction of energy-efficient buildings, showing how innovative technologies and design strategies can be used to create environmentally friendly and high-quality buildings.

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Calculation and Comparative Analysis of Reinforced Concrete Elements

Gaga Matsaberidze (Bachelor program student), Supervisor: Professor Lia Balanchivadze, Georgian Technical University

Abstract: One of the main principles of human practical activity is to make the best decisions under the given conditions. The topic of optimal design of constructions has been attracting special attention for a long time, and therefore a significant part of scientific research has been devoted to this issue. Interest in optimal design has increased especially in connection with the need to build multi-story buildings and skyscrapers.

Key Words: multi-story buildings, reinforced concrete, deformability characteristics, LIRA-SAPR, EUROCODE-2

Improving the existing methods of calculating the strength of reinforced concrete and searching for new ways to solve them, which ensure the reliability of the construction on the one hand, when the strength and deformability characteristics of the used material are used to the end, are the main requirements for optimal design of buildings, as a result of which the cost of construction and the cost of materials are reduced.

Reinforced concrete bending elements represent 70% of the load-bearing structures in buildings, that's why ensuring their strength and durability determines the stability of the entire building.

The increased demands placed on building structures and buildings in terms of strength, stability, economy and other criteria require the engineer to ask and solve complex optimal tasks of building structures and buildings.

Along with the development of construction, various construction standards were developed and formed, according to which projects are prepared and which were the basis for optimal design of constructions.

• Research conducted on a numerical example with different calculation methods

It allows to take into account the peculiarities of construction design allow.

In particular, a specific numerical example was carried out and calculated:

• limit states (with BR);

• finite elements (LIRA-SAPR);

• Calculations according to the deformed scheme of Eurocode 2.

Calculations are performed by the most common methods based on those given in different numbers - according to limit forces

BR2.03.01-84 and according to the frame rod model according to Eurocode 2.

Comparison of calculation methods was carried out according to the finite element model calculation program LIRA 2013 in R3. The norms used are: RB 2.03.01-84 and EUROCODE-2. Table 1 shows the calculation schemes provided.

The standards of all these countries, as well as the load values and reliability coefficient. strength calculation formulas, reinforced concrete bending elements are also given the said table.

Table 1

Comparative analysis of the calculation of reinforced concrete beams					
description	According to standards				
	BR-84	BAEL -91	CP 110	DIN-1045	USA 318-83
Standard load (gn+Vn) kn/m	50,6	50,6	50,6	50,6	50,6
Design load $(\gamma g_n + \gamma v_{ns})$; kn/m	59,4	71,9	75,64	50,6	77,48
Bending moment M, kn.m	267,3	323,55	340,38	227,7	351,18
Reinforcement area of the compressed zone A_s'; mm^2;	0	121	639	90	179
Reinforcement area of the tension zone A_s'; mm^2;	1610	2275	2302	2130	2159,2
Total reinforcement area $A_s' + A_s$;	1610	2396	2941	2220	2338,4

with concrete class B25, deformation modulus E=3,006,000 t/m2, Poisson's ratio - 0.2, according to BR 2.03.01-84.

- Concrete with class C20, deformation modulus E=3 100,000 t/m2, Poisson's ratio - 0.2, according to EUROCODE 2;
- Reinforcement with class A400C (working reinforcement) and A240 (for hangers), according to BR 2.03.01-84;
- Armature with class A500C according to EUROCODE 2;
- Eurocode -2, when designing concrete and reinforced concrete, uses the cylindrical strength of concrete, not the prismatic one, that is, it turns out that when designing the same structure, we use different strength and deformability characteristics:
- The load that concrete designed with BR receives is more reliable than with Eurocode - 2. Because the prismatic strength of concrete is 0.95 MPa, and that of Eurocode 2 is 2.2 MPa.
- Eurocode - 2 suggests to use higher classes of reinforcement, however, by analyzing the force graphs, we see that it is easier to design with Eurocode 2, because it does not take into account the change of cross-section along the entire length, which increases the reliability of the construction, but makes it more expensive. The amount of reinforcement and the type of anchoring in the supports and bars of the structure calculated according to the snip are also changed.

- There is also a difference in the anchoring rules, in the order and quantity of transverse reinforcement in the section. When designing the same coil of reinforced concrete (with snips and Eurocode 2), the amount of reinforcement is quite high compared to snips, which is due to the calculation according to Eurocode 2, where the loads are significantly higher.
- When comparing the norms of BR2.03.01-84 and the calculation method according to Eurocode 2, it was determined: that BR2.03.01-84 is based on the limit equilibrium method, and the European codes are based on the frame-stem scheme, despite the principle difference, the method of calculating the strength of inclined sections is preserved in both methods. According to the BR2.03.01-84 method, the tensile strength of the element is 1.5% lower than according to Eurocode-2.
- The principle difference between our norms and Euronorms is the assessment of the frequency of load modes and the danger of their modes. This is the reason for the calculation results of reinforced concrete constructions not matching the existing norms.

The research carried out on a numerical example with different calculation methods allows to take into account the features of construction.

Conclusion

1. Eurocode 2, which is dedicated to the design of concrete and reinforced concrete, uses the cylindrical strength of concrete and not the prismatic one, that is, it turns out that when designing the same structure we use different characteristics of strength and deformation: the load experienced by concrete. Obtained by the developed fragment, it is more reliable than Eurocode 2-c, because the prismatic strength of concrete is 0.95 MPa, while Eurocode 2 is 2.2 MPa.

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Tallest Buildings in the World

Giorgi Michilashvili (Bachelor student)_Supervisor: Professor Maia Chanturia, Georgian Technical University

Abstract: Tall buildings have fascinated mankind since the dawn of civilization. e.g. 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 high-rise buildings. The construction and development of modern multi-storey buildings began at the end of the 19th century, and they have a wide range of commercial and residential purposes. The development of high-rise buildings is taking place along with the growth of cities.

Key words: high-rise, buildings, tower, godol, reinforced concrete, metal.

Introduction

The process of urbanization that started with industrialization continues in developing countries. The construction of multi-storey buildings depends on the available materials, construction technology and appropriate service. In ancient Rome, multi-story buildings were built of wood. After the Great Fire of Rome, Nero used bricks and concrete-like materials. But the strength of wood was not enough for buildings five stories high. Since the end of the 11th century, high-strength and structurally more efficient materials such as steel and reinforced concrete have been used.

Main Part

According to an ancient Jewish myth, after the global flood, people (Mesopotamia) decided to build a city and a tower that would reach the sky. Enraged by man's insolence, God confused their language and scattered them over the whole earth. The unfinished city was called Babylon. Some modern scholars associate the Tower of Babel with famous structures, especially the ziggurat of Etemenanki, dedicated to the Mesopotamian god Marduk in Babylon (Fig. 1).

Fig. 1

People have always had a desire for the sky, many centuries-old structures had a ritual purpose, such was the Pyramid of the Sun - the largest pyramid of Teotihuacan, one of the largest in the Americas and located along the Avenue of the Dead, near the Pyramid of the Moon. Its length reached 224,942 meters, and its height reached 75 meters, after which it became one of the largest pyramids in the world; However, it is only half as tall as the Great Pyramid of Giza (146 m), which was built as the final resting place of Pharaoh Cheops. It is amazing that they have endured for centuries and still amaze the visitor today (Fig. 2).

Fig. 2

Centuries passed and the desire of people to reach the sky did not slow down. If earlier tall buildings were built with the desire to be close to God, then the purpose changed, this is what happened when the French engineer Gustave Eiffel came up with the idea of building a tower, which proudly reminds us of the faith in the progress of France in the 19th century and the perfection of science and civilization. the leading role of technology. The 350-meter-high tower was designed and built by Gustave Eiffel as a kind of monumental gateway to the 1889 World Exhibition in Paris (Fig. 3). At the time, it was the tallest structure in the world, taller than the Egyptian pyramids or Gothic cathedrals.

Fig.3

The Empire State Building is a 102-story modern art deco building in New York City, built in 1931. The skyscraper was named after the nickname of the state of New York and is still the tallest building in the city of New York. The American Society of Civil Engineers named the building one of the Seven Modern Wonders of the World. The building also belongs to the world's largest skyscraper federation. Construction of the Empire State Building was on pace to take the title of world's tallest building from the Chrysler Building. It remained the tallest skyscraper in the world for a record 41 years, until the completion of the World Trade Center and shortly after the Sears Tower. After the terrorist attacks of September 11, 2001, the Empire State Building became the tallest building in New York and the 2nd tallest building in the United States. The building's distinctive Art Deco chemistry was originally intended to be an airship depot, but after several attempts the idea proved impractical and dangerous due to the gusty winds caused by the building's size. The Empire State Building is 381 meters tall at the end of the 102nd floor, and the full height of the building reaches 448 meters. The building officially opened on May 1, 1931, although a large television antenna was added in the 1950s (Fig. 4).

Fig.4

Each time had its own tasks, along with the growth of cities, when the number of people increased, it became necessary to build residential houses that could accommodate as many people as possible. For this purpose, modern skyscrapers were built in the largest cities of the world, which should be distinguished by their architectural style. More than a century has passed since the first skyscraper was built. It can be said that today there is a boom in skyscrapers in the world, which are distinguished not only by their height, but also by their design. It is known that the majority of skyscrapers are in China due to their needs (Fig. 5).

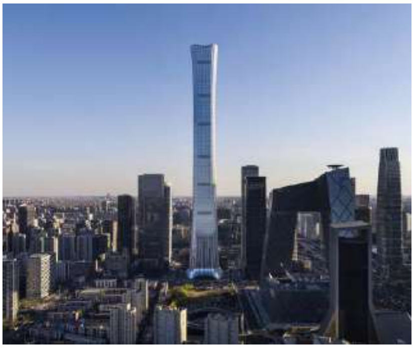 

fig.5. Tianjin financial center height 553 m; Guangzhou financial center height 530 m

Finally, the tallest building in the world - Burj Khalifa, located in Dubai, Saudi Arabia. Its main characteristics: construction - 2004-2010; Architect - Adrian Smith; Engineer - Bill Baker; height - 828 meters; floor - 163; Area - 389,472 sq.m.; Number of elevators - 57. The shape of Burj Khalifa derives from traditional Arab architecture and the initial flower of the shape is "Hymenocallis", which is an important part of Arab culture. However, such a shape is not only caused by beauty, and it is the basis of the strength of the building. The foundation was one of the main problems of the engineers, because the ground was loose even at a width of 140 meters, which would not allow the building to stand firmly, however, the engineers thought of something interesting, they laid the building on a large pad about 4 meters thick, and this pad was placed on 200 48-meter columns. They are supported, which in turn are completely buried in the ground and are supported on the basis of the force of friction generated between the ground and the concrete columns. It is interesting that the new brand of concrete, specially designed for this building, C50 and C80, was mixed with crushed ice, so that the concrete would not dry out quickly due to the hot climate, and it would reach the required strength. The building is structurally a rod, and its main axis is a hexagonal core, in which there are also elevators, after the hexagonal rod, so that the rod does not fall on its own, it has stiffened diaphragm walls on the sides, which also serve as a corridor, and are attached to the stiffened walls to prevent the building from turning against its axis due to the impact of wind. It also has load-bearing walls, which create a two-headed shape and turn the probability of turning into marginal norms. Based on aerodynamics and creative construction solutions, the building became the tallest building in the world. If the Burj Khalifa was symmetrical, it would cause resonant oscillations due to wind turbulence, which would eventually collapse the building, so the architect and engineers thought of an interesting thing, they made the building asymmetrical and spirally turned the stepped steps, which confused the wind flow and the resonance disappeared accordingly (Fig. 6).

fig.6

Jeddah Tower or Burj Jeddah is the latest skyscraper construction project in Jeddah, Saudi Arabia, which is planned to be the first 1km = 1000m tall building and will be the tallest building or structure in the world when completed, it will be 180m taller than the Burj Khalifa. The design, created by American architect Adrian Smith, who also designed the Burj Khalifa, incorporates many unique structural and aesthetic features. This is still unfinished, but the most ambitious project, the creator and leader of which is Prince Al-Walid bin Talal of Saudi Arabia, the grandson of Ibn Saud and the nephew of the kings of Saudi Arabia after Ibn Saud (Fig. 7).

Fig.7

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Reducing the Total Mass of Concrete in Residential or Industrial Buildings Using Wallspeed

Luka Modebadze (Bachelor program Student), Supervisor: Professor Gina Gureshidze, Georgian Technical University

Abstract: As a result of theoretical studies and trials, a material such as Abnie Moghavem Aria's production product, Wallspeed, appeared in the construction industry, which created an opportunity to practically eliminate the use of blocks, in interior partition walls, to maintain efficiency and obtain a significant economy of concrete. It is necessary to introduce a system of conducting tests on this material in the construction materials laboratories of Georgia, which can be used by any person with an engineering education.

Key words: reinforced concrete, concrete, block, wallspeed, polystyrene, construction

Introduction

New, effective building materials and constructions created on their basis are prerequisites for the development of the construction industry. A clear example of this is the concrete created in Rome and later the creation of reinforced concrete, the first simple constructions of which appeared in 1860-1880 and it remains the most demanded construction material, it is used in both residential and commercial construction. Reinforced concrete constructions are characterized by many good properties, which make this material a comfortable subject for the builder, high strength, stiffness, fire resistance, low operating costs, flexibility, resistance to atmospheric and many substances. However, the biggest problem of reinforced concrete constructions is the weight. Because of the latter, reinforced concrete buildings require antisemitic measures, additional strengthening of load-bearing elements and construction, large foundations, which ultimately significantly increases construction costs.

Along with the active use of iron and concrete, the tendency to lighten the overall weight of buildings by creating and using new efficient building materials appeared and developed. This tendency is related to the well-known question of the architect, theoretician Buckmister Fuller, "How much does your building weigh?".

From the end of the 19th century to the present day, the rapid development of scientific and technical progress is clearly visible in all areas of production, and new construction materials must meet the necessary standards, they must be characterized by fervent durability, be distinguished by strength, durability, etc.

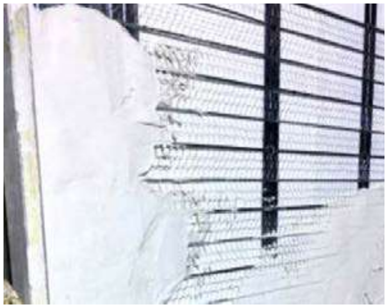
Main part

Since the appearance of reinforced concrete in construction, scientists, engineers and constructors have tried to find rational building materials that would reduce the use of iron and concrete to lighten the building, a good example of this is the use of Kobiax in inter-floor roofs since 1992, with the help of which the saving of inert material has significantly increased and the building has become lighter.

Also interesting in this direction is Abnie Moghavem Aria's company, whose products are known as Volspide, an Iranian system of Wallspide partitions, classified under the Drywall system, in which expanded polystyrene with a density of 20 kg/m^3 is used. This product can be used in interior partition walls. Expanded polystyrene is the main structure, and the strength of the panels is ensured by galvanized metal studs.

The Iranian company of Abnie Moghavem Aria has been in the construction industry for almost two decades and offers builders a product that virtually eliminates the use of any concrete production products in partition walls. It can also be used in prefabricated constructions.

Wallspeed panels are expanded polystyrene panels, length 3-7 meters, width 60-63 cm, height 8-20 cm. Installation of a special frame is required for the installation of panels, then the panels are inserted into the frame, it is also possible to cut off excess material for the panel in accordance with the shape of the wall and the project, metal grids are fixed on the installed panels, on which, with the help of cement, visible building materials can be reliably attached to the interior.

Wallspeed technical data in tabular form. The data is compared with the EU requirements for building materials.

Points	Data	Wallspeed S(E10C8)	Wallspeed S(E12C10)	Wallspeed S(E14C12)
Weight	Kg/m^2	4.83	5.445	6.2
Volume	Kg/m^3	22	22	22
Height	centimeter	425	580	620
moisture	%	Less than 1%	Less than1%	Less than 1%
Acoustic insulation	%	40	42	45
thermal conductivity	W/m.k	0.039	0.039	0.039
Behavior under fire	1-DIN4102 (B2)	Allowable slow burning; self extinguishing	Allowable slow burning; self extinguishing	Allowable slow burning self extinguishing
Fire Spread index	2-EN 13501-1 / EN 13823 /	Allowable	Allowable	Allowable
Spreading fire on the surface	EN ISO 11925-2	Allowable self-extinguishing	Allowable self-extinguishing	Allowable self-extinguishing

Volspeed is a light building material, unlike the previously known building blocks, which is its biggest advantage, due to the latter, the duration of the construction process and financial costs are reduced. The lightness along with everything makes its logistics process much easier.

Stuff	Before Packing	After Packing
Wallspeed	4.5 kg/sq. m^2	19 kg/sq.m^3
A.A.C. Block	41 kg/sq.m^2	79 kg/sq.m^3
Hollow brick	57 kg/ sq.m^2	115 kg./sq.m^3
Norway Maple	69 kg/ sq.m^2	127 kg/ sq.m^3

This Abnie Moghavem Aria technology has been widely used in various countries such as Germany, Canada, France, Russia, Italy, Chile, Switzerland, Belgium, Turkey, USA, etc.

Conclusion

Based on the above, it should be said that using Wallspeed is possible

- Reduce the dead load in the building by 35%, which makes the building 60% more effective against earthquakes.
- Reduce the number of fatalities in the event of building collapse during an earthquake

- Due to the speed of its installation, the duration of construction is significantly reduced.
- Due to its ease of installation, anyone with the skills to use a few necessary items and tools can install it themselves.
- Wallspeed panels maintain the acoustic and thermal insulation requirements established by the standard and increase the overall area of the interior space.
- Simple installation process after its installation does not require much time.
- It provides an opportunity to attach any wall building material provided by the project.
- Reduces concrete usage and logistics costs.
- It has sound and heat insulation, due to the high density of polystyrene, this product meets international standards.

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Production of Feed and Industrial Phosphates Based on Wet Process Phosphoric Acid from Moroccan Phosphate Rock

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Abstract: The results of a study of the purification of wet process phosphoric acid produced from Moroccan phosphorites by precipitation are presented. The high content of fluorine and sulfur compounds in phosphoric acids necessitates their removal in order to use the acid in the production of feed and technical phosphates. To remove fluorides, a precipitation mixture consisting of soda ash and liquid glass has been proposed, the use of which makes it possible to purify acids to a fluorine content of 0.04-0.07%. Calcium hydroxide is used as a sulfate precipitant to achieve feed and technical requirements. Based on the research carried out, the optimal parameters and standards for the technological regime for the purification of extraction phosphoric acids by the precipitation method were established.

The annual population growth accompanied by the increasing demand for phosphoric acids and products based on them, together with the growing cost of raw materials and the need to process phosphate rock, led to intensive development of research and experimental-industrial developments related to the purification of extraction phosphoric acid (WPA).

World practice shows that none of the known purification methods allows to get rid of all kinds of impurities. Purification technologies are carried out by successive, step-by-step removal of impurities consisting of various stages. To obtain acids suitable for use in feed and technical purposes there is no need for such a complex organization of the technological process, due to the possibility of achieving the required degree of purification of individual components in one or two stages.

In the production of feed and industrial phosphates, one of the main regulated requirements is the content of fluorides and sulfates in the acid, the amount of which should not exceed 0.2 and 0.05 wt.%, respectively.

One of the new types of phosphate raw materials currently supplied to the Republic of Belarus is Moroccan phosphate rock. There are several methods of WPA purification, however, due to the high content of impurities in the acid produced from Moroccan phosphate rock (Table 1), as well as the high cost of organic reagents, the use of extraction, sorption, crystallization and ion-exchange methods is inexpedient for implementation under conditions of industrial production.

Table 1 – Chemical compositions of extraction phosphoric acids produced from Moroccan phosphorites.

Composition	Content, wt. %	
	WPA	Evaporated WPA
P_2O_5	22,640	48,02
F^-	1,800	0,263
CaO	0,289	0,179
MgO	0,095	0,173
Fe_2O_3	1,590	0,272
Al_2O_3	1,635	0,253
K_2O	0,098	0,019
Na_2O	0,328	0,049
SO_4^{2-}	3,350	2,937
SiO_2	0,734	0,085

The most promising and economically feasible method of purification of phosphoric acids, which are subsequently used in the production of feed and industrial salts, is the method of precipitation of impurities in the form of poorly soluble compounds.

Purification from fluorine compounds was carried out using precipitation suspension consisting of sodium liquid glass, soda ash and part of the purified phosphoric acid, in the process of preparation of which the following reactions occur:

$$Na_2SiO_3 + 2H_3PO_4 + nH_2O = 2NaH_2PO_4 + SiO_2 \cdot nH_2O$$

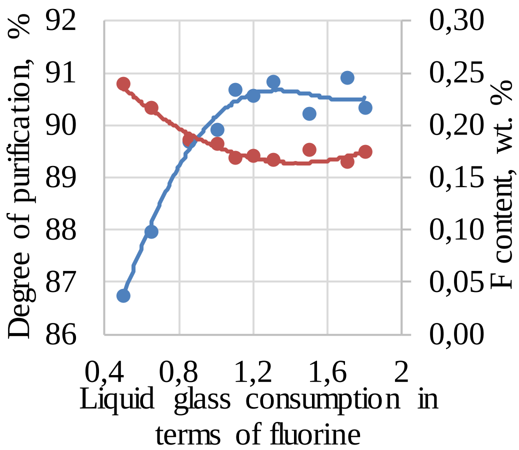
$$SiO_2 \cdot nH_2O + 6HF = H_2SiF_6 + (n + 2) \cdot H_2O$$

$$Na_2CO_3 + 2H_3PO_4 = 2NaH_2PO_4 + CO_2 + H_2O$$

$$Na_2CO_3 + H_2SiF_6 = Na_2SiF_6 + CO_2 + H_2O$$

$$H_2SiF_6 + 2NaH_2PO_4 = Na_2SiF_6 + 2H_3PO_4$$

The results of studies of the influence of consumption rates of precipitation reagents (Figure 1) showed that increasing their consumption leads to an increase in the degree of purification of wet process phosphoric acids from fluorine compounds up to a certain limit. This phenomenon is explained by the fact that the used suspension interacts with fluorine compounds represented by F^-, SiF_4^{2-}. However, it is unable to interact with more stable fluorine-containing complex compounds.



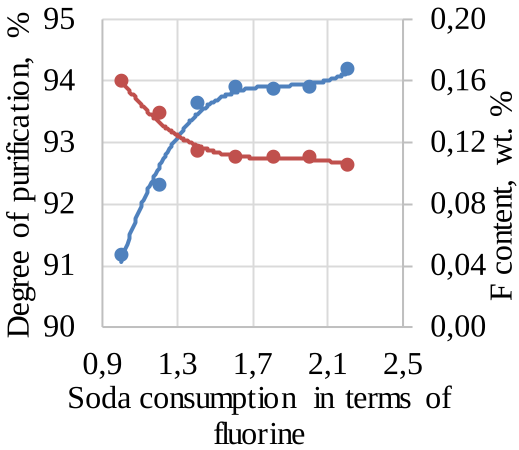


Fig. 1
Effect of liquid glass and soda consumption on the degree of purification and fluorine content in the purified WPA

The main stage of the process of purification of wet process phosphoric acid from fluorine compounds using precipitation suspension is the stage of growth of sodium hexafluorosilicate crystals. Analysis of the nature of the dependences of fluorine content in WPA on the process duration (Figure 2) showed that to achieve the maximum degree of decofluorination the process duration should be 60 hours.

Three zones can be observed on the obtained dependences: I – 24, II – 36 and III – 60 hours, respectively. The first zone corresponds to the process of Na_2SiF_6 crystal nucleation from a supersaturated solution. This zone is characterized by the maximum rate of phosphoric acid defluorination. The second zone is characterized by the growth of crystals, due to a decrease in the intensity of crystal formation, while the degree of defluoridation for the entire period is from 85.5 to 95.9 %.

The third zone is characterized by residual crystal growth, with insignificant change of fluorine content in purified WPA.

As shown by the analysis of the results of the composition of purified WPA, when using the precipitation method, in addition to F-, several impurities are removed. So, the degree of purification from iron and aluminium compounds for all types of phosphoric acids is 31.61 - 41.51 and 31.23 - 49.85 %, respectively. The decrease in the content of potassium and calcium ions is explained by the formation of potassium aluminosilicates and calcium fluoride in the sludge.

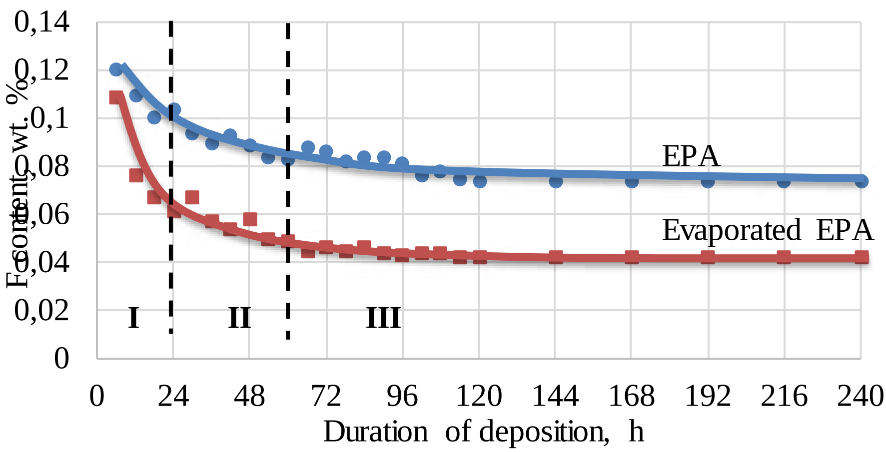


Fig. 2
Effect of deposition duration on fluorine content in purified WPA

Based on the conducted research, optimum parameters, and norms of technological mode at purification of extractive phosphoric acids by precipitation method are established, allowing to receive acid with fluorine content in the range of 0,04-0,07 wt. %.

Since the dominant impurity in WPA besides fluorides are sulfate ions, the main and determining stage in the purification process is the reduction of their content in the acid.

The main technological parameters affecting the quality of the obtained acid are the ratio of CaO : SO_4^{2-}, temperature and duration of the precipitation process.

In the course of studies, it was found that the use of excess precipitating reagent increases the degree of purification of WPA from sulfur-containing compounds, while purification from several other impurities is also observed. Thus, magnesium, iron and aluminium compounds are precipitated in the form of insoluble orthophosphates, fluorine-containing compounds pass into hard-to-soluble calcium fluoride, sodium and potassium compounds can be precipitated in the form of hexafluorosilicates or included in the structure of calcium sulfate crystalline hydrates.

It is established that the purification of WPA from metal impurities with increasing excess of calcium hydroxide occurs up to a certain value and then their content remains constant regardless of the ratio of CaO : SO_4^{2-}. However, with increasing the excess of calcium hydroxide also observed a negative effect - loss of P_2O_5 in the form of precipitating calcium phosphates and free phosphoric acid captured by calcium sulfate precipitate, while the degree of purification of components increases insignificantly.

The analysis of the dependence of sulfate content in purified WPA on the duration of the process (Figure 3) showed that for the first 30 minutes, characterized by the maximum degree of supersaturation and, accordingly, the speed of the process, the degree of desulfation reaches 63 %, and at the duration of 1 hour is 77.5 %.

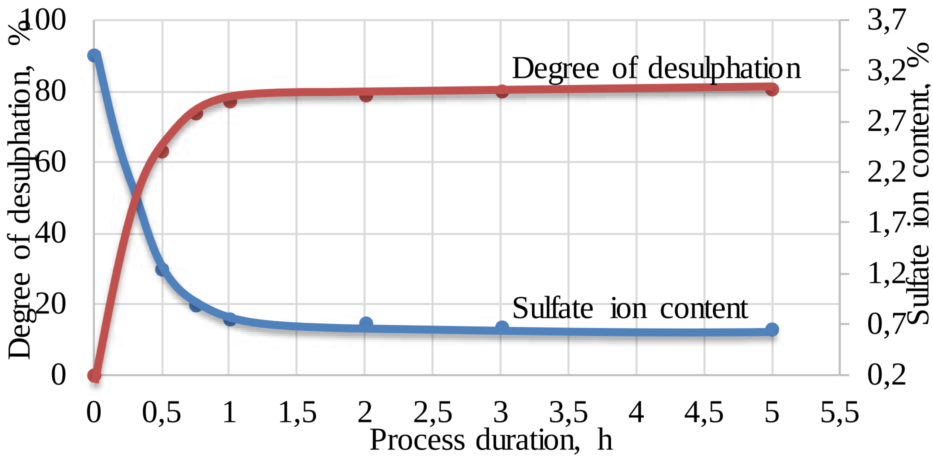


Fig. 3

Effect of sedimentation duration on sulfate content in purified WPA

Based on the conducted research the optimum parameters and norms of technological mode at purification of phosphoric acid, produced from phosphorites of Morocco, from sulfur-containing compounds by the method of precipitation by calcium hydroxide, allowing to receive acid with the content of sulfates in the range of 0,7 - 0,8 wt. % have been established.

Proceeding from the above-mentioned purification of phosphoric acid by calcium hydroxide not only the removal of contained sulfates, about 80 %, but also partial reduction of fluorine content, about 40 %, which is insufficient for the use of acid in the production of feed phosphates is achieved. To achieve deeper degrees of purification of acids with the production of technical phosphates on their basis, used in the production of detergents and other areas, it is necessary to study the selective removal of impurities.

Thus, according to the data obtained in the course of research was developed technology for the purification of WPA, including the first stage of purification from sulfur-containing compounds, which also allows for to reduction of the content of several impurities, in particular fluoride compounds, which helps to reduce costs for more expensive reagents for the subsequent stage of precipitation of alkali metal silicofluorides.

Feed phosphates and technical ammonia phosphates obtained on the basis of purifying wet process phosphoric acid according to the described technology ensure that they meet the requirements in accordance with GOST 23999-80 and 3772-74.

The Application of the Bravais Cubic Mesozoic in Some Logistical Challenges

Otari Okroshidze (Bachelor program student), Supervisor: Professor Nodar Poporadze, Georgian Technical University

Abstract: The structure of the crystallographic meser, which depicts the three-dimensional space containing the crystal's constituent pieces (atoms, ions, and molecules), is used to describe the inside of a crystal (transparent stone). Crystallographic characteristics (a, b, c) and the angles (α, β, γ) between them are required to define the meser.

Russian crystallographer E. Fedorov discovered 230 symmetrical space groups (forms of crystallographic arrangement of atoms in crystals) in 1881 and predicted the filling of a specific space.

Key Words: Bravais's 14 mesers, Hexagonal centered, Triclinic centered, Trigonal centered

Let's calculate Bravais's 14 mesers as follows:

Triclinic centered 1 mesers

Monoclinic-2 centered and monoclinic-centered: 2 mesers 2 mesers Rhombohedral-centered and hexagonal-centered: 2 mesers

Centered and surface-centered 4 mesers

Tetragonal-centered and tetragonal-centered 2 mesers

with a centered lattice

Hexagonal centered mesers 1

Trigonal centered mesers 1

Cubic-centered, cubic-centered with a centered lattice, and surface-centered mesers 3

In total, there are 14 Bravais mesers

The description of the internal arrangement of crystals (crystal lattice) is facilitated by the concepts of crystallography. A crystal lattice represents a spatial grid, the vertices of which are occupied by the building blocks of the crystal (atoms, ions, and molecules). To characterize the lattice, crystallographic parameters (a, b, c) and the angles between them (α, β, γ) are necessary.

At this time, all representatives of the 32 classes of symmetry are known.

Let's classify them into 7 crystal systems.

№1 Cubic

№2 Tetragonal

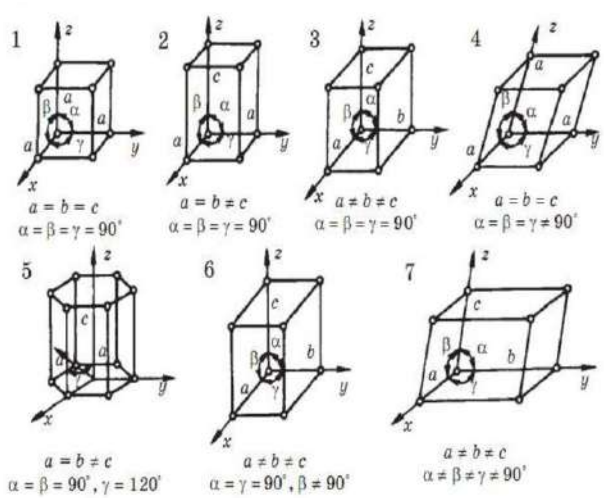
№3 Rhombohedral

№4 Trigonal

№5 Hexagonal

№6 Monoclinic

№7 Triclinic



There are a total of 14 mesers.

My attention is drawn to the cubic meser because the problem where meser properties need to be used follows the same symmetry.

Problem:

We have a cylinder with a uniform large number of spheres with diameter d and volume V. Considering all geometric constraints of the cylinder, divided by d diameter, what is the maximum number of spheres that can fit inside it?

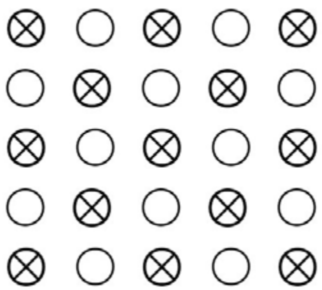
Solution

According to the problem's conditions, the spheres must be optimally distributed within the cylinder, meaning they should be distributed with maximum density. (Let's assume the cylinder has a straight parallelepiped form). The distribution on the floor will be as follows: each sphere is surrounded by 6 spheres (this is the first

layer).

In the second layer, each sphere will fit into the gaps between two spheres (each sphere is tangent to six others).

Mainly, the second layer will be analogous to the first one, except that



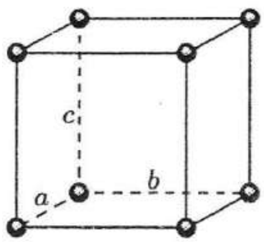
it differs vertically.

(x denotes the centers of the spheres in the first layer; o denotes the centers of the spheres in the second layer). The third layer can be distributed in two ways: I. Place the spheres in such a way that the centers of the third layer spheres lie exactly above the centers of the first layer spheres. II. Place the spheres in the remaining spaces of the third layer, and the centers of the third layer spheres will lie above the gaps between the spheres of the second layer.

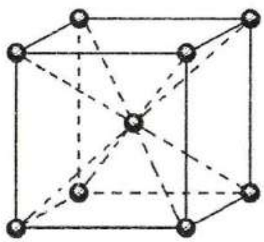
The crystal structure is analogous in both cases (both arrangements are correct).

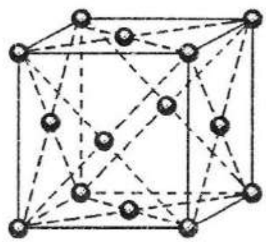
In one scenario, we obtain a hexagonal meser, while in the other scenario, we have a cubic-centered meser.

Now let's specifically discuss the form of the cubic-centered meser:



cubic-centered


centered density


face-centered

I-face centered: Each sphere contributes 1/8 to the interior density, as there are a total of $\frac{1}{8}$ such spheres. Thus, N=1 maximally fills the available space from the eight atoms of the 8 corners, which gives d=2R=a.

$a = d;$ $a = 2R;$ $R = \frac{a}{2};$ $R^3 = \frac{a^3}{8};$

$V_o = \frac{4}{3}\pi R^3 = \frac{4}{3}\pi \frac{a^3}{8}$; $V = a^3;$ $\eta = \frac{\pi a^3}{6a^3} \times 100\%;$

***η*=52,35%**

N=1

II-face centered and face-centered: Each sphere contributes $\frac{1}{8}$ to the interior density in face-centered lattices, which means one sphere per unit cell. Similarly, in face-centered lattices, there are 6 spheres contributing $\frac{1}{2}$ each, i.e., three in total. Thus, N=4 maximally fills the space based on the condition of filling the volume.

$2d = \sqrt{2}a;$ $\quad 4R = \sqrt{2}a;$ $\quad R = \frac{\sqrt{2}a}{4};$ $\quad R^3 = \frac{2\sqrt{2}}{8}a^3;$

$$V_o = \frac{4}{3}\pi R^3 = \frac{4}{3}\pi\frac{2\sqrt{2}a^3}{64} = \frac{\sqrt{2}a^3}{24};$$

$V = 4\frac{4}{3}\pi\frac{2\sqrt{2}}{8}a^3;$ $\quad \eta = \frac{\sqrt{2}a^3\pi}{6a^3} \times 100\% = 74\%;$ $\quad V = a^3;$

***η*=74%**

N=4

III-face centered and body-centered: Each sphere contributes $\frac{1}{8}$ to the interior density in face-centered lattices, which means one sphere and one fully counted. Thus, N=2 maximally fills the space based on the condition of filling the volume.

$\sqrt{3}a = 2d;$ $\quad \sqrt{3}a = 4R;$ $\quad R = \frac{\sqrt{3}}{4}a;$ $\quad R^3 = \frac{3\sqrt{3}}{64}a^3$

$V_o = \frac{4}{3}\pi R^3 = \frac{4}{3}\pi \frac{3\sqrt{3}}{64} a^3;$ $V = 2\frac{4}{3}\pi \frac{3\sqrt{3}}{64} a^3;$ $V = a^3;$

$\eta = 0{,}68 \times 100\%;$

***η*=68%**

N=2

We assert that the most densely packed distribution is face-centered cubic, ***η***=74%;

From the image, we can infer the volume, so to utilize it for problem solving, let's express the volume V as a fraction of the volume of this elemental cube, and then multiply by N:

$$Z = \frac{NV}{V_o} = \frac{4V}{a^3} = \frac{4V}{2\sqrt{2}d^3} = \frac{\sqrt{2}V}{d^3}$$

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PDCA Approach in Integrated Management System

Shota Papuashvili (PhD program student), *Supervisor: Professor Grigor Khoperia, Georgian Technical University*

Abstract: The purpose of the presented article is to discuss and reveal the role and importance of the PDCA approach in the Integrated Management System. The relevance of the issue is due to the risks facing the company based on modern market relations, which require action according to international standards and improvement of management systems. The diversity of management systems built in accordance with the requirements of various international standards is constantly increasing, while the lack of a unified approach to creating an integrated management system remains an important issue. Therefore, the paper focuses on the discussion of the principles and approaches of the integrated management system related to the "plan-do-check-act" process.

Based on the findings of the paper, the PDCA approach, or otherwise, the Deming cycle, is a practice for improving many processes of modern organizations. This approach is primarily related to quality management standards, increasing the efficiency of the organization and reducing errors in daily activities.

Key Words: Integrated Management System, PDCA, Deming cycle.

Introduction

In the context of the globalization of the world economy, the laws of market relations require from modern business a constant balance between the maximum possible satisfaction of the needs of all interested parties, competitive pressure and unconditional compliance with legislative and industry requirements. Achieving and maintaining this balance provides enterprises with the perspective of sustainable and successful development. To achieve the company's goals, the top management uses strategic programs, including those focused on the implementation of standardized requirements for the development, maintenance and development of official management systems. The latter are considered as real and effective tools for increasing profits and strengthening the organization through systematic risk management and continuous improvement.

Today, most organizations are at various stages of implementation, certification and further development of management systems in accordance with the requirements of various standards and/or technical conditions and specifications, for example: ISO 9001, ISO 14001, OHSAS 18001, ISO/TS 16949, ISO 22000, ISO/IEC 27001, ISO/IEC 20000, (Carter, 1999)etc. Enterprises working in this direction have steadily grown in Georgia over recent years.

A significant part of these organizations is characterized by their desire to simultaneously or sequentially introduce several management system models into the enterprise. As the most typical example, we can consider the practice of developing a quality management system (QMS) based on the requirements of ISO 9001, environmental management system (EMS) ISO 14001 and/or occupational health and safety OHSAS 18001 (Kunas, 2012). Often these systems function as independent autonomous models that are oriented to meet the requirements of different stakeholders.

However, (2019)according to Field, practice undoubtedly shows that the simultaneous operation of several autonomous (local) management systems in most cases leads to systemic risks of an organizational and economic nature: a) an increase in the cost of introducing and maintaining management systems; b) raising the level of bureaucratization; c) duplication of requirements and/or conflicts between different management systems; d) functional division of management systems; e) formal operation of management systems without their actual implementation in enterprise practice; f) different status of management systems; h) low efficiency of internal audit.

As a result, the above-mentioned risks inevitably lead to the emergence of systemic imbalances and contradictions between different management systems, which is accompanied by the deterioration of business manageability, a decrease in the motivation of the organization's employees, which has a very negative impact on the effectiveness of the management systems.

At the same time, it is possible to identify common elements in almost any international ISO standard, which should be managed in a unified way using an integrated approach. This circumstance justifies the desire to combine these systems into a single integrated management system (IMS) with varying degrees of integration. The cumulative effect of integrating the general requirements of the enterprise management system allows these management systems to work with maximum effect (Stein, Freeman, Bastable, Jacobs, & Bedocs, 2002).

It is the above-mentioned problems and the need to introduce an integrated management system to increase business efficiency that determines the relevance of the issue of this work. The aim of the paper is to reveal the role and importance of the PDCA approach in the integrated management system. To achieve this goal, the paper examines the essence of the integrated management system, principles and various approaches associated with PDCA . with the process. The methodology is based on the methods of synthesizing and analyzing the opinions obtained in the scientific literature.

The essence of the integrated management system

According to Pardy and Andrews (2009), an integrated management system (IMS) is a combination of at least two management systems that meet the requirements of two or more management system standards, are focused on different stakeholders, and operate throughout the organization. **IMS ensures greater consistency of actions within the organization, thereby enhancing the synergistic effect, which is that the**

overall result of coordinated actions is higher than the simple sum of individual results:

1. The introduction of an integrated management system allows the company to increase the competitiveness of the enterprise by raising the level of its business reputation and improving the quality of the organization's management;
2. IMS reduces the functional fragmentation of personnel in the organization, which occurs during the development of autonomous management systems;
3. Implementing an integrated system is usually much less time-consuming than creating several parallel systems. The costs of development, operation and certification of an integrated system are lower than the total costs of several management systems;
4. The volume of documents in an integrated system is significantly reduced compared to the total volume of documents in several parallel systems. In addition, in the integrated system, a higher degree of staff involvement in improving the organization's activities is achieved;
5. effectiveness of the integrated management system is increased by using joint activities in the integrated system, such as policy development, planning, staff training, etc. more attention is paid to the overall goals of the business;

6. Integration also helps to reduce conflicts and possible contradictions between issues related to quality, ecology and safety. A more holistic approach to increase profitability, more effective management of resources, improvement of consistency of information exchange process, elimination of duplication of processes is used .

Elements of management systems that benefit from integration into a single system are: a single policy of the organization; optimal use of resources; Comprehensive operational control and shared records management; unified approach to documentation development; general information and support systems; general system of personnel training and development; organizational structure and accountability structure; measurement and monitoring systems; records and reporting; unified audit; Unified analysis of management systems. (Pardy & Andrews, 2009)

Principles of management system integration

The creation and operation of the integrated management system, as well as the successful implementation of the project of its creation in the company, consider the observance of the following nine principles as a basis.

Table 1 Principles of Integrated Management System

principle	feature
A balance of stakeholder interests	A company's long-term success depends on understanding and anticipating, understanding and addressing the current and future needs and expectations of its customers . The company should strive to ensure a balance of interests by setting and achieving appropriate goals that take into account the requirements of all stakeholders.
leadership leadership skills	Managers ensure the unity of the company's goals and activities. Managers must have leadership qualities and actively demonstrate their commitment to the ideology of the integrated management system, which is focused on achieving the common goals of the organization. Company leaders must create and maintain an internal environment in which employees are fully engaged in solving problems and achieving common goals.
Staff involvement	Employees at all levels form the foundation of the company, its main resource and value. Continuous identification of training needs, development of competence, raising motivation and showing concern for personnel are the main conditions for using the capabilities of employees in favor of meeting the established requirements and achieving the planned results.
Compliance with Legal and Other Requirements	Integrated systems requirements are additional to (and not alternative to) certain technical and contractual terms of the product or service, legal requirements, as well as other requirements to which the company has agreed (ie to fulfill).

A risk-based approach	Any company works in conditions that are characterized by various internal and external factors affecting its activities, which have a corresponding impact on the quality of achieving goals. Risk management enables positive opportunities to be exploited and the likelihood of adverse events to be minimized.
process approach	effectively achieve goals , management must be based on understanding the nature of the work performed by specialists, identify activities that bring added value, provide them with appropriate resources, and implement them under controlled conditions.
Systematic approach	The management of the organization should use the integrated management system as the main tool for achieving the goals. On the other hand, the integrated management system is considered as a complex of interrelated processes, the management of which is carried out in the name of continuous improvement according to the general method: plan-do-check-act.
Fact-based decision making	Management activities at different levels of the organization are inextricably linked with making managerial decisions. The effectiveness of these decisions is based on the understanding of the specifics of the external and internal environment at the time of decision-making, as well as the systematic review of the company's activities, the specifics of the situation, and alternatives.
continuous improvement	Continuous improvement of the company as a whole should be considered as its constant goal.

Source:(Field, 2019)

Approaches that provide the possibility of combining management systems, joint effective and efficient use when creating an integrated management system are:

- PDCA approach;
- process and systems approaches;
- A risk-based approach. (Stein, Freeman, Bastable, Jacobs, & Bedocs, 2002)

However, the most universal of the above integration approaches is the PDCA approach. Process and system approaches are mainly used as integration approaches if the quality management system is included in the integration or the organization's goal is to increase the effectiveness of activities in the areas considered during the integration. A risk-based approach can be used by a company to organize a comprehensive planning and goal-setting system. It should be noted that all three integration approaches are interconnected (Gidey, Jilcha, Beshah, & Kitaw, 2014):

- The activity of the organization can be represented as a system of processes, including basic, auxiliary and management processes;
- The concept of risk is used for the goals and main directions of these processes, as well as for the strategic goals of the organization as a whole;
- Management of organization, processes and risks is carried out in accordance with PDCA methodologies.

Currently, process management is used as one of the most widespread means of improving the organization and increasing efficiency. Using the process approach means considering any activity as a process, that is, a stable, purposeful set of interrelated activities, which, using a certain technology, transforms resources into valuable products for consumers (Gidey, Jilcha, Beshah, & Kitaw, 2014).

To date, there is no single generally accepted model of the developed integrated management system, as well as a unified approach to the integration of management systems. Nor has an International Organization for Standardization (ISO) standard been developed that establishes requirements for an integrated management system. The most famous and widespread documents regarding the integration of management systems are (Kunas, 2012):

- PAS 99:2006 "Specification of common requirements for management systems as a basis for integration";
- AS/NZS 4581:1999 "Integrated quality management systems - Guidance for business, government and community organisations".

The similarity of the proposed models as the basis for the creation of an integrated management system is associated with the use of the integration process and systemic approaches, the use of the PDCA methodology and continuous improvement.

PDCA cycle as a continuous improvement approach

Continuous improvement is a set of iterative activities designed to increase the ability to meet requirements. It is one of the eight principles of quality management. (Chandrakanth, 2016) Actions related to continuous improvement include:

- Analysis and assessment of the current situation to identify areas for improvement;
- setting goals related to improvement,
- search for solutions to achieve goals,
- Evaluating these decisions and making choices,
- implementing solutions,
- measuring, verifying, analyzing and evaluating implementation results to determine whether objectives have been achieved;
- Formalize the changes.

According to Chandrakant (2016), the application of the principle of continuous improvement is related to the use of a consistent, comprehensive organizational approach to improve the organization's achievements - ensuring the participation of people experienced in the use of continuous improvement methods and tools, the continuous improvement of products, processes and systems Improvement, which is understood as the goal of each person in the organization.

William Edward Deming, a prominent American researcher, believed that management personnel and all employees should be involved in the process of continuous improvement. He created 14 principles, which later became the basis of the quality philosophy in the organization and the continuous improvement cycle PDCA (Plan - Do - Check - Act), which was called Deming's wheel/cycle. The Deming cycle is a sequence of actions aimed at improvement. This cycle is also designed to solve quality problems and introduce new solutions. (Pardy & Andrews, 2009)

As a basis for the integration of management systems, "PDCA" is adopted - an approach based on the "planning - implementation - verification - action" methodology, which is the basis of most management system standards, including: ISO 9001, ISO 14001, OHSAS 18001. (Carter, 1999)The essence of this approach is In that any activity can be represented by the following sequence of actions:

- "Plan" - determination of goals and processes necessary to ensure results in accordance with the requirements of interested parties and the policies of the organization;
- "Do" - execution of processes;
- "Check" - control and measurement of processes and products for comparison with policies, goals, requirements and presentation of results;
- "Act" - implementation of actions in order to further improve the execution of processes and continuous improvement of the efficiency of the management system and the organization as a whole.

According to Gidey et al (2014). The role of PDCA cycle integration in the creation of a control system involves two aspects. The first aspect is that the PDCA cycle can be used to maintain and continuously improve specific organizational performance, i.e. It controls:

- each individual process and process system of the organization;
- Processes implemented equally at all levels of the organization, including both strategic development and product release processes

The second aspect is that the PDCA cycle is used to ensure the functioning and continuous improvement of the organization as a whole and its management system, as well as individual functional management systems. At the same time, managing an organization can be considered a process. This approach is used in all the standards mentioned in the paper, as a result of which there are several common elements in the corresponding management systems, such as:

- Planning: setting goals and developing programs to achieve them;
- Implementation and operation: implementation of plans, organization of communications, documentation, management of activities and others as a result of the distribution of responsibilities;

- Control: monitoring and measurement, compliance assessment, non-compliance management, audit and others;
- Review and Improvement: Management's analysis of results and improvement planning.

Conclusion

Integration allows the company to reduce bureaucracy and possible inconsistencies in the process of meeting the requirements of various standards, to minimize the amount of documentation, to harmonize internal and external audit procedures, to reduce the consumption of material and time resources for development by using an integrated management system. The organizational and methodological basis for the creation of integrated systems should be the ISO 9000 series standards, since the basic principles and requirements established in these standards are most consistent with the concepts and principles of general management.

The PDCA approach is significantly related to the management system integration procedures, which, on the one hand, creates the basis for the continuous development of the organization, and on the other hand, contributes to the effectiveness of individual processes and the achievement of strategic goals at the level of the organization as a whole. The PDCA framework works well in all types of organizations. It can be used to improve any process or product by breaking it down into smaller steps or stages of development and exploring ways to improve each one. This is particularly useful for implementing Total Quality Management or Six Sigma initiatives and improving business processes in general.

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Dehydration of the Crushed Mountain Rock Mass - Additive for Improving the Structure of Concrete Obtained by Grinding

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Abstract: The influence of the concrete additive obtained by dehydration-grinding of the mass of crushed mountain rocks brought by landslides from the massifs of the mountains of Georgia on its strength has been studied. It is established that without reducing the strength, it replaces an average of 20% of cement in concrete, thereby: reducing CO_2 emission and footprint ("Carbon footprint") and the cost of concrete; reduces the size and number of voids and pores in concrete; does not increase the water/cement ratio in concrete; prevents negative events caused by free lime (CaOtav.) added to concrete with cement;

Key words: concrete, innovative admixture, dehydration, clays, argillites, portlandite, prevention, pozzolanization, rehydrogenation, pores and voids.

1. Introduction

By utilization of the mass of debris mountain rocks brought by landslides from the mountains, or excess soil formed on construction sites: dehydration-grinding.

Dehydration by retaining silicate mineral structure (Know-how).

It is ground so that the average size of the filler grains is greater than the maximum of cement used in concrete, less than the minimum of sand. During hardening of concrete, rehydro-liming occurs with the formation of structural crystal hydrates.

2. Main part

Concrete void filler (According to EN 206-1:2013, type II addition), is ready for use as an ingredient in concrete as a Type II admixture [1].

Even in the 21 century, cement and concrete made from it are products in high demand. By 2023, global cement production has reached 4.0 billion tons, and concrete has reached 10.0 billion m^3. According to the calculation, for every 1 person living on earth, [(4.0/8.0) billion t] there is 0.5 t of cement and (10.0/8.0 billion m^3) 1.2 m^3 of concrete produced.

Problem 1. During the production of 1 ton of cement clinker, the "carbon footprint" released at 1500 ^{0}C is equal to 0.8 t of CO_2 on average. [2]. In turn, if the cost of cement in traditional concrete = 300-400 kg/m^3, then "Carbon footprint" = 240-320 kg/m^3, i.e. (240-320) x 1.2 = 288-384 kg/m^3 per person, which is a very large amount and should be reduced.

Concrete according to EN 206-1:2013 [1] is made of cement containing grains of 0-90 μm, fine filler with grains of 0-5000 μm - sand, coarse aggregate containing grains of 6(6000 μm)-40(70) mm (gravel), mixed with water.

According to BS EN 197-1:2011 [3], cement is mainly prepared by ultrafine grinding in separators or mills, and also - mainly on the basis of clinkers fired using the "dry method";

Problem 2. The amount of CaO_{free} in the clinker fired by the "dry method" = 2-3 mass % - which then passes into the concrete and causes negative results: the unstable mineral portlandite $Ca(OH)_2$ is formed in the hardened concrete mass, which reduces the stability of the concrete. This problem needs to be solved!

Problem 3. When assessing the quality of concrete, they consider only defects caused by mistakes made in the process of manufacturing concrete products [4]. They do not consider technological deviations in the production of cement and concrete. In particular, the maximum sizes of ultra-finely ground cement grains in separator mills do not exceed 40-50 μm, and the minimum sizes of fine aggregate sand grains used in concrete are slightly less than 140 μm. Therefore, there is a shortage of 50-140 μm cement-sand grains in modern concrete **(Fig. 1.)** and the so-called "Filling defects in concrete", which is finally reflected in the mass of concrete and the formation of macro-sized voids on the surface **(Fig. 2.)**;

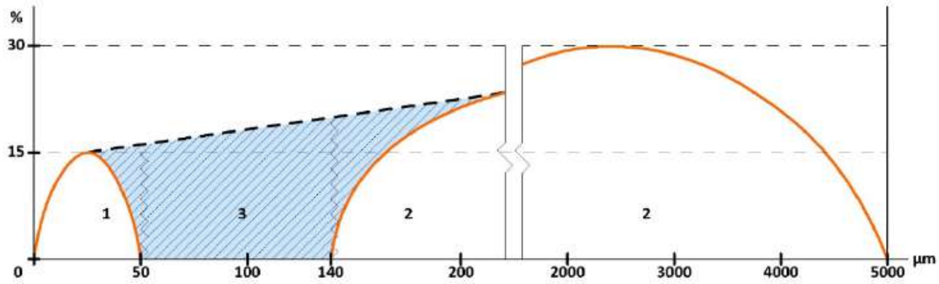

Fig.1. Granulometry of grains of Cement and Sand in a concrete mix
1 – Cement; 2 – Sand; 3 – Deficiency of 50-140μm grains of Cement and Sand in the concrete mixture.

Fig.2. Macro-sized voids on the concrete surface

Problem 4. In mountainous countries, mountain rivers are characterized by periodic flood regime. A typical structural landslide [5] is created, which brings clay-like mass containing silica (SiO_2) and alumina (Al_2O_3) turned into mud from the mountains to the location of accumulation with a capacity of no less than 200 m^3/s. In particular, in Georgia, the Duruj River brings it down from the Caucasus mountains every year and "collects" it in the valley above Kvareli as a mass containing no less than 0.5 ml/m^3 of stone-gravel clay-shale. It is necessary to take out and

utilize the mass of crushed mountain rocks brought from the mountains by torrents from the river bed, because otherwise devastating negative events and consequences are expected for the city of Kvareli.
During the construction of foundations, tunnels and other facilities, an excess amount of clay soil containing silica (SiO_2) and alumina (Al_2O_3) is inevitably generated, which must be removed and utilized [6].

Startup idea. To create a pozzolanic property [capable of hydraulic reaction with $Ca(OH)_2$, or containing $\mathbf{SiO_2}$ or $\mathbf{nAl_2O_3 \cdot m\ SiO_2}$] for filling voids caused by the lack of 50-140 μm grains in concrete. Which with the "presence" of 50-140 μm grains ensures the elimination of structural voids in the concrete mass and surface, due to the modification of unstable $Ca(OH)_2$ into water-stable compounds by the pozzolanization reaction - "doesn’t exist anymore":

$$\mathbf{5Ca(OH)_2 + 6SiO_2\, n\, H_2O + 4H_2O = 5CaO \cdot 6SiO_2 \cdot n9H_2O\ [C\text{-}H\text{-}S\,(1)] \quad (1)}$$

$$\mathbf{Ca(OH)_2 + nAl_2O_3 \cdot mSiO_2 + zH_2O = CaO \cdot nAl_2O_3 \cdot mSiO_2 \cdot zH_2O + H_2O \quad (2)}$$

Start-up offer. In order to prevent the problem of lack of 50-140 μm cement-sand grains in concrete and the presence of $Ca(OH)_2$, the filler will be made by utilizing the mass of debris mountain rocks brought by the mountain mudflow, or excess soil generated at construction sites: by dehydration-grinding.

Mountain rocks or soil must contain: either at least 25% silica (SiO_2) and at least 5-12% alumina (Al_2O_3), or at least 30-40% **$nAl_2O_3 \cdot mSiO_2 \cdot pH_2O$** type aluminium silicate.

Innovative. Prepared according to the outline presented in Fig. 3: by dehydrating the mountain rocks containing clays brought down from the mountains, or the soil containing argillites formed on the construction site, preserving the mineral structure (heat reament possible in all types of ovens at a temperature not more then 800 ^{0}C), after which it goes through a grinding process so that the average size of the filler grains (D_{filler}) should exceed the maximum of cement used in concrete (D_{cement}>40 μm) and should be less than the minimum of sand (d_{sand} <140 μm). This condition is achieved by grinding in such a way that the residue on sieve № 014 does not exceed 5 mass %.

Table 1. Oxide composition of the used mountain rocks

Name:	Chemical Composition mas%:										
	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	MnO	R_2O	Low	H_2O	Total
clay shale	59,23	18,02	4,58	2,41	2,31	1,01	0,38	5,10	4,90	2,06	100,00
argillite	56,77	22,07	0,89	5,54	2,59	0,67	0,08	3,80	5,37	2,22	100,00

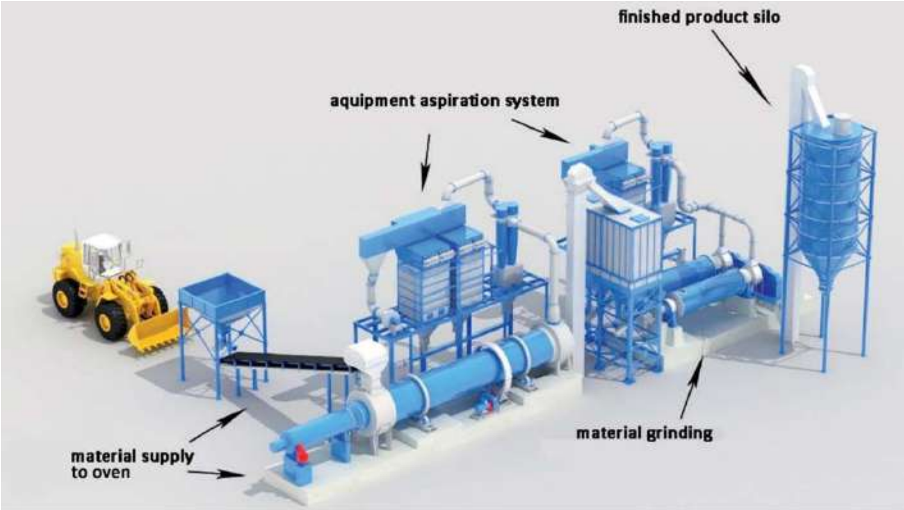

Fig.3. Technological Line for the Production of Filler

The result is that, the filler:

- **It is highly ecological and less energy intensive.** The carbon footprint is reduced by reducing the CO_2 emission in the environment during the production of the filling, as only 30.0 kcal/kg of heat and 0.0058 kg/kg of conditional heat are spent on dehydration. 1100 kcal/kg of heat and 0.292 kg/kg of conditional heating are spent on making clinker;
- In traditional concrete manufacturing technology, on average 20% (10-30%) of the cement mass will be replaced by concrete void filler - while maintaining the design strength, which will reduce the carbon footprint from 240-320 kg/m^3 to 192-256 kg/m^3.
- The cost of concrete also decreases. If 1t of cement costs $80.0, and 1t of filler costs $20.0, then the cost of cement in 1m^3 of unfilled B30 class concrete will be $80.0*0.4t/m^3 = $32.0/m^3, and the cost of cement-filling

in filled B30 class concrete will be \$80.0*0.32 \$/m^3=25.6\$/m^3. The cost of 1m^3 B30 grade concrete decreased by \$6.4/m^3 ;

- **The practical value of the innovative filler** is that it prevents the deficiency of 50-140 μm grains and the presence of **$Ca(OH)_2$** in concrete and is **highly economical**; The market value of the well-known "Filler" is 25-30 \$/t, and the innovative filling is within 20-25 \$/t;
- The volume of the Georgian concrete market exceeds 7.0 million m^3. In case of mixing 20 mass % innovative filler in all manufactured concrete, commercial/economic effect: 7.0 mln.m^3 $\cdot$ 5\$=5.6 mln.\$;
- Defects in the form of cracks and voids will no longer occur in the concrete product(s). In Georgia, the builder's time and money will no longer be spent on their prevention, which will speed up the construction process. It will contribute to the sustainable development of the economy in general.

Innovative Concret void filler- is a pinkish-brownish-blackish powder; The grain-particle sizes are 40-140 μm; specific surface 2300 - 2700 cm^2/g; true density 2.7 g/cm^3; bulk density 800 kg/m^3; Water requirement <25%; Pozzolanic activity 40 – 80 mg CaO/1g active mineral additive. The sale can be carried out either packed in bags of 25-40-50 kg capacity, "big-bags", or in bulk form;

Shelf life without deterioration of properties is 1 year.

The technological readiness level exceeds **TRL-5** and is ready for **Pilot** testing.

3. Conclusion

Supplement will prevent the problems and defects caused by the lack of 50-140 μm grains in the concrete mixture: it will improve the flowability of the concrete mixture, and it will reduce the size and number of macro-sized voids and pores in the mass and surface of the hardened concrete;

- When the concrete hardens, rehydro-liming will occur, with the formation of structural crystal hydrates. This is an innovation;

- prevention of negative events caused by free CaO added to concrete by cement;

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Responsive Architecture

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“Adaptation is the evolutionary process whereby a population becomes better suited to its habitat. This process takes place over many generations and is one of the basic phenomena of biology.”– Charles Darwin

Our lives are surrounded by constantly changing forces of nature and the environment. Everything is in a constant state of flux, with varying degrees of dynamism. Our lives too, are always in motion. The spaces we inhabit are constantly changing as well, although the change is slow and occurs through non-physical conditions. The physical state of the inhabitable spaces is more or less constant and not in motion.

Responsive architecture involves designing structures and systems that can adapt and respond to various environmental conditions, user needs, and external stimuli. The goal is to create dynamic and flexible buildings that enhance user experience, optimize energy efficiency, and improve overall performance. Here are some key aspects of responsive architecture:

- **Adaptive Facades:** One of the most common applications of responsive architecture is in the design of building facades. Adaptive facades can dynamically adjust to changing external conditions such as sunlight, temperature, or weather. This may involve the use of smart materials, sensors, and actuators to control elements like shading devices, louvers, or even the transparency of glass.

- **Climate-Responsive Design:** Architects use responsive strategies to address specific climate challenges. For example, buildings in hot climates might have passive cooling systems, such as natural ventilation and shading, while those in colder climates may incorporate active heating elements or insulation.
- **Smart Lighting Systems:** Responsive lighting systems use sensors to detect natural light levels, occupancy, and user preferences to adjust artificial lighting accordingly. This not only enhances energy efficiency but also contributes to the well-being and productivity of occupants.
- **Interactive Spaces:** Some architects incorporate interactive elements within the building's interior to respond to user actions. This could include movable partitions, reconfigurable spaces, or interactive displays that change based on user engagement.
- **Bioclimatic Design:** Bioclimatic design principles integrate natural elements such as sunlight, wind, and vegetation into the architectural plan. By considering the local climate and environmental conditions, architects can create buildings that respond harmoniously to their surroundings.
- **Energy Harvesting:** Responsive architecture may involve the integration of technologies that harness natural energy sources, such as

solar panels, wind turbines, or kinetic energy systems. These features contribute to the sustainability of the building.

- **User-Centric Design:** Responsive architecture takes into account the needs and preferences of the building's users. This can involve adaptable interiors, personalized climate control, and spaces that can be customized to suit different activities or events.
- **Sustainability and Green Building:** Many aspects of responsive architecture align with sustainable building practices. By optimizing energy usage, minimizing waste, and incorporating eco-friendly materials, responsive designs contribute to the broader goals of green building.
- **Dynamic Building Systems:** In addition to the static components of a building, responsive architecture may include dynamic systems that can be adjusted based on real-time data. This could include automated HVAC systems, smart shading solutions, or even structural elements that can change shape or position.
- **Data-Driven Decision Making:** Responsive architecture often relies on data collected from sensors and other monitoring devices to make informed decisions. This data can include environmental conditions, user behavior, and performance metrics, allowing for continuous optimization and improvement.

Architecture has transformed from being functional to intelligent, with changing requirements of the time. The social environment is a constantly changing parameter and architecture needs to modulate and change with it, too. Responsive architecture came as an answer to the traditional knowledge that "*building structures don't move, don't change and don't have the capability to respond and react*".

Architects around the world explored and started to envision a different kind of architecture, less rigid in materials, time and space. The first experimentations around this subject were in the 1950s with Frank Lloyd Wright who investigated inflatable houses. On this topic, Sharon Francis stated that "the lightweight flexible instantaneous nature of inflatables provided a dichotomy against the prevailing, brutalist, modernist architectural paradigm that was of that time".

Negroponte, an architect and pioneer in the field of computer-aided design (CAD), described responsive architecture in his theory of "architecture machines". In this theory, advances in Artificial Intelligence (AI) and the miniaturization of components collectively enable buildings to intelligently recognize inhabitants' activities as well as to respond to their needs. As a result of this development, architecture can change its internal and external environments. This concept is also found in Brodey's "intelligent environments" and Negroponte's "soft architecture machine". Thus, responsive architecture can be defined as an environment which has embedded computationally-mediated responsiveness . In the half-century since responsive architecture was first proposed, the ICT revolution, following Moore's law, has enabled faster and cheaper machines than ever before. Consequently, architecture has already become adjustable to the changing needs of its inhabitants. Furthermore, it exists in the informative and interactive surroundings, or so-called “thick air”, which is presumed to envelop a building in an invisible sensor cloud, involving kinetic, sensing and environment-responsive systems.

Responsive architecture is defined as a type of architecture that has the capacity to change its form in response to changing conditions. It is, therefore, an artificial entity that reacts to data and information collected by a variety of types of sensors, and sometimes many hundreds of sensors. The nature of the responsive architectural behavior may include physical actions (changes or movements) and adaptations in environmental services, such as lighting, heating and ventilation. For example, in Nicholas Negroponte’s “soft architecture machine”, responsive architecture is a physical environment exhibiting reflexive and simulated behaviors, and which is also a result of computation. Accordingly, the term responsive can refer to either adaptive or reactive activities, as well as intelligent ones, because the smart environment infers and presents diverse degrees of behaviors responding to different needs or circumstances. In this way, recent architectural responsiveness uses advanced computing technologies integrating Artificial Intelligence (AI), robotics and “machine intelligence”.

Several examples showcase the principles of responsive architecture, where buildings and structures dynamically adapt to various factors, including environmental conditions and user needs. Here are some notable examples:

- The Edge, Amsterdam, Netherlands

  The Edge is considered one of the most sustainable and responsive office buildings globally. It features a smart lighting system that adjusts based on occupancy and natural light conditions, optimizing energy usage. The building also incorporates rainwater harvesting and solar panels for increased sustainability. The Edge is an office building which opens itself up to the city with its 15-storey atrium. The atrium acts as a window between the world of work and the outside, as well as providing a social heart for the building, and serving as an environmental buffer to reduce energy use. That atrium is also the place where new working patterns meet digital systems. Rather than thinking of the technological systems in the building as autonomous and discrete layers, PLP used them to devise new types of workspace. People have the flexibility to work anywhere in the building; and with the help of a dedicated mobile app, people can find each other, look for a quiet empty desk and adjust the temperature and lights levels to their preferences.

The technology is also designed to manage energy use by making users aware of how much energy they use, wherever they work in the building. Fine tuning the shape and orientation of the Edge was the initial step in achieving the exceptional climatic and energy performance of the headquarters. The arrangement of large floor plates organized around a grand 15-storey north-facing atrium allows natural daylight to reach the vast majority of the office spaces, while the load-bearing structure and smaller glazed openings of the south facing facades provide thermal mass and shade. The atrium is the lung of the building, ventilating the office space while providing a buffer with the exterior in a way which reduces energy use in both summer and winter. As well as its energy-neutral temperature control, energy efficient design and green energy-generating technology, the Edge captures rainwater and stores it underground for use flushing toilets and watering plants in the interior and exterior gardens.

- Dynamic Tower, Dubai, UAE:

  The Dynamic Tower, designed by architect David Fisher, is a proposed skyscraper with rotating floors. Each floor can rotate independently, allowing the building to change its shape continuously. This dynamic design not only offers a unique visual experience but also allows residents to control the orientation of their living spaces. David Fisher quoted "Architecture as part of the environment, adjusting to the sun and the wind, to the view and to our momentary requirements" The true beauty of dynamics is the shape-shifting, ever-changing façade of a building which responses to nature and its surrounding almost tricking us as if it's alive.

It's very different from our traditional way of building rigid buildings and a bit challenging. But due to new technologies and advancement of construction techniques, Fisher had it sort out. Use of prefabricated modules that can assemble on-site resulting in 90% of the work done in the factory and the rest 10%, the core build on site. Apart from being dynamic and easy to build, this building has named itself as a green building as its rotation produces electricity for itself and the other buildings.

As a green building should be, the huge skyscraper generates electricity through the help of wind turbines located horizontally between the floors. As a result, there are almost 70 wind turbines throughout the building each generates 460,000kw/h of electricity. Electricity generated from one turbine is sufficient for 35 floors. The material used in wind turbines is carbon fibers. The building also provides sufficient sunlight inside the rooms, according to needs. As its rotations can adjust according to the sun’s orientation which allows light through the whole day. Also, to produce solar energy, the place photovoltaic ink is on each rotating floor. However, with 80 floors, the exposed areas for roofs are about 20% which is equivalent to 10 similar size buildings.

- The Al Bahr Towers, Abu Dhabi, UAE:

The Al Bahr Towers feature a responsive façade inspired by traditional Islamic architecture. The building's outer layer consists of thousands of dynamic shading elements that move in response to the sun's position, optimizing natural light and reducing solar heat gain.

The design is based on the concept of adaptive flowers and the "mashrabiya" - a wooden lattice shading screen, which are traditionally used to achieve privacy whilst reducing glare and solar gain. Aedas fused the principles of bio-inspiration, regional architecture, and performance oriented technology with an underlying performance criteria, grid-guide, and geometric composition. Traditionally, circles and orbits are used to reflect the concept of unification and unity evident in nature.

Using a parametric description for the geometry of the actuated facade panels, the team was able to simulate their operation in response to sun exposure and changing incidence angles during the different days of the year. The screen operates as a curtain wall, sitting two meters outside the buildings' exterior on an independent frame. Each triangle is coated with fiberglass and programmed to respond to the movement of the sun as a way to reduce solar gain and glare. In the evening, all the screens will close.

"At night they will all fold, so they will all close, so you'll see more of the facade. As the sun rises in the morning in the east, the mashrabiya along the east of the building will all begin to close and as the sun moves round the building, then that whole vertical strip of mashrabiya will move with the sun," said Peter Oborn, the deputy chairman of Aedas.

It is estimated that such a screen will reducing solar gain by more than 50 percent, and reduce the building's need for energy-draining air conditioning. Plus, the shade's ability to filter the light has allowed the architects to be more selective in glass finished. "It (the screen) allows us to use more naturally tinted glass, which lets more light in so you have better views and less need of artificial light. It's using an old technique in a modern way, which also responds to the aspiration of the emirate to take a leadership role in the area of sustainability," added Oborn.

To sum up, responsive architecture aims to create buildings that go beyond static forms, adapting to the ever-changing needs of users and the environment. The integration of advanced technologies and sustainable design principles plays a crucial role in achieving these goals.

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Getting into the Water area of Common Pollutants from a Natural Landfill, Determining the Degree of Pollution and Selecting a Bioremediation method for their cleaning

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Abstract: Uncontrolled landfills are a big problem in the country. Because of them, the ecological situation is deteriorating. Especially when the landfill is close to the river. The flows flowing into them pollute the river. Therefore, the research area is the lower reaches of the Aragvi River, near the village of Natakhtari. To the west of the restaurant "Chatto-Natakhtari" there is a household dump and a water channel. Contaminated water flows into the Aragvi River. Microbiological analysis of the channel revealed high levels of contamination. In particular, high rates of total coliformus and E.coli. Both are life-threatening bacteria. To solve the problem, it is necessary to select a bioremediation method and use it.

Key words: Uncontrolled landfill, pollution, channel, Bioremediation.

Today, there are many facts of the proliferation of uncontrolled landfills and, accordingly, the deterioration of the ecological situation in these areas locally. Pollutants entering surface waters are of particular concern, as they are expected to spread over larger areas due to water flow. It is important to know the geographical-geological and soil composition of the place in order to calculate the estimated distribution of the pollutants that have leaked into the water. Special attention should be paid to the small streams that eventually flow into the river. Based on this, we chose the research region, located in the Aragvi river valley, in the vicinity of Natakhtari village, which is distinguished by private fish farms, near which there are uncontrolled garbage dumps. The purpose of the work was the research area, the eco-chemical study of the water and soil samples of the canal taken from the uncontrolled landfill near the Aragvi river basin, the village of Natakhtari, in particular, in the area of the domestic waste dump at the back of the restaurant "Chatto Natakhtari", west of the restaurant. In case of pollution, it should be determined what kind of pollution is mixed into the canal water from the landfill area.

As a result of chemical and microbiological analysis, a high degree of pollution was revealed. The selection of the research site was due to the fact that the landfill had a negative impact not only on the nearby area, but also on the river channel that flowed near it and eventually joined the Aragvi River. Chemical analysis of the water from this channel did not reveal the pollutants that were detected in the soil sample. (Soil Analysis Table 1) But microbiological analysis of the canal water showed a high level of contamination. In particular, the total coliform count is 17,400 units/liter. Their increased amount in water is an indicator that we are dealing with strong pollutants. (Table 2)

Table 1. Soil analysis results

Sample name	Zn Mg/Kg	Cu Mg/Kg	Mn Mg/Kg	Pb Mg/kg
The surrounding area of Chateau Natakhtari village. Natakhtari	183,3	41,9	133	61,6
MPC	300	132	150	32

Table 2. Microbiological contamination of canal water

Microbiological contamination of canal water	accepted norm (ZDK) unit / liter	Actual rate per unit / liter
total coliformus		17400
E.coli	5000	9800

In the surrounding area, there are many human food wastes, animal faecal masses, household wastes, which are the source of this bacteria and the cause of its spread in the canal water. It should be noted that E.coli is a broad group of bacteria, some of which can cause various life-threatening diseases. In order to reduce such pollution and take preventive measures, we definitely consider:

1. Cleaning the landfill area;
2. 2. Detection of pollution in the vicinity of the landfill by bioremediation methods and, accordingly, improvement of the ecological situation.

Since the water of the canal is flowing, therefore, if the source of pollution is eliminated, the water will gradually self-clean.

In order to solve this problem, it is necessary, and we intend to select a bioremediation method that will give us the desired result in the shortest possible time. We carry out the work in laboratory conditions, which we will transfer to the selected area and see the results.

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The Influence of the Hydrological Regime of Rioni River on Poti Coastline

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Abstract: Natural or artificial changes in the hydrological regimes of sea waves and river runoff have a decisive impact on the formation of sea and ocean coastlines, their geomorphology, and ecological processes, accelerate or inhibit the processes of delta formation in river estuaries and coastal erosion processes, and lead to large-scale environmental changes [1,2].

Such changes especially affected and proved problematic for the coastline of the city of Poti in western Georgia, which is located between the confluences of the Rion River. Poti is warming and the entrance channel of Poti port, which is called the main sea gate of Georgia, needs systematic deepening.

Key words: Coastline; Sea Port, Erosion, Geotextil tubes.

Main Part

During the flood, the waters of the Rion River flowed abundantly into Paliastom Lake and Poti was threatened with flooding. To avoid this danger, it was decided to excavate a short channel from the Kaparchini River in order to quickly dump the waters from Paliastom Lake into the Black Sea. The 587-meter-long canal was cut in

1925. But observations showed that this hydro-engineering measure was not enough to protect Poti from floods.

In 1929, it was decided to change the direction of the Rion Riverbed, on the condition of bypassing the city. In 1936, the newspaper "Mgznebare Kolkhideli" wrote that throwing the river into a new bed would improve the sanitary conditions, help to dry up the swamps in the city, the proper functioning of the main and drainage canals, the normal functioning of the water supply and sewerage system, the center of malaria would be eliminated, and eventually, Poti would turn into a resort town. In 1934, a proper technical project was approved. Construction works were completed in 1939. As a result, the Rion River changed its course adapted to natural conditions over millennia, bypassed the Poti estuary 7 km upstream, moved into the Nabada River Kalpot, and 5.5 km north of Poti joined the Black Sea through a 70 m wide channel [1, 5].

Fig. 1. Coastline scheme of Poti city [3]

Therefore, although this measure saved the city itself from frequent flooding, it created an irreparable shortage of beach-forming sediment on the city's shore. The sea has catastrophically washed the coastline of Poti and pushed it back by hundreds of meters. On the banks of the Poti, many bunkers and breakwaters were built, a large number of concrete blocks, flat stones and boulders were laid, but these measures could not stop the intensity of the erosion of the Poti bank, which increased even more after the commissioning of the cascade of Gumati and Vartsikhe hydroelectric power stations on the Rioni River (Rioni River solid As a result of the construction of Gumati and Vartsikhe HPP reservoirs, the runoff on it decreased from 2.07 million m3 to 1.35 million m3 per year).

In addition, the river north of the port. The dumping of Rion created an irreparable problem for the Port of Poti, because the north-west storms and the south-facing sea currents caused the river to flood the entrance channel to the port and the water inside the port itself. with sediment from Rioni.

In 1959, on Rioni, seven kilometers northeast of Poti, a watershed junction with a dam-bridge and a Rab-regulator was built. Its purpose was to return up to 500 m3/year of the river flow to the old bed of the city and in this way to fill the existing sediment deficit (600 thousand m^3/year) on the seashore. But at discharges of more than 200 m^3/s, due to the sedimentation of the channel bed and the deformations of the escarpment, the city again became subject to flooding. Therefore, in the 80s of the last century, in order to restore the shore of Poti, the pulp pipes was installed, which, following the embankment of the city canal, carried out the transportation of inert material accumulated near the main structure and dumped it directly on the seashore, but due to wear, it was soon out of order and for various reasons it could not be restored [1 , 5].

In Poti's coastline, from the harbor to the river. Before the confluence of Rioni, the population was forced to relocate. Despite the fact that in the 80s, huge stone boulders were placed along the entire perimeter of the coastline to stop the processes of washing away the shore, but they soon sank into the fine sand saturated with water, and the sea continued to wash away the shore of Poti. Currently, Poti does not even have a narrow strip of beach and the sea continues to encroach.

At the southern mouth of the Rioni River, 500 m away from the hydrographic center of Poti, where the communication cable system of special importance for the state passes, the intensity of washing has increased greatly in recent years.

In 2018, for the first time in Georgia, geotextile tubes were used in coastal protection activities on this section. The sequence of the method is as follows: elastic geotextile pipes are placed on the seabed near the coast in the direction and dimensions established as a result of proper research, then it is filled with sand with the help of a special combine. Recently, this method has been successfully used all over the world [4].

In September 2019, observations showed that bank growth in a 500m strip bounded by geotextile tubes ranged from 2 to 12 meters.

Fig. 2. Located at the southern confluence of the Rioni River Geotextile tubes (2019).

The use of geotextile elastic ptubes should be preceded by its production in Georgia, this determines its economic effectiveness, and will increase the quality of coastal protection.

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Biosafety of Pharmaceutical Enterprises of Georgia

Givi Takvarelia (Master program student), Supervisor: Associate Professor Irine Metreveli, Georgian Technical University

Abstract: Today, the structure of pharmaceutical enterprises, the emergence and development of which is closely related to the field of medical biotechnology, is of particular interest. Medical biotechnology is one of the important parts of all fields of biotechnology. Precisely medical biotechnology has given quite a big impetus to the development of the pharmaceutical industry, which in itself is the future of humanity, and this future is developing so quickly that we get the result that its 2 steps are approximately equal to 76 steps of human development. Today, in the global pharmaceutical industry, it is very important to follow standard operating procedures worldwide, namely good manufacturing, good distribution and safe pharmacovigilance practices. Medical biotechnology is a branch of medicine that uses living cells and cellular materials for research and then the production of pharmaceutical and diagnostic products. These products help in the treatment and prevention of diseases. From the Ebola vaccine to mapping human DNA to the impact of agriculture, medical biotechnology is making huge strides and helping millions of people. All this requires a lot of effort and different protocols to be followed in order to get positive results without damaging the environment with different studies. Medical-biosafety (bioethics and pharmacosafety) is responsible for exactly these

protocols. Adequate assessment of various risks is the cornerstone of biosecurity. Although there are many ways to evaluate a particular experiment or procedure, professional judgment remains the most important. Biosafety protocols are universal, and its laboratory division into levels determines standards for protocols from safe (ie, unnecessary) to the highest safety (strictly protected). The goal of my research is to develop new norms in the pharmaceutical industry, which will help me to describe, study and prove the necessity of biosafety norms for enterprises.

Key words:

- **BSL** – Bio Safety Levels;
- **GMP** - Good Manufacturing Practice;
- **GDP**- Good Distribution Practice;
- **GVP** - Good Vigilance Practice;
- **SOPs** - Standard Operating Procedures;
- **EU** – European Union;
- **EMA** - European Medicines Agency;
- **ASP** - Assurance System Practice;
- **WHO** – World Health Organization;
- **USF** - The University of South Florida;
- **IBC** - Institutional Biosafety Committee;
- **rDNA** - Recombinant Deoxyribonucleic Acid;
- **BMBL** - Biosafety in Microbiological and Biomedical Laboratories;
- **NIH** - National Institutes of Health;
- **CDC** - Centers for Disease Control and Prevention;
- **CFR** - Code of Federal Regulations;
- **RIC** - RESEARCH INTEGRITY & COMPLIANCE;
- **PI** - Principal Investigators;
- **BS** - Bio Safety;

Review of Scientific Literature

1.1. Pharmaceutical company quality system

The quality system of the pharmaceutical company includes all areas that directly affect the quality of the pharmaceutical product, patient safety and is developed in accordance with the applicable guidelines:

1. Production: Guide to Good Manufacturing Practice (GMP - Good Manufacturing Practice) - Good manufacturing practice involves the continuous production of products that meet quality standards. This requires the implementation of a system that is responsible for minimizing all types of risks, which include the period from incorrect raw material selection and processing to incorrect labeling. The GMP system includes all parts of the production process, from raw materials to the production of the finished product;
2. Distribution: Guide to Good Distribution Practice (GDP) - Good distribution practice involves maintaining product quality and integrity at all stages of the supply chain. It sets minimum standards to ensure compliance of medical devices and pharmaceutical products with the regulations. It is used for warehouses, their storage and transportation of the same products. Of course, all the little things that collectively include this process, starting from the storage and sorting of the products and ending with its transportation. This minimizes the risk of

product degradation, which ensures the delivery of the product from a special warehouse to the specified point of issue;

3. Pharmacovigilance: Guidance on Good Vigilance Practice (GVP) - Good Vigilance Practice (GVP) is a set of measures drawn up in the European Union (EU) to facilitate the performance of pharmacovigilance. The GVP applies to marketing authorization holders, the European Medicines Agency (EMA) and medicines regulatory authorities in EU member states. It sets various special standards for pharmacies, according to which medical products should be received correctly, sorted and dispensed in correct doses to patients;

All activities are documented in adequate detail in written standard operating procedures [1].

1.2. Biosafety

Adequate assessment of various risks is the cornerstone of biosafety. Although there is no experiment or many methods of assessment, the most important is still professional judgment. Biosafety protocols are universal, and laboratory-to-laboratory divisions can be defined from protocols that are safe (i.e. unnecessary) to standards for the highest safety (strictly protective). The levels of biosecurity are accordingly distributed from safe (1) to the most dangerous (4) level:

1. **BSL 1 - the first level of biosafety,** is the lowest level of safety, which allows to produce cosmetics under its protection (to study non-pathogenic microbes);
2. **BSL 2 - the second level of biosafety,** is an average level of safety, which allows for its protection to be produced as cosmetics (using pathogenic microbes), medicinal preparations that have to enter the human body through the gastrointestinal tract, and also to study A, B and Hepatitis C, AIDS, Ecoli, Salmonella, Staphylococcus, Toxoplasma and Plasmodium falciparum studies;
3. **BSL 3 - the third level of biosafety,** is a strict safety level that allows the production of various medicinal preparations under its protection, and also at this level H5N1, Francisella tularensis, Chalamydia psittaci, SARS-CoV-1, MERS-CoV, Rickettsia rickettsii, Coxiella burnetii, Yersinia pestis, SARS-CoV-2, influenza virus, venezuelan and oriental equine encephalitis, tuberculosis, Rift Valley fever, chikungunya, brucellosis, yellow fever and West Nile fever;
4. **BSL 4 - Biosafety Level 4,** is the highest level of safety that allows only life-threatening diseases (eg, Ebola) to be studied.

1.3. Pharmaceutical industry of Georgia

Some germs of the pharmaceutical industry (pharmaco-chemical industry) in Georgia appeared in the first half of the 19th century.

1. **In January 1806,** in Tbilisi, the Governor of Georgia, Infantry General K.N. By order of Tsitsianov, a special plot of land was purchased for 2'000.00 manats and a special garden of medicinal plants was planted on it, which would supply Tbilisi's number one pharmacy;
2. **In 1853,** pharmacy number two was opened in Tbilisi for the sale of medicines with its own laboratory, in which galenic preparations were produced;
3. **In 1885-1886,** a rectification factory was already functioning in Tbilisi;
4. **By 1903,** a distillery was already operating in Zugdidi;
5. **In 1908,** the Kalinsky brothers opened an oil and soap factory in Tbilisi;
6. **In 1912,** the Kalinsky brothers already opened a carbon dioxide reception plant in Borjomi;
7. **In 1914,** the Borjomi carbon dioxide receiving plant finished its work;
8. **In 1919,** Borjomi carbon dioxide factory was started again by engineer Laganer;
9. **In 1921,** the first chemical factory was opened in Tbilisi;
10. **In 1923,** the university-semi-industrial laboratory was opened in Tbilisi, and the so-called A rectification plant was opened in Gori;
11. **In 1924,** together with the Red Cross, a turpentine and compression factory was opened, as well as A. year Rectification plant was opened in Kobuleti;
12. **In 1926,** a rectification factory was opened in Ozurgeti;
13. **In 1930,** a factory for the production of galenic preparations was laid on Kamo Street in Tbilisi;

14. **In 1932,** the scientific-research institute of pharmacochemistry was established in Tbilisi;
15. **In 1936,** a factory for the production of galenic preparations was built and opened on Kamo Street in Tbilisi, the so-called A caffeine production enterprise was opened in the place of the former factory of natural dyes in Batumi. Technological equipment for the production of potassium permanganate arrived in Tbilisi from Moscow;
16. **In 1937,** a rectification factory was opened in Vartsikhe;
17. **In 1939,** in Babushera (Sukhumi region) in Georgia, camphor alcohol and oils were already produced from camphor laurel;
18. **In 1942,** the production of gastrointestinal tract was started on the line of pharmaceutical industry;
19. **In 1943,** the tannin factory was opened. A special plant for receiving ether and ethyl was opened, as well as a raw material processing plant;
20. **In 1948,** the Mikoyan Meat Plant in Georgia started the production of medical and organ preparations (gelatin, liver extract and hematogen).

1.3.1. The target of the Georgian pharmaceutical enterprise

ASP - This is part of the quality Assurance System Practice, which guarantees that the product is continuously produced and controlled according to quality standards that are consistent with its purpose and are required by the trade license. The goal of the pharmaceutical enterprise is to produce a "good product" and develop the business, which is difficult in the world market, but much easier and safer in the Georgian market. The final target of the pharmaceutical enterprise is the patient, subsequently the user of the manufactured medicinal product, and the intermediate target is the pharmacy, subsequently the limited liability person, who qualifies the received medicinal product as satisfactory/good/best and sells it. Therefore, the main target of the Georgian pharmaceutical enterprise is the patient who consumes its product, and the intermediate target is the pharmacist who sells it and the doctor who promotes its promotion.

1.3.2. Standards met and to be met by Georgian pharmaceutical enterprises

According to the Ministry of IDPs from the Occupied Territories of Georgia, "Aversi Rational", "GM Pharma" and "Abi Pharma" are the Georgian pharmaceutical enterprises that fully met the SOP (GMP, GDP, GVP) standard system. According to the data of 2007, there were 138 pharmaceutical enterprises in Georgia, of which by 2023, few, if any, and only 3 enterprises fully comply with the SOP. Limited liability company 119 (86.23%), individual entrepreneur 2 (1.45%), joint stock company 12 (8.7%), public law legal entity 2 (1.45%), joint liability company 1 (0.72%), treasury 2 (1.45%). [6]

1.3.3. The number of pharmaceutical enterprises of Georgia and the medicinal forms produced by them

The number of active pharmaceutical enterprises in Georgia is 25.36% of the total number (138), which is equal to 35 locations. This is due to the fact that the total population of Georgia is 3,736,400 people, which is quite a low figure. The forms of medicinal preparations produced by this 25.36% in Georgia are - oral, percutaneous, rectal, inhalation. Of these, only inhaled and rectal medicinal forms are delivered to the body without passing through the gastrointestinal tract. [7]

The status of a Georgian pharmacist in today's Georgia is simply attainable, cashier-consultants working in a pharmacy, the education they received and the status of a pharmacist approved in a higher educational institution are mixed together. As a rule, a cashier-consultant working in a pharmacy should have "medical cashier" written on his identification card, which will distinguish between a real pharmacist and a simple cashier. Otherwise, in Georgia we have, roughly speaking - a person who has not received the education of a pharmacist or a related higher education, has undergone some training in working on the computer system of a particular pharmacy, starts working as a "pharmacist" in 2-3 months, and the same "pharmacist" who has received the education In a higher educational institution, he studied 4-6 years for a bachelor's degree, then 2-3 years for a master's degree, he can continue his education and another 3 years for a doctorate. These two pharmacists in Georgia have the same name. All this contradicts the connection between the pharmacist and the patient and creates a kind of mistrust between the patient and people with the status of "pharmacist".

1.4. Biosafety as an integral part of Georgian history

Here I want to review the ancient history of Georgia, the development of pharmacy and metallurgy in it. In particular:

1. **Pharmacy - Paleolithic;**
2. **Metallurgy - Bronze Age;**

In the Bronze Age, the Caucasus was the most important chemical and metallurgical center of the whole Eurasia. This age in the Caucasus is divided into three parts: Early Bronze (3rd millennium BC), Middle Bronze (2nd millennium BC, Fig. 1) and Gwin Bronze (2nd millennium BC, Fig. II) ages. In the Early Bronze Age, the Central and Eastern Transcaucasia - the Kolkheti plain, BC-c. Caucasus "Maikopi culture" and "Mtkvar-Araks culture". in the eastern part of the North Caucasus, in Anatolia, in northern Iran. In the Middle Bronze Age, several independent cultures emerged in the Caucasus, namely Trialeti, Sevan-Uzerlik, Tazakent-Kyzilvanki, Das. of Georgia and BC. Cultures of the Caucasus. During the Late Bronze Age, great economic and socio-political changes took place in the Caucasus. One of the main results of the development of productive forces and means of production was the discovery and exploitation of iron (the end of the 2nd millennium BC), which played a revolutionary role in the history of the development of society. The fact that today we have no way to establish, confirm or deny the fact that the metallurgists in the Caucasus were primitive people, or did not suffer from lung cancer, which mostly affects smokers and metallurgists with age, we can assume that the ancient Caucasians, who were quite Well versed in chemistry, pharmacy, and metallurgy with great skill, they would also have well-developed biosecurity for the era. Therefore, we can assume that biosecurity emerged in the Bronze Age, when primitive Caucasians mastered metallurgical activity. It should also be noted that pharmacy was recorded in the ancient Caucasus before metallurgy, it is assumed that it appeared in the Stone Age, but based on the fact that the oldest records are preserved at the level of folklore, we must conclude that it appeared in the Paleolithic, at the beginning of the Stone Age. The following provisions lead to this conclusion:

1. Lina Eristavi's book "Pharmacognosia (Medicinal Plants)" in chapter 1 "Brief history of the development of pharmacognosy" on page 16, paragraph 2 reports: "Thus, the garden of Hekate and Medea, which existed 3,400 years ago, in the world-famous Babylon There were 5 centuries before hanging gardens in ancient Georgia";
2. The Hanging Gardens of Babylon were built by Nebuchadnezzar II B.C. year It was built in the 6th century.

From these two historical-folkloristic sections, we can conclude that the Hanging Gardens of Babylon were built by Nebuchadnezzar II in BC. year It was built in the 6th century, and the garden of Hekate and Medea preceded it by 5 centuries. year They knew in the XI century.

This means that the Caucasian peoples knew about biosecurity before the Bronze Age, and it goes even further, that is, the discipline of biosecurity dates back to BC. year It was developed in Georgia in the XI century.

1.4.1. SOPs - Standards

SOPs - Standard Operating Procedures are procedures, that include adequate detailed written documentation of all required activities. These are the details:

1) **Packaging-sorting guide (GMP - Good Manufacturing Practice),** which means continuous production of products in accordance with quality standards. This requires the implementation of a system that is responsible for minimizing all types of risks, which include the period from incorrect raw material selection and processing to incorrect labeling. The GMP system includes all parts of the production process, from raw materials to the production of the finished product;
2) **Distribution Guidelines (GDP - Good Distribution Practice),** which means maintaining the quality and integrity of products at all stages of the supply chain. It sets minimum standards to ensure that medical devices and pharmaceutical products comply with the regulations. It is used for warehouses, their storage and transportation of the same products. Of course, all the little things that collectively

include this process, starting from product storage and sorting, ending with its transportation. This minimizes the risk of product degradation, which ensures the delivery of the product from a special warehouse to the specified point of issue;

3) **Guidelines for pharmacovigilance (GVP - Good Vigilance Practice),** which refers to a set of measures drawn up in the European Union (EU) to facilitate the performance of pharmacovigilance. It applies to marketing authorization holders, the European Medicines Agency (EMA) and medicines regulatory authorities in EU member states. It sets various special standards for pharmacies, according to which medical products should be received correctly, sorted and dispensed in correct doses to patients;

1.4.2. BSL and SOP sequence, and research on the necessity of that

In order for a pharmaceutical enterprise to be considered a properly functioning enterprise, it is necessary for the enterprise to meet at least the first condition of the SOP, i.e. the packaging-sorting guide (GMP - Good Manufacturing Practice), which implies the continuous production of products in accordance with quality standards. But the enterprise consists of various devices and departments, the totality of which is the enterprise, but the environment of this enterprise, what it should be and what protocol should be followed by each device, each technologist, if scientist, all this is accompanied by special security protocols. Compilation and implementation of these protocols is the responsibility of biosafety specialists.

- What medicinal forms are there?
- Oral, Injectable, Inhaled, Sublingual, Percutaneous, Rectal, Vaginal and Ocular;
- Which forms require the third level of biosafety?
- A general answer is given to a specific question, these are the forms that can be taken without passing through the gastrointestinal tract, for example:

▪ **Injectable** (solutions, suspensions, emulsions, powders and tablets, as well as capsules and tablets for implantation), which enter the body through the human cardiovascular system without passing through the gastrointestinal tract. In this way, various infections can be freely introduced into the blood, if the injectable substance is not produced under strict safety conditions, which in turn provides the third level of biosafety (eg: HIV+/-);

▪ **Inhalation** (gases, vapors and aerosols), which enter the body through the human lungs and respiratory system without passing through the gastrointestinal tract. In this way, various infections can be freely introduced into the lungs, if the substance is not produced under strict safety conditions, which in turn provides the third level of biosafety (eg: SARS COV-2);

- **Rectal** (suppositories, ointments, capsules, aerosols, foams, solutions, suspensions, emulsions, microinjections), which without passing through the gastrointestinal tract, passes through the anus of a person into the rectum. In this way, various infections can be freely introduced into the rectum, if the substance is not produced under strict safety conditions, which in turn provides the third level of biosafety (eg: HUS - hemorrhagic-uremic syndrome); [2]
- **Vaginal** (suppositories, balls, tablets, solutions, emulsions, suspensions), which enter the female genital organ without passing through the gastrointestinal tract. In this way, various fungal infections can be freely introduced into the female genital organ, if the substance is not produced under strict safety conditions, which in turn provides the third level of biosafety (eg: vaginal candidiasis fungal infection); [3]
- **Ocular** (solutions, ointments, plates, gels, tablets, minims, lamellas and shafts), which, without passing through the gastrointestinal tract, get into the eyeball area and areas. This is one of the ways to get an infectious eye disease. If the medicinal substance is produced under strict safety conditions, which in turn provides the third level of biosafety, the risk of getting

infectious eye diseases when taking such a drug is reduced, but eye infections are airborne and therefore they can still get into the eye, but it is reduced to a minimum, because the human eye is protected in this case Ciliary membrane, eyelid, tear and cornea. Exactly outside of these natural ways of protection, where the medicinal drug meets it, different infectious diseases can occur (eg: conjunctivitis - inflammation of the mucous membrane of the eye); [4]

- As for the remaining pharmaceutical forms, what are they and what level of biosafety ensures their safety?
- The second level of biosafety is the average level of safety, which allows for the production of cosmetic products, as well as drugs that have to enter the human body through the gastrointestinal tract. These medicinal forms are:

▪ **Percutaneous** (ointments, solutions, creams, plasters, liniments, pastes, gels, conventional foaming and foaming aerosols), which are taken on the human skin and through the sweat pores can enter the bladder with sweat, which also includes the gastrointestinal tract, but from the skin The possibility of getting into the body in this way is from 2% to 5%;

▪ **Oral** (solutions, suspensions, syrups, emulsions, elixirs, extracts, decoctions, tinctures, powders, tablets, dragees, pills, granules, capsules and microcapsules), which are taken from the mouth, through the esophagus into the stomach;

- **Sublingual** (drags, powders and tablets), which are taken orally, through saliva and through the esophagus into the stomach;

1.4.3. Alignment between BS and GMP

„BS-Biosafety", is the basic designation of Biosafety, but it is also divided into 3 main subspecies, which, depending on the name, are tailored to different areas, e.g.:

1. **"Geosafety",** it is geographic, geophysical, climate, or man-made safety of land, sea and atmosphere, in short geosafety is environmental safety which is the main target of ecologists;
2. **"Agrosafety",** it is agrarian, agro-biotechnological and, in general, agricultural products, both plant and animal products. In short, agrosecurity is food safety, which is the main target of agronomists;
3. **"Pharmsafety",** it is the protection of the safety of medical and/or pharmaceutical products or treatments, in short, this pharmasafety is the target of bioethicists.

Due to the fact that Georgia is a developing country, according to the decision of the World Health Organization (WHO), various Georgian enterprises, such as fuel production, mineral extraction and processing, agro-enterprise and pharmaceutical enterprises, are required to follow protocols of special norms drawn up by biosafety specialists.

Of course, there is no need for biosafety specialists in pharmaceutical enterprises in Georgia, because according to the WHO, Georgia will need specialists in this field as soon as the SOP standards will be completely overcome and the country will move to a new stage of development [5]. BSL3, is responsible for creating strict production safety conditions, i.e. what conditions must be met by the temperature index inside the production space, must there be a vacuum, if air is allowed, are radar substances allowed in this air, should there be moisture, what should be the pressure in the enterprise area, how safety standards What kind of protocols should be followed by those employed and what kind of protocols should be followed for proper/proper pharmaceutical industrial production. BSL3 is responsible for all of this. After everything is in order in the enterprise, the strict biosafety conditions of production can already be started and the enterprise can start working and follow the system described according to the GMP standard, which includes all parts of the production process, from raw materials to the production of the finished product. Therefore, before starting industrialization, it should be determined precisely:

- What kind of medicinal product should we take?
- When choosing the BSL2 level, we prepare medicinal forms that will necessarily pass through gastric juice when they enter the human body;

- When choosing the BSL3 level, we prepare such medicinal forms that, when entering the human body, are carried out without passing through the gastrointestinal tract.

After the biosafety norms are completely respected, the enterprise can freely start working in accordance with the GMP standard.

1.4.4. Old Kolkhian method of drug dosage

The old method of dosing medicinal drugs - in 1927, the Soviet Union abolished the commonly tested and justified dosage in pharmacy, namely 1v (drachma) = 1/8 oz = 4 g, drachma is the ancient Georgian letter "v" itself, it is still used today as a letter, sacred In practice, it will be used as a unit of measurement in the metallurgy of the Patriarchate for the dosing of various substances and in the community of blacksmiths of Georgia. As a rule, since time immemorial in Kolkheti, metallurgy, blacksmithing and pharmacy are interrelated branches, therefore, their measuring units and the safety norms necessary for their work were also similar.

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Mathematical Algorithm for Calculating Egg Volume

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Abstract: We have made measurements for the given egg, In particular Egg length, diameter and distance from the narrow tip to the top to a wide place. We also found the maximum of the contour of the egg with the help of the Cartesian coordinate system. We modeled the outline of the egg, first with a parabola and then with a more complex function.

The parameters were selected in such a way that they met the theoretical conditions.

Then, to obtain the surface of the egg, rotate the obtained profile around the OX axis. We found the volume of the obtained model and compared it with the experimental result. The accuracy was satisfactory.

Main Part

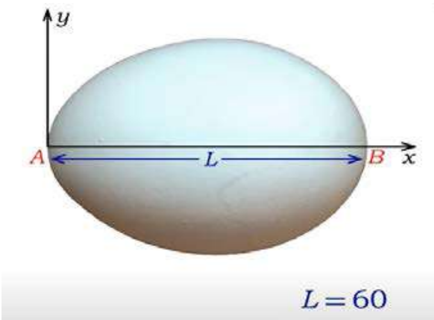
Rotating body

Our goal is to calculate the volume of the egg, first by a mathematical method, then experimentally, and compare these two results. For that

We will first build a mathematical model of the surface of the egg. Then, with the help of calculus, we will find its volume and compare the obtained result with the experimental result. We find the volume of the egg by the ancient method of Archimedes. In this cross-section, or in the foreground, we have a circle and the egg is a rotating body. This reduces our task. It is enough for us to get the profile function of the egg, and then we get the surface of this egg if we rotate this profile around the axis of symmetry.

We will need to make some measurements for this. Egg dimensions are L=60 millimeters, diameter 47 millimeters. The distance from its apex to its widest point.

Let's try to show the profile of the egg with some function. We will choose the coordinate system in such a way that the symmetry axis of the egg coincides with the OX axis and the sharp tip of the egg coincides with the coordinate origin. Let's denote the length of AB by L (L=60 mm). We will build another coordinate system and try different functions.



Our goal is to construct a graph of some function in the first quarter (square) that repeats the outline of the egg. Obviously, this graph must pass through points A and B.

We also made measurements to determine the coordinates of point C (32; 23,5). At point C we will have the maximum of the function, 23.5 which is half the diameter (diameter 47 mm). This graph must also pass through point C.

Let's try some simple function (simple is good, because it will be easier to calculate the volume)

Take $f(x) = x(L - x)$, where L is the length of the egg.

That is, our function is the following parabola, $f(x) = x\,(60-x)$. It passes through the points A (0,0) and B (60, 0) (in fact, if instead of x we insert first 0 and then 60, we get a true equality). Also, at interval AB it has one maximum and is convex upwards.

We now need to "deform" the graph so that it is more similar to the profile of an egg. To do this, let's multiply the function f by some constant K, so we can stretch and contract the function along the y-axis. Apart from that, let's classify the x variable in the p degree, and (L-x) in the q degree, and if we change these k, p and q, we will be able to deform the graph.

We must take the degree of p and q to be positive, if we took p to be negative, then the graph would not pass through the origin and at this point we would get a break of the second genus. We face the same problem if we take q negative.

Lines passing through points A and B are parallel to the OX axis. This can be achieved when the constants p and q are less than one, i.e.

$0 < p < 1$, $0 < q < 1$. If we choose p and q in this way, then f is the derivative of the function.

Points A and B will tend to infinity and the sides will be vertical.

To find the volume of the egg, it is enough for us to consider the function only in the first quarter.

For example, let's construct a symmetric function of this f function with respect to the OX axis, so the image will appear more clearly. In order to deform the graph, we need to change three parameters p, q and k at the same time.

Add point C to the graph. We want the maximum of the function to coincide with the line C. For this we need to change this parameter.

When $p=0.82$ $q=0.66$ and $k=0.15$

It's like we maxed out in C, but the graph still doesn't look like an egg. Let's change the parameters again, take $k=0.61$ and $p=0.57$, then the shape is almost like an egg. Let's take $q=0.5$ and change the rest of the perimeters. Finally if $L=60$; $k=0.61$; $p=0.57$; $q=0.5$ then this shape is very similar to the given egg.

Volume

The surface of the egg is obtained by rotating the graph around the OX axis.

Now let's take a surface centered along the OZ axis and with the pointed tip up. Let's move on to calculating the volume, first find the volume without taking the numerical values of the parameters (that is, in a general way)

$v = \pi \int_0^L f^2(x)\, dx =$

$$v = \pi k^2 \int_0^L x^{2p} (L - x)^{2q}\, dx$$

Let's insert the following into the integral

X = L * t After this notation, the limits will be 0 and 1.

$$\pi k^2 \int_0^1 L^{2\rho} \cdot t^{2\rho} (L - L \cdot t)^{2q} \cdot L\, dt =$$

We got L outside the integral

$$\pi k^2 L^{2\rho + 2q + 1} \int_0^1 t^{2p} (1 - t)^{2q}\, dt =$$

(Let's remember that this type of integrals $\int_0^1 t^{x-1} (1 - t)^{y-1}\, dt$

Gamma and beta function

the so-called beta function B(x,y))

$$\pi k^2 L^{2p + 2q + 1} B(2\rho + 1, 2q + 1) =$$

In our case, we randomly took q equal to 0.5. When q=0.5 everything becomes simpler, we get a simple integral

$$\pi k^2 L^{2\rho + 2} \int_0^1 t^{2\rho} (1 - t)\, dt = \pi k^2 L^{2p+2} \left(\frac{t^{2p+1}}{2\rho + 1} - \frac{t^{2p+2}}{2p + 2} \right) \Bigg|_0^1$$

$$= \frac{\pi k^2 L^{2p+2}}{(2p + 1)(2p + 2)} \approx 66{,}66 ml$$

The final result was 66.66 milliliters.

Archimedes' experiment

Archimedes was asked by a king to figure out whether the king's crown was pure gold or gold mixed with silver. Archimedes knew that he had to figure out the crown's density: how heavy it is compared to how much space it takes up (which is mass divided by its volume). It was easy enough to figure out how heavy it was but its volume was tricky.

Archimedes went off to think about this in a nice hot bath. While he was in the bath he noticed that the more of himself he put under water, the higher the water level rose. He realized that the amount of water that rose was equal to his own volume. He was (supposedly) so happy to make this discovery that he ran out into the streets naked shouting "I found it!" ("Eureka!").

Archimedes had found an easy way to measure the volume of an irregularly shaped object. If you submerge the object in water, it will displace a volume of water equal to its own volume. He could use this method to find the volume, and thus the density of the crown. Legend has it that he was able to compare the crown's density to the density of gold, and thus show that the metal in the crown wasn't pure.

When we fill up a glass with water, put an egg in the glass and measure the water that rises up (or spills out), we discover the volume of the egg. The volume is about 65 or 66 milliliters, which confirmed the accuracy of the mathematical model.

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Analysis and Theoretical Foundations of the Experience of Residential Complexes Reconstruction

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Abstract: The paper provides an overview and analysis of the experience of residential complexes reconstruction n Georgia and abroad, elaborates the theoretical foundations of the implementation of reconstruction that implies the necessity of differentiated of reconstruction development concept for different periods and for differentiat buildings. At the same time, the approach to reconstruction should be based not on a single building, but on their complexes: a group of buildings, a block, a microdistrict. This gives the possibility to the task of urban planning to be assessed in a complex manner and to make rational decisions that meet modern requirements and provide a connection between different architectural periiods.

Key words: reconstruction, residential complexes, buildings, efficiency.

Introduction

The complex reconstruction of existing territories, individual populated areas of cities and buildings represents a process of reorganization of the urban environment, the content and duration of that are determined by interrelated actions, such as designing, planning and implementation of reconstruction measures. In this regard, the complexity lies both in the design of reconstruction objects and in the selection of methods of project decisions implementation.

The aim of the paper is to establish the theoretical foundations of the reconstruction of residential complexes, literary review and analysis.

The main objectives of the research are:

1) The essence of the concept "Evaluation of the efficiency of residential development reconstruction";

2) Analysis of Georgian and foreign experience in the reconstruction of residential development, current state of the problems of the housing fund during reconstruction.

The definition of reconstruction in the Code of "Georgian Spatial Planning, Architectural and Construction Activities" is given as follows: reconstruction is the essential change of an existing building and/or part of it for the purpose of their physical, qualitative and qualitative renewal.

In other scientific literature, reconstruction is a combination of construction works and organizational and technical measures related to the change of basic technical and economic indicators (load, planning of buildings, volume and total area of building structure, engineering equipment) to change operating conditions. Compensation of maximum loss from physical and moral wear and deterioration, reaching of new goals of building operation.

Main Part

The concept of building reconstruction is differentiated for various periods and for different buildings. At the same time, the approach to reconstruction should be based not on a single building, but on their complexes: group of buildings, block, a microdistrict. This gives the possibility to the task of urban planning to be assessed in a complex manner and to make rational decisions that meet modern requirements and provide a conneection between different architectural eras.

In the urban planning practice of the 1960s and 70s in the Soviet Union, including Georgia, reconstruction meant the demolition of existing buildings and their replacement with new ones.

In France, at the same time, high-rise concrete industrial buildings were being destructed by explosion and replaced by new ones.

Ten years later, the Germans began to follow the French example, but quickly made economic calculations, came to the conclusion that it is more expensive to demolish residential buildings and replace them with new ones than to reconstruct them, and found a successful method of reconstruction, which they called "careful renewal".

The design of the reconstruction of the urban development is carried out in five successive stages:

1) The general plan of the city reconstruction;

2) Residential area reconstruction project;

3) Project of reconstruction and improvement of inter-highway areas;

4) Residential group reconstruction project;

5) Reconstruction project of individual buildings.

At the same time, all cities, different from each other, have a variety of development, but during the reconstruction, three main zones are outlined in them:

1) Conservation zone - historical core; requires maximal keeping;

2) Regulation zone - existing living environment that needs renovation and reconstruction (improvement of living comfort);

3) Transformation zone - the farthest from the historical center, requiring the demolition of old buildings, rearrangement and new development.

All methods and types of residential development and reconstruction of buildings are generalized on Table 1 These methods are used in different countries worldwide, but the emphases and approaches are different everywhere due to various reasons: political, demographic, social, economic, etc.

Table 1

All reconstruction methods of residential development

Reconstruction regulations	Typical for reconstruction methods
Reconstruction	By keeping functions By changing function

Reconstruction regulations	Typical for reconstruction methods
Restoration	Restoration of architectural monuments Renovation of monuments lost volumes
Preservation	Monuments preservation Renovation of monuments lost volumes
Sanitation	Transfer of industrial and dangerous enterprises to suburban area Reshaping Cleaning
Reconstruction of development	Demolition of whole building Demolition of some parts of building Rearrangement of building
Compaction of development	New construction after demolition of old building Add a superstructure on building Extension of building Inclusions and ჩაშენებები
Improvement of buildings exterior	Without changing building exterior (face-lift) With partial change of building facade fragments Change of building exterior Improvement of area in dront of house Complete rearrangement
Repair	Operating Sample

Common methods that are now widely appled are reducing and increasing the density of development.

Recently, a lot of attention has been paid to improving the appearance and amenities of buildings in Tbilisi. Tbilisi City Hall has issued a number of resolutions with the program of improvement of courtyard areas and building entrances. Much has been done to improve the appearance of the buildings, especially in the central part of the city.

Before selecting a reconstruction method, it is necessary to study the factors affecting decision-making.

The relevance of the complex reconstruction of the old districts of existing cities is stipulated due to a number of social, urban planning and economic factors. Social factors are related to the low quality of housing and potential breakdown rate, high operating costs of its maintenance, accumulated insufficient repairs.

The transformation of residential development would be an integral part of the reconstruction project of the multifunctional central planning district, its parts (public complexes and junctions, streets, zones). In this case, the following issues should be interrelated in the project:

1) Ratio of residential and public spaces and organization of planning;

2) Construction of new residential and public buildings, demolition of old (depreciated) ones;

3) Rearrangement, overhaul (modernization) and reconstruction of preserved residential and public buildings;

4) Engineering equipment and neighbourhood improvement.

Currently, a number of targeted programs are aimed at solving reconstruction problems, such as "housing", "preservation and development of the architecture of historical districts", "program of complex reconstruction, modernization and improvement of residential areas of Tbilisi", etc.

In general, the complex reconstruction, modernization and improvement of residential areas is aimed at the transition from the territorial growth of cities to the qualitative transformation of the existing development, which requires a balanced solution of urban planning and housing problems.

Foreign experience in residential complexes reconstruction

In connection with the rapid integration of modern trends and technologies, special attention should be paid to studying the experience of other countries in scientific activities.

At the First International Workshop on Urban Reconstruction and Modernization, held in The Hague in August 1958, it was declared that the main goal of urban renewal is to consciously change the environment and create modern living areas and working conditions for citizens by changing the existing spaces. Initially, the main principles were developed to extend the life cycle of existing city areas, aimed at strengthening the activity of all structures that, as a result of moral and physical wear and tear, ceased to fulfill the functions of providing a comfortable life and work for the population. Initially, the renewal of the territories affected the historical centers of the cities first of all. This circumstance was due to the fact that the main economic, social, political activity was concentrated in their central parts, and the need to introduce new technologies and improve public comfort was especially acute.

The first large-scale urban renewal project is the renewal of Paris, carried out by Baron Haussmann in the middle of the XIX century (Fig. 1).

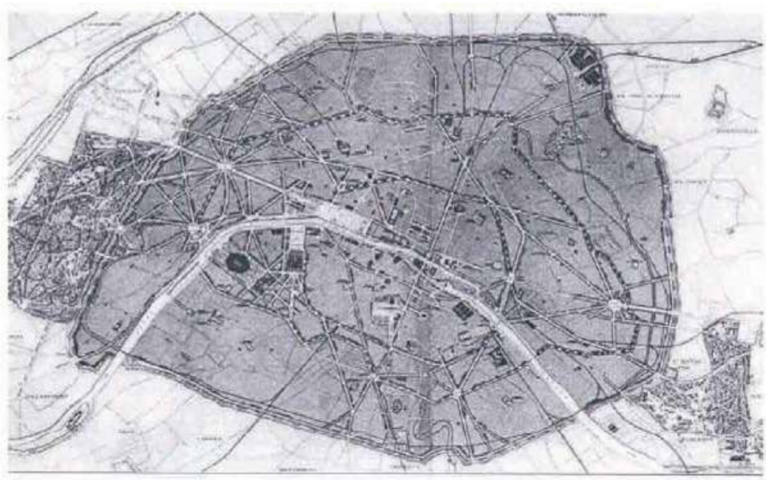


Fig. 1 - Paris reconstruction scheme implemented by Baron Housman in the middle of the XIX century

However, the United States of America is the first state that develop complex national urban reconstruction programs. This circumstance was caused by the need to renew a large number of cities due to their active urbanization.

The first step of the US government in the field of urban revitalization was the adoption of the Housing Act in 1949, which became the main instrument for the modernization of urban areas, aimed at the active demolition of old housing and the active construction of new ones.

The program was based on three main elements: prevention, restoration of structure and surroundings and their reconstruction. However, private investors were reluctant to participate due to restrictions that made the projects focused on residential construction that was not the most profitable investment in the long term. As a result, the cities were reconstructed mainly by demolishing old houses. The implementation of the programs was going on with many problems and was accompanied by the relocation of industries and enterprises and the active demolition of residential buildings. In addition, the implementation of this policy led to a huge imbalance between the amount of investment in the development of business districts located in the central parts of cities and the limitation of attention to the social problems of residential areas. This policy ultimately led to the active growth of luxury housing and the reduction of the volume of low-cost housing with low rents.

When looking at the politics of mainstreaming approaches to urban regeneration in Europe, trends similar to those in the United States can be observed.

Active modernization of the old central areas of European cities began during the industrial revolution, which occurred a little later in Europe than in the United States. Thus, the experience of the United States of America and their basic principles were used as a model by European countries. However, unlike the United States, European countries have implemented the reconstruction of urban areas without developing specific national programs. As an example of the active participation of the state in the reconstruction of urban areas, we can cite the experience of Great Britain in the middle of the 19th century, when it pursued an active policy to eliminate outdated residential areas. In the 1920s, Europe actively began to implement works in the direction of reconstruction and modernization of cities, which was connected with the results of the First World War. As a result, for this period, the most reconstruction works were carried out in one generation. After the Second World War, in the 1950s, there was an increased interest in the restoration of historic buildings, the reconstruction of urban ensembles of the previous era, and much attention was paid to the preservation and restoration of historic cities and urban areas.

Hong Kong and Singapore are the clearest examples of active policies of modernization and renewal of Asian city areas. Hong Kong and Singapore are examples of active implementation of

Initially, the reconstruction of Hong Kong was dominated by the private sector. Government intervention in urban regeneration in Hong

Kong first began in 1954 with the adoption of a large-scale demolition scheme for old housing. In 1972, an extensive program was implemented to renovate estates built in the 1950s, turning them into autonomous institutions. Schools were created in such buildings, or conditions were created for their administrative or social use.

In 1987, the state's approach to the reconstruction of Hong Kong changed. The government decided to create conditions for the development of public-private partnerships, for that a special body, the Land Development Corporation, was created, which was responsible for raising private funds for the implementation of reconstruction projects.

The main objective was to accelerate the pace of private sector reconstruction in certain areas of Hong Kong, as well as to improve the quality of projects and their economic benefits by reducing government subsidies. A visible result of the implementation of these concepts is the example of the reconstruction of Hong Kong's western cultural district.

Singapore's experience in the field of reconstruction of existing buildings

Considering the period of the 1960s special attention deserves. This period was characterized by outdated residential houses.




90-ies of previous century prior reconstruction


After reconstruction

Active demolition and modernization and active reconstruction of the area were performed in many quarters. In 1964, with the help of foreign consultants, an urban reconstruction program was developed and started in the central part of the Chinese city of Singapore.

The result of the implementation of this program was the reconstruction of all the colonial districts in the central part of the city, which were mainly built with two-three-story buildings. Special attention was paid to the creation of the resettlement fund, before the reconstruction or demolition of the existing buildings, new modern buildings were built in the surrounding areas, which reduced the level of social tension.

Currently, the central part of the city is completely reconstructed and updated. Shopping complexes, office and residential buildings are located on its territory, high-rise Singapore replaced the colonial city. In the territory of the city, only a few luxurious colonial residential areas have preserved their original appearance.

In Western European countries, the 21st century is characterized by a complex approach to the reconstruction and modernization of existing territories.

Consider the reconstruction process in Georgia on the example of the old districts of the city of Tbilisi.

By the end of 2023, according to the data of Mtatsminda District Administration, the number of dangerous buildings amounted up to 707;

According to the data of 2016-23, the number of objects restored by the Tbilisi Development Fund is 160 units;

56 residential houses are planned to be reconstructed and restored in 2024;

The number of resettled families during the reconstruction is 402 families;

Reconstruction of the recreation area was carried out in 5 objects.

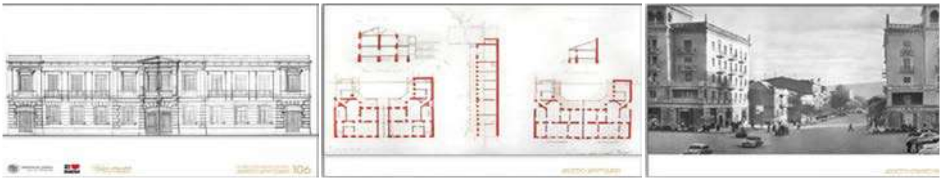
Below are fragments of the reconstruction in the old district of Tbilisi.

Within the framework of the "New Tbilisi" project, Tbilisi Development Fund carried out rehabilitation works of residential houses located in Orbeliani Street N31 and N33 in Mtatsminda district. The building located in the historical part of Tbilisi has the status of a cultural heritage monument.

After the completion of the rehabilitation, the living conditions of the apartment owners living at 31 and 33 Orbeliani Street will be improved, and two more restored and renovated buildings will be added to the tourist route of Tbilisi.

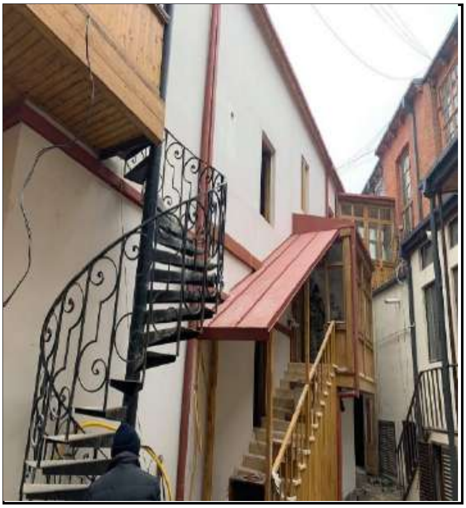
Let's consider several examples of restoration in Tbilisi, David Agmashenebeli Avenue

N 106 David Agmashenebeli Avenue



სურ. 1.8. შენობის რეკონსტრუქციისა და ძველი პროექტის ფრაგმენტი

სურ. 1.9. მიმდინარე რესტავრაციის ფოტოფიქსაცია



Tbilisi Development Fund, within the framework of the "New Tbilisi" project, completed the rehabilitation works of the Darejan Dedofli Palace monastery complex.

In the territory of the monastery complex of the Darejani Palace, in a deep trench prepared for strengthening the foundation and making a drainage system, archaeological remains were discovered, including fragments of the wall, which were cleaned and preserved by archaeologists in accordance with the relevant rules.

Within the framework of the project, the conservation works of the wall painting of the 18th century church of the Mother of Transfiguration Monastery were carried out.




Factors affecting the choice of housing reconstruction option and performance evaluation indicators

The mass character and social orientation of the measures implemented during the reconstruction of the housing fund increases the role of the economic efficiency of the invested funds.

The measures of modernization of the housing fund provide for the elimination of the moral wear and tear of the building along with the elimination of its operational deficiencies. During modernization, the indicators of apartment planning are improved, engineering equipment systems are improved, the quality of amenities and the sanitary and hygienic properties of buildings, etc., are increased.

Increasing the living area is one of the most important results of the reconstruction in the case when it is necessary to increase its density in the existing part of the building from the point of view of city planning. Another, no less important goal of building reconstruction is the qualitative renewal of the foundation, which does not meet modern requirements.

This leads to the consideration and evaluation of the option of demolishing the buildings and building a new building in their place that gives the possibility to solve the task of receiving modern housing. This task can be ensured by the option of new constructions in peripheral areas, the costs of which have their own accounting characteristics.

Conditional (evaluative) economic effect - e(p) is defined as the difference in income that can be obtained from the sale of apartments in the housing market at their market value, minus the costs of reconstructed or newly built residential buildings. In addition, the market price of 1 sq. M. The total area of apartments f(m.b) for new construction and reconstruction is assumed to be the same, since, according to the condition of comparison, the category of compared houses should be the same and the economic and social effect should be equal.

Conditionally, it is assumed that all costs are incurred during the year and coincide with the results obtained in time. The time of construction and reconstruction of a new house coincides with each other. Then as a result of reconstruction m(r) is received conditional (evaluative) economic effect or for new construction of a residential building m(a) is calculated as a profit from the invested capital received as a result of the sale of apartments in a reconstructed or new house at a single market price per square meter of common living space.

At the reconstruction, the consumer properties of the housing should be brought up to the level of the new construction.

$$e(p) = m(r) - m(a), \tag{1}$$

a) Calculation of profit at reconstruction.

In the case of reconstruction carried out without resettlement of residents, the profit calculation formula will be as:

$m(r) = f(m.b)\times \Delta N - k(r),$

(2)

where f(m.b) is the market price of 1 square meter of the apartments total area;

ΔN is the area increase as a result of reconstruction;

k(r)- capital investment in reconstruction.

In the reconstruction of the house that is related to the accommodation of residents, re-planning of apartments and their subsequent sale, formula (2) takes the form:

$$m(r) = f(m.b)(N(r)+ \Delta N) - k(r) - X(research, resset), \quad (3)$$

where $N_{(r)}$ is the total area of the apartments before the reconstruction of the house;

X (research, resset)- are expenses for accommodation of old house residents.

A positive value of the conditional (evaluative) economic effect e(p)>0 indicates the efficiency of the investment costs of the object's reconstruction

Conclusion

A review and analysis of the experience of the reconstruction of residential complexes in Georgia and abroad was carried out, the theoretical foundations of the reconstruction were elaborated, which means that the concept of the reconstruction of the development should be differentiated for different periods and for different buildings. Factors affecting the choice of housing development reconstruction option and performance evaluation indicators were identified.

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The Role of Dam Population in Energy Production

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Abstract: Hydropower, a renewable energy source, utilizes dams to harness the kinetic energy of flowing water, generating electricity through turbines and generators. Mega dams like the Hoover, Three Gorges and Itaipu exemplify human engineering feats, their efficient designs contributing to substantial energy outputs. However, such projects come with ecological consequences, prompting reevaluation of greener approaches. In Europe, countries like Norway and Sweden lead in hydroelectricity production, highlighting its pivotal role in sustainable energy generation. For Georgia, hydroelectric power presents untapped potential, with abundant water resources promising energy independence. Efforts to restore fish populations impacted by dam development underscore the necessity of balancing energy production with environmental conservation.

Key words: Hydropower, Renewable energy, Electricity, Dam, Sustainable energy

How do we get energy from water:

Hydropower, or hydroelectric power, is a renewable source of energy that is generated by using a dam or diversion structure to alter the natural flow of a river or other body of water.

There are many types of hydropower facilities, they are all powered by the kinetic energy of flowing water as it moves downstream. Through the use of turbines and generators, this kinetic energy is efficiently converted into electrical power.

How exactly is electricity generated at hydropower plants:

The water from a river or reservoir is channeled into the hydropower plant through an intake structure – a pipe or penstock. It is designed to control the flow of water and direct it towards turbines which are typically located at the base of a dam or the diversion channel. The water flow causes the rotation of blades of these turbines. As they rotate, the turbine spins the shaft of a generator which is connected to it. The generator then converts the mechanical energy from the turbine into electrical energy through electromagnetic induction. This electrical energy is initially in the form of low-voltage alternating current. It is then transmitted through transformers, which increase the voltage to levels suitable for long-distance transmission over power lines.

Mega dams of the last century:

Hoover dam (1936): Located in the rocky area of the Colorado River's Black Canyon, the Hoover Dam with its strategic 222-meter-high wall is a famous example of human skill and engineering.

The original concept of this dam’s construction was a straight concrete wall, which was not considered ideal due to vulnerability to the water pressure that it was supposed to face. Instead, engineers opted for a gravity arch dam design, which allowed for more efficient distribution of forces and better utilization of the natural geological features of the canyon. This design, featuring slight flexibility and broadening at the base, effectively alleviates the water pressure, thereby ensuring the structural integrity and resilience against hydraulic forces.

The Hoover dam has 17 turbines and generators in total and has been generating around 4.5 billion kilowatt-hours of electricity annually.

Three Gorges dam: The world's largest dam holding a recording amount of 33 enormous turbines (each capable of producing 700 megawatts of electricity) and 34 generators (weighing 6000 tons each). Thus, when the dam is running at its full capacity, it's producing over 4 times more energy than the most powerful nuclear power plant in the world and can provide the daily electricity requirement for about 20 million people in UK.

By 2013 the dam had already paid out itself by energy output (opening year – 2003).

The consequences to the ecosystem: The name of the dam came from flooding three gorges – Qutong, Wuxia, and Xiling – to build this huge 2.3 km-long wall. Its 410-mile reservoir would flood 244 square miles of land, displacing many people, and submerging towns, cities, plants, and historical sites underwater. Supporters argued that the dam would reduce China's reliance on coal power and boost trade along the Yangtze River. They also said the dam could prevent future floods, but recent reports show this might not be true, partly because of climate change. Now, the main struggle is dealing with floods and keeping the reservoir's water level below 175 meters. The concerns about large dams stemmed from the perceived failure of the Three Gorges Dam to fully meet its intended purposes. However, even in very last decade the engineering has evolved, after which a lot reconsidered their opposition to dams and started to look more into a greener approaches suggested by harnessing hydro-resources.

Itaipu Dam: In 2014, the Three Gorges Dam held the record for producing 98.8 million MWh of electricity in a year. Two years later, an older dam with fewer turbines broke this record by generating 103.1 MWh of electricity in a year, a record that stood until 2020. This impressive achievement was mainly due to favorable water conditions and efficient operations.

The amount of electricity generated doesn't just depend on the number of turbines; the force and frequency of the water hitting the dam are also crucial along with the height of the wall itself. In the case of Itaipu, its strategic location on the upper Parana River means it's basically powered by a waterfall. In 2016, the Parana River had higher-than-average water levels and flow rates. This abundance of water sided with the favorable height of 118 meters allowed the dam to run its turbines at full capacity for longer periods, resulting in more electricity being produced. By carefully managing water releases and turbine output, Itaipu maximized electricity production while keeping the power grid stable.

The hydro-resource utilization in Europe:

While discussing the topic of dam importance and hydro-resource utilization in Europe, some countries worth mentioning are Norway, Sweden, Switzerland, Austria, and France.

The most important place-holder with significant portion of 93% generated electricity being from hydro-electric plants is **Norway**, with the average energy consumption being around 125 TWh per year with total production being 145 TWh.

Sweden generates a substantial amount of electricity from hydroelectric power plants worth approximately 42% of Sweden’s total electricity production. Consumption and production being around 145 TWh per year.

Around 57% of **Switzerland’s** total electricity production is contributed by hydroelectricity, with both, total production and consumption being worth of 65 TWh per year.

Hydroelectric power plants generate around 60% of **Austria's** total energy production, with both, total production and consumption being worth of 65 TWh per year.

Electricity produced from hydroelectric power plants is an important component of **France's** electricity mix. Contributing around 10% to the total electricity production of 550 TWh. This percentage represents notable portion of the nation's energy supply, considering that the main source of power in France is the nuclear one, generating around 75% of the nation's energy output.

Hydroelectric power is a fundamental element of sustainable energy generation, valued for its renewable nature, reliability, and low environmental impact. As we strive for a greener future, hydroelectricity plays a crucial role in ensuring energy stability and reducing carbon emissions. Its significance in shaping our energy landscape remains undeniable as we transition towards cleaner and more sustainable sources of power.

Restoring Fish Populations Impacted by Power Plant Development

When the power plants were built in Norway, the level of environmental awareness was much less than it is today. Many also probably thought that fewer salmon in the river was a small price to pay for having electricity in the home.

Efforts to restore fish populations impacted by the development of power plants involve both traditional stocking practices and innovative solutions. The focus has shifted towards implementing measures that enhance local conditions for fish and promote the establishment of self-sustaining ecosystems. Key considerations include ensuring adequate water flow in rivers, regulated through minimum flow requirements set in hydropower licenses. Residual water flow from groundwater and tributaries further supports fish migration. Additional measures, such as installing spawning gravel and creating safe habitats for young fish, are also crucial for fostering sustainable fish populations.

Meaning of hydro-electrical power to Georgia:

Based on data from the past decade, average consumption of electrical power in Georgia is 12.1 billion KWh a year, 11.52 billion of which is produced locally by various power plants and the rest is imported. While this may seem promising that about 74% of locally generated power comes from hydroelectric plants there is still untapped potential for increased power production that could potentially eliminate the need for imports. Although there are many claims that other types of renewable power sources are a better and more environmentally appropriate, their reliability remains a concern due to inefficiencies leading to higher costs and lower power output. Currently, only 0.8% of total generated power comes from other types of renewable power source plants, the rest 25.3% is delivered from non-renewable fossil fuels.

Georgia's significance lies in its abundance of water resources being over 26200 rivers. The geography is nearly similar to Norway's, which has already utilized the resources and is now working on optimizing the ecological condition with gaining the most out of years of work on over 1300 different size hydro-electrical dams.

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Sediment Problem on Enguri Dam

Ana Tsulaia (Bachelor program student), Supervisor: Associate Professor Manoni Kodua, Georgian Technical University

Abstract: Dams play a crucial role in managing water resources, providing hydroelectric power, and mitigating floods. However, these structures face challenges, and one significant concern is the accumulation of sediment. Sedimentation in dams poses various problems, affecting their efficiency, lifespan, and overall functionality.

The Enguri Dam in Georgia, a marvel of human engineering and natural resource synergy, is not exempt from the sedimentation dilemma that plagues many global dams. This piece delves into the sedimentation predicaments facing the Enguri Dam, exploring their origins, implications, and potential remedie.

Key words: Dam, Sedimention, Hydrological system.

The Enguri Dam scenario:

The Enguri Dam, a towering hydroelectric complex in Georgia, epitomizes the marriage of human ingenuity and natural resources. However, amid its grandeur, the dam contends with a persistent adversary – sedimentation.

However, like many dams worldwide, the Enguri Dam faces the persistent challenge of sedimentation, impacting its operational efficiency and long-term sustainability. In this article, we will delve into the specific sedimentation issues confronting the Enguri Dam, examining their causes, repercussions, and proposing tailored solutions to address these challenges.

Sedimentation Challenges at Enguri Dam:

Natural Erosion in the Enguri River Basin:

Natural processes like erosion and weathering contribute to the gradual accumulation of sediment in rivers and reservoirs. The Enguri River Basin, the primary source of water for the dam, experiences natural erosion processes. The geology of the region contributes to the steady influx of sediment, posing an ongoing challenge for the reservoir.

Land Use Changes in the Watershed:

Changes in land use, including deforestation and agricultural activities in the Enguri River watershed, accelerate soil erosion. This heightened sediment runoff contributes to an increased sediment load in the dam reservoir, impacting its storage capacity.

Climate changes (Glacial Meltwater and Sediment Transport):

Changes in precipitation patterns and extreme weather events associated with climate change can intensify erosion and sedimentation. Increased rainfall and more frequent storms can lead to higher sediment loads in rivers, impacting dam reservoirs. Georgia, like many regions, is experiencing the effects of climate change, including altered precipitation patterns. These changes influence sediment transport dynamics in the Enguri River, exacerbating sedimentation concerns for the dam.The presence of glaciers in the Upper Svaneti region contributes meltwater to the Enguri River. This glacial meltwater, combined with eroded sediment, poses a unique challenge, requiring specialized strategies for effective sediment management.

Repercussions of Sedimentation at Enguri Dam:

Reduced Reservoir Storage Capacity:

Sedimentation leads to a gradual reduction in the Enguri Dam's reservoir storage capacity. This diminished capacity affects the availability of water for various purposes, including irrigation, municipal supply, and industrial use.

Impact on Hydroelectric Power Generation:

Sediment-laden water poses a direct threat to the efficiency of the dam's turbines and other components. This can result in increased maintenance costs, decreased energy output, and a potential reduction in the dam's role as a reliable power source.

Water Quality Concerns:

Sediment accumulation in the reservoir can trap pollutants, affecting the water quality downstream. This poses challenges for downstream ecosystems and communities that rely on the Enguri Dam for a clean and stable water supply.

Mitigation Strategies for Enguri Dam:

Sediment Flushing and Bypass Systems:

Implementing sediment flushing and bypass systems tailored to the unique characteristics of the Enguri Dam can help manage sediment accumulation effectively, preserving reservoir capacity and ensuring optimal power generation.

Watershed Conservation Programs:

Collaborative efforts with local communities and authorities to implement sustainable land management practices, afforestation initiatives, and erosion control measures in the Enguri River watershed can mitigate sediment runoff.

Climate-Resilient Infrastructure Design:

Factoring in climate change projections when planning dam operations and infrastructure upgrades will enable the Enguri Dam to adapt to evolving environmental conditions, minimizing the impact of sedimentation.

Continuous Monitoring and Research:

Establishing a robust monitoring system to track sediment levels, water quality, and dam infrastructure conditions is crucial. Investing in ongoing research specific to the Enguri Dam will inform adaptive management strategies tailored to its unique challenges.

Now I want to discuss the prospective avenues available to us.

In 2023, students from the Technical University of Georgia, in collaboration with German scientists, undertook an investigative study on the Enguri Dam hydrological system. This comprehensive research involved collecting numerous samples from both the dam and the Enguli River along the Svaneti route. Our findings suggest that the construction of a minor by-pass tunnel presents the most viable solution to the addressed issue. Specifically, prior to the sediment's arrival at the river basin, it will encounter a series of strategically placed dams. These installations will be equipped with milibet technology, facilitating the diversion of sediment into the Magana River. Our analysis indicates that precipitation poses no significant threat to the Magana River, neither exacerbating its flow nor presenting a risk of catastrophic events. In conclusion, this approach is deemed to be both the safest and most cost-effective method.

In conclusion I want to say that, addressing sedimentation challenges at the Enguri Dam demands a site-specific and multidimensional approach. By combining innovative engineering solutions, sustainable land management practices, and adaptive strategies, we can ensure the continued success of this vital hydroelectric facility. As the Enguri Dam navigates the complexities of sedimentation, proactive and collaborative efforts will be key to maintaining its role as a cornerstone of energy production and water resource management in the region.

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Rolled Roofing

Nino Tsutskiridze (Bachelor program student), Supervisor: Associate Professor Zaal Tsinadze, Georgian Technical University

Abstract: In recent years, there has been a radical transformation in the technique of building waterproofing works with the creation of new materials based on polymers and other new materials. The problems of waterproofing reconstructed buildings and structures have particular interest. In should be noted that the importance of waterproofing is often underestimated. Although the cost of waterproofing is insignificant compared to the total cost of construction, it's role in ensuring the durability and operation conditions of the building and structure is very important.

Key Words: roll roof; strength, elasticity, waterproofing.

Introduction

The rolled foor is made of bitumen and bitumen-polymer material, with a reinforced base (synthetics, cardboard). Parchment, roofing material and roofing are the most commonly used materials for rolled roofs. The basis of all these materials was cardboard. The main disadvantages of pergamine and tar paper roofing materials are short-lived, low frost resistance and susceptibility to rot. Rolled roofing is mainly used where it is impossible to use other roofing materials. The roof is usually made of rolled materials in 3-4 layers in the form of a carpet (the layers are glued together). Bitumen-polymer rolled roofing is based on a material that is not laminated. Rotting in bitumen fiberglass with the addition of a polymer modifier makes the roofing material resistant to heat and frost. The mat is attached to a concrete or metal base by melting or gluing with mastic.

Main Part

One of the types of roofing material is a rolled welded roof or, as it is also called, a rolled roof. The technology of the rolled roof is such that it can be laid in any direction, which is one of its outstanding advantage (Fig. 1).

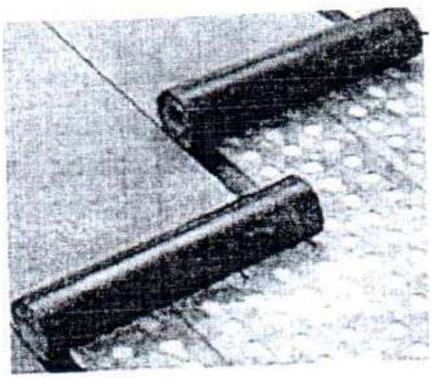

Fig. 1. General view of the rolled roof

*Materials made on the basis of copper (as well as honey concrete, etc). are not used due to carcinogenicity.

Of course, this material is not elite, but it rightfully takes its place among other popular roofing materials. Opinions about different types of tiles and other roofing materials have changed quite often but rolled and mastic roofs have never lost their positions. The main advantages of a rolled roof include the following:

- This material is light enough, I. e. it is easy to transport;
- Laying of the rolled material is carried out easily and simply;
- This material is characterized by strength, elasticity, good sound and waterproofing properties;
- The welded roof complies with fire safety standards;
- Modern welded roof is made of environmentally friendly materials;
- This material has a high thermal proteqtion index, in addition, it retains it's properties under prolonged untraviolet radiation and temperature fluctuations.

In recent years, the design of the rolled roof and it's materials have undergone major modernization. If earlier the roof was made of building cardboard impregnated with bitumen and carcinogenic compounds, today fiberglass and fiberglass have replaqted these materials. The bitumen composition is mixed with environmentally friendly polymers (Fig. 2).

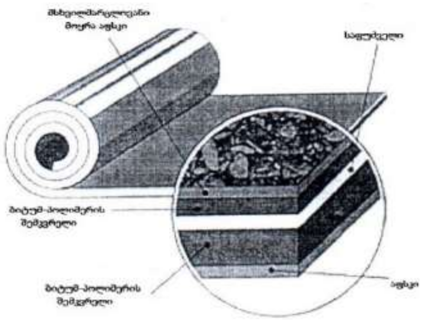

Fig. 2 The composition of the roll.

Installation of a rolled roof, if performed by professionals, is carried out easily and quickly. In addition, it is necessary to observe the temperature regime, and the slope of the roof should not be more than 20°. In the arrangement of the rolled roofing material includes a multilayer coating, which consists of a vapor barrier, insulation and a waterproofing layer. The choice of the action of ultraviolet rays of precipitation and temperature changes.

The Bicrost soft melded roof, individual houses usually have a protective roof of various configurations, but there are buildings with a flat roof. As for premises or garages, they most often have a slope of less than 20°, a soft roof “Bicrost” or “Ruflex” is best suited for such a structure. Before we talk about how it fits, let’s figure out what it is and how it differs in the roofing materials market today.

“Bicrost ХПП” – is a layer of bitumen with special additives applied to the base of the soit. The upper and lower base are covered with a protective coating. It is used as the bottom layer of a freshly welded roof.

"Bicrost ХКП" differs from Bicrost ХПП in that the upper protective layer is coated with granulate instead of film. This difference is used for laying the top layer of a freshly welded roof. Shale grains (flakes) are used as a strewn. The strewing protects the bitumen layer from ultraviolet light. The mass of this material is greater than of the material covered with film.

"Bicrost ТКП" differs from ХКП in better characteristics. It is based on fiberglass. The upper layer of ТКП consists of granulate or slate, and the lower one is a protective layer, ХКП can only be put on an unloaded roof, then ТКП is suitable for the arrangement of the upper layer of an inversion roof. "Bicrost ТПП" is used for the lower layer of the roof while the upper layer is in some combination as ТКП or ХКП – as in ХПП, the upper and lower frame fiberglass are protected by a special polymer film.

Based on experience, it is usually not recommended to use the same type of foundation for the lower and upper layers of a new roof. If you use ХКП for the top layer, then ТПП is better for the bottom layer. The leading position in the market of roofing materials are hold by roll-welded "Bicrost Technicol" and bitumen – "Aquaizol". The manufacturer provides a quality certificate for all roofing materials.

The rolled roof is installed on the cement-sand screed. Waterproofing and thermal insulation work should be carried out in advance. In addition, the welded roof is used to repair the old roof (Fig. 3).

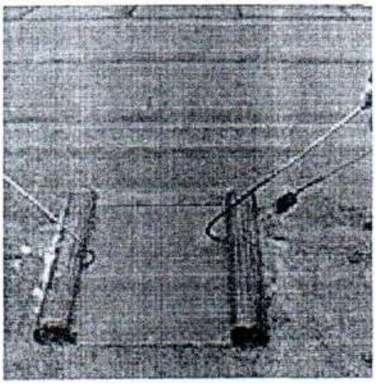

Fig. 3. The welded roll roof   Fig. 4. Laying the roll

The technology of laying the roof “Bacrost” on a new roof provides for the laying of two layers with different characteristics, when repairing, one layer of a rolled roof is enough.

The “Bictost” soft roof looks the same on the prepared surface (Fig. 4). To do this, the cement-sand screed is freed from debris and dust, it’s humidity is checked, which should not be more than 4% - if the old roof is being repaired, then it is removed, all cracks and edges are sealed. Before adding the Bicrost, the roof surface should be treated with special composition called a Primer. The Primer can be prepared from almost all grades of bitumen and solvents, for example, gasoline, kerosene, in a ratio of 1/3 or 1/4. As a primer, you can use mastic, the heat resistance of which is above 80°C. The primer can be applied with a brush. It is necessary to completely dry the soil. To do this, a clean dry cloth is applied to it, if it is not colored, you can proceed to the next stage. The rolls will be laid transverse to the slope with more than 8 cm enlarged edges. Laying begins from the bottom up. The overlap between the edges of the different rows should be at least 15 cm. The edges of the different rows should be moved to each other so that you do not get an even row across the entire roof. The roll is rolled out, the required size of edges is measured, heated with a gas burner and sealed with a roller. The roofer rolls the roll to himself on one side, then moves to the other side. It won't be able to walk on a freshly welded roof, because the steps remain, the structure of the material is broken, in particular waterproofing. Along the edge of a properly heated roof layer, the bitumen will fall off a little. What you should pay attention to when gluing a heated canvas so that creases do not appear. To do this, the canvas is stretched from the center to the edge. Various compositions are applied together with the first layer of the roofing carpet. How to lay a rolled roof at the joints? To do this, it is necessary to glue two reinforcing layers. The material from which the lower layer of the roof is made, cut a piece 40 cm long (25 cm vertically, 15 cm horizontally). First, the part that is glued point-be-point is heated, then the part that is glued horizontally. After the top layer of the roof is ready, the procedure is leaders in the production of soft roofs (including in our market):

- Ikopal (Finland), the concern includes 64 plants in many countries of the world, the main production is located in Finland and has a history of more than 100 years.
- Rufeex (Finland), more than half a century manufactures soft roofing at the Katepel plant.
- Pikipoika და Karabit (Finland), both brands are manufactured by lemminkainen in the finnish city of Lohia.
- Тегола (Italy). The largest manufacturer of flexible roof tiles in Europe has representative offices and factories all over the world 15 countries.
- Cartain Teed (USA). The oldest company in the country produces shingles in more than 40 regions on North America.
- Iko (Canada). The Company has been operating 20 plants in the USA, Canada and Europe for more than fifty years.
- Onduline (France). The Onduline Indernational concern has been engaged in the production of soft roofing for more than forty years.
- Texnikol (Russia). It produces soft roofing shingles with an international quality certificate.
- Uralkrovlia (Russia) in Yekaterinburg – produces a soft roof made of copper foil.

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The History of the Origin of the Railway Track Gauge Standard

David Udesiani (Bachelor program Student), Supervisor: Professor Nugzar Rurua, Georgian Technical University

Abstract: The article examines the history of the emergence and spread of railway gauge in various countries of the world. According to the gauge, railways in the world are divided into narrow-gauge, broad-gauge and regular gauge. Railways with different track widths are also found in some countries, the dimensions of which are given in the work.

Key words: railway, gauge, narrow-gauge, broad-gauge and standard-gauge.

Introduction

The gauge of a railway track is defined as the clear minimum perpendicular distance between the inner faces of the two rails.

You might be wondering what different types of gauges are currently found around the world? About 60% of the world's railroad tracks use the standard 1435mm (4 ft 8 1/2 in) gauge today. The other 40% use either a narrow gauge or a broad gauge. The gauge wider than 1435mm is called the broad gauge, including 1676mm, 1524mm, 1520mm, etc. The gauge narrower than 1435mm is called the narrow gauge, including 1067mm, 1000mm, 762mm, 600mm, etc.

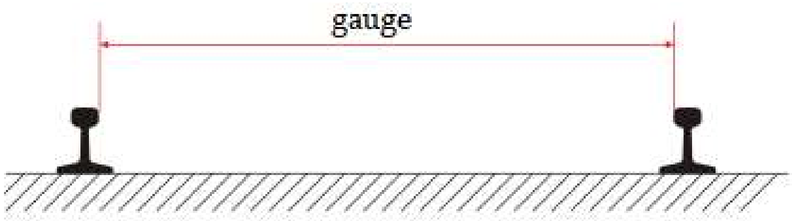

Fig. 1. Determining the track width

Main part

The width of the first railway track, opened in 1830 between Manchester and Liverpool, was chosen by the English engineer George Stefansson - 1435 mm, which in English units was 4 feet and 8.5 inches. After 16 years, this width has become a European standard and is used in many countries around the world. According to many railway experts, it remains unclear by what criteria the value of 1435 mm was chosen as the gauge. There are many versions of the origin of this gauge, but practically none have accurate and documented evidence.

About the origin of the standard track gauge, some believed it originated from the wheel spacing of ancient Roman chariots.

The gauge of 1435 mm was rejected by the railway engineers of the Russian Empire for defensive reasons.

The width of the first railway track of Tsarskoye Selo in the Russian Empire was 1829 mm. The gauge of 1524 mm was first used in the Russian Empire during the construction of the Nikolaev Railway (mid-19th century). The track width indicated above was recommended by the American consultant John Whistler. This track was very popular in the southern United States. The 1524 mm gauge was also supported by Russian engineers P. Melnikov and N. Kraft, who were in the United States before the construction of the Nikolaev Railway. This width was also convenient because it was exactly 5 feet. In the Russian Empire, a gauge of 1524 mm was adopted as the standard. Since May 1970, in the territory of the former Soviet republics, the track width has been assumed to be 1520 mm. The decrease in track width by 4 mm was caused by enhanced track stabilization. Currently, the track width in Georgia is 1,435 mm, from Akhalkalaki to the border with Turkey (Kartsakhi).

In some US states, the track width was different - 1829 mm, 1676 mm, 1524 mm, 1435 mm and so on. Starting in 1865, gauge uniformity began, which was completed in 1886. 21,000 km of railway was rebuilt in 1435mm within 2 days. The same track width is in Canada.

The most widely used gauge sizes in the world are shown in Table No.1, in Fig. 2. and in Fig. 3.

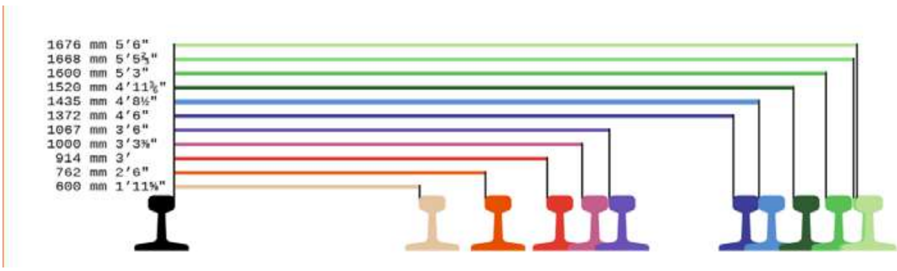

Fig. 3. Track width variability

The different track widths created a problem for trains moving from one track to another. In 1964, Talgo developed a technology for automatic gauge replacement, which was put into operation in 1968.

The famous English engineer Isambard Brunel (1806-1859) fought very vigorously for the expansion of the track. He proposed a gauge of 2,135 mm (seven feet) on the Western Railway, which was completed in 1835 (959 km long).

In 1845, the British Parliament passed a bill stating that all railways in the UK were built with a standard gauge of 1435 mm. The law prescribed the transfer of all railways with different gauge widths to the standard one. Therefore, Western Railway was also forced to install a third rail on the track and thus create a standard gauge. An exception was made for Ireland, where the gauge was 1600 mm (5 ft and 3 in). In the 40s of the nineteenth century, there were 6 standards of gauge in Ireland - 1880 mm or less. Currently, the track width in Ireland is 1600 mm.

Table No.1

Track gauge width, mm	Name and percentage	Length, km	Used in the following countries
1676	Indian gauge 3,3%	> 42300	India (42000 km), Pakistan, Argentina, Chile
1668	Iberian gauge 1,1%	14300	Portugal, Spain

1600	Irish gauge 0,8%	9800	Ireland, partly Australia (4017 km), Brazil (4057 km)
1524	Russian gauge 17 %	7000	Finland, Partly Estonia
1520	Russian gauge 17 %	220000	Post-Soviet countries, Mongolia
1435	Standard gauge 60%	720000	Central and Western Europe, USA, Canada, China, Korea, Australia, Middle East, North Africa, Mexico, Cuba, Panama, Venezuela, Peru, Uruguay,
1067	Cape gauge 9%	112000	South and Central Africa, Indonesia, Japan, Taiwan, Philippines, New Zealand, Partly Australia, Russia (Sakhalin railway)
1000	Metric gauge 7%	95000	Southeast Asia, India (17000 km), Brazil (23489 km), Bolivia, northern Chile, Kenya, Uganda

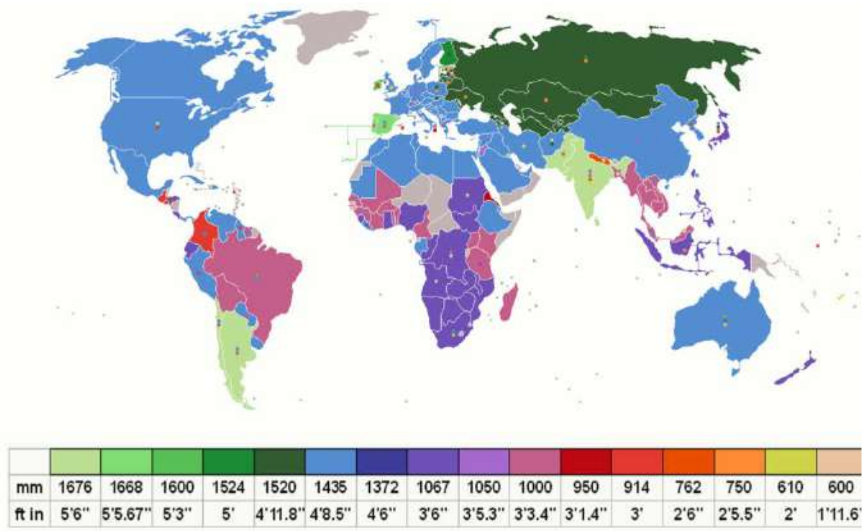

Fig. 3. Different Railway Track gauges Around The World

In the 30s of the twentieth century, specialists of the Third Reich developed a high-speed railway project with a track width of 3000 mm. A track of this width was first supposed to be built in Europe, and then on the Asian continent, and this railway would connect the Indian and Japanese railways. A railway of a certain length was built, but this project was not fully implemented.

In 2001, a railway with a track width of 2000 mm was created to lift skiers as a mountain funicular. The width of a similar railway track in the Netherlands is 1945 mm. In England, the maximum width reached 1880 mm. The width of the first railway track of Tsarskoye Selo in Russia was 1829 mm. The value of this indicator in France is 1,750 mm.

Narrow gauge railways are widespread all over the world. The track width is shown in Table No. 2.

The only narrow-gauge railway in Georgia (the gauge is 912 mm) is located between Borjomi and Bakuriani, which was opened in 1902.

Table No.2

The main gauge widths of narrow-gauge railways of the world's states

N	States	Gauge width, mm
1.	France, Greece, Germany, Lithuania, Latvia, Poland, Sweden, England	600
2.	Wales, Brecon	603
3.	Australia, India, South Africa, England, USA	610
4.	Wales	686
5.	Argentina, Denmark, Indonesia, Spain, Netherlands, France	700
6.	Greece, Poland, Russia, Switzerland	750
7.	Brazil, Austria, Bulgaria	760
8.	Australia, Chile, India, Sierra Leone, USA	762
9.	Georgia (Borjomi-Bakuriani)	912
10.	Colombia, Peru, Canada, El Salvador, Guatemala, USA, Spain, Georgia (New Athos)	914
11.	Italy, Eritrea	950
12.	Argentina, Bangladesh, Benin, Brazil, Bolivia, Burkina Faso, Myanmar, Vietnam, India, Cambodia, Cameroon, Kenya, Laos, Malaysia, Mali, Pakistan, Poland, Portugal, Senegal, Tanzania, Tai-land, Tunisia, Uganda, Spain, Switzerland, Russia, England	1000
13.	Angola, Australia, Botswana, Ghana, Ecuador, Indonesia, Japan, South Africa, Canada, Congo, Costa Rica, Malawi, Mozambique, Namibia, New Zealand, Nicaragua, Nigeria, Russia, Sudan, Taiwan, Tanzania, Honduras, Sweden, Estonia, Belgium, UK, India, Spain, Liberia, Holland, Norway, Philippines, Zambia, Zimbabwe	1067

Conclusion

Based on the above, it can be concluded that the width of the various tracks on the railways of the world is mainly due to interstate relations, considerations of road defense, the cost of railway construction, the purpose of railways, etc.

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