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TECHNOLOGY

Electronic collected materials
of XI Junior Researchers' Conference
(Novopolotsk, May 23 – 24, 2019)

Novopolotsk
2019

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211440, ул. Блохина, 29, г. Новополоцк,
Тел. 8 (0214) 53-63-40, e-mail: inter.office.psu@gmail.com

Технический редактор Чапкевич Ирина Николаевна
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EFFECT OF DIFFERENT TYPES OF SHEAR REINFORCEMENT ON THE STRENGTH, STIFFNESS AND CRACK RESISTANCE OF BENDING REINFORCED CONCRETE ELEMENTS

JAMAL FARRAN, HASSAN MATTAR, ALEXANDER KOLTUNOV
Polotsk State University, Belarus

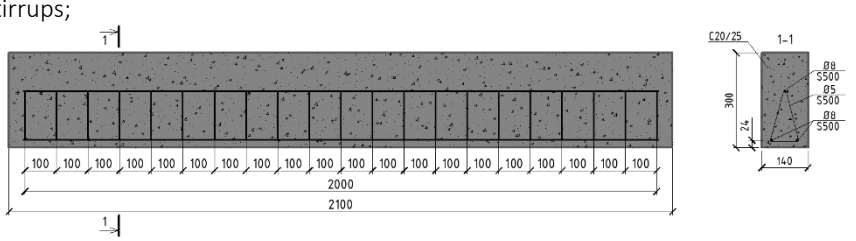
This article describes the effect of three different types of shear reinforcement on the strength, stiffness and crack resistance of bending reinforced concrete beams. This paper reports experimental data on the behavior of reinforced concrete beams, reinforced with different shear reinforcement. Tests were conducted on four reinforced concrete beams, one with stirrups and three with different types of shear lattice girder (truss) reinforcement. The behavior of the reinforced concrete beams is analyzed and supported with statistical evaluations. Conclusions are drawn, showing that the beams act differently under the action of the same subjected load, providing numerical data ensuring the effectiveness of the two types of shear reinforcement with respect to the standard widely used model (model with stirrups).

Introduction. Precast-insitu slabs are widely used in the construction of modern ceilings. This is attributed to the ease in construction, the strength, and effectiveness of such ceilings. Yet, in the construction industry, the beams (primary or secondary) have different types of reinforcement [1].

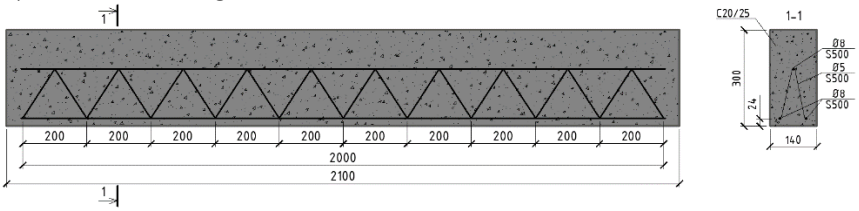
Task formulation. Analysis of the strength, stiffness and crack resistance of bending reinforced concrete beams, taking into consideration their different types of shear reinforcement.

The reinforcement frames of the beams:

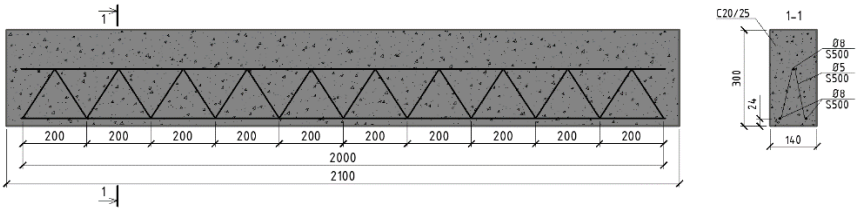
1) Beam with stirrups;



2) Beam with a symmetrical lattice girder frame;



3) Beam with a symmetrical lattice girder frame (control beam);



4) Beam with a non-symmetrical lattice girder frame.

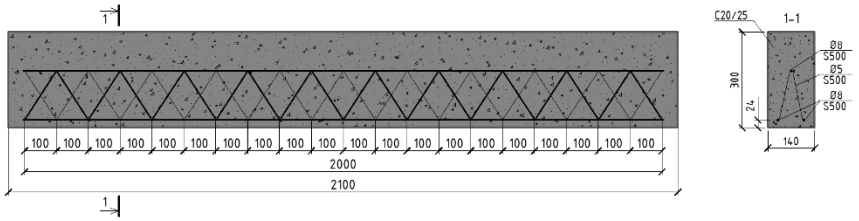


Figure 1. – Reinforcement frames

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The experiments conducted in the 'Department of constructions' in the Polotsk state university laboratory, consisted of using a specific system to provide the beams with exact force values, insuring the fact of providing accurate data and results. This system included: a jack – to provide an accurate scalar value of the subjected to the beams loads , two cross-arms – one for transmitting the central force on the jack to two forces on the beams, and the second for bracing and fixing the structure in whole, and three deflectometers – subjected for measuring the deflections at different points of the beams. For evaluating the time of crack appearance, between the increasing of the load, a microscope is used. It is essential to state that the three beams where produced by the same constructional materials in the same day. The class of concrete used was $C^{19.5}_{24.3}$. The class of the steel bars was S500, with three longitudinal re-bars of diameter 8mm, and shear (transverse) re-bars of diameter 5mm. The experimental scheme of the experiments is the same for all four beams.

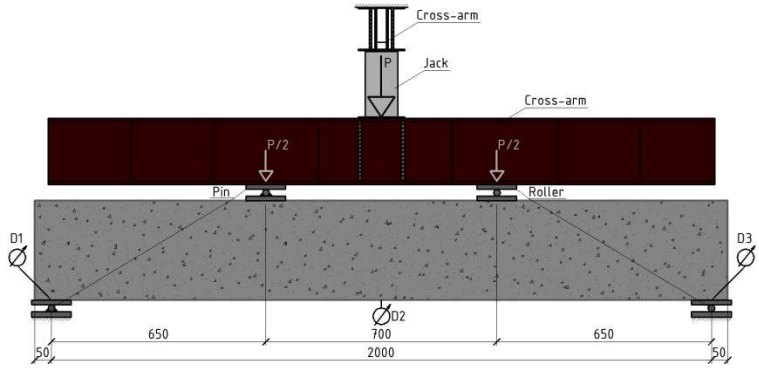


Figure 2. – Beam testing scheme

Cubic strength of the samples. It is essential to state that a statistical experiment was provided on 12 cubes, ensuring that the guaranteed cubic strength is 24.3 MPa.

Preliminary experiment. To form a general idea concerning the effect the three types of frames, a preliminary experiment was conducted for the frames. The four frames where subjected to 3 points loads in the same place for each respective one. Their deflections where calculated by using deflectometers.

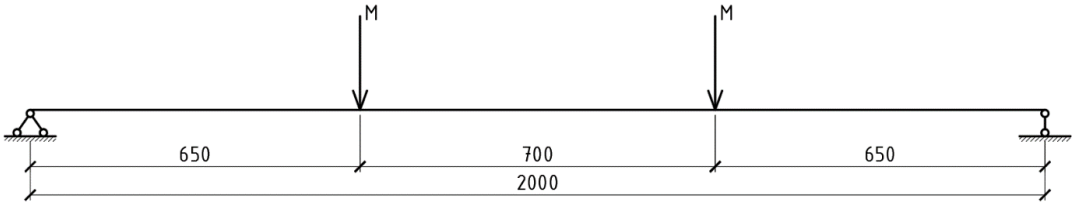
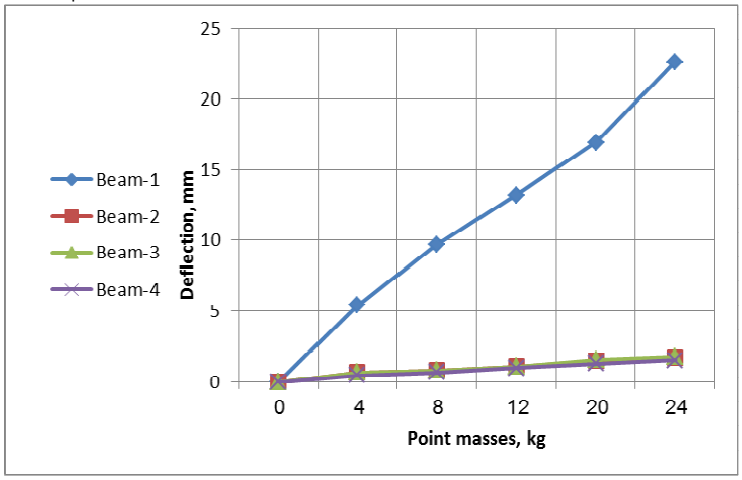


Figure 3. – Frame structural scheme of the frames subjected to several masses (M)

It can be stated, that both point masses are equal in their value, and the presented graph, is provided by the equivalent mass at both points.



Graph. 1. The deflection (mm) of the frames under several points masses

The graph states that the first frame deflects the most.

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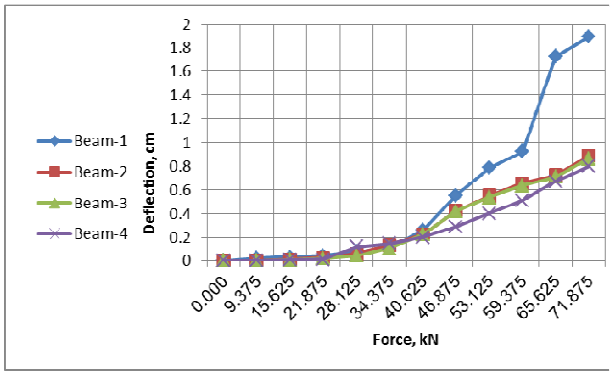
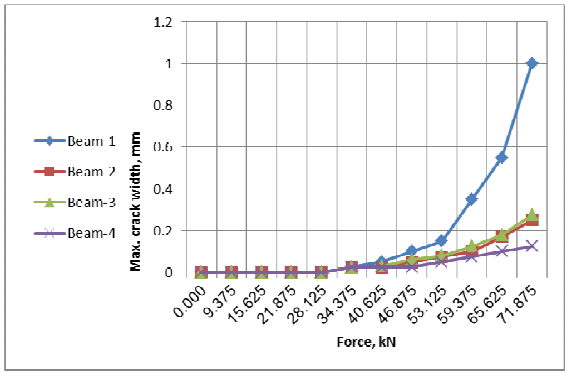
Experiment. The four beams, subjected to same load, where analyzed and studied. The results show that on every studied aspect, the beams act differently.



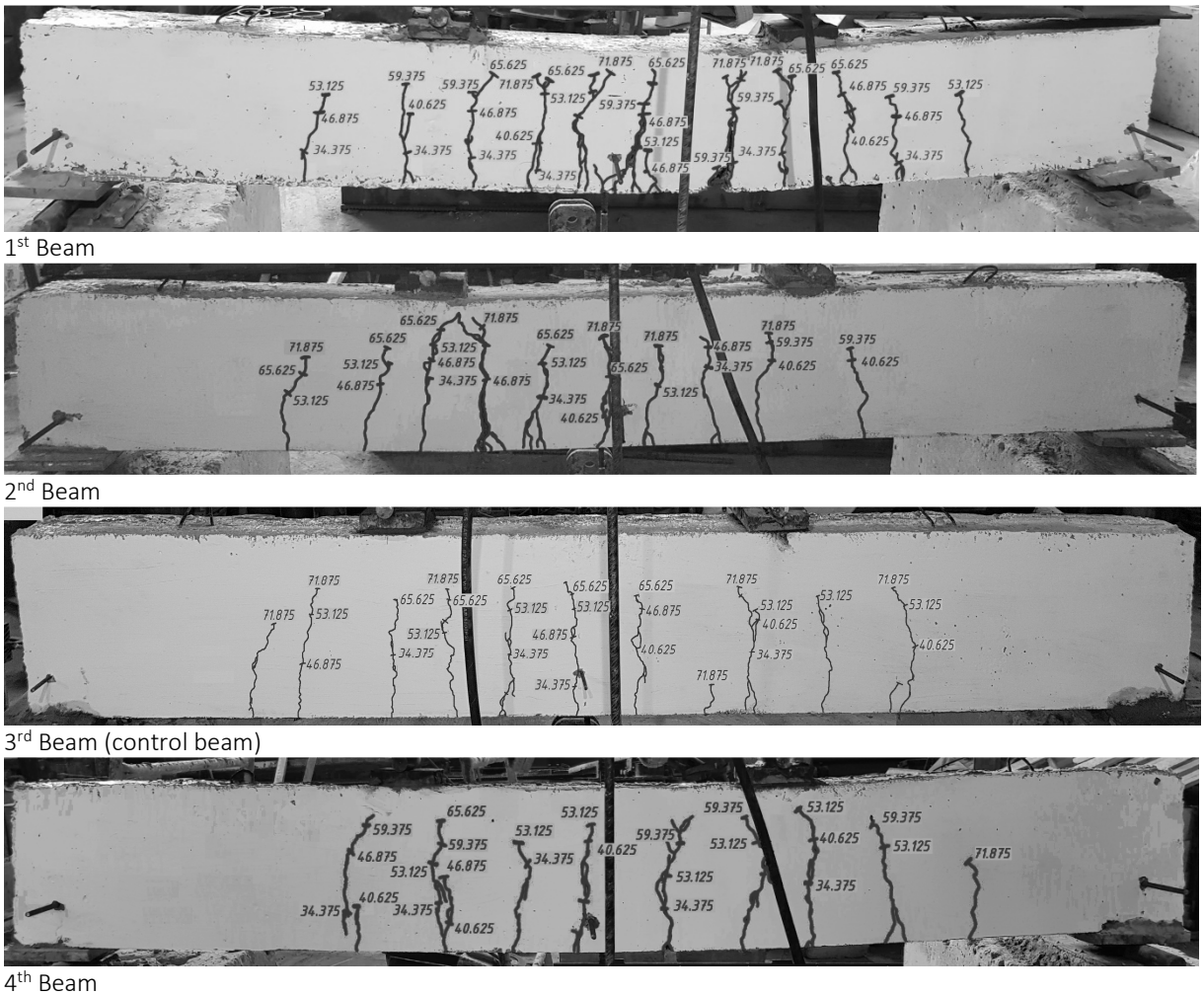
Graph. 2. Deflection (cm) of the beams



Graph. 3. Maximum width cracks (mm) in the beams

In the civil and structural engineering norms for reinforced concrete structures, the maximum allowable crack width is 0.3mm. The first beam exceeded this limit at the load P=59.375 kN. The destruction of all beams was by exceeding the crack width limit state.

Yet, it strictly important to state that this can be explained, by the fact that, shear rebars in the 2nd,3rd, and 4th beams, function in a way, enhancing the resistance of the beam to the acting bending moment.



1st Beam

2nd Beam

3rd Beam (control beam)

4th Beam

Figue 4. – Deformation of the four beams

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Conclusion. The research carried out in the work, allows us to formulate a general idea of the effect of the lattice-girded frame on the strength, stiffness, and crack resistance of bending reinforced concrete elements. According to the obtained results, we can draw the following conclusions:

1. The beams with a symmetrical and nonsymmetrical lattice-girder reinforcement, deflected 2 times less than the beam with stirrups. This can be explained by the fact that the truss increases the rigidity in the center of the beam, due to the redistribution of internal forces on the frame into longitudinal forces in its rods.

2. The number of cracks formed in the first beam is smaller in value, but their width is 2 times larger than in the other beams. However, in the second group of limit states, the first beam reached this limit at the load of 59.375 kN, whereas the rest at 71.875 kN.

3. The beams with a symmetrical and nonsymmetrical lattice-girder reinforcement have the strongest, and most durable cross-section. In each taken cross section, two additional rods interfere, which are included in the work of the beam's section.

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1. Effect of Type and Position of Shear Reinforcement of High-Strength Reinforced Concrete Deep Beams /Dr.Omar Qarani Aziz(Assist Prof.), Dr.Sinan Abdulkhaliq Yaseen/Civil Engineering Dept. / College of Engineering / University of Salahaddin-Hawler.

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CONCERNING THE CALCULATION OF TRUSSED-BEAMS

JAMAL FARRAN, LEONID TURISHEV
Polotsk State University, Belarus

For a single-strut trussed-beam, a comparative analysis of the internal forces' values are obtained by two methods. Initially, it is calculated as a single structure using the 'Force Method' (FM). Secondly, a separate calculation of its parts is carried out. The stiffness (main) beam is calculated as a continuous beam, whereas the struts – as a truss. It is shown that the separate calculation of the trussed-beams, can lead to errors in determining the internal forces associated with the assigned dimensions of the stiffness beam's and the pillar elements' cross-sections. The comparative analysis of internal forces' values is carried out using the software MathCAD.

Introduction. Trussed-beams are widely used in the reconstruction of industrial buildings and structures. Such structures are indistinct combined systems consisting of a stiffness beam (upper beam), reinforced from below by a hinge-rod system (strut). By the number of pillars in the truss, such structures are divided into single-strut (type with a central strut), double-strut and multi-strut systems. Depending on the structural material used in the building practice, the most common types of trussed-beams are steel, timber, steel-timber, reinforced concrete-steel.

Trussed-beams are statically indeterminate structures, and their calculation as a unified structure is set to be done by using the FM [1]. However, in the practice of engineering calculations, in order to simplify calculations, the component parts of the trussed beams are usually calculated separately: the stiffness beam is calculated as a continuous beam (two, three or multi-span), and the struts – as a truss [2] – [4].

A single-strut trussed-beam, the components of which are made of different structural materials, is studied. The beam is loaded with a uniformly distributed load along the entire span (Fig. 1,a)

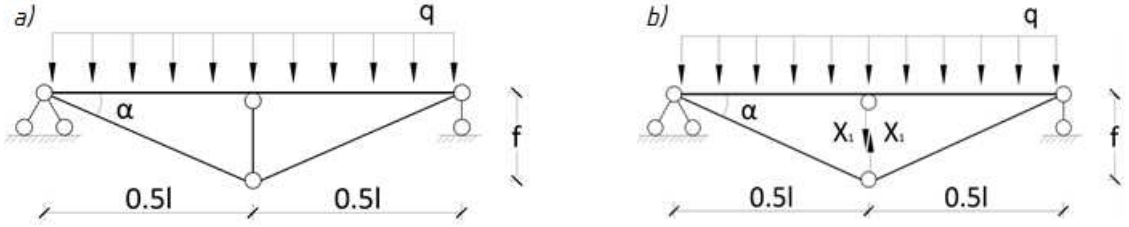

Figure 1. – A single-strut trussed-beam

A comparative analysis is conducted concerning the characteristics of the stress-strain state (SSS) of the trussed-beam, obtained by calculating by the FM as a single structure and by separately calculating its components.

When performing calculations, the following dimensionless parameters of the trussed-beam are introduced:

$\varepsilon = \frac{E_b}{E_p}$ – elasticity modulus of the stiffness beam to the pillars ratio, where E_b is the modulus of elasticity of the main beam, E_p is the modulus of elasticity of the struts;

$\omega_1 = \frac{A_b}{A_i}$, $\omega_2 = \frac{A_b}{A_v}$ – parameters of the geometric characteristics of the cross-sections, where A_b is the cross-sectional area of the stiffness beam, A_i is the cross-sectional area of the inclined struts, A_v is the cross-sectional area of the vertical strut;

$\zeta = \frac{f}{l}$ – slope parameter of the struts;

$\lambda = \frac{l}{h}$ – design flexibility parameter of the struts;

$\xi = \frac{x}{l}$ – stiffness beam's sectional abscissa.

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The calculation of the trussed-beam as a single structure is carried out by the FM using the main scheme provided in Fig.1.b. The dimensionless internal forces in the main system are described by the following functional dependencies:

– unit bending moment in the stiffness beam

$$m_1'(\xi) = 0.5 \cdot \xi \quad (0 \le \xi \le 0.5)$$

$$m_1'(\xi) = 0.5 \cdot (1 - \xi) \quad (0.5 \le \xi \le 1)$$

where $m_1'(\xi) = \frac{m_1(x)}{l}$;

– unit axial (normal) force in the stiffness beam

$$n_{1b}(\zeta) = \frac{\zeta}{1 + 4\zeta^2}$$

– unit axial force in the inclined struts

$$n_{1i}(\zeta) = -\frac{\zeta}{\sqrt{1 + 4\zeta^2}}$$

– load bending moments in the stiffness beam

$$M_P'(\xi) = 0.5(\xi - \xi^2)$$

where $M_P'(\xi) = \frac{M_P(x)}{ql^2}$.

The canonical equation of the FM has the form:

$$\delta_{11} X_1 + \Delta_{1P} = 0 \tag{1}$$

The coefficient and free term entering into equation (1) is described by the following functional dependencies obtained according to the Maxwell-Mohr formula:

$$\delta_{11}'(\varepsilon, \omega_1, \omega_2, \lambda, \zeta) = \frac{\lambda^2}{4} + 4 \cdot \varepsilon \cdot \omega_1 \frac{\zeta^2}{\sqrt{1 + 4\zeta^2}} + \omega_2 \cdot \zeta + \frac{4\zeta^2}{(1 + 4\zeta^2)^2}$$

$$\Delta_{1P}'(\lambda) = \frac{5}{32} \cdot \lambda^2$$

where $\delta_{11}' = \delta_{11} \cdot \frac{E_b \cdot A_b}{l}$, $\Delta_{1P}' = \Delta_{1P} \cdot \frac{E_b \cdot A_b}{ql^2}$.

Hence the main unknown, which is the axial force in the rack of the struts, is described by the following functional dependence

$$X_1'(\varepsilon, \omega_1, \omega_2, \lambda, \zeta) = -\frac{\Delta_{1P}'(\lambda)}{\delta_{11}'(\varepsilon, \omega_1, \omega_2, \lambda, \zeta)}, \tag{2}$$

where $X_1' = \frac{X_1}{ql}$.

In turn, the dimensionless internal forces in the trussed-beam are described by the following functional dependencies:

– bending moment in the stiffness beam

$$M'(\varepsilon, \omega_1, \omega_2, \lambda, \zeta, \xi) = m_1'(\xi) X_1'(\varepsilon, \omega_1, \omega_2, \lambda, \zeta) + M_P'(\xi); \tag{3}$$

– axial force in the stiffness beam

$$N_b'(\varepsilon, \omega_1, \omega_2, \lambda, \zeta) = n_{1b}(\zeta) \cdot X_1'(\varepsilon, \omega_1, \omega_2, \lambda, \zeta); \tag{4}$$

– axial force in the inclined struts

$$N_i'(\varepsilon, \omega_1, \omega_2, \lambda, \zeta) = n_{1i}(\zeta) \cdot X_1'(\varepsilon, \omega_1, \omega_2, \lambda, \zeta). \tag{5}$$

In the case of calculating the stiffness beam as a two-span continuous beam, the bending moments do not depend on the parameters of the trussed-beam and are described in dimensionless form as the following functional dependencies as a function of the stiffness beam's sectional abscissa:

$$M_{cb}'(\xi) = \frac{m_{1cb}'(\xi)}{32} + M_{Pcb}'(\xi), \tag{6}$$

where

$$m_{1cb}'(\xi) = \begin{cases} 2\xi & if\ 0 \le \xi \le 0.5 \\ [2\xi - 4(\xi - 0.5)] & if\ 0.5 \le \xi \le 1 \end{cases}$$

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$$M'_{pcb}(\xi) = \begin{cases} (0.25\xi - 0.5\xi^2) & if\ 0 \le \xi \le 0.5 \\ [0.25\xi - 0.5\xi^2 + 0.5(\xi - 0.5)\,] & if\ 0.5 \le \xi \le 1 \end{cases}$$

In turn, the dimensionless axial forces in the struts are described by the following functional dependencies as a function of the slope parameter:

$$N'_i(\zeta) = \frac{3}{16}\frac{\sqrt{1+4\zeta^2}}{\zeta}, N'_v(\zeta) = \frac{6}{16} \quad (7)$$

Where $N'_i(\zeta) = \frac{N_i}{ql}, N'_v(\zeta) = \frac{N_v}{ql}$

The obtained functional dependencies (3), (6) for the bending moments of the trussed-beam, allow one to compare the results of their determination in two ways depending on the parameters of the trussed-beam.

Figure 2 shows the bending moment diagrams, obtained in two ways, for the trussed-beam, made of the same material ($\varepsilon = 1$), with the following values of the remaining parameters $\omega_1 = 1,\ \omega_2 = 1,\ \lambda=5,\ \zeta = 0.25$.

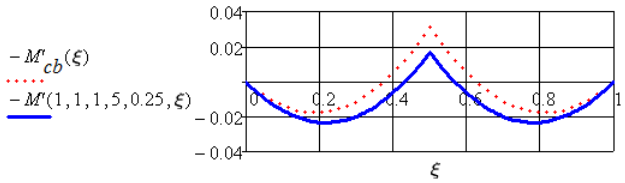

Figure 2. – Bending moment diagrams

From the above diagrams, it can be seen that the bending moments in the stiffness beam obtained in the calculation by the FM are quantitatively different from the moments, if it is calculated as a continuous beam. In the support's section, they decrease by 46%, and in the middle of the spans they increase by 33%. The difference in the values of the bending moments obtained in two ways, substantially depends on the other parameters of the trussed-beam.

Figure 3 shows the bending moment diagrams of the stiffness beam as a function of the slope parameter ζ.

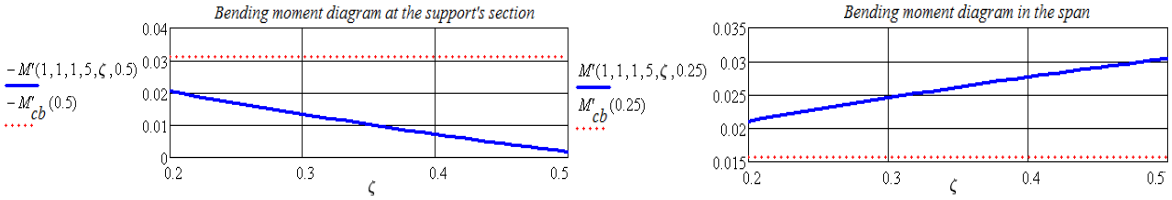

Figure 3. – Bending moment diagrams as a function of the slope parameter

From the above diagrams, it can be seen that with an increase in the slope parameter, the difference in the magnitudes of the bending moments increases. When the value $\zeta = 0.5$ in the reference section, it is 94.5%, and in the span – 67.5%.

Figure 4 shows the bending moment diagrams of the stiffness beam as a function of the flexibility parameter λ.

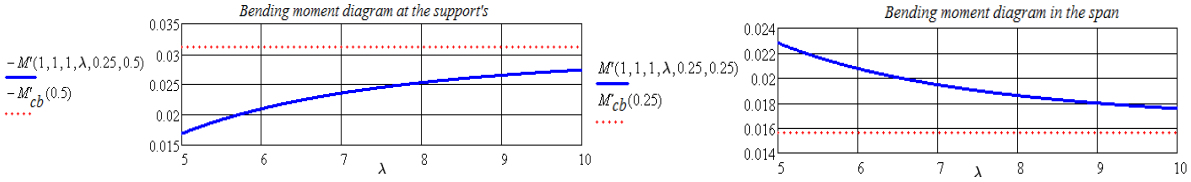

Figure 4. – Bending moment diagrams as a function of the flexibility parameter

From the above diagrams, it can be seen that when the flexibility parameter increases, the difference in the values of bending moments decreases. With the value $\lambda = 10$ in the reference section, it is 12.4%, and in the span – 8.8%.

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Figure 5 shows the bending moment diagrams of the trussed-beam as a function of the structural material when $\varepsilon < 1$, with the following values of the remaining parameters $\omega_1 = 1,\ \omega_2 = 1,\ \lambda=5,\ \zeta = 0.25$

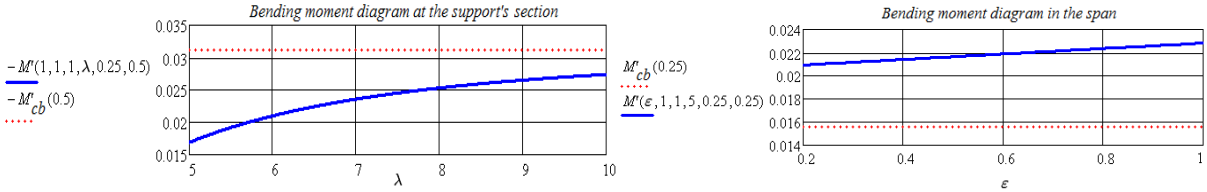

Figure 5. – Bending moment diagrams as a function of the structural material

From the above diagrams, it can be seen that the difference in bending moments obtained by two methods for a trussed-beam made of different structural materials decreases and, if the value $\varepsilon = 0.2$ in the reference section is 33.9%, and in the span – 24.2%.

The obtained functional dependences (4), (5), (7) for the axial forces of the trussed-beam allow us to compare the results of their determination in two ways depending on the parameters of the trussed-beam. Comparison of the obtained results allows us to draw the following conclusions.

First, it should be noted that if by using the first method, the axial forces in the struts depend on the parameters of the trussed-beam, in the second method, the axial forces in the pillars depend only on the slope parameter, and the axial force in the rack of the truss does not depend at all from the parameters of the trussed-beam.

Figure 6 shows the axial forces diagrams of the vertical rack strut, calculated by the two methods, as a function of the slope ζ and flexibility λ parameters

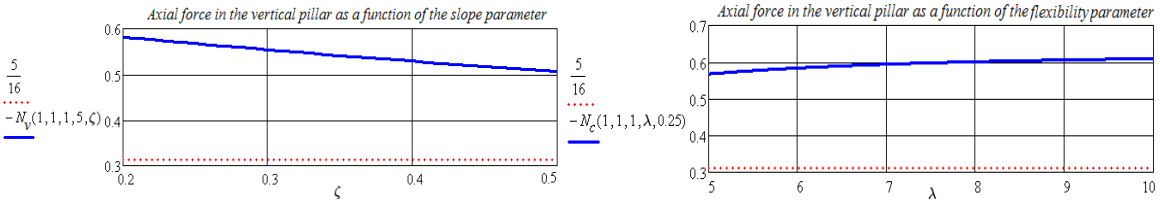

Figure 6. – Axial forces diagrams of the vertical strut as a function of the slope and flexibility parameters

From the above diagrams, it can be seen that with an increase in the slope parameter, the difference in the axial force in the vertical strut of the truss, obtained in two ways, decreases, and with increasing the flexibility parameter, it increases. In the considered intervals, with the change of the parameters, the decrease in the first case is 5.3%, and the increase in the second is 3.8%. These differences are reduced for the trussed-beam made up of different structural materials ($\varepsilon < 1$).

Figure 7 shows the axial forces diagrams of the inclined struts, calculated by the two methods, as a function of the slope ζ and flexibility λ parameters

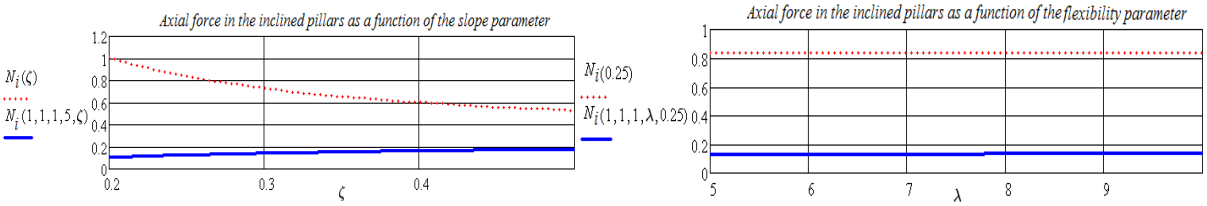

Figure 7. – Axial forces diagrams of the inclined struts as a function of the slope and flexibility parameters

From the above diagrams, it can be seen that with an increase in the slope parameter, the difference in the axial forces in the inclined struts of the truss, obtained in two ways, decreases by a factor of 1.5, and does not change with the increase of the flexibility parameter. These differences are practically the same for the trussed-beam, made up of different structural materials ($\varepsilon < 1$).

Secondly, it should be noted that in the case of a separate calculation of the trussed-beam, additional axial forces arising in the stiffness beam are considered independent of the parameters of the trussed-beam.

Figure 8 shows the axial forces diagrams of the stiffness beam as a function of the slope ζ and flexibility λ parameters

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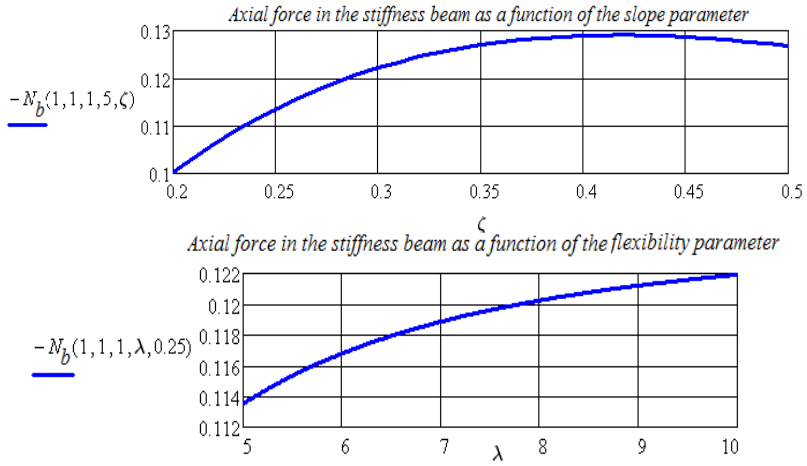

Figure 8. – Axial forces diagrams of the stiffness beam as a function of the slope and flexibility parameters

From the above diagrams, it can be seen that the axial forces in the stiffness beam increase, both with the increase in the slope parameter and with the increase in the flexibility parameter. In the considered intervals, with the change of the parameters, in the first case, the increase is 39.5%, in the second is 16.5%.

Figure 9 shows the axial forces diagrams of the stiffness beam as a function of the structural material when $\varepsilon < 1$, with the following values of the remaining parameters $\omega_1 = 1,\ \omega_2 = 1,\ \lambda=5,\ \zeta = 0.25$

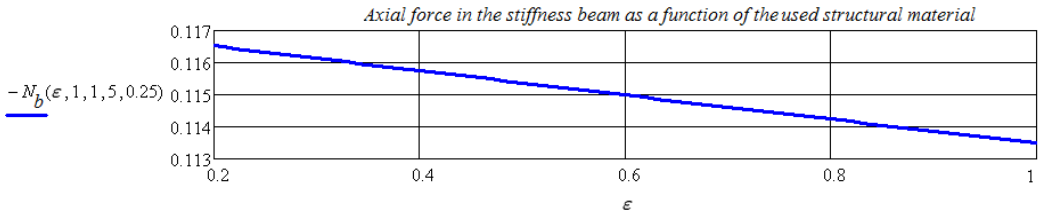

Figure 9. – Axial forces diagrams of the stiffness beam as a function of the structural material

From the above diagram, it can be seen that the axial forces in the stiffness beam of the trussed-beam, made of different structural materials, additionally increase, if the value $\varepsilon = 0.2$ in the reference section increases by 3%.

Thus, the separate calculation of trussed-beams used in the practice of engineering calculations, can lead to errors in determining the internal forces, with the assigned dimensions of the stiffness beam's and the strut elements' cross-sections and the assessment of their bearing capacity.

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UDC 691.162

MECHANISM OF MANIFESTATION OF STRUCTURAL AND PHASE TRANSFORMATIONS IN CEMENT AND SILICATE COMPOSITE MATERIALS

JAMAL FARRAN, ILMYRADOV ILMYRAT, DMITRY SHABANOV, ALEXANDR YAGUBKIN
Polotsk State University, Belarus

The problem concerning the development of the corrosion front in concrete when exposed to an aggressive environment is considered, as well as studied. The article presents the results of studies that reflect the effect of a complex additive on the physical and mechanical properties of concrete under normal and aggressive conditions. The general state of the problem of protecting reinforced concrete elements from aggressive external influence is described. The article builds a response surface from the dependencies obtained.

Introduction. The task of the construction industry is to maximize the economy of material assets and technological energy consumption in the production of constructional works, with ensuring the maintenance and performance characteristics of structures. One of the most important ways to improve productivity in construction, aside to using modern equipment, is the addition of chemical admixtures for various purposes.

One of the big advantages of reinforced concrete in comparison with metals and other materials, is its high corrosion resistance. Concrete protects embedded steel from corrosion due to its alkaline nature. A high pH environment in concrete (usually above 13.0) leads to the formation of a passive and non-corrosive protective oxide membrane around the steel.

Task formulation. The study of various chemical admixtures and their effect on concrete.

Chemical additives are those ingredients in concrete, other than the binder, water, and aggregates that are added to the mixture immediately before or during mixing. The development of ideas concerning the mechanism of additives is inextricably linked with the progress in the theory of hydration and hardening of mineral binders. In addition, research related to the rational economy of heat treatment of reinforced concrete structures is very relevant, but they require the optimal class of the additive with its optimization with mineral binders.

The effectiveness of additives depends on factors such as its composition, the rate of addition, adding time, type, brand and amount of cementing materials, water content, total shape, gradation and proportions, mixing time, recession or sediment of concrete, and temperature of concrete.

In aggressive mediums, we take into consideration the environments in which the corrosion of building materials occur. In accordance with its state of aggregation, the aggressive mediums can be gaseous, liquid or solid, and in many cases multiphase. Based on the modern concept of physical and chemical phenomena and the theory of surface contact interactions, we can -in the desired direction- change the properties of the cement paste, concrete mix and concrete itself by introducing concrete additives (modifiers) into the cement system [1].

The concept of "corrosion" is defined as the process of irreversible deterioration of the technical characteristics of a building material (concrete) as a result of physicochemical, chemical, biological effects of the external environment or chemical processes occurring in the material itself, changing its structure and properties. We can say that the cause of corrosion of concrete is both the interaction of cement stone concrete with aggressive components and environmental factors, and the interaction between the components of cement stone, where it is represented in the form of electrochemical processes [2].

According to modern concepts, the corrosion of concrete and reinforced concrete is classified in liquid media into 3 types:

– Type I - corrosion associated with the exposure to aqueous media with a low salt content with a predominantly neutral reaction (pH = 6.8 ÷ 7.2);

– Type II - corrosion when exposed to very aggressive media, for example, acids, alkalis, some salts, such as sodium or magnesium chlorides;

– Type III - corrosion caused by the penetration into the pores of concrete of liquid media containing components forming insoluble crystalline compounds with a pore liquid or cement stone.

Each type of corrosion is characterized by its own characteristics, specific physico-chemical processes and reactions that determine the nature of corrosion damage [3].

The superplasticizer produced in the Polotsk State University [4], hydrophobizer GKJ-10, and carboxymethylcellulose CMC were used as the main additives improving the corrosion resistance, as well as strength and mobility.

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Studies were carried out on fine-grained concrete of composition 1:3. As well as, portand cement M:300 and sand M_s- 2,1. The testing of the beams $40 \times 40 \times 160$ cm, were carried out according to the GOST-310.4-8 for determining the bending strength, were studied on the MII-100 installation, on the hydraulic press PSY-125 for determining the compressive strength, and also for the corrosion resistance according to the methods approved by NIIJB, based on the exploitation conditions of the studied structures. In quantitative terms, the admixtures from the weight of the cement in (%) were:

1) Superplasticizer: 0.3-1.0%;
2) CMC: 0.5-1.0 %;
3) GKJ-10: 0.2%.

All additives were introduced with the medium dissolved after preparation of dry cement-sand mixtures. The sample where put in a normally humid medium.

The tests computing the increase in strength, were characterized by the two additives S-NPI and CMC. The results showed that the additives increased the strength:

- Compression: 1.7 times;
- Bending: 1.4 times.

When determining the corrosion resistance, the samples were placed in a $CaCl_2$ solution (calcium chloride), of concentration 30 grams of salt per 100 ml of water at a temperature of 50°c. Intermediate tests of the samples were carried out after 7 days.

Table 1. – Levels and intervals of variation factors.

Parameter designation	Factor levels			The intervals of variation of factors
	Lower level	Main level	Higher level	
	-1	0	1	
X1	0	0.5	1	0.5
X2	0	0.01	0.02	0.01
X3	0	0.5	1	0.5

The model of a three-factor experiment is determined by the formula:

$$y = B_0 + B_1 \cdot X_1 + B_2 \cdot X_2 + B_3 \cdot X_1 \cdot X_2 + B_4 \cdot X_1^2 + B_5 \cdot X_2^2$$

Table 2. – Plan of the experiment in natural and normal variables.

X 1	X 2	X 3	Superplastizer	GKJ-10	CMC
+	-	-	1	0	0
-	+	-	0	0.02	0
-	-	+	0	0	1
+	+	+	1	0.02	1
+	-	+	1	0	1
-	+	+	0	0.02	1
+	+	-	1	0.02	0
-	-	-	0	0	0
+	0	0	1	0.01	0.5
-	0	0	0	0.01	0.5
0	+	0	0.5	0.02	0.5
0	-	0	0.5	0	0.5
0	0	+	0.5	0.01	1
0	0	-	0.5	0.01	0
0	0	0	0.5	0.01	0.5

For this particular experiment, the polynomial is:

$$y = -42.6657 - 0.3899 \cdot X_1 + 0.4570 \cdot X_2$$

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Table 3. – Strength measurement at different times in different mediums

№	Code	S-NPI	GKJ-10	CMC	Measurement	28 days		3 months in water		2 months in salt		2 months in water		5 months		4 months in salt		4 months in water	
		X_1	X_2	X_3	Y_1^1	C	B	C	B	C	B	C	B	$\bar{S}_c^2$	$\bar{Y}_b^2$	C	B	C	B
1	a	1	0	0	2.2	460	54.6	384	57.2	421	114	409	66.5	326	73	364	77.5	400	44.8
2	b	0	0.02	0	2.2	324	44.7	292	37	297	72.6	323	39.9	258	32.9	200	62.7	302	44.6
3	c	0	0	1	3	248	33.4	169	30.9	192	40	221	41.6	156	41	155	43.1	138	38.6
4	abc	1	0.02	1	3	192	30.2	166	34.3	138	21	163	28.1	168	28.2	136	36.3	105	24.3
5	ac	1	0	1	2.8	162	25.5	116	23.9	80	22.85	93	14.6	104	12.8	73	30.7	71	21.3
6	bc	0	0.02	1	2.9	228	32.6	226	35.2	188	51.9	187	31.9	190	39.9	143	48.4	105	27.8
7	ab	1	0.02	0	2	456	48.1	377	44.4	370	51.9	308	49.4	306	37.9	203	57.7	358	46.9
8	-1	0	0	0	2.3	340	41.1	139	44.4	325	75.9	300	49.6	302	35.6	273	61.8	354	48.2
9	2a	1	0.01	0.5	2.9	200	26.8	152	29.4	186	50.6	163	324	169	29.6	91	31.6	153	25.8
10	(-2a)	0	0.01	0.5	2.8	224	31.3	209	35.7	117	53.4	178	30.1	184	33.4	137	39.6	151	34.5
11	2b	0.5	0.02	0.5	2.6	168	23.7	199	31.1	107	19.7	164	38.2	120	25.9	95	31	135	34.8
12	(-2b)	0.5	0	0.5	2.8	288	33.4	236	40	235	38.7	213	40.1	184	34.9	132	42.4	156	39.6
13	2c	0.5	0.01	1	3	218	37.5	208	35.7	163	30.7	203	35.5	136	28.5	108	34.1	193	36.2
14	(-2c)	0.5	0.01	0	2.3	314	34.2	332	46.4	385	81.3	296	45.5	242	415	161	71.4	260	53.2
15	0	0.5	0.01	0.5	3	212	20	184	30.6	195	33.7	150	35.2	213	37.2	101	35.1	140	36.5

Based on experimental calculations, a comparative analysis concerning the mechanism of the effect of additives on the coefficient of water saturation in a water and salt medium was performed. On the basis of calculations, the required amount of medium was established, where, with the shaking of sample mixtures, the spreading of the cone reaches 107 mm.

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Table 4. – This table shows the variation in water saturation based on the medium

Line number			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Mass of the solution in grams			1750	1680	1700	1600	1600	1675	1750	1750	1700	1650	1750	1650	1625	1750	1750
			1660	1580	1800	1590	1590	1750	1800	1750	1750	1650	1750	1850	1675	1800	1800
Average mass			1705	1630	1750	1595	1595	1712.5	1775	1750	1725	1650	1750	1750	1650	1775	1775
Water medium	Mass of dry samples	1	545	500	475	440	435	480	515	533	480	470	475	465	470	500	465
		2	545	510	490	480	435	480	512	500	485	475	450	490	425	505	470
	Mass of saturated samples	1	600	545	535	500	495	530	555	595	540	520	520	520	540	540	515
		2	580	550	550	535	495	530	560	555	535	530	500	550	555	550	520
	Water saturation coefficients	1	10.09	9	12.63	13.63	13.79	10.41	7.77	11.63	12.5	10.63	9.47	11.82	14.8	8	10.75
		2	6.42	7.84	12.24	11.45	13.79	10.41	9.38	11	10.3	11.1	11.1	12.24	12.24	8.91	10.64
		average	8.225	8.42	12.44	12.54	13.79	10.41	8.58	11.32	11.4	10.87	10.29	12.03	13.52	8.46	10.7
Salty medium	Mass of dry samples	1	555	505	475	465	445	505	510	540	475	505	500	490	480	520	485
		2	550	525	490	480	445	495	530	510	480	490	475	485	485	485	485
	Mass of saturated samples	1	595	540	530	530	515	565	560	590	540	555	550	545	575	570	540
		2	580	565	540	540	515	540	580	565	550	555	535	545	535	540	550
	Water saturation coefficients	1	7.2	6.93	11.57	13.9	15.7	11.88	9.8	9.25	13.68	9.9	10	11.22	13.54	9.61	11.34
		2	5.45	7.62	10.2	12.5	15.7	9.09	9.43	10.78	14.58	13.26	12.63	12.37	10.3	11.34	13.4
		average	6.31	7.28	10.89	13.2	15.7	10.49	9.62	10.02	14.13	11.58	11.32	11.8	11.92	10.48	12.37
The required amount of media shutter for slumping the cone by 107 mm			18 kgs. of the mixtures														
			2200 ml	2200 ml	3000 ml	3000 ml	2800 ml	2900 ml	2000 ml	2300 ml	2900 ml	2800 ml	2600 ml	2800 ml	3000 ml	2300 ml	3000 ml

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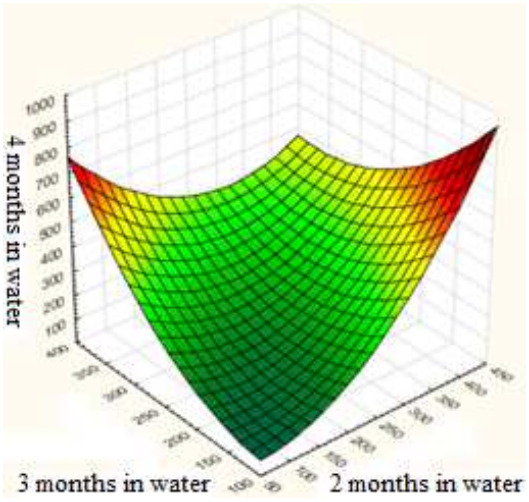
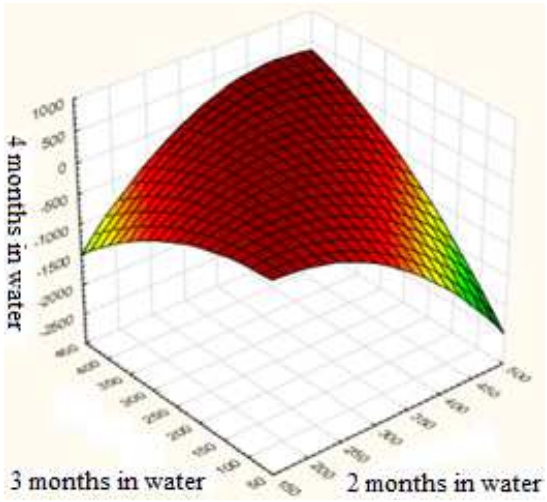
The dependences obtained above allowed us to construct response surfaces that reflect the mechanisms for changing the set of compressive and flexural strengths in series, depending on the environment being exploited.

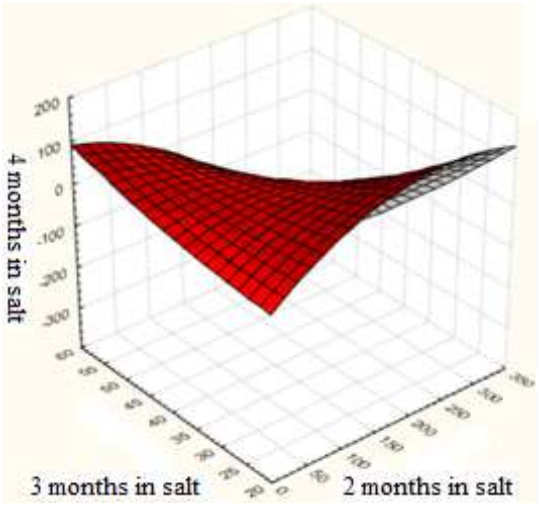


Compression

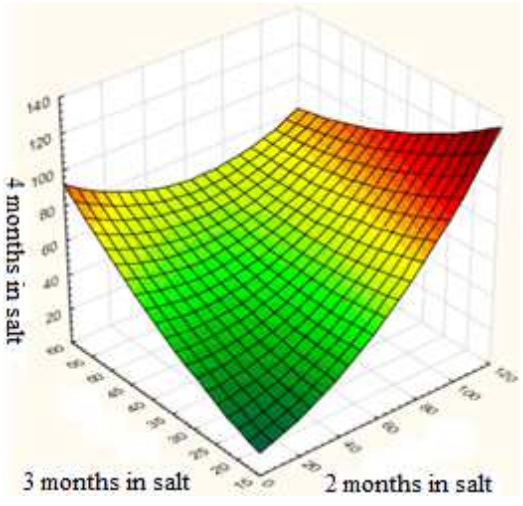


Bending

Figure 1. – The change in the compressive strength in water and salt



Compression



Bending

Figure 2. – The change in the bending strength in water and salt

After these studies, we can draw several conclusions:

1. The use of superplasticizer reduces the water-cement ratio, has a great effect on increasing the mobility of the concrete mix and significantly increases the strength of concrete in compression, as well as on bending.
2. The use of CMC helps in obtaining better concrete in the case of mobility while maintaining the strength of concrete. The use of CMC also increases the inhibition of corrosion of the concrete solution.
3. The use of GKJ-10 helps to preserve the durability of concrete by a large factor.
4. The use of complex additives, in our case the previous three, helps to maintain the durability of concrete while maintaining corrosion inhibition.

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In order to describe the process of destruction of structural elements in an aggressive environment, additional parameters should be added to the system of defining parameters, taking into account the characteristic features of the impact of an aggressive environment. The characteristic features of an aggressive environment are described by complex mathematical and differential functions, which lead to difficulties in representing the work of the structure under a study. Consequently, the transition to computer simulation of the state of reinforced concrete structures when exposed to chloride corrosion, makes it much easier to study the physic-mechanical properties of reinforced concrete structures when changing the physic-chemical parameters of concrete [5].

Often, the results of virtual tests provide a wider picture of the processes occurring than a full-scale experiment, providing more opportunities for optimizing and improving performance, saving a considerable amount of time and money. In addition, the use of numerical-experimental research methods is practiced, when the results of field tests are complemented by the results of simulation modeling, which are unattainable in a field experiment.

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INFLUENCE OF THE ACCEPTED CONCRETE DEFORMATION DIAGRAMS ON THE RESULTS OF CALCULATING BENDING REINFORCED CONCRETE ELEMENTS

LIZAVETA SIARHEYEVA, YAHOR LAZOUSKI
Polotsk State University, Belarus

The article describes the influence of various types of concrete deformation diagrams on the accuracy of the deformational analysis of a bending concrete element. By analyzing different forms of diagrams, we get results with the help of the software "Beta 4.2 (5.0)". After getting the results, conclusions are drawn, according to particular qualities concerning the investigated element.

The strength and deformability of concrete in a reinforced concrete structure depends on the structure of the already hardened concrete, which includes pores and micro-cracks. As numerous experiments have shown, the smaller the number of defects in concrete, the more durable it is. The strength of concrete increases by improving its composition, technology of production and subsequent concreting of structures. Due to the fact that the strength of concrete depends on many factors, the calculation of structures is based on the deformation diagrams of concrete, which are essentially the generalized characteristics of the mechanical properties of concrete. The deformation diagrams are completely different under certain conditions, considering the action of the loads on the specimen: two-axial, three-axial compression/tension, tension - compression; short-term/long-term and others [1].

In this paper, we will consider the basic characteristics of concrete, obtained as a result of an axial short-term compression and tension. The diagram shows the relationship between stresses σ and longitudinal relative deformations ε of compressed (tensioned) concrete. To describe the deformation diagrams, we will use two values of relative deformations: - ε_{c1} relative deformations, corresponding to the peak stresses in the diagram; - ε_{cu} limit relative deformations of concrete under compression.

Introduction. To evaluate the stress-strain state of reinforced concrete elements at different stages of their loading, currently, the most promising is the nonlinear deformation model, since it is more accurate. The choice of one or another form of the diagram and its influence on the calculation results, will be considered in this paper by using the software "Beta 4.2 (5.0)".

Task formulation. Calculation of a beam having a rectangular cross-section concerning its strength, using the deformation method for different options of the concrete deformation diagrams.

Given:

b = 300 mm

h = 800 mm

c = 70 mm

$l_{eff} = 4500$ mm

Concrete class C20/25 ($f_{ck} = 20\text{MPa}; f_{cd} = 13.4\text{MPa}; E = 27000$ MPa.)

Tensioned reinforcing bar of class S500 ($f_{yk} = 500\text{MPa}; f_{yd} = 450\text{MPa}; E_s = 20 \cdot 10^4\text{MPa}.$) $A_{st} = 1963$ мм^2(4Ø25 S500).

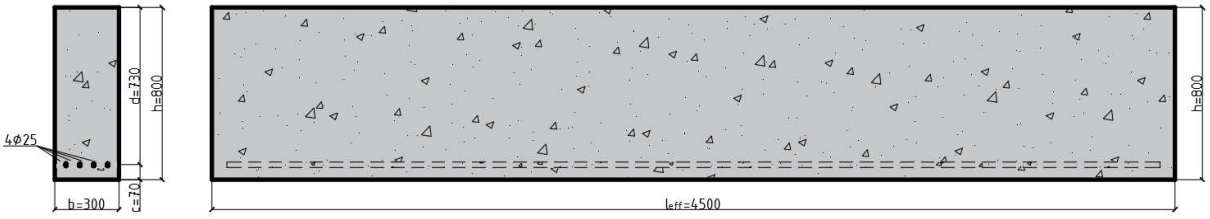

Figure 1. – General view of the beam

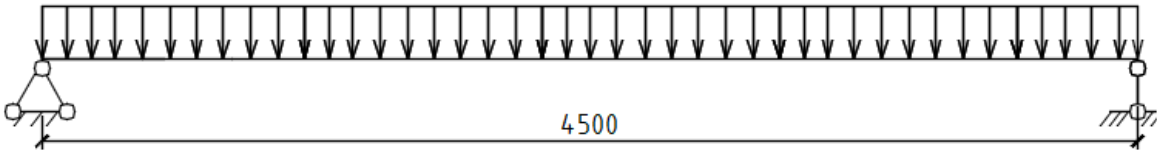

Figure 2. – Beam's design scheme

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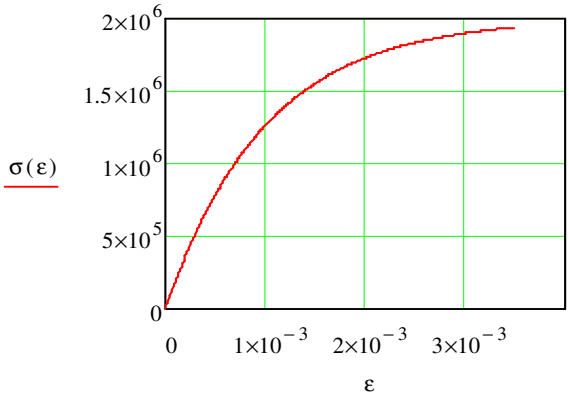
Table 1

Sample	Design value, M_{Rd}, кН×м							
	Limit state method ($M_{Rd(1)}$)	Simplified deformation method ($M_{Rd(2)}$)	General deformation method ([9]) ($M_{Rd(3)}$)	Simplified deformation method ([8]) ($M_{Rd(4)}$)	General deformation method (diagram 1) ($M_{Rd(5)}$)	General deformation method (diagram 2) ($M_{Rd(6)}$)	General deformation method (diagram3) ($M_{Rd(7)}$)	General deformation method (diagram 4) ($M_{Rd(8)}$)
	531.96	515.72	543.1	542.5	539.3	540.9	545.8	547.2

Diagram 1. Based on the formula of Yashchuk V.E. [2]. It is used to determine the stresses in elasto-plastic materials:

$$\sigma(\varepsilon) := R_1 \cdot \left(1 - e^{-E \cdot \frac{\varepsilon}{R_1}}\right)$$

where E_0 –initial modulus of elasticity; R_1 – final strength of a concrete sample.

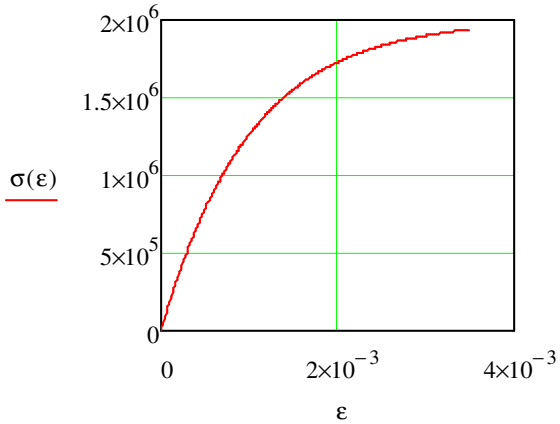


Graph 1. – First deformation diagram (by Yashchuk V.E.)

Diagram 2. Based on the formula of Murashkin G.V. and Murashkin V.G. [3, 4]. The advantage of this formula is that it combines both experimental data (coefficients) and theoretical specifications:

$$\sigma(\varepsilon) := \alpha \cdot \varepsilon^{b} \cdot \exp\left(b \cdot \frac{\varepsilon}{p}\right)$$

where α, b, p –coefficients, determined from the calculated assumptions incorporated in [5].



Graph 2. – Second deformation diagram (by Murashkin G.V. and Murashkin V.G)

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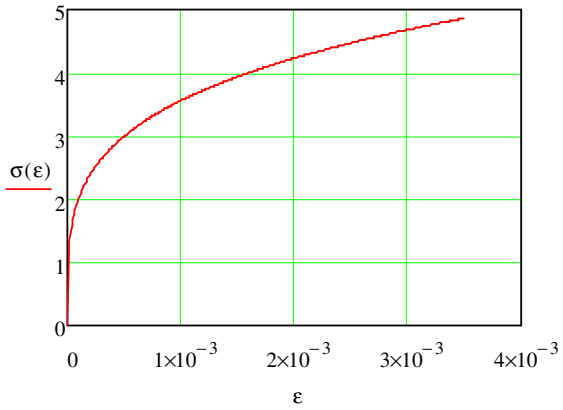
Diagram 3. Based on the formula of Sheykin A.E. [6]. Here, it is taken into account that the creep deformations of concrete are directly proportional to the magnitude of the stresses in it and the time of the load:

$$\sigma(\varepsilon) := \frac{\varepsilon}{E_0} + \alpha \cdot \varepsilon^2$$

where E_0 – initial modulus of elasticity; α – coefficient of proportionality in accordance with [5].

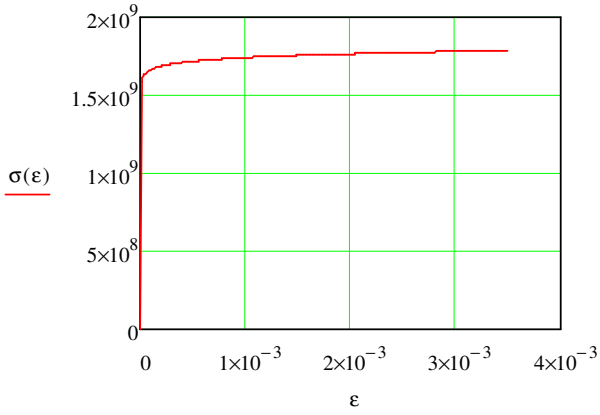


Graph 3. – Third deformation diagram (by Sheykin A.E.)

Diagram 4. Based on the very first formula (after Hooke's law), proposed in 1729 by Bülfinger G.B., later written down as [7]

$$\sigma(\varepsilon) := A \cdot \varepsilon^k$$

where A – a constant, having the unit of stresses; κ – degree index (unitless dimension); from a material with an arbitrary value of k, you can automatically obtain a solution for linear-elastic and rigid-plastic structures.



Graph 4. – Fourth deformation diagram (by Bülfinger G.B)

Diagram 5. Based on the formula of M.Sargin, recommended by the Euro-International Committee for Concrete (CEN)[8]:

$$\sigma(\varepsilon 1) := \frac{k \cdot \frac{\varepsilon 1}{\varepsilon 10} - \left(\frac{\varepsilon 1}{\varepsilon 10}\right)^2}{1 + (k-2) \cdot \frac{\varepsilon 1}{\varepsilon 10}} \cdot f$$

where f – average strength (28 days), table.3.1 [8];

ε_1 – relative deformation;

ε_{10} – relative deformation at the maximum (peak) stress value in accordance with table 3.1 [9].

$$\eta = \frac{\varepsilon_1}{\varepsilon_{10}}$$

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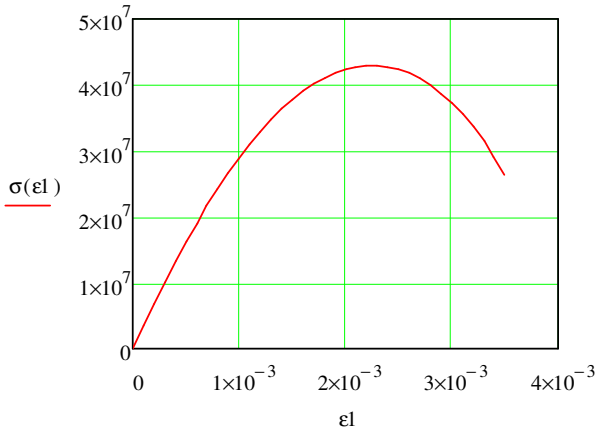
$$\kappa = \frac{1{,}05 \cdot E \cdot |\varepsilon_{10}|}{f}$$



Graph 5. – Fifth deformation diagram (by EN 1992-1-1-2009)

Conclusion. Based on the obtained data, it can be concluded that the choice of a particular concrete deformation diagram will not actually affect the calculation results, since there is no significant difference in the results.

Hence, the concrete did not show us all the tensile stresses because of the analyzing of the limit values of the reinforcing bars.

Analyzing in more detail, it is obvious that the most deviated from the average value of the result, was by the simplified deformation method. This is explained by the fact that the calculation is carried out using tables (approximations), therefore this method is the most inaccurate and the calculation is carried out in the safety margin.

Despite of the fact that the limit state method is one of the most common methods, it also gave an inaccurate result due to the calculation using empirical formulas and taking into consideration the engineering errors of calculation.

The general deformation method gave almost identical results, the error between the most deviated values is Δ = 1,44%. The small divergence between the results is due to the fact that the exhaustion of the structural strength occurs as a result of reaching the limit values of either the compressed concrete's zone or the tensioned reinforcing bars. In this case, the destruction occurs in the tensioned reinforcement after reaching the yield strength.

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UDC 693.2

INCREASING THE BEARING CAPACITY OF BEAMS WITH COMPOSITE ELEMENTS

VALERYIA KUNEVICH, ALEXANDER SHCHERBO
Polotsk State University, Belarus

The article considers the research findings on the operation of experimental samples and steel elements reinforced with composites. A comparative analysis of the control and reinforced elements is conducted,the recommendations for the use of this type of reinforcement are given.

In recent years,much attention has been paid to the reconstruction of existing buildings and structures due to re-equipment of many industrial enterprises and in order to extend the service life of various construction facilities. Sometimes,after the reconstructionstructural elements do not meet the strength and stiffness requirements and need reinforcement.At present, composite materials based on carbon fibers are used to strengthen building structures.These materials are characterized by high strength, they are also comparable with structural steels at a much lower weight and have the same tensile-and-compression strength.Below are the results of the research on reinforcing steel beams with elements of composites, namely, carbon fiber tapes.

The studies were conducted in two stages.

1. Experimental studies of steel samples from the applied polymeric tapes.

2.Experimental studies of steel beams reinforced with polymer tapes.

In the first stage, mechanical tensile testing of the control and experienced samples.

Samples of the first stage.

Experimental and control samples were made of flat steel St.Z with a thickness of 8 mm and a width of the working part 50 mm Was tested 3 the steel control sample and 3 samples with glued composite tapes.Connection of composite tapes on the basis of carbon fibers and steel samples was made using epoxy glue with pre-treatment of contact surfaces. The mechanical characteristics of the material of composite tapes according to the manufacturer are presented in table 1 [1].

Table 1. – Mechanical characteristics of the material of composite tapes according to the manufacturer

Elastic modulus	$1{,}65.10^{5}$ MPa
Tensile strength at break	3050 MPa

The mechanical characteristics of the composite obtained experimentally are presented in table 2.

Table 2. –-Mechanical properties of the composite obtained experimentally

Elastic modulus	$1{,}62.10^{5}$MPa
Tensile strength at break	2980 MPa

Comparison of the data in tables 1 and 2 indicates a practical coincidence of mechanical properties.

The method of the experiment was as follows. The test and control specimens were stretched on a standard test machine under the same conditions: the strain rates of all specimens were the same, all specimens were loaded to failure of the steel and composite parts [1].

All control steel specimens under tension were deformed according to the classical scheme, typical for plastic materials, and collapsed in the middle zone with the formation of a pronounced neck. The defined yield strength and tensile strength correspond to the characteristics determined by the standard for the steel in question. The destruction of the test samples took place in stages: the first one broke before the destruction of the composite material in the form of rupture of the carbon fibers at the developed metal plasticity; the second one broke before the rupture of the steel sample with the formation of a neck. The tensile force at the end of the first stage was much greater than the tensile force of the reference metal. The deformation diagrams of test samples with glued composite material qualitatively repeat the diagrams for brittle materials, while the tensile strength was 22% higher than the tensile strength of the steel of the control samples. The brittle nature of the destruction of carbon fiber tensile involves careful and attentive approach to the use of such reinforcements.

Second stage samples.

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I-beams of control samples are made of two channels by longitudinal seam welding with subsequent processing. Prototypes – the same beams with the polymer tape pasted in the stretched zone. Before gluing the surface of the steel beam is treated with degreasing liquids [1].

At the second stage, the bending deformation of steel beams made of two channels with polymer tapes(prototypes) and beams without reinforcement (control samples) glued in the stretched zone was carried out. In experimental studies of beams at each stage of loading measurements of deflections in the middle of the span beams, the relative deformations of steel, composite material gain.

The destruction of the "clean" steel control beam occurred in the middle of the span as a result of the steel reaching the yield point, which is typical for structural steels. The relative deformation of the steel in the stretched zone was 2.21%, the destruction occurred smoothly, the deflection increased without increasing the load. The bending moment corresponding to the breaking load is 10.6 kNm. The beam deflection in the middle of the span at the load corresponding to the operating value was 6.8 mm.

The test steel beams reinforced with composite had quasi-brittle fracture. Comparing the parameters of the test and control beams deformation, it should be noted that the best results of reinforcementare as follows: on deformations – 11%, on the destructive moment – 8%, on deflection – 12%.

On the basis of the research of the bent steel elements reinforced with composite materials it is possible to draw the following conclusions.

1. The use of composite material to strengthen steel structures is undoubtedly progressive.

2. The special aspects of the operation of the bent steel elements strengthened with composite materials on the basis of carbon fibers are established.

The aging of the polymer base of composites and the fragile nature of the destruction should be noted as negative factors in the application of this type of reinforcement. The most reasonable application of this reinforcement is for a short further service life of structures, i.e. temporary strengthening. Further long-term operation of the reinforced elements requires additional close monitoring [2].

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UDK 72.04

VERTICAL GARDENING CONSTRUCTIONS

ALESYA KHRYSHCHANOVICH, YANA IKSANAVA, RAISA PLATONOVA
Polotsk State University, Belarus

In this article the analysis of conceptual and realized domestic and foreign projects on vertical gardening are executed, the most effective designs of gardening of building facades for Republic of Belarus are offered.

Introduction. In conditions of high population density, lack of oxygen and lack of free space, vertical gardening has become one of the most relevant methods to solve the problem of comfortable well-being and human activity in an aggressive urban environment.

The research part. Our ancestors knew about vertical gardening in 600 BC, when hanging gardens of Babylon – one of the seven wonders of the world were erected in ancient Babylon. The founder who patented and introduced a new way of gardening was Peter Blank. He proposed to move the green cover from the horizontal plane to the vertical one – a technology known as "Vertical gardens" (Vertical Garden System), which will allow to green large areas of facades, and later "green walls" include directly in the interior of buildings. The most ambitious project of vertical landscaping by Peter Blanca today is the design of the Museum walls of modern art Quai Branly in Paris (Fig. 1). On the wall with a total area of 800 m^2 there are more than 170 species and 15,000 plants [4].

Figure 1. – Museum of modern art Quai Branly in Paris

Initially, for planting vertical gardens mountain plants in Thailand and Malaysia were selected. More than two thousand species of tropical plants are able to take root on rocky slopes in conditions of insufficient lighting, a small amount of minerals and lack of moisture. Peperomy, alocasia, asparagus, Pilia, Anthurium, spatifilum - these and many other plants are found in nature on rocky slopes and in the beds of waterfalls. All that is needed for the growth of such plants to have the ability to fix the roots, sunlight and plenty of water.

The main components of the green walls are: plants, substrate, supporting elements around which plants grow, and the system of tubes and pumps that deliver water and fertilizers. These plants are found in nature on the rocks and in places inconvenient for growth with a minimum of soil. At the bottom of the vertical garden shade- and water-loving plants are planted, and at the top – the able ones to withstand the bright sun and wind. The choice of plants depends on the climate and the location of the wall relative to the cardinal points.

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The main systems of vertical gardening are: frame system, "Living wall " system, and tiered terraces [3].

Frame system, an adjacent to the surface of the facade – a frame of steel, wood, or plastic nets, which are attached to the enclosing structure, and they grow climbing plants. Frames can be flat, consisting of cables of ropes and nets, and three-dimensional, formed of rigid frame and cellular structures. This type of support structures is differentiated by the types of the following systems:

– the system of wire mesh is intertwined mesh of aluminum or light steel cables attached to the facade with brackets. Plants usually grow from special modules located along the entire height of the wall;
– the system of cables and ropes consists of flexible vertically stretched elements;
– Rigid system is a trellis design. It can be both flat and three-dimensional.

Due to its spatial rigidity, it can be held not only by mounting on walls or columns, but also without any vertical support elements.

The "Living wall" system is a system where plants do not curl around a supporting grid attached to the wall – they are integrated into its structure together with the substrate (earth or perlite). The main difference between the living wall is that its device uses herbaceous plants. To protect the enclosing structures from moisture, they are covered with a moisture-proof membrane. The irrigation system can be equipped with rain sensors. There are two types of living walls:

– Suspension system with felt pockets. The roots of the plants are located in these pockets, filled with nutritious composition.
– Modular system of non-plastic rectangular, mostly plastic, containers, filled with nutritious composition. Such a system is either attached to a vertical wall, or stands freely, relying only on the surface of the earth. The system of containers is made of light metal or plastic. It can be boxes or wire cages. In some cases, the containers are divided into smaller cells at an angle to the back of the container. Plants are grown directly in these modules, filled with soil, inorganic nutrient composition or natural fiber. An example of using such a system is one PNC Plaza in Pittsburgh (Fig. 2).

Figure 2. – Modular system of containers. One PNC Plaza in Pittsburgh

Tiered terraces usually consist of concrete stepped ceilings, in which plants are planted. The life cycle of such plants can be both seasonal – plants are installed in mobile containers and tubs, and they are perennial. This type of landscaping system allows you to diversify the types of vegetation, not limited to vertical climbing plant species. Among the most famous buildings of this type are the ACROS building in Fukuoka city in Japan; Solaris and Parkroyal in Singapore. The use of this type of landscaping on the Keppel Bay building in Singapore showed that the longline terrace gardening can be used at high altitudes.

Conclusion. Thus, with the help of landscaping systems, you can decorate the facades of buildings, mask unsightly buildings and create a favorable microclimate in the building. Given the climate of Belarus is established that currently, for this purpose you can use the following green spaces: hops, edible and decorative

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grapes, honeysuckle, vine, lianas, hydrangea creeping ivy, black beans, climbing rose, curly header, Actinidia, perfoliate, kirkazon, Highlander, English and clematis [1], [2].

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UDC 69.059.4

THE LIFE CYCLE REDUCTION FACTORS OF BUILDINGS AND CONSTRUCTION IN THE CONDITIONS OF INNOVATIVE ECONOMY DEVELOPMENT

MARYIA KORSHUNAVA, GENNADY SERYAKOV
Polotsk State University, Belarus

The paper analyzes the concepts of the life cycle of non-movable assets, the economic and physical life terms. The analysis of the life cycle stages of buildings and structures was carried out, the characteristic features of each of them at the present stage of development were noted. The factors affecting the shortening of the building life cycle and structures at each stage were identified.

Nowadays, the Republic of Belarus is facing the task – the final transition of the economy to an innovative path of development. The solutions are one of the main ways to achieve the dynamic development of the country in the long term.

The analysis of current trends in the development of the leading Western countries economies shows that an innovative economy is an economy of society, which is based on knowledge, innovations, a perception of new ideas, systems, technologies, and on readiness for their practical implementation in various spheres of human activity. It highlights the special role of scientific knowledge and innovation.

The transition to an innovative way of development and a formation of a new technological order requires an accelerated updating of fixed assets and production capacities in almost all sectors of the national economy.

The life cycle of production technologies and the buildings and structure created for their use are sharply reduced, in the context of the world economy globalization, the intensification of competition in the commodity and product markets, and the transition of the economy to an innovative development path.

The non-movable asset life cycle as a physical object is a sequence of processes for the existence of a non-movable asset from the idea to the liquidation (disposal) [1]. It includes the term of economic and physical life.

Term economic life determines the period of time during the object is used as a profit source. It ends when the improvements made cease to contribute to the value of the object and operating costs exceed the potential income from the asset use.

The term of physical life is the period of the non-movable asset existence in a functionally fit state before its demolition. It is determined by regulatory documents.

Stages of the non-movable asset life cycle are shown in Fig. 1.

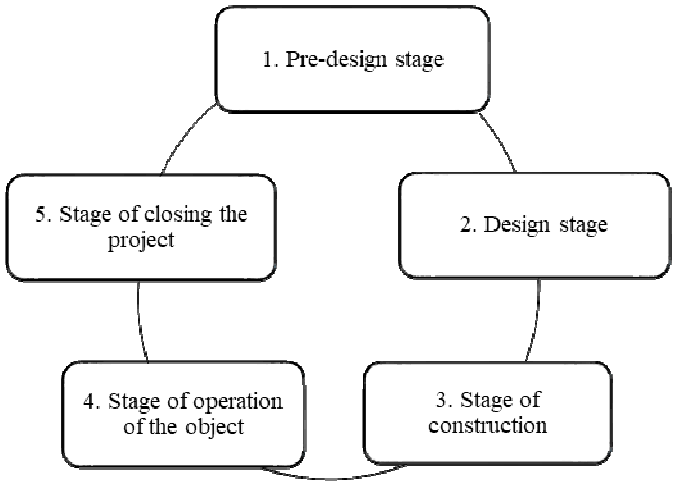

Figure 1. – Stages of the non-movable asset life cycle

Pre-design stage includes the analysis of the non-movable asset market, the formation of a project strategy, an investment analysis, execution of initial permits, attraction of investment funds [2]. In the innovation economy this stage plays an important role.

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The design stage includes a development of a financing scheme, a choice of a project management team, an architectural engineering group [2]. The introduction of BIM-processes in the design leads to a reduction in the timing of project preparation and its integration with financial and analytical indicators.

Obviously, the profit is not formed at the early stages. These projects are important aspects for active project work. At the moment, there is a reduction in the duration of the first two stages, as well as minimization of operating costs for all stages of the life cycle of an object.

Under the existing design system, not enough attention is paid to the concept of costing over the entire life cycle. In Europe, the emphasis is placed on "a cost of the whole life cycle" [3]. Even before making a decision on the project implementation, it is necessary to consider several options for its implementation and distinctly understand the goals pursued by the investor.

The rationally constructed cost calculation system taking into account the entire life cycle will make it possible to distinctly represent the need to choose one or another constructive solution of the building. The developer seeks only to minimize the initial investment, not comparing with the cost of operating real estate.

Making decisions based only on the initial benefits is not appropriate. Of course, the task of calculating the cost of operation is complex. But the implementation of this strategy will allow to achieve significant savings in the further operation, spending a little more at the initial stages.

Construction stage consists in the selection of a contractor, coordination of construction work, and quality control of construction [2].

Currently, they are striving to shorten the construction period so that the results of the project will be of benefit in the chosen direction of investment activity as early as possible. A clear and well-developed project management system in the construction industry makes it possible to achieve a total savings of up to 10% in construction, reducing the project implementation time.

Operation stage involves the operation of facilities, their maintenance and a repair. Operating expenses at the operational stage make up 75% of total expenses throughout the entire life cycle of buildings and structures (Fig. 2) [4].

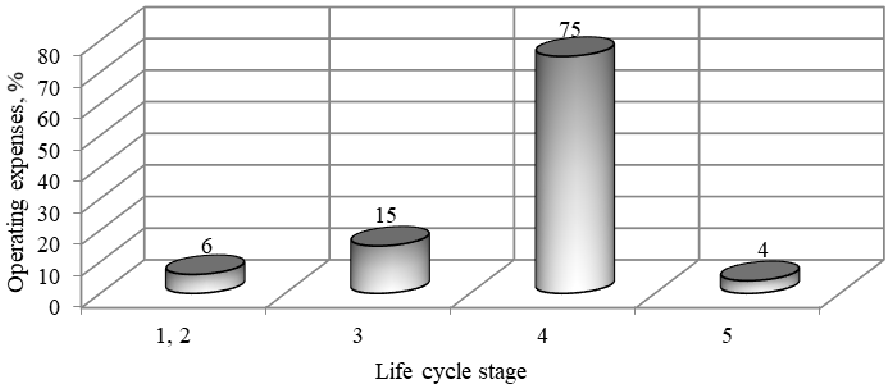

Figure 2. – Distribution of operating costs by life cycle stages

Obviously, managing costs and operating time can bring significant value and time savings. This diagram proves the importance of planning the entire life cycle cost in the first stages.

Project closing stage is the complete liquidation of its original and acquired functions, as a result of which is either demolition or a qualitatively new development.

As a result of the study, factors that affect the shortening of the life cycle of buildings and structures at each stage were identified. This is facilitated by:

- improvement of the innovation management system in the building complex;
- the speed innovation increase;
- the emergence of new methods of planning and design;
- introduction of information technology in the design process, the development of BIM-design;
- expansion of online commerce;
- production of modern building materials and improvement of existing ones;
- improvement of constructive solutions for buildings and structures;
- an increase in the rate of obsolescence of materials and equipment;

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- the quality research improvement;
- accelerated modernization of fixed assets of the construction complex;
- increasing the skill level of engineering and technical workers and construction workers;
- legal and financial support for the development of innovative activities in construction.

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THE RELEVANCE OF GREENING OF RESIDENTIAL BUILDINGS IN THE CITY OF NOVOPOLOTSK

YANA IKSANAVA, ALESYA KHRYSHCHANOVICH, RAISA PLATONOVA
Polotsk State University, Belarus

This article presents an analysis of the relevance of landscaping in Novopolotsk. On the basis of conceptual and implemented foreign landscaping projects their main advantages and disadvantages were identified.

In Novopolotsk, the main sources of air pollution are oil refining, chemical industry, heat power engineering and motor transport. When conducting environmental monitoring for December 2018 high and extremely high pollution level in Novopolotsk were not detected. The horizontal and vertical greening of residential buildings are considered for a more balanced and healthy ecosystem of the city. This would improve the overall quality of the atmosphere, reduce the temperature in the city in summer, increase the amount of oxygen, reduce the cost of heating and air conditioning of buildings with green roofs [1].

An example is the project of the Gary Comer Youth Center and its roof-farm landscape-architectural company Hoerr Schaudt Landscape Architects-Chicago, Illinois, USA (Fig.1). The green roof is located directly above the gym and the cafe Gary Comer Youth Center and it is covered with a 60-centimeter layer of soil. Among the dozens of plant species you can find not only herbs and flowers, but even vegetables and fruits. This green layer provides good insulation below the premises, thus reducing the energy costs of heating and cooling the entire building.

During heavy rains, the vegetation-covered roof areas absorb rainwater, reducing the load on the city's drainage systems. This partially helps to solve the problems associated with rapid storm water runoff such as sudden floods and water pollution. Round metal rings in the interior of the garden play the role of both artistic elements and quite functional skylights that let natural light into the rooms below.

The air temperature on the roof is higher than at the bottom, which allows the use of garden plots from early spring to late autumn. The fertile soil gives rich harvests of cabbage, potatoes, tomatoes, carrots, lettuce, and even strawberries. For all its functionality, the green space is not just a garden, but it is also a beautiful place to relax. Planted along with vegetables and fruits, pale yellow daffodils, sunflowers, daisies, lilies and a variety of creeping herbaceous plants contribute to this.

Figure 1. – Gary Comer Youth Center

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In Russia, an example is the business centre Crowne Plaza, located in St. Petersburg (Fig.2). Greening smooths out the sudden changes in temperature, helping to create a comfortable microclimate of the premises, detains dust and absorbs rain water, removing the load from the sewer systems. From an economic point of view, such roofs have also a number of advantages over conventional roofs despite the high initial cost: green protects the roof from ultraviolet radiation, extending its service life, protects the building from hypothermia and overheating, which reduces the cost of heating and air conditioning.

Figure 2. – Crowne Plaza Business Centre

In the Republic of Belarus, special attention has also begun to be paid to the greening of roofs. On June 27, 2017, the press conference of the pilot initiative "greening of building roofs", implemented within the framework of the project "Assistance to the transition of the Republic of Belarus to a "green economy", funded by the European Union and implemented by UNDP, held on the territory of Marjina Gorka grammar school. The aim of the initiative was to create and disseminate the best available practices in Belarus for the construction and operation of the roof with soil cover. The result is a unique experience in the development, design and construction of such an object [3].

The analysis revealed the main advantages and disadvantages of greening the roofs [2], [4], [5].

The advantages include the following factors:

– Air quality improvement

Green spaces on the roof improve air quality by absorbing carbon dioxide in the atmosphere and releasing oxygen. Atmospheric pollutants are washed out in green roof substrates through precipitation, where they are filtered out and cleaned from harmful particles and impurities. Green plants and plants also moisturise the air by evaporating clean water.

– Roof cover protection

The vegetation on the roof protects its surface from extreme weather conditions, temperature and ultraviolet radiation, thus extending the service life of the roof.

– Aesthetics

Greening the roofs is considered one of the most effective and aesthetic ways to make the city more beautiful, pleasing to the eye and perception of the city residents.

– More efficient temperature regulation

During the lifetime plants use the thermal energy of the environment and evaporate water. During the passage of condensation and evaporation cycles, plants are thus able to cool and moisten the surrounding air improving the microclimate.

– Improvement of storm water runoff

Storm water runoff is stored on a green roof substrate and then absorbed by the plants, from where it returns through evaporation to the atmosphere. In summer, green roofs can save 70-80% of the rain falling on

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them. In winter, they can retain 25-40% of moisture. Green roofs are also able to delay the time at which runoff occurs, which reduces the load on drainage and sewerage systems during peak storm water flow.

– Reduction of energy costs

Layers of green roof are able to improve its thermal characteristics, reducing solar heat penetrating into the building. The temperature under the green roof can be at least 3-4°C colder than the air outside, when the temperature ranges from 25°C to -30°C, therefore, reducing the cost of maintaining the air temperature inside the building. In winter, a green roof can also help reduce heat loss through the roof.

– Creating a positive social effect

Green roofs, among all other advantages and positive effects, create new competencies for the care of green roofs, directly involved in eco-education, including among children.

Main disadvantages are:

– Significant weight of the system on the building structure

A significant weight of the system on the structure of the building, which can reach several tons/m^2, can adversely affect the strength of the structure, which must be taken into account in advance when designing.

– Increased risk of fire

In addition, when designing a fire system, it is necessary to take into account the increased risk of fire.

– Damage of waterproofing by plant roots

The device of the green roof should include anti-root insulation to protect the coating from the destructive power of the roots.

– High cost of greening and maintenance costs

Conclusion. The initial cost is higher compared to the conventional roof, but the given advantages of the costs are recouped due to the fact that the service life of waterproofing coatings of buildings increases up to 40-50 years and keeps the heat in the building. Saving money allows a significant reduction in heat loss -2 litres/m^2 of the building area annually, if we consider the equivalent value of petroleum products. Green roofs save money on storm drains, reducing the drain by 10-50%.

Thus, it can be concluded that at this stage of development of energy-efficient technologies, taking into account the climatic and social features of the region of the Republic of Belarus, the introduction of urban greening of residential buildings is important, as it contributes to the formation of an attractive, comfortable and environmentally friendly urban environment in Novopolotsk.

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CHURCH OF ST. ILYA IN URBAN SETTLEMENT BESHANKOVICHY

MARYIA KLASKOUSKAYA, ANASTASIYA GARDEY, RAISA PLATONAVA
Polotsk State University, Belarus

The article is devoted to the architectural heritage of Beshankovichy, namely Church of St. Ilya. We consider not only the history and architecture, but also the restoration of the previously erected buildings.

The Church of St. Ilya was built of brick in the pseudo-Russian style (1866–1870), was on the site of the temple of the 15th century, founded by Polish king Kasimir IV Jagellonica. The church with a cross dome is crowned with five octagonal light drums with hip ends and bulb onions. Temple has straight analogy with the church of Apostles in Solonikakh (1312–1315). In the architectural decor they are used the elements of Old-Russian and byzantine architecture — kokoshniks, three-bladed arches. As well as in Byzantine churches four sailing arches are covered images of evangelists [1].

In the temple are stored the icon 17-19th of centuries – "Saint Of Eufrosinia Polotsk", "Secret vespers", "Mother God Kazan'", "Archangel Mikhail", "She saved". It is decorated with three-bladed arches, panels, niches, pilasters. The cupolas are renovated after restoration on the temple, roof is covered with tile, is completely painted southern pride, consecrated in honor of the Saint blessed prince Alexander Nevsky is completely painted, works in a northern side-altar which is consecrated in honor of the apostles Peter and Pavel [2 – 4].

The temple strongly suffered in the years of World War II, fascist's adapted sacred thing under the storage. Survived a few photos taken at the beginning of July 1941, which depicts damaged during the fighting the Church of St. Ilya and environs scorched (fig. 1).

Figure 1. – Church in the war-time

At the present time (fig. 2) the Church of St. Ilya changed, gladdening its parishioners by its external and internal decoration: by gold cupolas; by the new wooden iconostasis of manual work, by paintings on walls. However, after the reconstruction, the red brick was hidden under a layer of white plaster. The Church has a Sunday school and a Sisterhood. The temple belongs to the architectural values of the Republic of Belarus and is protected by the state. After his visit, he will long remain in the memory of tourists.

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Figure 2. – Church in our days

In addition the Church of St. Ilya in Beshankovichi there is a small chapel-tomb, built in the 19th century in style very typical for such constructions (fig. 3). Chapels of such type were preserved in Belarus not much; therefore this chapel has the specific historical and architectural value.

Figure 3. – Chapel

Undoubtedly, these attractions complement the tourist atmosphere of the city of Beshankovichi and give it certain attractiveness in the eyes of travelers.

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ESTATE OF KHREPTOVICHY IN BESHANKOVICHY

ANASTASIYA GARDEY, MARYIA KLASKOUSKAYA, RAISA PLATONAVA
Polotsk State University, Belarus

The article considers the questions of the history of appearance and building of the estate of Khreptovichy in Beshankovichy. In addition, it reveals its historical and architectural value and need of full restoration for the use in tourist aims.

Beshankovichy is an urban settlement in Vitebsk region of Belarus, the former river port on the Western Dvina. On archival sources it is known from 15th century. In the 16-17th centuries the town belonged to princes Oginsky, Khreptovichy.

The name of Oginsky is associated with the flourishing of the then-occurring of Beshankovichy. In the middle of the 18th century the town becomes the city. In the same years here begin to be carried out the fairs, to which it assembles 4–5 thousand people not only from the surrounding cities, but also from Russia and Poland.

After the death of Ignatius Oginsky in 1775, Beshankovichy passes to the chancellor of Grand Duchy of Lithuania Joachim Khreptovich. He decides to build a Palace in the city, which was destined to become the most interesting sight of Beshenkovichy. The estate of Khreptovichy (fig. 1) created at the end of the 18th century was saved to our days practically in a primordial kind [1].

Figure 1. – The estate of Khreptovichy

In the architecture of the palace, built in 1770, there is no portico traditional for the early classicism. Most of the details of the building belong to the empire style. As for its structure, the Palace has a U-shape, consisting of three interconnected buildings: two-storey central and one-story side wing. The solution of the main facade is generally flat, used for housing. The main halls and offices were located in the central building. Openwork balcony of the second floor with a beautiful twisted cast iron fence (fig. 2), located directly above the main entrance, small cornices and flat niches make up a modest architectural and artistic decor of the building [1].

Figure 2. – Balcony of the second floor

Next to the Palace there was a greenhouse and various farm buildings, where there was a kitchen and a stable (some of those buildings are preserved). The palace was surrounded by the magnificent park with alleys and ponds in the"Anglo-French" style. The main alley was closed by an arched pond. Another circle-shaped pond had an

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island with an arbor in the middle. Also, two artificial reservoirs with islets were created. Spouting springs under the water did not allow them to freeze, which made it possible to keep there swans year round. In 1821, during a visit of Emperor Alexander I to Beshankovichy, the park was enriched with small architectural forms. A wooden, straw and fir hall for 1500 people was built near the Palace among the park. Subsequently, count Irenaeus Khreptovich installed a monument sign with a height of 3 feet and 12.5 inches (269 cm). This sign consisted of four parts: a granite plate, a brick plaster pedestal and a truncated cone column. The monument was crowned with a granite ball with a diameter of 5 inches (22.2 cm). On the pedestal there was an inscription in gold letters in Latin: "Count Irenai Khreptovich in memory of the stay at this place of the divine sovereign Alexander I with his troops". The monument was surrounded with fencing from the chains suspended on eight granite columns.

Palace at different times was a place of stops of different people. In 1812, the Neapolitan king Murat and Napoleon arrived in Beshankovichy. The Emperor of France liked the reception organized by Khreptovich so much, that he decided to spend a few more days in the Palace. It is interesting that the room in the Palace of Count Iriney Khreptovich, where Napoleon spent the night, was being carefully preserved in the same form as the emperor had left it for over a century and shown to all guests. By the way, it was in the "room of Napoleon" in 1821 in Beshankovichy for the review of troops stopped another Emperor, but the Russian - Alexander I [2–3]. The Palace of Khreptovichy in Beshankovichy was captured by Napoleon Orda on one of his watercolors (fig. 3) in 1876.

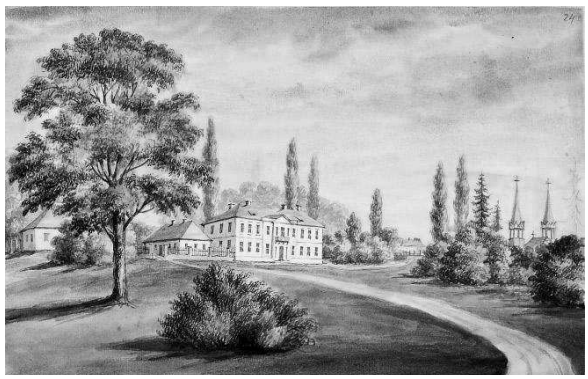

Figure 3. – Napoleon Orda's watercolor with the image of the Khreptovichy Palace

However, in 1918, the contents of the Palace were badly damaged by looting, but the building itself has retained its appearance and is now a historical and cultural value of the Republic of Belarus. Currently, its main building is used as the Beshankovichy School of Art.

Thus, the Palace of Khreptovichy is now of great importance as a historical and architectural monument, and with its full restoration can be an important tourist attraction.

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USAGE OF CONCRETE ADDITIVES CEMENT SETTING RETARDERS ON THE COLD JOINT OF CONCRETING

NATALLIA SHPILEUSKAYA, MARYNA PARUSAVA, ALEXANDER SHVEDAU
Polotsk State University, Belarus

Continuous concreting in the production of concrete work can not always be ensured. Therefore, during breaks, due to both technological and organizational factors, arrange cold joint. One of the possible technological solutions in such cases may be the introduction of setting retarder into the concrete mix.

To ensure solidity, the process of concrete casting must be conducted continuously. However, this is possible with minor amounts of work and for the construction of relatively simple carcass. But in other cases it is difficult to avoid breaks in the laying of the concrete mix, and therefore on construction sites are forced to resort to the device, the so-called "cold joint".

Their device is associated with certain difficulties and requires additional expenditures of working time, as for reliable adhesion of a new concrete with an old one, it is necessary to treat carefully the surface of previously laid concrete [1]. All this complex of works can be avoided if you conduct concreting continuously or with such breaks during which the process of setting the previously laid mixture has not yet begun.

One of the possible technological solutions in such cases may be the introduction of retarders and hardening of concrete into the concrete mix. Such a reception should be carried out taking into account the intensity of concrete work and the supply of concrete mix to the place of installation. Another important direction in the use of setting retarding agents is related to the need of transporting the concrete mixture over long distances, as well as preservation of the technological properties of the mixtures in the case of forced breaks during concrete work.

The mechanism of action of additives-retarders setting and hardening of concrete [2, 3] is to slow down the hydration and hydrolysis of clinker minerals, i.e., causes a delayed release of free lime into the solution and slows down the processes of coagulation and the convergence of grains of cement and its hydrated newgrowths. As a result, the intensity of the setting of clinker cements slows down. Setting of cement paste can be slowed down and as a result of the action of additives that, without interfering with the hydration and hydrolysis of the clinker minerals, quickly bind free lime released from C_3S (tricalium silicate). Retardation is also caused by the influence of individual electrolytes, which, depending on their content in the water-cement paste, can prevent the coagulation of the colloidal groutand hydrated newgrowths. According to the requirements of reliability, setting retarder should increase the time of slump loss of the concrete from the initial value to 2 cm 2 times or more (at an ambient air temperature (20 ± 2) ° C). For additives that slow down the curing of concrete and mortar, the criterion is the reduction of concrete strength by 30% or more in the age of up to 7 days. At the same time, at project age, after 28 days, the strength of concrete increases and the transmissibility decreases [4].

Retardation of saccharine on the cement setting process is due to its interaction with hydrate of lime, formed during the hydrolysis of tricalcium silicate. At the same time, firstly, for some time a supersaturated hydrate of lime solution does not form, which slows down the process of crystal formation; secondly, colloids of tricalcium sugars form a long-existing coagulation structure with thixotropic properties. Over time, due to the creation of a supersaturated $Ca(OH)_2$ solution in the water-cement paste, crystallization processes begin, and the colloids age irreversibly (the syneresis of the colloids), dehydrate and compact. Both of these processes proceed simultaneously and lead to the creation of a crystallization-coagulation structure, which imparts the properties of a solid body to the water-cement paste [5]. An effective set setting retarder at a temperature of 90 ... 160 °C is a concrete of apple acidand sodium dichromate.

Construction practice has some experience in the use of the following types of retarders for setting and hardening concrete and mortar mixes (Table 1).

In addition to those specified as additive retarders for concrete mixtures and concrete hardening, medium- and slightly plasticizing additives of increased concentration can be used. Setting retarders are quite effective in small concentrations, while the slower setting is caused by the adsorption of additives on cement hydration products, especially hydrate of lime $Ca(OH)_2$ (slaked lime), as well as on the surface of the raw non-hydrated minerals. Most of the introduced retarding agent is spent on aluminate phases of cement, therefore the effect of retarder is more pronounced in low-aluminate cements, as well as in cements with a minimum content of alkalis, since the latter destroy the retarder. It should be borne in mind that in many cases slowing the concrete setting based on Portland cement is a side effect of the introduction of other targeted additives, and their effect

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may be very significant. For example, setting up time retardation may be the result of the introduction of water reducing admix, water-retaining and thickening agents, etc. [6]

Table 1. – Additives retarders setting and hardening

Additive	General characteristics	Gauging	Advantages and disadvantages	Application area
1	2	3	4	5
Nitrilotrimethyl phosphonicacid	White crystalline powder.	0,02...0,15% masses of cement.	Advantages: – easily soluble in water and not soluble in organic solvents. – additive is effective for all types of cement, including high-alumina. – has a plasticizing effect. – does not cause corrosion of reinforcement. – low toxicity. – low cost. Disadvantages: – overdose may provoke cement strength degradation	– production of site concrete in a dry hot climate. – construction of massive monolithic construction. – to ensure good joining of concrete laid at different times. – preparation of concrete transported over long distances.
Mother liquor production nitrilotrimethylphosphonic acid RCB-500	Powder.	0,02...0,15% masses of cement.	Advantages: – has a plasticizing effect. – does not cause corrosion of reinforcement.	- apply in monolithic construction. -for ensuring good joining of concrete laid at different times. - preparation of concrete transported over long distances
Sugarmolasses	A thick, viscous liquid of dark brown color.	0,05...0,3% masses of cement.	Advantages: – it is well dissolved in water. – there is a slow development of strength in concrete and matrix up to 7 days old. – has a plasticizing effect. Disadvantages: – do not apply to prefab reinforced concrete.	- apply in monolithic construction. - concreting massive structures. -for ensuring good joining of concrete laid at different times. - preparation of concrete transported over long distances in a dry hot climate.
Milkserum	Yellow liquid.	1,5...3% masses of cement.	Advantages: – It has a strong inhibitory effect when added directly to the concrete. – has a plasticizing effect. – does not cause corrosion of reinforcement. – does not reduce the freeze-thaw resistance.	- apply in monolithic construction. -for ensuring good joining of concrete laid at different times. - preparation of concrete transported over long distances.

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Continued Table 1

1	2	3	4	5
Sodiumgluconate	Finely crystalline powder or granules from white to brown.	0,05...0,25% masses of cement.	Advantages: - possesses the plasticizing and water-retaining action. - completely biodegradable. - let's well dissolve in water.	- apply in monolithic construction. - for ensuring good joining of concrete laid at different times. - preparation of concrete transported over long distances.
Sulfiteyeastmash	Viscous dark brown liquid or dark brown solid mass.	0,1...0,6% masses of cement.	Advantages: - has a plasticizing effect. - it is well dissolved in water. Disadvantages: - do not use in the manufacture of prestressed structures. - concrete strength reduction. - low toxicity.	- apply in monolithic construction. - for ensuring good joining of concrete laid at different times. - preparation of concrete transported over long distances.
Ethyl- or methyl Siliconate Sodium	Transparent liquids from pale yellow to brown.	0,05...0,15% masses of cement.	Advantages: - has a plasticizing effect. Disadvantages: - Do not use in the manufacture of prestressed structures.	- apply in monolithic construction. - for ensuring good joining of concrete laid at different times. - preparation of concrete transported over long distances.
sulfite-celluloseliquor	Liquid consistencyand solid.	0,1...0,6% masses of cement.	Advantages: - has a plasticizing effect. - it is well dissolved in water.	- apply in monolithic construction. - for ensuring good joining of concrete laid at different times. - preparation of concrete transported over long distances.
Additives of foreign manufacturers				
Addiment VZ 2		0,2...0,7% masses of cement.	Advantages: - has a plasticizing effect. - does not cause corrosion of reinforcement.	- apply in monolithic construction. - for ensuring good joining of concrete laid at different times. - preparation of concrete transported over long distances. - for operation at high temperatures. -used for prestressed concrete.

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End Table 1

1	2	3	4	5
Addiment VZ 6		0,2..1,7% masses of cement.	Advantages: - has a plasticizing effect.	- apply in monolithic construction. - for ensuring good joining of concrete laid at different times. - preparation of concrete transported over long distances.
Peramin R	Clearsolution	0,2…1,0% masses of cement.	Advantages: - has a plasticizing effect. - does not cause corrosion of reinforcement.	- apply in monolithic construction. - for ensuring good joining of concrete laid at different times. - preparation of concrete transported over long distances.
Pozzolith 100-XR	Liquid from brown to black.	0,2…0,3% masses of cement.	Advantages: - has a plasticizing effect.	- apply in monolithic construction. - for ensuring good joining of concrete laid at different times. - preparation of concrete transported over long distances.
Cementol Retarde		0,2…0,8% masses of cement.	Advantages: - has a plasticizing effect.	- apply in monolithic construction. - for ensuring good joining of concrete laid at different times. - preparation of concrete transported over long distances.
Sika Retarder	Yellowish brown liquid.	0,2…2,0% masses of cement.	Advantages: - has a plasticizing effect. - compatible with all types of Portland cement, including slag Portland cement.	- apply in monolithic construction. - for ensuring good joining of concrete laid at different times. - preparation of concrete transported over long distances.

The mode of its administration also affects the retarding ability of an organic compound. If the setting retarder is introduced into the concrete after 2 ... 4 minutes after mixing, the setting time is extended by 2 ... 3 hours compared with the time obtained with the introduction of the modifier with mixing water. The most widely used in practice are slow-acting hydrocarbon acids or their salts, such as citrates or heptonates, as well as calcium or sodium lignosulfonates. [7]

The effect of these setting retarder on the strength and longevity of concrete, depending on the kinetics of the formation of a cement stone structure in their presence and on their participation in chemical reactions, cannot be predicted. Therefore, the content of setting retarder in concrete or matrix is established experimentally with simultaneous testing of compressive strength in accordance with the requirements of current regulatory documents.

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EFFICIENCY OF THE APPLICATION OF A COMPLEX MODIFIER IN THE COMPOSITION OF GYPSUM BINDERS

ALIAKSANDRA KATULSKAYA, LUDMILA PARFENOVA
Polotsk State University, Belarus

The article presents the results of the study of the physical and mechanical properties of modified gypsum binders by the complex use of water preparation sludge, dolomite flour and plasticizer. It is shown that the modification of gypsum binders contributes to the increase in their strength characteristics.

Building materials based on gypsum raw materials are characterized by low energy consumption during their production and the best environmental performance compared to other materials of similar purpose. The actual direction of the study, which will allow to expand the range and scope of materials based on gypsum binders, is to increase their physical-mechanical characteristics [1].

The studies aimed to study the feasibility of effective use sludge of water treatment of Novopolotsk HES as a modifier of gypsum binder are of practical interest. The chemical composition of the sludge of water treatment is shown in table 1.

Table 1. – Chemical composition of sludge of water treatment of Novopolotsk HES

$CaCO_3$	3MgCO*MgOH*2H_2O	$CaSO_4$x2H_2O	$Fe(OH)_3$	SiO_2	$CaSiO_3$	Organic compounds
62,8 - 68,2%	5,8 – 10,6%	3 – 9,5%	4,1 – 6,7%	0,5 – 4,7%	3,9 – 6,6%	4,9 – 8,9%

Analysis of the chemical composition shows that the main compound contained in the sludge is calcium carbonate (62.8 – 68.2%). For the experiments, the sludge was dried in a drying cabinet of the brand «SNOL 58/350» for 5 hours to constant weight at a temperature of 110 °C. The dried sludge, after cooling, was ground in an DIM drum mill and sieved on a MS mechanical sieve. The fraction of the sludge passed through the № 008 sieve was used. The value of the true density of the sludge of water treatment was determined according to GOST 8735 [2] and it was 2170 kg/m^3. The bulk density corresponds to STB EN 1097-3 [3] and was 780 kg/m^3.

Dolomitic flour produced by OS «Dolomit», which corresponds in its characteristics to GOST 14050 [4], was also considered as a modifier. Superplasticizer «Stakhement 2000M Zh30» was used as a plasticizing additive, the mass fraction of dry substances in the superplasticizer is 30%. The concentration of hydrogen ions (pH) is 6.

The method of mathematical planning of the experiment based on a three-factor plan of the second order was used to determine the optimal number of components of the complex modifier of the gypsum binder. The following factors were considered as variable factors: the mass of gypsum binder sludge of water treatment (x_1), plasticizer «Stakhement 2000M Zh30» (x_2) and dolomite flour (x_3), and the compressive strength, bending strength of gypsum stone. Factors and intervals of their variation are presented in table 2.

Table 2. – Factors and intervals of their variation

	Lower level (-1)	Main level (0)	Upper level (+1)	Variation interval	The name of the factor
x_1	1	2	3	1	Sludge of water treatment
x_2	0,1	0,2	0,3	0,1	Stakhement 2000M Zh30
x_3	5	10	15	5	Dolomite flour

For carrying out experimental studies, the gypsum building «Taifyn Master » N 35, type G-5 III A, produced by LLC «Taifyn», was used. The determination of the physical mechanical characteristics of the modified gypsum binder was carried out on samples of beams 40×40×160 mm. The test samples were carried out 2 hours after molding in accordance with GOST 23789 [5] on a hydraulic press brand PGM – 500 MG 4A.

The experiment planning matrix in coded and natural variables and the results of the studies performed are presented in table 3.

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Table 3. – Planning Matrix and Experiment Results

Experience number (u)	Planning matrix			Natural values of variables			Output parameter – strength, MPa	
							Bending	In compression
	x_1	x_2	x_3	Sludge of water treat-ment	Stakhe-ment 2000M Zh30	Dolomi te flour	y_1	y_2
1	-1	-1	-1	1	0,1	5	2,3	5,7
2	+1	-1	-1	3	0,1	5	2,5	4,6
3	-1	+1	-1	1	0,3	5	3,6	6,3
4	-1	-1	+1	1	0,1	15	3,0	5,1
5	-1	0,19	0,19	1	0,219	10,95	3,5	5,7
6	0,19	-1	0,19	2,19	0,1	10,95	3,0	6,2
7	0,19	0,19	-1	2,19	0,219	5	4,1	8,2
8	-0,29	+1	+1	1,71	0,3	15	2,9	5,7
9	+1	-0,29	+1	3	0,171	15	3,3	5,9
10	+1	+1	-0,29	3	0,3	8,55	3,7	6,7

After carrying out mathematical processing of the experimental data, it was found that the extremum of the response function is within the limits of variation of the variable factors. The extremum value is y_1 opt = 3.881 MPa, y_2 opt = 7.651 MPa. The extremum of the response function corresponds to the values of the factors: x_1 (sludge of water treatment) = 2.252 (% by weight of the gypsum binder) and x_2 (Stakhement 2000M Zh30) = 0.227 (% by weight of the gypsum binder) at x_3 (dolomite flour) = 10 (% by weight gypsum). For further research, control samples were made without a modifier (composition 1) and samples with the optimum content of the components of the complex modifier (composition 2). The results of studies to determine the physicomechanical properties of the gypsum binder are shown in table 4.

Table 4. – Physical and mechanical properties of the modified gypsum binder

Normal density	Density, kg/m³	Setting time, min		Water absorption, %	Total porosity, %	Strength, MPa (%)	
		Start	End			Bending	In comp-ression
0,46	1672	6	15	5,0	8,36	2,5 (100)	5,5 (100)
0,48	1681	6	14	6,1	10,3	3,6 (144)	7,7 (140)

Analysis of the obtained results shows that the use of the complex modifier of the properties of the gypsum binder can increase the flexural and compressive strength by 44 and 40%, respectively. At the same time there is a decrease in the density of the gypsum stone by 0.5%. The end of the setting time was 1 minute less compared to the control. Thus, the modification of the gypsum binder complex additive on the basis sludge of water treatment, dolomite flour and plasticizing additive allows to increase the strength properties and reduce the density of the gypsum stone.

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USING OF WASTE OF VARIOUS INDUSTRIAL PROCESSES FOR THE MANUFACTURE OF LIGHT CONCRETE

IGOR MOROZOV, YAROSLAV SEMENYUK
Belorusian-Russian University, Mogilev

Concrete industry is one of the major sources of consuming high volume of natural resources. In this article we try to examine and evaluate the effectiveness of existing ways of solving this problem.

Lightweight concrete based on various aggregates is widely used in industrial and civil construction. The benefit of using this type of concrete is obvious: claydite-concrete structures, for example, due to its low density, can improve the thermal and acoustic properties, as well as to some extent reduce the weight of buildings. Therefore, the number of lightweight concrete produced in the Republic of Belarus and in the world is constantly growing. In 2002, the global total concrete production reached 6.5 billion tons, and in 2009 (according to some data, in 2008), this figure was already 10 billion tons. According to the work we studied, scientists Mechta and and Monteiro (New York, USA), by 2050 the volume of concrete produced annually will increase to 18 billion tons. M. Nomel and A. Riaz in their work from 2015 showed an equation by which one can calculate the amount of carbon dioxide emitted during the manufacture of 1 cubic meter of concrete. So, in the production of 1 cubic meter of concrete from 300 kg of Portland cement, 890 kg of sand, 970 kg of gravel and 150 kg of water, carbon dioxide emissions will be an incredible 287 kg. Of course, it should be borne in mind that during the hardening of concrete, cement consumes about 43% of the total mass of this gas, but the emissions are still enormous. Due to the constant growth of concrete production, this process will increasingly adversely affect the environmental situation in the areas of its production. In this regard, there is a certain motivation to study the possibility of using such components in the production of concrete, which will reduce water consumption and carbon dioxide emissions.

In order to deal with this issue, we have studied several works on this topic. The works of our compatriots (Y. Semenyuk, M. Filchenko), as well as the works of Polish and American authors (P. Tomas, D. Mihalki, M.Godzezh) were accepted.

The source of CO^2 emissions in this case is the cement itself, so if we replace it with another substance, it will be possible to achieve a reduction of CO^2 emissions into the atmosphere. However, the question arises: what can replace the cement? In addition, you can also replace the placeholder with any kind of waste production.

Today, domestic and foreign experts offer ground granulated blast furnace slag, fly ash, sewage sludge (dirt in municipal wastewater treatment plants).

The biggest question in this case is how strong the concrete will be if you replace part of the cement with the above components and what percentage will be optimal.

As part of the work, the test methods of our foreign colleagues were studied. Despite the fact that the methods themselves are non-standard, the process itself and the research methodology are as follows: the aggregates were mixed in a 0.25-cubic-meter motor drum mixer, then were mixed in a mixer with cement, fly ash and lime for 2 minutes. Water was then added and stirring continued for 2 minutes. Further tests were carried out using the cone shrinkage method. After the mixture was prepared, cubes were cast with sides of 100 mm, cylinders with a diameter of 100 mm and a height of 200 mm, prisms with dimensions of 100x100x500 mm and 100x100x300 mm. Samples were compacted using a vibrating table.

To assess the compressive strength of concrete and the quality of the samples as a whole, an ultrasonic pulse method was used. Tests were carried out after 1, 3, 7, 28, 56 and 90 days. The temperature in the laboratory was 29 ± 3 ºC and a relative humidity of 67-82%.

Let's compare the samples made using the above elements with the samples made and tested by the same method, but not including industrial waste products.

The final samples, in which the cement was replaced by waste (fly ash, automobile glass and sewage sludge) to 40% of the mass fraction, with a 10% decrease in the amount of water used, turned out to be 25-40% lighter. The strength was the same from 7 to 56 days, however, they further showed an increase in strength up to 12% (fig. 1).

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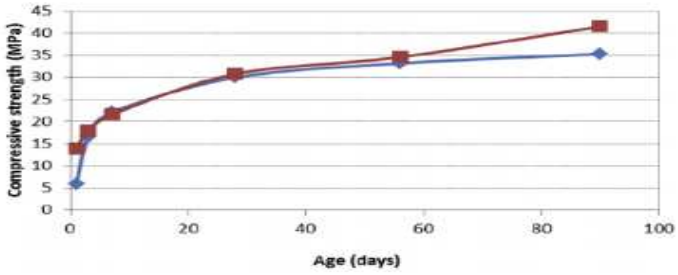

Figure 1. – Compressive strength development of regular (blue line with the rhomb points) and lightweight (red line with the square points) mixes

In conclusion, it should be said that nowadays, when restrictions on production and carbon dioxide are gradually imposed on production of carbon dioxide, and waste is controlled and is worth the money, enterprises should use waste as much as possible for the production of concrete, because we can not only reduce harmful emissions, but also increase the strength characteristics, thermal and acoustic properties of concrete.

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INTERIOR LIGHTING

DARYA BEHUNOVA, DZMITRY ZHUKAU
Polotsk State University, Belarus

The article considers general issues connected with lighting. The main focus is on interior lighting. It is an integral part of almost any interior and plays a significant role in human perception of the environment.

One of the key roles in interior creation belongs to light. In a room lighting helps people to feel visual comfort. Therefore, when designing and arranging interiors, it is necessary to take into account the sources of illumination and its types in order to avoid problems that cause inconvenience or threaten human health.

The purpose of this study, the initial part of which is presented in the article, is to determine the optimal lighting options in the interior as the result of studying factors having impact on the quality of light and to consider them separately and in interaction.

There are two types of lighting: natural and artificial.

Natural lighting is the result of natural processes and depends on the geographical data of an area, the time of year, the time of day and the state of atmosphere.

Natural lighting is necessary for any person, but nowadays there is a need for other sources of light in order to provide people with comfortable way of life. Therefore, natural lighting can be supplemented with artificial lighting in an optimal way.

There are practical and decorative features of natural, artificial and combined lighting.

An interior designer, being an artist, with the help of lighting is able to set certain compositions that correspond to the subject of the created interior. Lighting allows to highlight the desired items, as well as to hide certain disadvantages of a room. In addition, lighting can set the "mood" of the interior or, in other words, create the desired emotional atmosphere of the subject-spatial environment.

Light is inextricably linked to one of the most important properties of objects – color. A designer, as a rule, uses properties and characteristics of light and color when creating an interior as a whole. Thus, the color can change its qualities depending on how bright the light in the room is and what its temperature is. For some interiors, the choice in favor of one or another type of lighting according to light temperature is preferable. Light is "warm" and "cold." The ability to choose the tone of lighting often plays a significant role in the light interior design [1].

The most often used sources of artificial lighting are LED, fluorescent, and halogen lamps. Incandescent lamps are less frequently used due to their inefficiency. At the same time all of these light sources have a certain color temperature.

The temperature describes the color of the light. Three main light colors are:

– warm-white – less than 3300 K;

– cold-white – from 3300 to 5300 K inclusive;

– daylight – more than 5300 K.

In this case, lamps with the same color may have different color characteristics due to the spectral composition of the color emitted. The color rendering value reflects the level of conformity of the natural color of the body with the visible color of this body when it is illuminated with a specified light source.

An important aspect when choosing lighting is the energy efficiency of lighting devices. It means the quantity of light emission by some source at a certain cost of electricity. Energy efficiency of various means of lighting is presented in table 1.

According to the International System of Units (SI), the luminance unit is lux (lux), the unit of luminous flux is lumen (lm).

In addition to light, meaning the amount of light emitted by some source, there is a concept of luminosity. Luminosity is the process by which light is reflected, absorbed, or passes through an illuminated object. A related concept of luminosity is reflected brightness. It results from the presence of reflective bright surfaces in sight.

Artificial lighting can be set differently. There are four main types of artificial lighting: general, local, combined and emergency.

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Table 1. – Energy efficiency of various means of lighting

Energy efficiency	Less		Higher	
Types of lamps / Luminous flux, lm	 Incandescent lamps	 Halogen lamps	 Fluorescent lamps	 LEDs
450	40 W	29 W	9 W	5 W
800	60 W	43 W	14 W	7 W
1100	75 W	53 W	19 W	9 W
1600	100 W	72 W	23 W	11 W
Approximate life span	1 year	1–3 years	6–10 years	15–25 years
Comparative savings	–	up to 30% and more	up to 70% and more	up to 80% and more

In general lighting and light sources are selected and arranged so that light in a room is distributed evenly.

Local lighting is given by luminaires that concentrate the flow of light specifically on surfaces that require lighting. Basically this type is used for decorative purposes. For example, in order to highlight a designed object or to adjust a room from a compositional point of view.

Combined lighting involves combination of light sources with different characteristics. This type of lighting is especially good in places where precise work is done.

Emergency lighting is useful in case of emergency and performs a coordinating function, highlighting the signs that direct to an exit. Also, an emergency type of lighting can be used when conducting particularly hazardous work, when it is life-threatening if the main lighting fails.

Requirements for natural room lighting are:

1. Uniformity;
2. Ensuring the required illumination of working surfaces;
3. Elimination of directional blinding and reflected sunlight;
4. Ensuring the necessary brightness of the surrounding space due to a sufficient level of illumination and color finishing of the interior surfaces [2, p. 110].

In architecture, a daylight factor (DF) is a parameter characterizing the amount of natural light entering a room [3]. The normalized values of DF in a room are selected depending on two factors: the complexity of visual work and natural lighting system [4, p. 100].

The coefficient of natural lighting is determined by the following formula:

$$DF = \frac{E_i}{E_0} \times 100\ \%,$$

where E_i is a natural illumination at a certain point inside a room;

E_0 – external illumination on a horizontal surface.

To find out the DF, it is necessary to carry out measurements outdoors and indoors simultaneously. To ensure sufficient measurement accuracy, the instrument, that is used, should be calibrated and, if necessary, synchronized with other devices.

A luxmeter is a device used to measure the amount of light. You can learn the principles of its operation using a smartphone. A smartphone application that performs the function of a luxmeter can be installed from the Play Store or the App Store, an app store from Google and Apple, respectively. For more accurate measurements the instrument should be configured.

To ensure a comfortable human life, there is a need to combine natural and artificial types of lighting. This is mainly required in the morning and evening hours.

If the DF in a room of a certain type does not meet the standards of lighting, artificial light sources are used. At the same time, it is important to choose a lighting device with characteristics as close as possible to the characteristics of natural lighting so that the space can be felt most holistically in the daytime [2, p. 162].

One of the most important characteristics of light in the interior is light comfort. It is created by the optimal selection of light sources.

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Figure 1. – Luxmeters

You cannot underestimate the effect of lighting on the human body, since it defines how accurately the biological mechanisms will work in a body. Poor lighting negatively affects human condition. For instance, uneven lighting has a negative effect on vision and its adaptation to the environment. Strong fluctuation of light flux increases not only the fatigue of the visual apparatus, but that of central nervous system too causing headaches, dizziness and insomnia. Poor lighting leads to rapid fatigue, reduces performance, causes discomfort and adversely affects the mental state of a person.

The objectives of the organization of light in the interior in relation to the impact on human health are the following:

1. Ensuring clarity in distinguishing objects;
2. Reducing fatigue of the visual apparatus [5].

The next stage of the research will be connected with the detailed analysis of software products and rating the parameters necessary for solving problems related to the type of lighting.

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BASIC PRINCIPLES OF IMPROVING THE FUNCTIONAL ORGANIZATION OF STUDENT HOUSING

VASILISA METLA, YULIYA KHALETSKAYA, ALIAKSANDRA BARAUKOVA
Polotsk State University, Belarus

Nowadays higher education programs quality in Belarus allows the republic to prepare well-competent specialists in various fields. The curriculum and whole atmosphere in community and at the university campus are making great influence on efficiency of studying. Furthermore, living environment, where non-resident students hold most of their time, is important, because it is where basic human needs for food, rest and communication are being fulfilled.

The notion "dormitory" has been known since the first educational establishments appeared. Belarus was a part of the Soviet state, and higher education institutions accepted students from cities and republics all over the union. Therefore, an important issue was the provision of nonresident students with living space [1].

Since then much has changed. New knowledge and technologies appeared, and this can be applied to improving the existing housing stock as well as to avoiding mistakes in the design of new facilities. It is important to provide the living environment to correspond to all the modern requirements and even to be ahead of the demands of residents for a few years ahead to achieve the most long-term and economically viable effect. There is no doubt that accommodation facilities should be accessible for all categories of citizens, to promote the formation of a human-friendly environment, to ensure the possibility of communication between members of the student community, to promote the active interaction with the administration and allow residents to satisfy their needs, interests and professional activities as entirely as possible.

During the analysis of the design standards and tendencies in the formation of the residential and public environment, the following general principles, the observance of which will allow creating comfortable living spaces, were formulated:

– barrier-free and accessible environment for everyone. Discrimination of people is unacceptable, so consequently any object should be designed with taking into account needs and opportunities of any person, including physically weakened persons, because in some periods of life everyone belongs to this category of citizens. It is necessary to consider not only equipment for unobstructed movement without assistance, but also information filling [2];

– the space, divided into private and public, with the allocation of quiet and active areas. The interaction within the student community should not be limited by the classrooms of the educational institution; places for informal communication or specific interaction, for example, performing group tasks, are needed. In addition, occasionally most people need a quiet and secluded space for rest or concentrated work;

– attention to the issues of physical activity, sports and health in general. For a person to perceive and assimilate a huge flow of information, he or she needs physical and mental health. Sports grounds, gyms, medical facilities should be equipped in close proximity to the places of residence with taking into account the number of visitors, without neglecting the rules of accessibility;

– favourable conditions for communication and formation of a healthy community, involvement and responsibility. In such situation students will be interested in maintaining cleanliness and order on the territory of residence, they will actively participate in solving issues related to the places of life, and manifest civil initiatives. In addition, students should not be separated from the life of the city. Cooperation and mutual assistance between citizens, authorities and students should be established, to involve the latter in the preparation and implementation of socially important projects;

– ecological compatibility and energy efficiency. The future depends on how we manage the present, so students should also become responsible inhabitants of the world. Sorting of garbage, insulation of enclosing structures, attention to window fillings, the use of the latest technologies of heating and ventilation, control of water consumption, reduction of resource consumption and recycling of waste would give the further generations an opportunity to live on the Earth;

– temperature-humidity and air conditions should be taken into account as one of the most important factors in the formation of human well-being [3];

– diversity of the environment and freedom of choice. Each student can choose his or her own option for a comfortable stay from several options, differing in terms of convenience, price, community specifics (for ex-

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ample, one building is given to the architects, another for the linguists; or in one building there are blocks with rooms for two and a bathroom for a bundle of four rooms, a common living room and a gym, and in another building every room is equipped with a bathroom, an open terrace for two floors and a cafe/bar on the first floor).

Unfortunately, nowadays in the student dormitories of the republic these principles are partially and sometimes completely not executed. Some of them are not achievable in the nearest future due to lack of funding. The hostels are often located in comparatively old buildings, built according to the norms that have already lost their relevance. This entails a number of problems:

– inaccessibility of the environment for physically weakened persons;

– lack of functional division of space in the dormitory, lack of places for active recreation and communication, special places for classes;

– often there are no equipped sports grounds in the immediate proximity, the gym is not in the dormitory buildings. Medical care for students living in dormitories is not always available;

– dormitories of the corridor type that have a shower located only on the first floor. This cannot be considered as sufficient for comfortable maintenance of hygiene;

– no places to store bicycles, a low level of improvement of the territories adjacent to the dormitories;

– the detachment of students from participating in solving issues related to the place of residence;

– insufficient attention to energy saving, reduction of consumption and waste sorting.

To solve these problems, the following options are developed:

– to provide the accessibility of the environment by eliminating irregularities, arranging normative ramp slope, equip building with an elevator (or arranging rooms for people with limited mobility on the first floor), expanding doorways, where necessary, moving switches, sockets, handrails, door handles, fire protection equipment at an accessible height, working out the information equipment [2];

– to equip places for studies or creativity;

– to create the opportunity to do sports in the dormitory;

– to pay attention to the design and ergonomics of the elements of the environment; to attract professionals to the equipment purchase;

– to reconstruct the system of sanitary and hygienic service (by uniting rooms into blocks and equipping every block with a sanitary unit);

– to allocate an area on the ground floor or arrange a place on the street for bicycles storaging, to organise sports grounds and recreation areas for students;

– to actively involve students in solving various issues, to promote the organization of workshops, and summer schools, to establish open competitions, to conduct practice with the application of knowledge and skills to improvement of the environment;

– to pay attention to environmental issues;

– to carry out events, markets, lectures, educational programmes, to promote waste sorting and reasonable consumption, to strive to reduce resource consumption.

Thus, as a result of the work done, the basic principles of creating a comfortable environment in a student dormitory were derived, current shortcomings were identified and ways to solve problems were proposed. In existing conditions, it is also important to note that the situation should be reformed in a complex, including the arrangement of training places, the adjacent territory, places of employment, sports fields, shops, cafes, cinemas, parks, pedestrian crossings, sidewalks, courtyards – total urban space. This is important because in such an environment people will be able to direct their power to something really important and contribute it for the development of society.

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INFLUENCE OF POLYMER ADDITIVES ON STRENGTH OF CEMENT STONE

ANASTASIYA LASTOUSKAYA, LUDMILA PARFENOVA, SATI RABIH
Polotsk State University, Belarus

The article presents the results of strength tests of cement stone with polymer additives. It is established that polymer additives can both increase and decrease the strength and density of cement stone. It is shown that the polymer additive DLP2141 accelerates the set of strength of cement stone at the early stages of hardening.

The task of improving the physical and mechanical characteristics of concrete does not lose its relevance in modern construction. Numerous studies show the prospects of using polymer additives as modifiers of concrete. It is noted [11] that simplification of technology of polymers application in concrete and improvement of physical and mechanical characteristics make such concrete attractive for production of corrosion-resistant and high-strength products and designs. Polymer additives are widely represented in the construction market, but the issues related to the study of their impact on the strength of cement compositions require further study.

Physical and mechanical characteristics of cement compositions modified by polymers are influenced by a number of factors. The paper [1, 2, 3] presents the results on the influence of hardening conditions on the strength of cement-polymer compositions. It was found that at high temperatures a polymer with a high film formation temperature increases the strength characteristics of cement-polymer compositions, but reduces the deformation characteristics. Under normal conditions, the process of film formation in the cement-polymer stone ends within 48h hardening system. It has been determined [4] that the compressive strength of cement composites decreases as amount of polymer increases, as polymers delay the hydration of cement. It was found [5, 6] that part of the water – soluble polymer can concentrate at the interface of the "involved air-solution phases. Small, evenly distributed air has a plasticizing effect on cement dough, which results in an increase in the diameter of their melt. It is shown [7, 8] that the interaction of polymer additives with other starting materials can lead to capturing of a significant amount of air during mixing.

The study of the influence of polymer additives on properties of cement compositions is an urgent task, since polymer additives allow to adjust the mechanical characteristics and obtain materials with improved properties.

In this paper, we studied the effect of polymer additives on the strength of cement stone. For carrying out the research, TSEM I, 42,5 N cement of JSC Belarusian cement plant was applied, which met the requirements [9]. Physical and mechanical characteristics of cement are given in Table 1.

Table 1. – Physical and mechanical characteristics of cement

Type of cement and name of the manufacturer	Density, kg/m^3	NGCT, %	Setting time, h-min		Activity, MPa
			the beginning	the end	
Portland CEM I, 42,5 N, D0 G. Kostyukovichi	3200	25,0	3-10	4-50	45

Polymer additives Primal SM330, DLP2141 and DLP2000 were used as modifiers.

The main technical characteristics of polymer additives Primal SM330, DLP2141 and DLP2000 are given in Table 2.

Table 2. – The main technical characteristics of polymer additives Primal SM330, DLP2141 and DLP2000

The name of the polymer additive	Polymer base	Appearance	Residual moisture, max.%	Bulk density, g / ml (g/cm^3)	Ash content, %	Minimum film formation temperature (MFFT), ^{0}C	pH	Dry residue, %
DLP2141	Vinyl acetate-ethylene copolymer	White, free-flowing powder	2	0,400-0,550	10-14	0	7,5	-
DLP2000				0,375-0,525		3	6	-
Primal SM330	Acryl	Milk, white liquid	-	1,06	-	10	9,5-10,5	46.5 - 47.5

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Dosages of polymer additives for construction mixtures on mineral binders are usually in the range of 1-5%. The optimal dosage is determined based on the need to achieve the maximum values of the useful property (or a set of basic properties) at minimum cost [5].

To determine the effect of polymer additives on the mobility of the cement paste and polymer, additives were introduced in amount of 1%, 3% and 5% by weight of the cement on a dry matter basis. Water-cement ratio is 0.5. Determination of the mobility of the cement test is carried out by the RICRC method [10], on a mini-cone. The 3 cm high mini-cone was filled with cement paste with polymer additive. After raising the mini-cone, cement dough spread, the value of the cone melt was determined in 2 directions by a metal ruler, with a division price of 1 mm, (Fig. 1).

Figure 1. – Determination of cement paste melt with a polymer additive DLP2000

Cement paste melt without polymer additives amounted to 6 see. The results of the influence of polymer additives on the mobility of the cement paste are presented in Table 3.

Table 3. – Influence of polymer additives on the mobility of cement paste

The name of the polymer additive	Mobility of cement paste cm, with the introduction of additives in % by weight of cement		
	1	3	5
Primal SM 330	8	8,7-8,8	8,5-9
DLP2141	4,8	5,2	5,8
DLP2000	7,7	8,8	9,5

The study showed that the polymer additive DLP2141 1.2 times reduces the mobility of the cement paste. The introduction of polymer additives DLP2000 increases the mobility of cement paste by 1.45 times. By increasing the dosage of the polymer additive, the mobility increases. The addition of Primal CM330 increases the mobility of the cement paste by 1.42 times, but with the increase in the dosage further increase in mobility does not occur.

To determine the strength of cement, stone samples were made – cubes 20×20×20 mm (Fig.2). The samples were left to solidified for 24 hours in air-dry conditions at a temperature of t = 18-20 C , then for 2 hours the samples were subjected to temperature treatment at 60 C. After that they continued to harden in air-dry conditions at a temperature of t=18-20 C. The weight and geometric characteristics of the samples were determined before the tests. The strength of the samples was determined by the press PGM-500MG4A after 7 days (Fig.3).

Figure 2. – Samples of cement stone with polymer additive DLP 2141 (I-1%, III-3%, V-5%)

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Figure 3. – Samples after testing (with 3% polymer additive Primal CM330)

The results of determining the strength of cement stone with polymer additives Primal SM 330, DLP2141 and DLP2000 are presented in Table 4.

Table 4. – Strength of cement stone with polymer additives

The name of the polymer Additive	Amount of additive, % by weight of cement	Compressive strength Rst, MPa (% $R_{st}^{test.}$)	Density, kg/m^3
Primal SM 330	1	9,48(37,98)	1508,75
	3	14,81(59,33)	1577,71
	5	18,36(73,56)	1597,50
DLP2141	1	38,23(153,16)	1820,63
	3	34,59(138,58)	1804,17
	5	24,89(99,72)	1776,25
DLP2000	1	19,28(77,24)	1697,92
	3	21,3(85,33)	1700,21
	5	21,91(87,78)	1724,58

The density of the control sample without polymer additive was 1670,31 kg/m^3, compressive strength $R_{st}^{test.}$=24.96 MPa.

According to the results of the study, it was found that polymer additives lead to a slowdown in the process of gaining strength of cement stone. Increasing the dosage of the polymer additive Primal SM 330 from 1% to 5% by weight of cement, leads to an increase in the strength of the cement stone at the age of 7 days. Thus, the strength at a dosage of 1% is 9.48 MPa; at a dosage of 3%-14.81 MPa; at a dosage of 5% -18.36 MPa, which was 73.6% of the strength of the control sample without additives. Polymer additive DLP2000 leads to a slight slowdown in the set of strength of cement stone, by the age of 7 days the strength reaches 83.45% of the reference value. Increasing the dosage does not significantly affect the intensity of the strength gain. The greatest effect on the intensity of the strength had an additive DLP2141. At a dosage of 1% by weight of cement strength at the age of 7 days reached 153.16% of the strength of the control sample; at a dosage of 3% -138.58%; at a dosage of 5%-99.72%. Cement stone, modified with addition of DLP2141, has a denser structure compared to the cement stone without additives.

Thus, it is established that the polymer additive DLP2141 based on vinyl acetate-a copolymer of ethylene accelerates the strength development of cement stone at an early age and contributes to the formation of more dense structure of cement stone. The dosage of the polymer additive DLP2141 should not exceed 3% by weight of cement.

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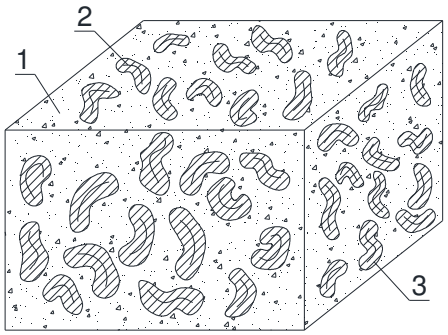
APPLICATION OF ALKALI-RESISTANT GLASS NETS WASTE IN FIBRO CONCRETE

ANASTASIYA BRIL, OLGA KAMECKO, VLADISLAV KHVATYNETS
Polotsk State University, Belarus

The article describes the modern building material – fibro concrete. A list of basic materials used for dispersed reinforcement for concrete is presented. The basic mechanical and physical properties of these materials are described. Also, the possibility of using alkali-resistant fiberglass waste as a fiber is considered.

Nowadays, one of the priority areas in construction is the reduction of the value of the construction project, due to the economy of materials and waste-free production [1]. One of the ways that immediately meets two criteria is the use of alkali-resistant fiberglass waste for fiber reinforcement of concrete.

Fiber concrete is a composite building material which consits of concrete with the inclusion of fibers evenly distributed throughout the volume (Fig. 1). Dispersed reinforcement of concrete increases the crack resistance and tensile strength when the material is bent. Also it slightly increases the compressive strength.



1 – concrete matrix; 2 – fiber; 3 – zone of contact interaction of the fiber and concrete
Figure 1. – Fiber concrete structure

Fiber is divided into two main groups [2,3]:

– metal – the raw material is steel. This fiber has different geometric shape and size;
– non-metal – is made from materials such as glass, cotton, basalt, acrylic, polyethylene, carbon, carbohydrate and so on.

The main mechanical and physical properties of the fibers are presented in table 1 [4].

Table 1. – Mechanical and physical properties of the main fibers

Fiber name	Density, g/sm^3	Young's modulus, 10–3 MPa	Tensile strength, 10–3 MPa	Elongation at break, %
Polypropylene	0,9	3,5–8	0,4–0,77	10–25
Polyethylene	0,95	1,4–4,2	0,7	10
Nylon	1,1	4,2	0,77–0,84	16–20
Acrylic	1,1	2,1	0,21–0,42	25–45
Polyester	1,4	8,4	0,73–0,78	11–13
Carbon	2,0	245	2	1
Cotton	1,5	4,9	0,42–0,7	3–10
Asbestos	2,6	68	0,91–3,1	0,6
Glass	2,6	70–80	1,05–3,85	1,5–3,5
Basalt	2,6	80–100	1,6–3,6	1,4–3,6
Steel fibers	7,8	200	0,80–3,15	3–4

The main advantages of fiber concrete include:

– reduction of construction costs, when replacing the reinforcing mesh or frame fiber;
– reducing the consumption of concrete;
– thanks to the fiber, the material becomes viscous, which allows to save specifications after the end of life;

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– fibers can be used both in heavy and light concrete;
– use of fiber increases the crack resistance of the structure.

Analysis of the scientific literature has shown that the use of dispersed reinforcement, allows to produce building structures with increased strength, but of less weight. In addition to economic considerations, the choice of fiber is determined by the properties that a design should have to meet the specified requirements [4, 5]. Early studies on the possibility of replacing fiberglass waste with other fibers in concrete showed that the resulting durable concrete is a promising building material [6, 7].

Fiberglass waste is produced during the production of mesh for plastering works as a result of cutting off uneven edges.

Waste consists of trimming the edge with an alkali-resistant SSSh-160 (100) -1800/1800 grid (fig. 2). Characteristics of waste alkali-resistant fiberglass are presented in table 2.

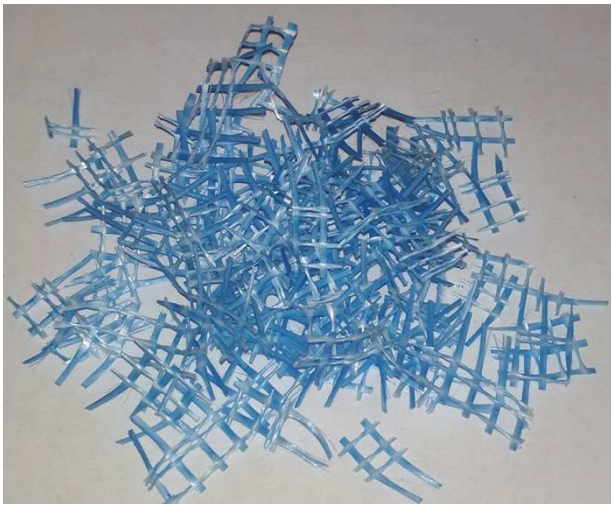

Figure 2. – Alkali-resistant fiberglass waste

Table 2. – Waste characteristics of alkali-resistant fiberglass

Fiber Properties	Value
Fiber length, mm	20-200
Nominal weight, g/m^2	160
Explosive loading, N	1800
Chemical resistance	Very high
Electrical Conductivity	Very Low

The use of waste alkali-resistant fiberglass as a dispersed reinforcement of concrete gives a double economic effect. On the one hand, the use of fiber reduces the overall cost of construction, on the other hand - the use of waste will bring additional profits to the organization and solve the problem of disposal. Hence, the use of fiber improves the mechanical and physical properties of concrete. The resulting fiber-reinforced concrete surpasses traditional concretes in all indicators. Also, the possibility of using alkali-resistant fiberglass waste as a fiber for dispersed reinforcement of concrete is noted.

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PolotskSU

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THE DESIGN CONCEPT OF THE AIRSHIP AS A MOBILE RESIDENTIAL BUILDING

MIKITA BRYTSIKAU, DZMITRY ZHUKAU
Polotsk State University, Belarus

The article deals with General issues related to the development of the design concept of the airship as a mobile residential building. For a specific purpose, this airship is a tourist hotel. It is a largely autonomous energy-efficient facility that generates electricity and heat from renewable energy sources.

One of the most important tasks of ensuring the sustainable development of human civilization is the development and implementation of measures that allow the efficient use of energy. And in the modern context, energy saving on the ways to achieve greater energy efficiency means simultaneously improving the quality of life in its various aspects. Including in the most seemingly unexpected and exotic-for example, in the use of airships as the main elements of advanced tourist systems. It is these aircraft experiencing a second youth, and is devoted to the study presented in the article or, more precisely, its initial stage.

The airship as a mobile residential building of hotel type with specific interiors and engineering equipment was chosen as the object of the esearch.

The object of the study can be named as follows:

1) airship – tourist hotel (veresion 1);

2) airship-hotel (version 2);

3) THA-airship (version 3; THA – tourist hotel airship).

The subject of the research is design harmonization of TNA-airship.

The aim of the study is to develop a holistic design concept of the TNA-airship which is a comfortable, energy efficient and environmentally friendly, without damaging the environment, the object.

The research tasks:

1. Analyse the existing experience in airship construction and use of airships in tourism including mobile hotels.

2. Analysy the existing experience in wind and solar power, adapted for large land, water and air vehicles including airships.

3. Analyse the exterior and interior solutions of large land, water and air vehicles including airships.

4. Analyse the typological range and space-planning solutions of hotels suitable for implementation in an adapted form in TNA-airships.

5. Develop variants of the initial design concept of the TNA-airship reflecting mainly its three-dimensional solutions.

6. Develop a simplified (schematic) design concept of infrastructure for TNA-airship and related logistics.

7. Develop variants of functional and technological scheme of TNA-airship.

8. Develop technical diagrams of THA-airship.

9. Develop variants of the functional scheme of the hotel part, or N-part, THA-airship.

10. Develop variants of space-planning solutions of the THA-airship N-part.

11. The development of options for the interiors of the THA-airship N-part.

12. Select and design adaptation of engineering equipment including wind and solar power systems.

13. Bring to completion the options of a holistic design concept of THA-airship and its corresponding infrastructure and logistics components of the overall design complex.

14. Determine the approximate technical, energy, environmental and economic characteristics of the variants of the TNA-airship and the corresponding infrastructure and logistics components of the overall design complex.

To date, a wealth of experience in creating energy-efficient buildings has been accumulated. With respect to TNA-airship special attention to the stationary ground targets like passive house and windbreaks.

A feature of the passive house as a specific type of energy-efficient buildings is the absence of the need for the usual, powerful enough heating system due to the extremely low energy consumption through the use of passive energy saving methods. Ideally, a passive house can be non-volatile, does not require the cost of maintaining a comfortable temperature in the premises. The passive house receives a significant share of thermal energy in the form of heat generated by household appliances and people and animals living in it. Renewable

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energy sources – heat pumps, solar water heaters (solar collectors), solar photovoltaic modules and wind power plants-increase energy security and energy efficiency of passive houses.

Relatively recently began to develop above-ground (air) passive houses, which are designed to be fully Autonomous architectural and technical objects. An example of such developments can be found in Russia.

The Russian project is based on the airship, in which it is planned to install the currently available energy saving technologies and the smart home system. In the present study is considered as TNA-airship itself and the whole system of "spot – the dirigible and the corresponding infrastructure". One of the sketch images of TNA-airship is shown in figure 1.

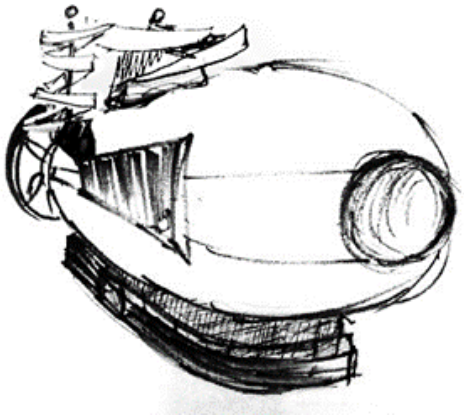
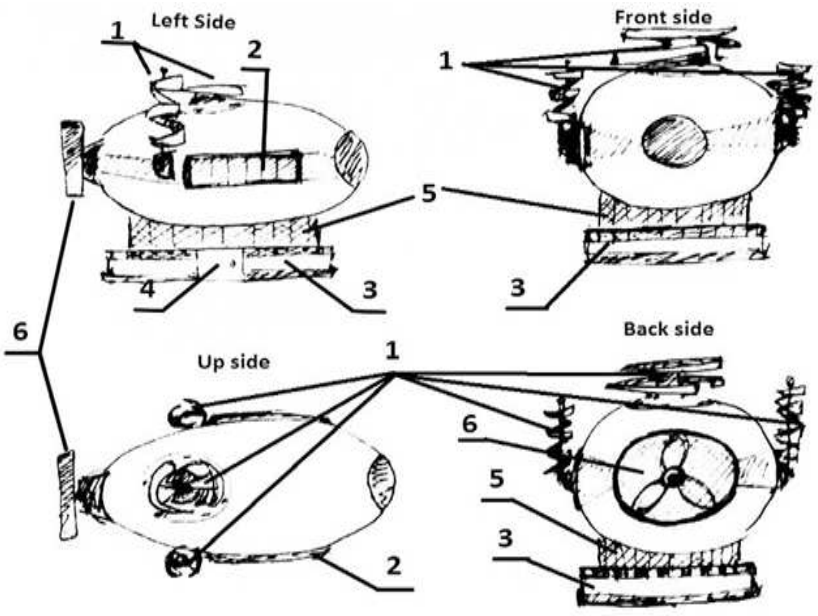


Figure 1. – General view of TNA-airship (figurative solution)

This airship seems massive in appearance design smooth curvilinear outlines. Figure 2 shows one of the schemes of the general architectural and technical solutions.



1 – vertical-axial wind power plants; 2 – solar photovoltaic modules and solar collectors; 3 – walking platform; 4 – docking platform; 5 – hotel (residential) part

Figure 2. – Scheme of the general architectural and technical solution of TNA-airship

The energy intensity of the airship-hotel located above the clouds and clouds is much higher compared to the ground object of the same useful volume and area of the hotel part. At the height and the number of hours of sunshine, and wind energy is much more than the earth and on earth.

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As a constructive prototype of the airship – a tourist hotel, a hard-type airship was chosen due to its greater load-bearing capacity and reliability compared to non-rigid airships.

To provide the crew and residents of the THA-airship with drinking water and food, as well as other purposes, it is proposed to create special landing bases. They are special towers or towers. To maintain the full (long-term) autonomy of the THA-airship in the air, its external maintenance can be carried out directly in flight mode with the help of special refueling airships.

Provision of THA-airship with hot water is assumed by means of heat pumps and solar collectors located on its body. Electricity will be generated by either one large wind power plant or two or three relatively small ones. It is assumed to use their vertical-axial versions with helicoid blades and spatial wind flow concentrators.

As for the sewage system, the best for the THA-airship is a closed-type sewerage system operating on the principle of liquid recirculation. This liquid is initially taken from a special tank, which is filled before departure. In flight, the sewage liquid is filtered, and the filtered liquid is used for reuse – for example, for flushing toilets. In this case, substances for disinfection and deodorization of the liquid are added to the tank. After refueling THA-airship all the impurities, as filtered and liquid, is extracted in a special tank of the refueling airship-tanker and transported. If necessary, the same refueller refuels the tank of THA-airship fresh chemicals through the filling pipe on the service panel toilets. In the gondola part (N-part), THA-airship is provided an observation deck. THA-airship must be equipped with the "smart home"-system. Furniture and interior equipment will be presented in the form of modular structures. Some of them, in order to save space and create more space, it is supposed to hide in the walls and call either on the signal of the user, or automatically thanks to the capabilities of the "smart home" system. Interior elements should be as variable as possible.

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COMPARATIVE ANALYSIS OF THE METHODS FOR THE CALCULATIONS OF THE STABILITY OF SOIL SLOPES

VIKTORYIA ARTSIAMIONAK, ALIAKSEI KAROTKI,
NIKOLAI VISHNYAKOV, ALEXANDER KREMNEV
Polotsk State University, Belarus

The article discusses various methods for calculating the coefficient of slope stability on three options of soil slopes. The results of the calculations in the software systems PLAXIS and FSS-PSU are provided. The conclusion is made concerning the discrepancy of the obtained results.

Introduction. In construction practice, it is often necessary to assess the stability of slopes to prevent their collapse. A proper assessment concerning the stability of slopes, allows us to predict the formation of landslide processes in advance, provide arrangements to strengthen the slopes, and avoid undesirable consequences.

Currently, various software systems are increasingly used to calculate the soil slopes. The use of software systems allows us to reduce the complexity of calculations and improve their accuracy, due to more complex design models of soil behavior. However, even the most advanced software systems can produce results that are inconsistent with the actual data from field tests and observations. In this case, the discrepancy between test and calculation data can sometimes reach tens of percent or more. The reason for the discrepancy between the calculation results and the experimental data may depend on both, the initial data, and the accepted computational model of the soil.

Software systems for such calculations have been widespread recently, which are based on the finite element method. One of such software systems is PLAXIS, which allows us to carry out a wide range of calculations in the field of geotechnics. Its peculiarity is the presence of various soil models, which allows describing its work with various degrees of adequacy.

When creating a geometric model in PLAXIS design complex, the soil mass is divided into 15-node triangular iso-parametric finite elements. Displacements are determined at 15 nodes, whereas stresses are at 12 points. When modeling the work of the soil under a load, the elastic-plastic model of Mohr-Coulomb is used, which includes 5 initial parameters: deformation modulus E, Poisson's ratio ν, internal friction angle φ, specific cohesion c, dilatancy angle ψ (not considered) [1].

In assessing the overall stability of a slope, the coefficient of overall stability is used, which can be determined as the ratio of the factual soil shear strength to the shear strength in the limit state. If the Mohr – Coulomb strength condition is taken as the condition for the limit equilibrium, then the overall stability coefficient is determined by the following formula (1):

$$\xi = \frac{c + \sigma_n \cdot \tan\varphi}{c_r + \sigma_n \cdot \tan\varphi_r} \quad (1)$$

where c and φ – strength characteristics of soils at the base;

σ_n – factual axial stress;

c_r and φ_r – values of the strength characteristics of the soils in the limit state.

To assess the overall stability in PLAXIS, the Phi-c-rediction method is implemented (the values of φ and c are respectively reduced before the soil is destroyed). The stability is determined by the coefficient $\sum M_{sf}$ (2):

$$\sum M_{sf} = \frac{c}{c_r} = \frac{\tan\varphi}{\tan\varphi_r} \quad (2)$$

The graph-analytical method of the circular-cylindrical sliding surfaces, implemented in the FSS-PSU complex, developed at Polotsk State University, is also widely used in practice. The software is an objectively associative system which allows to organize the storage and manipulation of complex structured data. It allows to calculate the stability using the method of circular-cylindrical surfaces for any soil bases. In this case, the search for the most dangerous sliding surfaces is performed by an iterative method using a special algorithm [2].

When adopting a circular-cylindrical sliding surface, the circular-cylindrical sliding surface method is used.

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The principle of such calculation, is that we set the sliding surface with a center point O, and to find the stability coefficient, we determine the ratio of the sum of the holding moments to the sum of the shear moments (3):

$$\eta = \frac{M_h}{M_{sh}} \quad (3)$$

The circular-cylindrical sliding surface method is very popular, and is used for calculating the bearing capacity of foundations, as well as to assess the stability of slopes.

The greatest difficulty in this method is the search for the most dangerous slip surface, for which the safety factor is a minimum [3].

To compare, in the PLAXIS and FSS-PSU software systems, a slope 13m high with a setting angle of $\alpha =$ 60, was considered. Three options of the geological structure of the slope were considered:

1st option – varved clay;

2nd option – fine sand;

3rd option – in the lower part of the slope there is varved clay, whereas on top there is fine sand.

For these types of soils, the physical-mechanical characteristics provided in table 1, were taken.

Table 1. – Physical-mechanical characteristics of the soils

Soil name	Specific weight $\gamma, kN/m^3$	Specific cohesion C, kPa	Internal friction angle $\varphi,^o$	Deformation modulus E, MPa	Poisson's ratio ν
Fine sand	15	1,5	31	20	0,30
Varved clay	20	19,12	7,91	18	0,35

The calculated finite element scheme of the slope in the PLAXIS software system, is shown in figure 1, whereas in figure 2, the design diagram of the slope from the FSS-PSU is provided. The calculation results are presented in table 2.

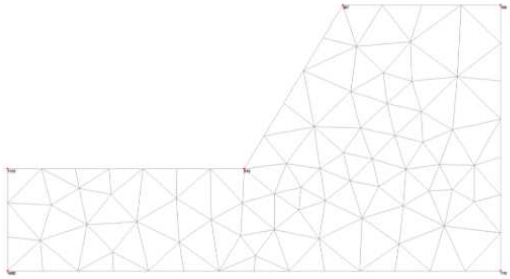

Figure 1. – Calculated finite element slope scheme

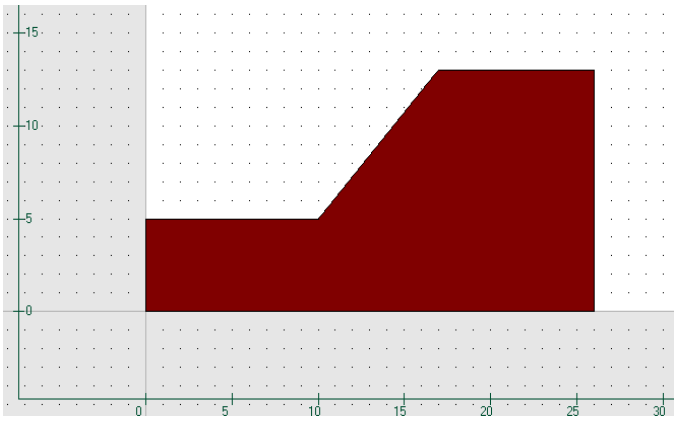

Figure 2. – The design scheme of the slope of the software system FSS-PSU

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The results of determining the stability coefficient of the slope are shown in table 2.

Table 2. – The calculation results of the slope stability

Slope sliding options	Stability coefficient in PLAXIS	Stability coefficient in FSS-PSU	Discrepancy in %
1st option (varved clay)	0,966	0,880	8,9
2nd option (fine sand)	0,797	0,700	12,2
3rd option (in the lower part of the slope there is varved clay, whereas on top, there is fine sand.)	0,940	0,870	7,4

By analyzing the obtained results, we can conclude that different approaches to the evaluation of the slope stability, implemented in the PLAXIS and FSS-PSU software systems, provide acceptable -for the construction- convergence in the calculation results. Thus, the maximum discrepancy was obtained for the slope, composed of fine sand, which is 12.2%. This proves the possibility of using various design models to assess the stability of slopes.

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PolotskSU

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THERMAL INSULATION MATERIAL, USING WASTE COTTON PRODUCTION AS A PLACEHOLDER

MEKAN ROZYYEV, ALEXANDER BAKATOVICH
Polotsk State University, Belarus

The results of investigations to determine the thermal conductivity of cotton fiber waste to be used as filler for efficient insulating materials are used in the article.

In Central Asia and Europe, large amounts of production comes from mineral wool release as an effective insulation, but also special attention to technologies for production of thermal insulation materials is given to the fibrous waste of plant origin, formed after the collection or processing of the crop. Plant waste is not only an additional source of environmentally friendly raw materials, and provides expansion of the range of local building materials, but also contributes to the preservation and rational consumption of non-renewable natural resources. These criteria are aimed at developing new effective insulation based on plant fiber materials; contribute to the development of contemporary trends in the production of thermal insulation.

The most widely used in insulation materials among the fibrous raw material are mineral wool plates and mats, molded from basalt and glass fibers. Mineral wool materials with a density of 30–190 kg/m^3 provide the coefficient of thermal conductivity 0.032– 0.048 W / (m · ° C) and the water vapor permeability coefficient of 0.3 mg / (m · h · Pa), absorption coefficient – 0.75 – 0.9, the compressive strength at 10% deformation – 0,005 –0.08 MPa [1]. According to the flammability group, plates and mats are non-combustible materials. With high thermal characteristics, mineral wool insulation has significant drawbacks. At first, they are a high water absorption more than 100% by weight, a significant increase in the volume of water-saturated state. When mineral wool is frozen in a water-saturated state, irreversible destructive processes occur in the thermal insulation layer. The use of synthetic resins, including those based on phenol formaldehyde has a negative impact on human health and the environment. To resolve this problem, the German company «Knauf» in recent years has begun using modified starch in bonding fibers, however, until now, only soft basalt plates are produced on an environmentally safe binder, which are unsuitable for the device of thermal fur coats and ventilated facades with insulation.

Serious alternative mineral wool plates and mats are insulation materials on fillers of plant origin. Thus, in Belarus and Russia they produce insulating panels «AKOTERM FLAKS» and «Ekoteplin" on the basis of flax fibers used for thermal and acoustic insulation of walls and ceilings of residential and public buildings [2, 3]. In the composition of the plates «AKOTERM FLAKS» synthetic polyester fibers in an amount of 15% by weight of the aggregate are used as a binder. Thermal conductivity coefficient of plates «AKOTERM FLAKS» equals to 0.038 W / (m · ° C) at a density of 32 kg / m^3. Plates have the flammability group G4 so high flammability is a major drawback of insulator. The specificity of molding technology does not allow manufacturing rigid plates; as a result, soft insulation cannot be used when the device is thermal fur, which limits the scope of application of the material.

Insulation plates "Ekoteplin" are manufactured using starch as a binder component, and for fire and biosecurity fibers are treated with boron salts [3]. As a result the plates correspond to combustibility group G1 and low-combustible materials. At a density of 32–34 kg/m^3, the thermal conductivity of plates "Ekoteplin" corresponds to 0.037 W / (m · ° C) and the vapor permeability is 0.4 mg / (m · h · Pa). Due to the low density, insulation has application limitations and quickly passes water and gets wet, to eliminate this disadvantage isolation of insulated walls with a special membrane is done. One more disadvantage, in spite of the environmental safety of plates, is the high cost of an insulator.

At present, the Department of Construction industry of Polotsk State University the study of physical and mechanical properties of the insulation developed on the basis of linters flax fibers, and liquid glass are conducted. Plate heat insulation of flax fibers is characterized by the coefficient of thermal conductivity 0.036– 0.041 W / (m · ° C) and a compressive strength at 10% strain 0.11 – 0.33 × 10^{-2} MPa at a density of 50–110 kg/m^3 [4]. The high heat-insulating ability of flax fiber plates is caused by the presence of elementary fibers 8–12 microns in diameter, separated from the disheveled bundles, with a randomly oriented arrangement in the volume and the presence of hollow channels in the 4–6 microns elementary fibers, which is comparable to the sizes of solid fiber mineral wool that ensures the formation of effective insulating structure.

In tropical latitudes of Asian and African regions there is a considerable interest in the possibility of using fibers of the oil palm bark as a filler for insulation [5]. The obtained samples of insulation plates during the tests showed the following characteristics: thermal conductivity of 0.054 W / (m · ° C), density of 50 kg/m^3. It should be noted that during testing insulation material showed absolute resistance to occurrence of moldy fungi on the fiber surface at a relative humidity of 97% due to the chemical composition of the fibers themselves and climatic conditions of growth of palm oil.

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It is known the use of jute fibers for the production of thermal insulation materials with high resistance to rotting and harmful effects of insects [6]. Jute fibers are obtained from plants and to bind together into a web they are passed through a needling machine. With the heater density of 150 kg/m^3 coefficient of thermal conductivity reaches 0.036 W / (m · ° C) and the water vapor transmission rate is up to 0.4 mg / (m · h · Pa). The main negative factor in the operation is the fire hazard of the material.

Coconut fibers also have found their use as filler in the manufacture of insulation plates produced in Russia under «Bauplit Cocos» trademark [7]. In the structure, material comprises 85% coconut and 15% polyester fibers. In the molding process, the mixture of fibers is treated with hot air and polyester fibers are fused, glued to each other and coconut fibers, thereby forming a continuous structural lattice. Thermal conductivity coefficient of plates «Bauplit Cocos» is 0,038–0,042 W / (m · ° C) and the water vapor transmission rate equals to 0.59 mg / (m · h · Pa). But this material has several disadvantages. For fire, insulation refers to a group of flammability T4. Also low density of 30 kg/m^3 restricts application of «Bauplit Cocos» due to the lack of strength compression. In addition, insulation «Bauplit Cocos» has a high cost, as it is made from imported raw materials.

On the basis of wood fibers in Germany and Poland insulation plates "STEICO" using paraffin as a binder are produced. Insulation «STEICO» is universal and applied for thermal insulation of external walls, roof slabs, roofs [8]. The thickness of the insulation plates may reach 200 mm. At a density of 50– 270 kg/m^3 plates have thermal conductivity in the range 0.038–0.07 W / (m · ° C) and a compressive strength equal to 0.04 – 0.2 MPa. In addition to high prices for thermal insulation plates «STEICO», main disadvantages are brittleness and crumbling under abuse conditions of transportation and stacking technology. In the USA after a series of research scientists came to conclusion that while burning paraffin allocates hazardous chemical compounds containing benzene and toluene, which are hazardous substances to human life [9].

Based on the foregoing additional source of raw material for the production of thermal insulation materials may be waste cotton fibers. Such wastes in large quantities are produced in Central Asia, including Turkmenistan.

In the process for manufacturing of the investigated samples was used as a filler fiber waste cotton production. Waste is obtained in a preliminary stage of preparation of fibers on cotton plants (Turkmenistan) and meet the requirements of GOST 6015. In the studies waste cotton fiber with the length of 10 cm was used.

In the manufacture of insulation plates sodium water glass produced by JSC "Domanovo Production and Trade Plant" (Belarus), corresponding to the requirements of GOST 13078, was used as a binder component.

In the first series the samples were formed without a binder. The connectedness of the structure was provided by the interweaving of fibers. The required amount of material was placed in a mold of 250 × 250 mm and pressed in layers to a sample thickness of 30 mm. The resulting soft plate was removed from the mold to determine the average density and placed in the device ITP - MG4 to establish the thermal conductivity.

For the compositions of the second series of samples, liquid glass was used together with fiber waste. Previously, the dosage of the components was made. The waste fiber was laid in the form of layer-by-layer impregnation with liquid glass and pressed. Samples were kept in the form for 4 hours at a temperature of 20 ± 2 °C and then dried for 6 hours in a drying oven at a temperature of 40 – 45 ° C. After that the average density and thermal conductivity of semi-rigid boards were determined.

The average density and the thermal conductivity of the samples was determined according to GOST 17177 and 1618 respectively on the plates of 250 × 250 × 30 mm.

The average density of the first series of samples ranged from 40 to 120 kg/m^3. The range of average densities taken for the study is explained by an attempt to determine the minimum coefficient of thermal conductivity for plates of cotton fiber waste. Results of determining the average density and the thermal conductivity are shown in Table 1.

Table 1. – Physical characteristics of insulation plates From waste cotton fibers

№ batch of samples	The average density, kg/m^3	Coefficient of thermal conductivity, W / (m · ° C)
1	40	0,039
2	50	0,037
3	60	0,037
4	70	0,038
5	80	0,039
6	90	0,039
7	100	0,041
8	120	0,044

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Analysis of the data reveals that the lowest thermal conductivity index 0.037 W / (m · ° C) Corresponds to the density of the fibers of waste 50 – 60 kg/m^3 (batch of samples 2, 3). The best result of thermal conductivity is achieved by reducing the volume and size of voids while simultaneously localizing into separate closed micro spaces that do not bind to each other. At the same time, the functioning of the end-to-end air flow stops. Such an organization of the inner air space is caused by optimal number of contact (contact points between the fibers).

Reduction of density 40 kg/m^3 already causes an increase of thermal conductivity by 0, 002 W / (m · ° C)%, which can be explained by decompression fibrillation leading to reduction in the number of contact points between the fibers and facilitating the passage of air flow through the material.

Increasing the density of the first series of plates in 1.6 – 2 times (batch samples 5 - 8) with respect to batches of samples 2, 3 also leads to a gradual increase in the thermal conductivity. So, at a density of 100 – 120 kg/m^3 coefficient of thermal conductivity is increased by 11 – 19% relative to batches of samples 2 and 3. Presumably data samples gradually reduced the number of closed micro cavities, with the lack of air circulation therein, area and number of point contacts between the fibers increases, which eventually leads to increased thermal conductivity.

When liquid gas was put into the batches of samples 2, 3, the thermal conductivity increased slightly to 0.039 W / (m · ° C). Thus, according to research results an effective insulating material in the form of semi-rigid plates on the basis of waste cotton fibers and water-glass was obtained for Turkmenistan and other countries of Central Asia.

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PolotskSU

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USE OF FOAM CONCRETE AS OVERLAPPINGS OFLOW-RISE RESIDENTIAL BUILDINGS

ALEKSEI KOLTUNOV, ALEXANDR KOLTUNOV
Polotsk State University, Belarus

Fo am concrete conquers the market of structural materials. It is quite natural, largely due to the surprising properties of this material. This research paper was performed in accordance with the concept of introducing perspective materials in to housing construction, reducing the proper weight of constructions, reducing both binder consumption and cost, improving the quality and reducing construction terms.The scientific significance of the results of the research is in opening up reserves for the reduction of the cost and material consumption in the manufacture of foam concrete compared to reinforced concrete.

The object of the research is foam-concrete plates with reinforcing by flexible reinforcing rod stock of class S500.

The aim is to define a possibility to use foam concrete plates with a volume weight of 600kg/m^3 executed with use of foaming agent on the basis of protein hydroisolate, for overlappings of residential buildings, in accordance with the load applied for of this kind; to compare the experimental and theoretical results of a research of durability of the bent reinforced elements from foam concrete.

In compliance with the objectives specimen's pieces in the form of plates of rectangular section in number of two pieces with section sizes of 262x600mm and 279x601mm, reinforced by with longitudinal rod stock with a diameter of 10 mm made of class S500 steel are designed and made. For a pull in gin order to exclude (anchoring violation) corners "No. 63" were welded on trailer sites of longitudinal fittings.

Experimental samples were made from concrete of one batter in a timbering of wooden boards with inner metal sheeting. Characteristics of exemplars are presented in tab. 2.

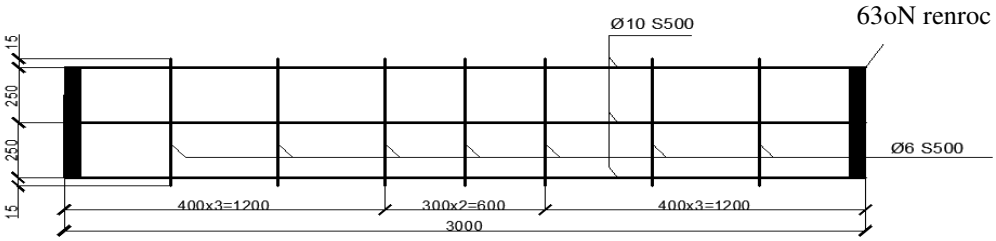

Figure 1.– Reinforcing mesh

Figure 2.– A photo of the reinforcing grid laid in a timbering

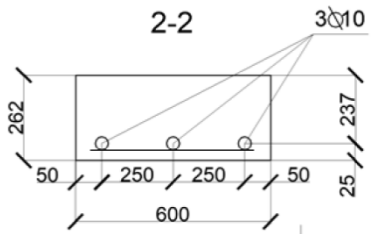

Figure 3. – Reinforcing of plates

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Characteristics of experimental plates concrete. To define the physical-mechanical characteristics of the material, along with producing the main samples, control specimens of foam concrete were made in cubes with an edge size of 100 mm (8 pieces) and prisms with a size of 100x100x400mm (3 pieces).

A compression test of concrete prisms was conducted on the press with measuring the deformations on each of the sides. Prismatic durability of fck was determined by the relation between the tension-breaking load and the actual sectional area of a prism. The initial elastic modulus of concrete during compression was defined on the basis of measuring prism deformations. Similarly the cubical durability of concrete was defined $f_{c,cube}$.

Table 1. – Physical-mechanical characteristics of experimental plates concrete

Cubic strength of concrete $f_{c,cube}$, MPa	Prism strength of concrete f_{ck}, MPa	Modulus of elasticity of concrete E_c, MPa
0.781	0.625	11.27

Methods of conducting experimental studies. Testingtheexperimental pieces for bending was carried out by putting unit loadsin the form of cubes weighing 95 kg. Load on beams was applied in the form of four concentrated, symmetrically applied forces in relation to the force carrier. The distance between the points of force application is accepted as constant equalling to 750 mm. In the course of testingthe designs measurements were taken: the efforts of the formation and opening of cracks; the width of opening and the length of cracks; deflections in the middle of the span of plates.

The width of opening of slanting cracks was measured in the places where they crossed the rod stock of longitudinal fittings with MPB-2 microscope with a precision of 0.05 mm.

In the middle of plates span measuring of points movement with an accuracy of 0.01 mm with a flexometer 6 PAO was taken, measuring of points movement over support of plates was also taken to define and exclude settling of the design support and to receive the immediate value of deflections.

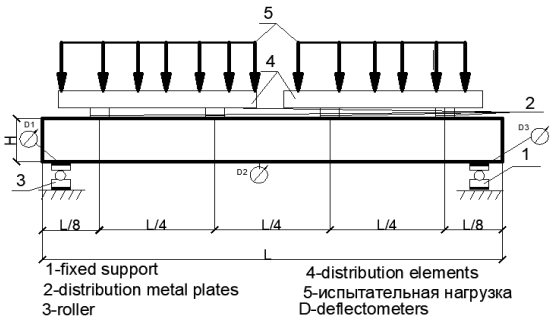

Figure 4. – Diagram of experimental pieces testing

At the initial stages mainly normal cracks were formed in the centre of plates as well as in the areas of combined application of the deflection moment and cross force around the support point. The emergence of cracks was observed at the fourth stage of loading, with 370kgf (3.7 kN) at that moment. The width of the opening was <0/05mm. Later in the process of testing the cracks opened up to the ninth stage while applying additional loads - 704 kgf (7.04 kN). The width of the opening was between 0.1mm and 0.25mm.

After this stage of loading the speed of the opening slowed down or stopped, while new cracks emerged and opened.

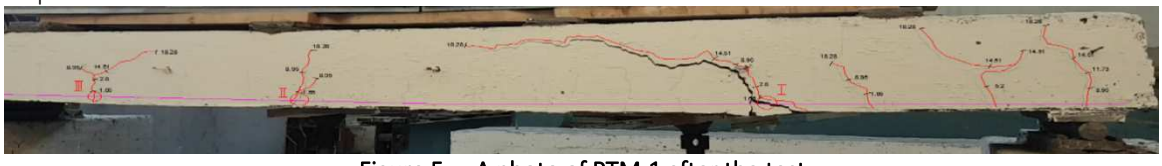

Figure 5. – A photo of PTM-1 after the test

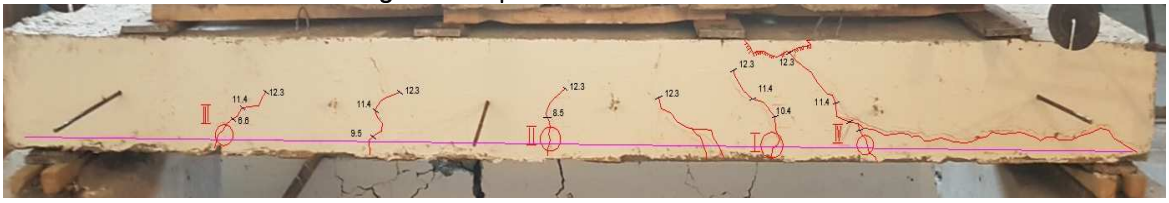

Figure 6. – A photo of PTM-2 after the test

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Figure 7. – A photoof concretecrumbling with anchorage corneraround the support point

Table 2. – Durability and crack resistance of plates.

Code of beams	Geometrical sizes, mm					Experienced cross forc-es, kn			P_{crc}/P_u	$P_{0.4}/P_u$	Destruction type
	b	d	h	L/4	$L_{эф}$	P_{crc}	$P_{0.4}$	P_u			
PTM-1	600	237	262	750	3010	1.65	13.58	15.43	0,09	0,84	2
PTM-2	601	254	279	750	3011	3.7	10.45	11,4	0,271	0,857	1

Notes: 1. Destruction types:
1 – Smashing of concrete over top of aslanting crack;
2 – Aconcrete crumbling around the support point

Table 3. – Ratio of experimental and calculated values of plates.

Code of beams	Maximum load, kN (test data)	V_{RDCT}	V_{SD}	M_{rd}	M_{sd}
PTM-1	18,28	1,551	0,914	15,43	9,63
PTM-2	13,3	1,592	0,65	11,4	11,04

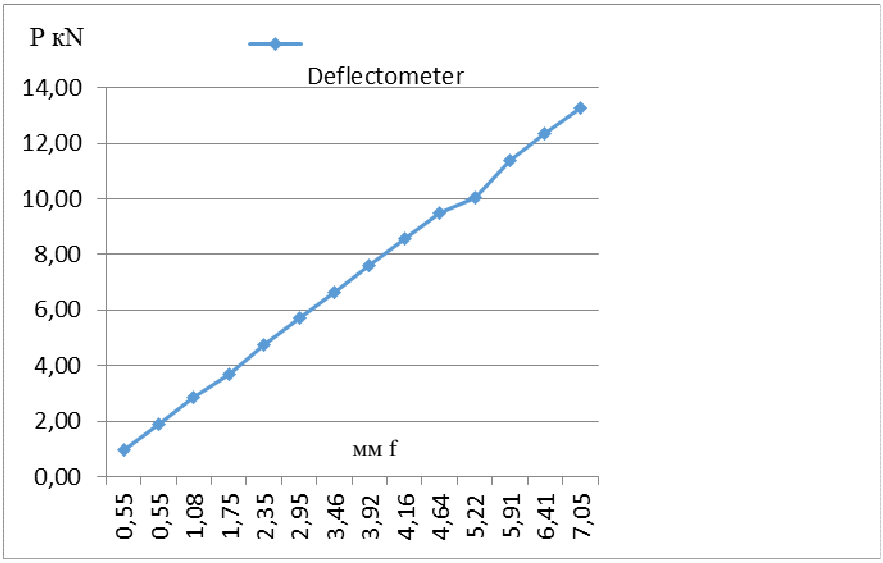

Figure 8. – Relation of a deflection to the load onPTM-2

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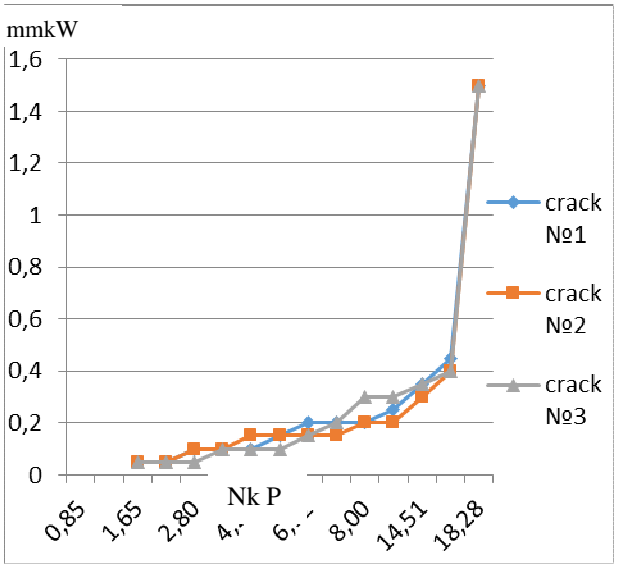

Figure 9. – Relation of the width of crack opening to the load onPTM-2

Based on theconducted calculation on the action of cross forces, according to the method used to calculate heavy concrete, it was revealed that the cross force arising in the section of both samples doesn't give a complete convergence with the theoretical data; the practical test data bearing ability appeared up onthe theoretical data by 10-55%. A crack opening of more than 1.5 mm was accepted as a criterion of destruction. A study of the regulatory base and methods of calculation for light (cellular) concrete is required.

The main conclusions

1. Plates made of foam concrete can be used as overlappings of low-rise residential buildings.

2. The methods used for calculations of heavy concrete give poor convergence of the results when calculating designs from light concrete and foam concrete.

3. The actual carrying capacity exceeded the theoretical assumption by 1.1 - 1.6 times.

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COMPUTER SIMULATION OF STRUCTURAL DEFECTS OF CONCRETE SAMPLES

EGOR TRAMBITSKY, DMITRY SHABANOV, ALEXANDER YAGUBKIN
Polotsk State University, Belarus

This article discusses the issue of the effectiveness of using computer simulation in the study of the deformation characteristics of concrete. An analytical review of the works, the authors of which were used computer simulation tools. The complex computer-aided modelling of the structure of concrete was considered using the programs VCCTL, MSC.NASTRAN, SolidWorks, ANSYS. Improving the methods of computer modelling of the behavior of structures made of composite materials will allow to optimize their resistance to destruction, strength, attrition resistance and other parameters.

Computer simulation of testing building elements and structures is an important task in the construction industry. Linking the results of virtual and real tests, we get a deeper analysis of the ongoing structural changes in the studied systems. Providing a correlation between these two research methods, the most rational and optimal results are obtained. Further, there will be an overview of domestic and foreign works of authors involved in the simulation modelling of concrete structures.

The article [1] discusses approaches to solving problems of deformation of structures made of composite materials by the finite element method. Examples of modelling composites using elementary cells of the material and based on real microstructures are given. The authors presented the results of calculations of concrete and reinforced concrete structural elements taking into account the internal contact interactions between the composite matrix and the reinforcing phase. It has been established that it is advisable to use modelling of the real structure to simulate the behavior of materials without any noticeable regulation of the structure, as well as analysis of the formation and development of cracks in materials. It is said that a significant drawback of this approach is the need to create a new complex model for each material microstructure under consideration, which does not allow the effective use of this approach to improve the material or parts made from it.

The work [2] is devoted to the finite element modelling of the stress-strain state of a composite reinforcement with spherical granules. There is the investigation of influence of the size of the granules and the adhesive properties between the phases of the composite on the stress-strain state of the material. A periodicity of a cell was adopted as a computational model, including parts of two granules and the surrounding matrix. The contact interaction of the granules with the composite matrix was taken into account. Thus, the application of the elementary cell modelling method, which takes into account the contact interaction between the matrix and the reinforcing phase made it possible to establish the features of the stress-strain state of the composite material. Reduction of the size of the reinforcing granules leads to a significant improvement in the adhesion of the granules with the matrix.

The authors of [3] proposed a structural-imitation model of the macrostructure of lightweight concrete and its components - cement-sand stone and porous aggregate. Using the methods of fracture mechanics, the development of initial structural defects under load is described, the effect of macrostructure parameters on the strength of lightweight concrete is experimentally evaluated.

The article [4] describes the joint work of phases that are heterogeneous in properties within the framework of structural-imitational modelling of composites. In this article, the author demonstrated the stages of modelling various elements of concrete: matrix, aggregate, fiber and pores. These stages include:

- creation of geometry and orientation of elements in space;
- the appointment of effective properties;
- consolidation of the created model;
- testing (loading) of the created model.

Various variants of the geometric form of the aggregate, pores are presented, the ranges of variation by their characteristic dimensions and orientation in space of the cement matrix are indicated. This article is the basis for a computational experiment, which includes all the above steps to obtain new data on the process of gradual accumulation of damage in the structure of fibrous concrete under static load. and MSC.PATRAN-NASTRAN), developed by specialists in this field

The mechanism of concrete destruction, is associated with the formation and development of micro- and macrocracks under the action of the load. The reason for the appearance of the first microcracks is the stress concentration near the structure defects: pores, inclusions, dislocations [6]. The peculiarity of the stress-strain

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state of micro- and macrocracks is that the material in the dead-end part of the cracks works beyond the elastic limit. Since the size of the dead-end part of the crack is at the atomic-molecular level, the non-linearity of the material is determined by the nature of the interatomic interaction forces [3].

To simulate the microstructure of concrete Virtual Concrete and Cement Testing Laboratory (VCCTL) was used [5]. This program was developed by the National Institute of Standards and Technology (NIST), USA. The program models 3D - microstructures of cement systems and allows predicting the final properties of the resulting composite. The hydration of these microstructures can be modelled according to different hardening conditions, and the resulting hardened material can be analyzed for a number of properties, including linear elastic moduli, compressive strength and relative diffusion coefficients. 3D - packaging of small and large aggregates in mortar and concrete mixtures can also be created. In connection with the transition of the country to the European standard (TKP EN), this program is also relevant for the Republic of Belarus [8].

a) b)

a) Visualization of the microstructure of concrete in the VCCTL [5];
b) General view of the concrete sample
Figure 1. – Presentation of the modelling of the structure of a concrete sample

To correctly determine the residual life of the structures, the source data must be determined from the results of field tests and measurements. Unfortunately, for most structures, obtaining reliable source data is difficult, which naturally reduces the accuracy of calculations [7].

Studies that are carried out in [8–10] should be supplemented with computer simulation results, which will give a broader picture of the processes occurring in concrete structures and will allow optimizing the data already obtained taking into account their structure at various levels of organization. Further tests are planned to be carried out in accordance with the most promising areas of concrete structure simulation. The virtual test algorithm involves several steps:

1. Simulation of microstructure and prediction of the operational properties of concrete (VCCTL software);
2. Creating a complex structure of composite material (SolidWorks);
3. Virtual testing of the obtained model (ANSYS);
4. Calculation and visualization of crack formation in the studied model (MSC.PATRAN-NASTRAN).

In conclusion it must be said that the task of structural simulation modelling of composite elements is complex and requires careful study of the components at each of its stages.

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STRENGTH CHARACTERISTICS OF SULFUR CONCRETE MADE OF VARIOUS COMPOSITIONS

IRYNA LAZOUSKAYA, VICTOR TUR
Polotsk State University, Belarus

The article presents the results of an experimental study of the compressive strength properties of the sulfur concrete cube samples, made of various compositions: modified gypsum binders by the complex use of water preparation sludge, dolomite flour and plasticizer. It is shown that the modification of gypsum binders contributes to an increase of their strength characteristics.

Currently, the oil and gas industry, in particular, the extraction, transportation and refining of oil and gas, poses a serious environmental risks. The significance of research of sulfur concrete is determined not only by the properties of the material, but also by the global environmental aspects of utilization of technical sulfur [1]. Refining waste volumes are constantly increasing due to increased oil and gas production.

For many years of research and experimental work, it was found that concrete based on sulfur binder, comparing with Portland cement based concrete, has better physical-mechanical and strength properties. The main drawbacks of sulfur concrete, identified in the early stages of its use, were low resistance to elevated temperatures, the formation of cracks when laying large volumes. With the development of research and manufacturing technology of sulfur concrete, some indicators have been improved. The solution to some problems was the addition of modifying agents to the sulfur binder, as well as the use of various aggregates in the sulfur concrete composition. This led to the improvement of the plastic characteristics of the sulfur binder and made it possible to reduce the number of cracks, thereby increasing the strength of the material. [1]

Sulfur concrete is a stone-like material, which consists of a solid mixture of aggregates and sulfur. The composition of sulfur concrete includes sulfur binder, inert aggregates and fillers. The use of the latter is quite widespread. They use crushed stone, gravel, sand, various slags and other rocks. [2]

The consequence of high strength properties of sulfur concrete is the structure obtained by combining inert aggregates, fillers, sulfur binder and modifier. Without the use of filler, sulfur is a homogeneous structure, and its molecules are close to each other. The introduction of the filler binds sulfur molecules in such a way that the resulting porosity of the material is minimized (Fig. 1).

Figure 1. – The homogeneity of the obtained sample of sulfur concrete

There are different strengths without modifier in the composition of sulfur concrete, sulfur crystallizes, acquiring an amorphous state. Also, the change in its density causes shrinkage deformation due to the occur-

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rence of internal stresses causing micro- and macrocracks in the concrete body. With the introduction of the modifier, the sulfur crystal has a constant strength and remains unchanged when exposed to various factors. Depending on the obtaining desired properties of sulfur concrete, a different modifier can be used. [3]

Sulfur filling with finely dispersed materials has a positive effect on its structure, which is reflected in the increase in strength properties. [4, 5] Therefore, to study the strength characteristics of sulfur concrete, samples of various compositions were made, using materials combining in their grain size distribution both fine particles with a particle size of less than 0.08mm and particles of sand fractions with grain size up to 5 mm.

In one of the compositions we used natural crushed stone FR 10-15, river sand FR. to 5mm, fly ash 0.08, modified sulfur. In another composition, fly ash was replaced with dolomite flour [6] of the same fraction. Depending on the number of all components we've received four versions of the samples. An important feature of the preparation of samples from sulfur concrete was the use of materials from the local region, the use of which is the most appropriate for further study and introduction of new composite materials into the construction industry of the Republic of Belarus.

One of the main technological feature of the preparation of sulfur concrete is the heating of all components of the mixture. The first inert filler and filler was heated to 160 ° C. The modified sulfur was heated separately to a temperature of 140 ° C in order to avoid the release of sulfur dioxide. Next, all the components of the mixture were thoroughly mixed in a heated stirrer until a viscous paste (such as "in / liquid") or solid plastic consistency was formed, depending on the composition. Samples were molded in heated form, and a vibrating table was used to compact the mixture. The test result data are shown in table 1.

Table 1. – Compressive strength of sulfur concrete of various compositions

Variants of the composition of sulfur concrete mix	Set time strength, h	Compressive strength, MPa
Sulfur 25% + modifier 7% + crushed stone 30% + sand 20% + dolomite flour 18% (option 1)	3	59,3
Sulfur 25% + modifier 5% + crushed stone 40% + sand 15% + dolomite flour 15% (option 2)		60,7
Sulfur 25% + modifier 7% + crushed stone 30% + sand 20% + fly ash 18% (option 3)		61,0
Sulfur 25% + modifier 5% + crushed stone 40% + sand 15% + fly ash 15% (option 4)		62,5

Sulfur concrete possesses rapid curing, therefore, the obtained samples of cubes with a final size of 100mm were tested after they were completely cooled (3 hours after production) They were tested to failure under uniaxial short-term compression. In the process of testing, the load, applied to the sample, was monitored. The general view of the samples after the tests are presented in Figure 2.

Figure 2. – Type of destruction of prototypes 2 and 4 options of the composition

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Currently, there is a selection of compositions, as well as options for the replacement of the filler and aggregate with various wastes. The results show, that, depending on the type of filler and different variations in the mass fraction of the components, the strength of sulfur concrete changes. Also it is necessary to mention, that the strength of all samples, made of obtained sulfur concrete, is not inferior in strength characteristics to samples of traditional concrete, based on Portland cement. Further study of the properties of sulfur concrete will make it possible to judge the advantages and disadvantages of using different types and amounts of sulfur concrete components.

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MODERN TECHNOLOGIES OF RECEIVING THE FACILITATED REINFORCED CONCRETE STRUCTURES

AL NAHDI AMJAD SULAEMAN, HSSAM S. ,HAIL M.
Polotsk State University, Belarus
KHALID ABDEL HALIM HAIDER
University of Aden, Yemen

This work is an economic rationale for the use of non-retrievable hollow cores, in monolithic floor slabs directly at the construction site. Questions of technical and economic efficiency, with similar types of overlapping are considered. The pros and cons of this technology are reflected.

One of the possible directions for obtaining lightweight structures is the use of technology arrangement of floors with non-removable inserts-voids. Reducing the weight of the structure by removing the material from it (by 20-40 %), which does not participate in the robot, without worsening, at the same time, the strength characteristics, in conjunction with the procedure of delivery to the object of a smaller amount of concrete mix for concreting the structure determines the corresponding economic effect. In addition, the effectiveness of this approach is enhanced by reducing the level of loading of the supporting elements of the structure and its foundations.In recent years, standardized modules made of polymeric materials of various shapes have been widely used abroad as non-removable void-forming liners. Such systems include

According to the ***Air deck technology*** [1], the plant produces the lower covering of the floor slab in the form of a precast concrete structure with embedded polypropylene inserts Figure. 1. Working dimensions of inserts-cartons of 20×20 cm, and the height varies from 12 to 35 cm Step liners-boxes is constant and equal to 30 cm.

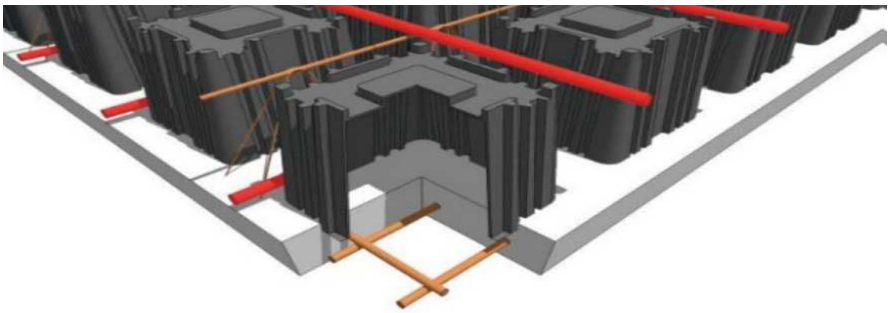

Figure 1. – According to The airdeck technology, the concrete mixture is first placed in the formwork

Bubble Deck technology [2] is divided into three types:

a. analogue of Airdeck technology, differs only in reinforcement and the shape of the liner Figure. 2.;
b. flat reinforcement modules the size of the plate consisting of liners and reinforcement cage are installed in the formwork on the construction site, and carry out concreting on a two – stage technology;
c. ready prefabricated reinforced concrete slabs with liners for delivery to the construction site.

Figure 2. – The device is light weight concrete slab by bubble deck technology

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Hollow balls of spherical or elliptical shape made of recycled plastic (polyethylene, polyvinyl propylene or polyvinyl chloride) with a diameter of 18 to 36 cm, depending on the thickness of the concrete slab, are used as inserts.

The inserts are located inside the reinforcement module and are held in the design position due to the special shape of the lower and upper mesh cells

Cobiax technology [3] uses two types of linear reinforcement modules (up to 250 cm long) with inserts in the form of an ellipsoid of rotation ("Slim-Line" system) for concreting slabs with a thickness of 20 to 35 cm and in the form of a spherical ball ("Eco-Line" system) for slabs with a thickness of 30 to 60 cm Figure. 3.

The main difference from the previously listed technologies is the layout manually reinforcement modules with the ear bud cavities prior to the placement of concrete in the formwork.

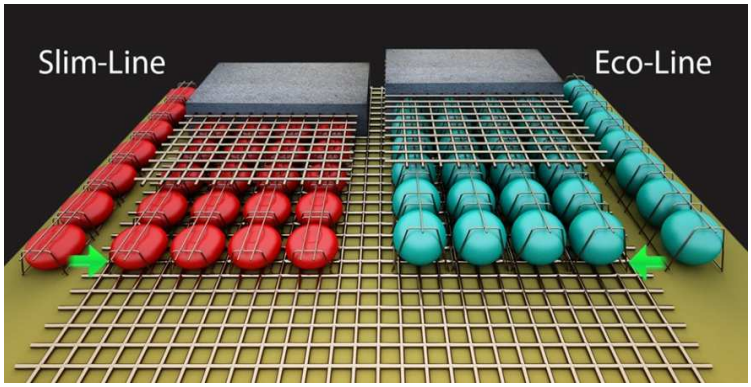

Figure 3. – cobiax system: "Slim-Line and Eco-Line»

Daliform Group [4] is one of the Cobiax technology is similar, but with significant differences. It has two *systems U-Boot Beton* and U-Bahn Beton Figure. 4. System U-Boot Beton applies ear block form made of recycled polypropylene, with working dimensions of 52×52 cm and a height of from 10 to 56, see using the ear system U-Boot Beton allows to concrete slab thickness from 20 to 76 cm distance between the ears exposed with the aid of spacer couplings with a graduated scale.

Figure 4. – The device is light weight concrete slab u BootBeton system

The U-Bahn Beton system uses U-shaped inserts with working dimensions of 120×40 cm and a height of 20 cm from recycled polypropylene, the ends of the inserts can be closed with standard plugs. This system is specially designed for the implementation of unidirectional slabs of reinforced concrete.

In parallel are widely used in modern construction technology produce lightweight structures using as unrecoverable liners-hole-forming cores of the panels are made of polystyrene.

A striking example of the use of such technologies is the construction of the highest residential building in Mexico, the skyscraper "Santa Fe II" height of 167 m, built in 2013 Figure 5. [5].

Reinforced concrete slabs have a thickness of 250 mm and an average weight of only 3.5 kN / m^2. The 80×80 cm Styrofoam liners are placed in the slab in two directions in increments of 100 cm, providing concreting of the inner ribs with a thickness of 20 cm Figure. 6.

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Figure 5. – Mexico skyscraper "Santa Fe II" height 167 m, built in 2013

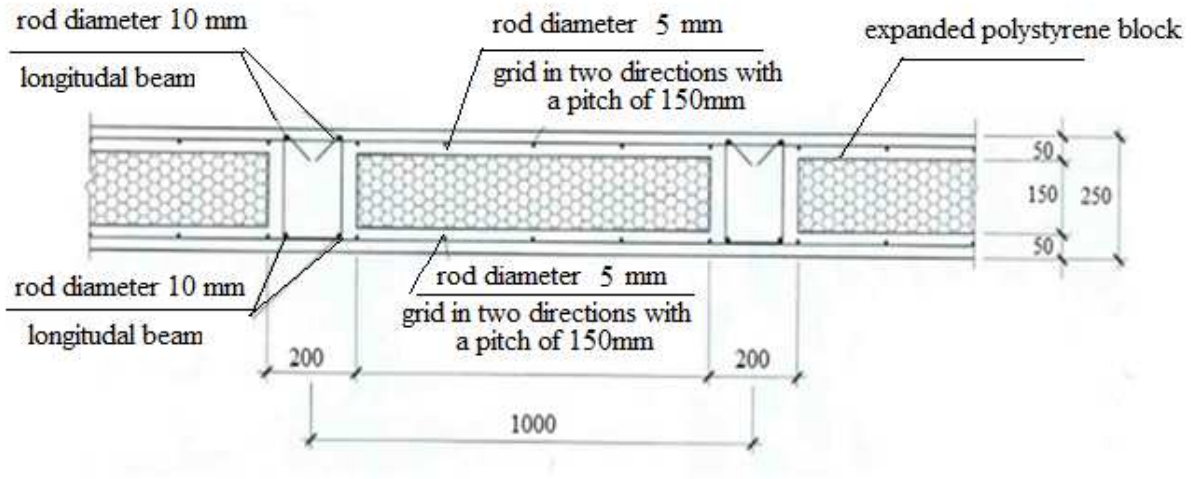

Figure 6. – Cross-section of reinforced concrete floor of a skyscraper

The modern industrial and civil building of Ukraine considered the technology with inserts from polymeric materials, standard forms were not used, and there is widespread concreting of constructions with unrecoverable liners-hole-forming cores made of Styrofoam.

This technology, developed under the leadership of Professor V. S. Schmookler successfully applied in the construction of buildings systems "RAMP", "ICARUS", "DOBOL" and "Monofont" [6, 7].

We present a comparison of technical and economic indicators of different technologies for the use of inserts (table. 1).

Table. – Technical and economic indicators of floor structures

Name technology	structural thickness of the slab, cm	Volume of the liner, cm^3	Step liners, cm	number of inserts, PCs / m^2	volume of inserts, m^3 / m^2	thickness of the floor, cm
Airdeck	25	4100	30	11	0,045	20,4
Cobiax	25	3100	20	25	0,076	17,2
BubbleDeck	25	9100	35	8,2	0,075	17,5
U-Boot Beton	25	28000	64	2,44	0,068	18,2
Monofont	25	121500	100	1	0,1215	12,85

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Table 1 shows that the given thickness of the overlap with the use of non-removable inserts-hollow polystyrene foam is much less than for other technologies, which ultimately minimizes the weight of the structures.

Fewer liners per 1 m2 of the slab facilitates the reinforcement and the concrete process, at the same time predetermining the rationalization of the sections without reference to a standard form liners made of polymer materials.

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THE ANALYSIS METHODS OF MASONRY STRENGTHENING WITH COMPOSITE MATERIALS AND SCREW RODS

AL NAHDI AMJAD SULAEMN, DEEB S.,
Polotsk State University, Belarus
KHALID ABDEL HALIM HAIDER
University of Aden, Yemen

The review and analysis of Modern methods of strengthening brick walls of buildings with using composite materials, as well as using screw rods from of stainless steel are reviewed and analyzed; features of technology enhancements are considered, there identified the advantages and disadvantages of each of the methods that should be relied upon when deciding on strengthening brick walls of buildings.

Brick is one of the most general construction materials load bearing walls. Successfully applied as in high-rise residential and industrial construction as well in private build up.

The issue of providing constructive reliability and durability of brick walls buildings will always be relevant. But masonry is not the best way works in tension and is very sensitive to shear stress. Therefore, one of the most common type's damage to brick buildings is their cracking.

The most common reasons causing cracks in the stone constructions, according to statistics are [4]:

– Uneven precipitation of bases (65–75%);
– Overload of structures (10–15%);
– Temperature deformations (10–15%);
– Moisture deformations (5–8%); special loads and impacts (2–5%).

Among the traditional ways to enhance brick walls can be distinguished such as:

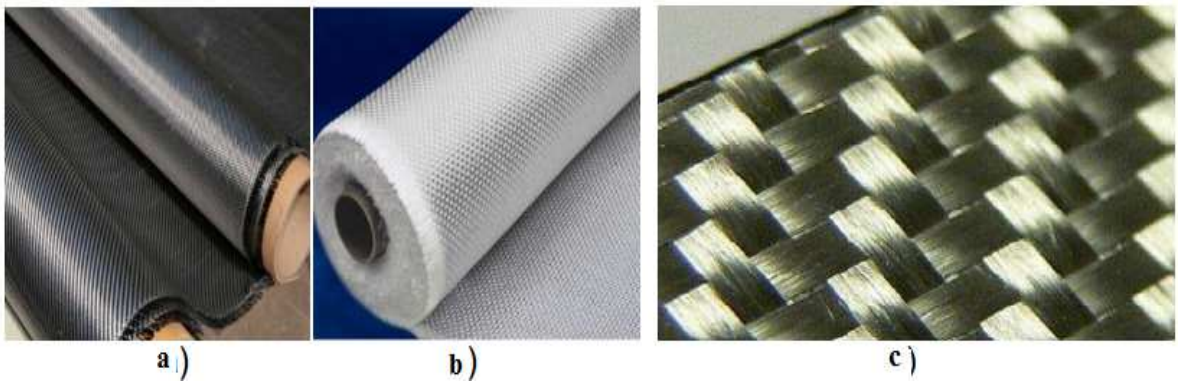
– reinforcement with steel, reinforced concrete clips, clips based solution;
– device metal or reinforced concrete core;
– partial or full replacement masonry elements;
– injection of solution in the cracks of layer

Traditional amplification methods masonry is quite effective; however, in some cases their use is impossible. Most of them are expensive and labor intensive. In addition, after the reinforcement of structures with the help of clips, the aesthetic external changes appearance of the building. Consequently, for repair and reinforce the brick walls of buildings all more use of new technologies and materials. These include [1]

1. External reinforcement of composite mi materials.
2. Application of screw rods from of stainless steel.

Composite materials are fabrics, nets, ribbons, canvases. They consist of reinforcing fibers and binders components. Inorganic and organic fibers can act as reinforcement. Inorganic fibers include carbon plastics, fiberglass plastics, basalt fiber (Fig. 1). To organic fibers include aramid, flax and hem fiber [2, 3].

Abroad given amplification system known as FRP (Fiber Reinforced Polymer) reinforced with polymer fiber. Polymer systems possess high strength, rigidity, and lightness and corrosion resistance.



a. – carbon fiber; b – fiberglass; c – basalt fiber
Figure 1. – Inorganic fibers of composite materials

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To ensure adhesion Composite material with a design as an adhesive using epoxy glue or glue based on micro cement. Epoxy glue is a thermosetting synthetic product consisting of epoxy resin and additional components in the form of a hardener. It has high technological characteristics; however, has a low fire resistance.

It should be noted that epoxy vapor resin and glue entering open areas skin adversely affect human health. In this regard, when working with epoxy glue. It is important to adhere to special security measures.

The glue on the basis of micro cement is more effective in terms of fire resistance and safety of work. The technology of external reinforcement composite materials is the following (Fig. 2, 3):

1. On the cleaned surface of the brick laying after its impregnation and priming is applied epoxy glue or a layer of plaster with a smooth metal spatula layer up to 6 mm thick.
2. Up to the moment of setting of a layer polymeric systems (fabrics, grids) keep within, tape, canvas) in the applied layer of the solution.
3. Next, apply a layer of plaster a minimum thickness of 3 mm, the surface of which is subjected to finishing.
4. Providing high strength reinforcement, if necessary in the protective layer can fit the second element of the system (fabric, mesh, tape, canvas).

Possible gain as bent structures in stretched zones and on in the zone of action of transverse forces, as well as compressed and eccentrically compressed elements [2].

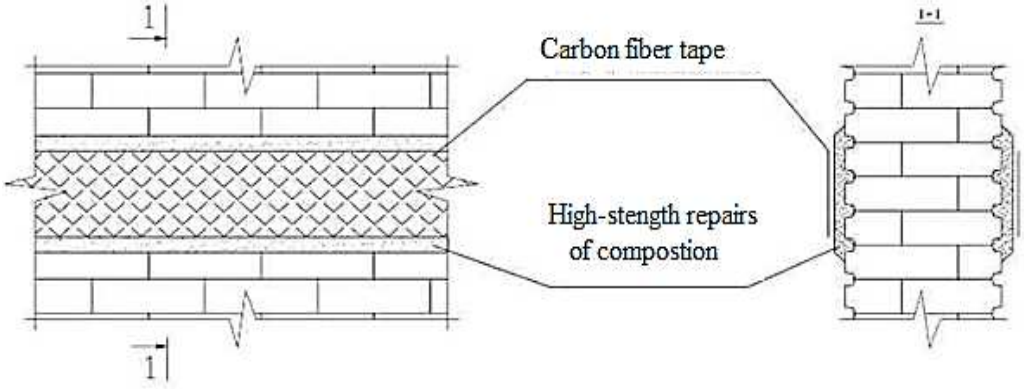

Figure 2. – Strengthening of brick walls with a tape of carbon fibers

From an economic point of view fiberglass are the cheapest polymer fibers. A composite reinforcement material of brick walls and multilayered designs allows us to highlight the following their advantages:

- high values stiffness and strength;
- relatively low density; corrosion resistance;
- the ability to perceive shock loads;
- ease of installation;
- low material weight and how consequence of minimal load on reinforced structures;
- preservation of the architectural appearance of structures.

Figure 3. – Strengthening of brick walls with a tape of carbon fibers

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At the same time, the system under consideration has several disadvantages: hygroscopicity composite materials; low fire resistance index of epoxy adhesives (starting from 50 ° C); toxicity of resins entering into composition of epoxy adhesives; possible burns when epoxy glue gets on your skin person; high specific volume.

In the new construction of buildings in quality increase stability and strength of one of the most promising products from polymer composites is composite based reinforcement carbon, glass, and basalt or aramid fiber.

The second effective method of strengthening brick walls of buildings is to strengthen with the help of screw rods from of stainless steel. This method is applied not only to repair and strengthen brick masonry cracking as well as in multilayer structures for interconnecting layer with the outer layer of cladding.

Spiral Flexible made by cold rolling of round stainless wire cross section. In the manufacturing process cruciform creation initially occurs molds from central core and adjacent flat edges of the "wings", then formed screw rod. The surface of the "wings" becomes very hard, at the same time the core keeps spring properties. Further hardening gives "Wings" pressers, and core due to different structure, this hardening is not exposed.

Due to this, tensile strength more than doubled. The technology of pushing through a special matrix in such a way that the “wings” wind up around the core (Fig. 4).

Manufacturing technology includes by a number of production stages, as a result those who turn out the product combining in itself high flexibility and elastic guest [4, 5].

Standard screw connection made of stainless steel 304 or 316. To reinforce brick walls rods of nominal diameter are used 4, 5, 6, 8 and 10 mm. In rare cases, may rods up to 14 mm are used. Standard the length of these rods is from 1 to 10 m. can overlap, bend, and knit together wire.

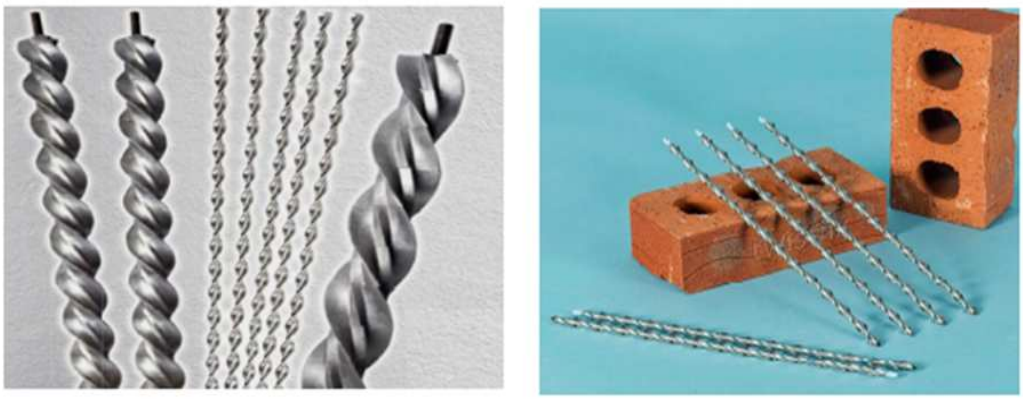
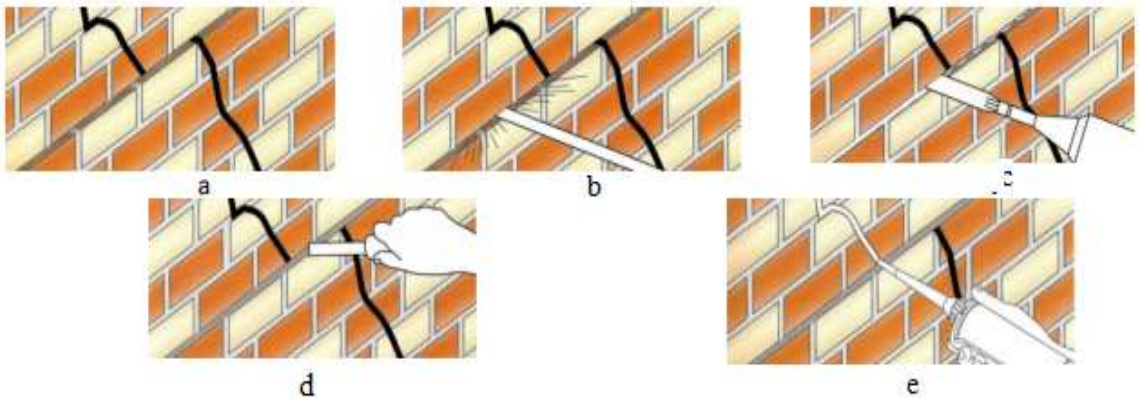


Figure 4. – Screw-down stainless steel rods to strengthen the masonry

The technology of strengthening represents deepening of screw cores in a special solution. The solution is placed in a pre-drilling well with a diameter of 12-16 mm or in a 1 mm wide hole. The solution is placed in the cleaned well with a hand gun. Then, using the applicator or manually laid screw rod. Then cracks are injected (Fig. 5).

A spiral rod and a special solution create a spring effect and, thus, are created small movements of the United edges of the cracks'. As a result, it is provided durability of the brick wall of the building



a – groove device; b – cleaning the groove with compressed air; c – sealing the seam with a special solution; d – installation of the rod; e – injection of cracks

Figure 5. – Technological operations of strengthening the brick wall with screw rods

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Adhesive solution is a two-component composition (powder and liquid), has high adhesion to various materials. To prepare the solution, only the ingredients should be used, supplied by the manufacturer (banned add water, cement, sand, plasticizers, etc.).

The spiral edge of the rods provides the ability to also mount them by driving or twisting them into the masonry using a hand-held power tool with a special adapter attachment.

At the base of a hollow brick connection is established using chemical anchors [3].

To advantages of strengthening of brick the walls of the buildings are screw rods:

– high strength, stiffness and elasticity of the material;
– light weight of the material;
– not time-consuming to implement (no mechanized equipment);
– resistance to corrosion; in the presence of external damage there is no need to interfere with the design from the inside;
– preservation of the architectural appearance of structures;
– technological compatibility with all materials.

Disadvantages of this method: high cost of materials; there is a need for skilled workers [3, 4].

Strengthening of brick walls of buildings with composite materials and screw rods are massively used in foreign countries, however, in Belarus they were not yet widely used due to the lack of regulatory framework governing use of these methods.

Thanks to modern technology and materials are effectively eliminated defects and damage in building structures, ensuring safe and operational reliability of the brick walls of buildings.

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ON THE ISSUE OF GAS HOLDERS DESIGN FOR GAS STORAGE

NIKITA VOITESHONOK, EVGENY KUKOR, ALENA KREMNEVA
Polotsk State University, Belarus

The generalized classification of gas holders is given. Particular attention is drawn to the types of spherical gas holders. The analysis of cutting sheets of surfaces of spherical gas holders is given, their advantages and disadvantages.

Gas holders are widely used for storing, mixing, leveling the composition of gases in the petrochemical, chemical, metallurgical industry, light and textile industry. They are included in the gas network between the sources of gas and its consumers as a kind of battery.

The history of gas holders started in 1775 with gas holder of Neret (Fig. 1).

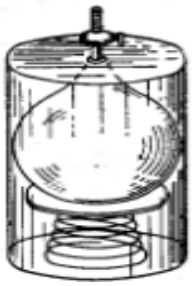


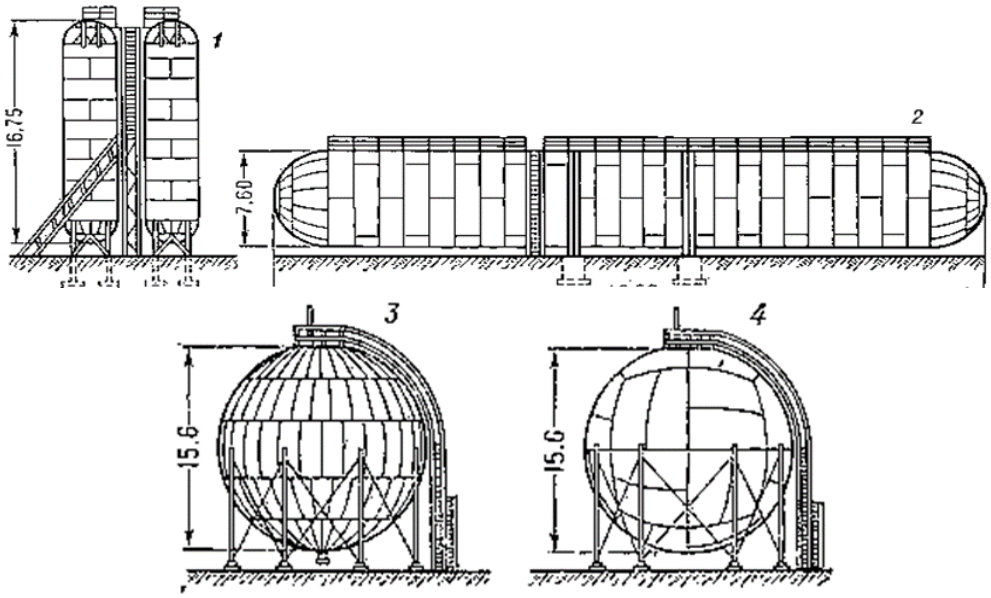
Figure 1. – Gas holder of Neret

The rapid development of the chemical industry nowadays makes special demands on the structures of gas-holders, since various types of gases are used. Wet gas holders, dry gas holders, including ones with a flexible section, are used for gas storage. [2].

Depending on the applied pressure, gas-holders can be divided into two main classes – of low and of high pressure. Low pressure ones, as a rule, are of constant pressure and can be further divided into two groups - wet and dry.

Geometrically gas holders of constant volume are divided into two main types, Figure 2:

- cylindrical gas holders with spherical bases;
- spherical gas holders, built on individual racks or on a special glass.



1 — vertical cylindrical; 2 — horizontal cylindrical; 3 — spherical of five belts; 4 — spherical of football cut
Figure 2. – Gas holders of constant volume (sizes are in metres)

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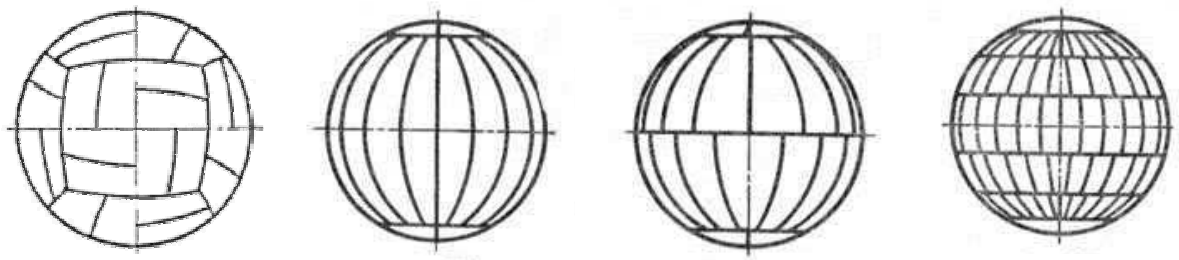
In constructive terms, cylindrical gas holders have much in common with vertical tanks designed for the storage of petroleum products. In this regard, they are manufactured and assembled according to the same technological rolling schemes as steel tanks. The sequence of works is as follows: manufacturing of roll panels of bases and walls, delivery, unfolding and installation of rolls, welding of rolls and steel roof elements, etc.

Spherical gas holders, built on individual racks or on a special glass, have a more sophisticated manufacturing technology than cylindrical, but with such a form, the stress in the structural elements of the liquefied and compressed gases is more evenly distributed, [3]. Therefore, spherical gas holders in comparison with cylindrical ones of the same capacity have the following advantages: less weight and materials cost; less floor area.

In the Republic of Belarus, spherical gas holders with a volume of 600 m3 are mainly used. Advantages: simplicity of design and maintenance. Disadvantage: limited volume of stored gas. Spherical gas holders are used in order to create emergency gas reserves: air for instrumentation and automation systems, nitrogen for fire extinguishing systems, air and nitrogen for purging process equipment, etc.

The cutting of spherical gad holders surface is quite specific. Separate types of cutting are given in Figure 3.

a) b) c) d)



a) – cutting according to the Plato's bodies ("football ball" type);
b) – meridional cutting; c) – equatorial-meridional; d) – mixed type of shell
Figure 3. – Development drawing of gas holders

The shell of the spherical reservoir is usually constructed from petals of double curvature. The choice of the type of the shell cutting is of great importance not only for the economical use of the metal, but also for reducing the labor intensity and the duration of the installation work. Petals should be as large as possible, of the same type and interchangeable. When assembling the shell of petals, the design geometric shape of the shell should be provided without fitting operations during installation.

When choosing the most rational method of cutting the shell, the following tasks are set: making petals from sheets of the same width and length; reduction of the length of welds, including assembly; reducing the number and types of mounting elements; reduction of waste losses; the location of the welded joints of the shell should provide ease of installation.

When cutting the shell according to the "Plato's bodies" type, all sheets have the same configuration, their edges and corners are equal to each other. This is usually a tetrahedron, hexahedron or octahedron.

Meridional cutting is most convenient for automatic welding, since in this cutting there are long, equally directed seams and there are no equatorial and circular seams.

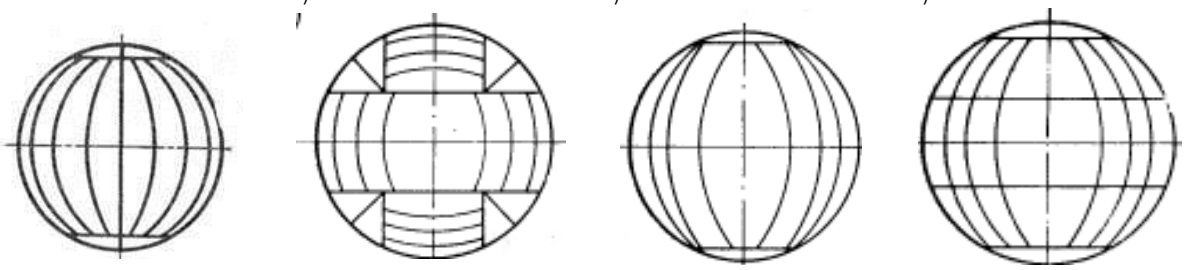
Equatorial-meridional type of cutting is most often used in the construction of large-diameter spherical tanks. Such tanks are always divided into belts.

Mixed type of cutting is rarely used.

In this regard, the research task is to determine the most efficient cutting, including the minimum amount of metal waste and the length of the welds.

The investigated types of cutting are presented in Figure 4.

a) b) c) d)



a) – one-belt type; b) – one-belt mixed type; c) –two-belt type; d) – three-belt type
Figure 4. – Types of meridional cutting

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Because of the most massive use of these types of cutting, they were taken for comparing the options. The results are in the table.

Table – Comparison of tanks cutting types

Cutting type	Size of panels, mm	Steel waste when cutting, %	Weld length, м
Three-belt meridional cutting	2300x6000	24	520
	2600x7000		
	2300x5500	20,1	531
	2600x7000		
	2600x8300	10,9	556
	2100x7000	7,4	650
	2600x7000		
	1600x7000	7,7	807
	2500x7500	8,8	616
	2100x7000	8,6	750
Two-belt meridional cutting	2000x8400	21	597
One-belt meridional cutting	2600x8000	14,5	488

Based on the above and the results obtained from the carried research (table 1), we can draw the following conclusions:

- minimal steel waste in a three-belt type of cutting, but the length of the weld is large;
- the minimum length of the seam in one-belt mixed type of cutting, however, the steel waste exceeds twice in the previous type of cutting.

Thus, the best option for the cost of electric power is a three-belt meridional type of cutting.

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TO THE QUESTION OF STRENGTHENING BENDABLE REINFORCED CONCRETE ELEMENTS

KSENIYA KASTSIURYNA, YAHOR LAZOUSKI
Polotsk State University, Belarus

The article discusses options for strengthening the stretched zone of bent reinforced concrete elements. Timely work on the strengthening and repair of building structures is of practical importance. Also, reinforcement of building structures is often required for the technical re-equipment and modernization of industrial and civil buildings. Bent reinforced concrete elements often need to be strengthened, as a rule.

Introduction. At present, the reconstruction of buildings and structures is not inferior in relevance to new construction and even surpasses it. In the conditions of dense development, great attention is paid to ensuring reliable operation of existing structures. Often, the dismantling and replacement of certain structural elements is much more expensive than repairs, and sometimes even impossible. Most of the existing modern buildings and structures are made of concrete, reinforced concrete or brick. Their premature destruction, loss of bearing capacity or other performance characteristics may pose a threat to the integrity of the structure and entail undesirable consequences. Thus, timely work on the strengthening and repair of building structures is of practical importance. Also, reinforcement of building structures is often required for the technical re-equipment and modernization of industrial and civil buildings. For the most part, bending reinforced concrete structures, as a rule, require reinforcement.

Strengthening of reinforced concrete structures, in comparison with other types of structures (metal, wood), has some peculiarities associated with the difficulty of ensuring that the concrete structure in operation with the new concrete works together with increasing cross-section and difficulties with increasing the reinforcement cross section concrete [1].

Main part. The first step in designing the gain of existing structures is to assess the state. On the basis of the obtained results, a probabilistic scheme of destruction of the structure is established, thereby determining its so-called "weak zone". Based on the destruction schemes of reinforced reinforced concrete structures, we can conditionally separate the reinforcement methods. In the general case, the destruction of bending elements occurs in the stretched, compressed zones or in the shear zone due to the action of transverse forces [1]. Therefore, it is more expedient to design reinforcement of reinforced concrete structures in its weakest zone.

The choice of the method of strengthening the structure is also influenced by the conditions in which it is located: loads, aggressiveness of the environment, fire and explosion hazard of the structure being strengthened. Do not also neglect the manufacturability and efficiency of the selected method.

Strengthening the stretched zone of bent reinforced concrete structures is performed by increasing the cross-sectional area of the working reinforcement. Ensuring joint operation of reinforcement reinforcement is achieved by the following methods:

– by installing additional reinforcement with welding to the working reinforcement of the structure and subsequent wrapping;

– by gluing additional elements in the stretched area.

The method of welding additional reinforcement to the existing one depends on the state and thickness of the protective layer of the existing structure. Welding can be done lap-jointed with striking the protective layer along the length of the additional reinforcement, with the aid of short legs, the diameter of which exceeds the thickness of the protective layer or using staples. The disadvantages of this method are the need to beat off the protective layer of the existing structure and the high complexity of the work carried out. The use of new materials in construction has pushed this method into the background.

Strengthening the stretched zone of structures by gluing additional elements has a number of options presented in Fig. 1 [5]. Each of these methods has its advantages and disadvantages, and each option is applicable in certain conditions. However, some of them are very expensive, due to the high intensity of metal. The most optimal in terms of "price - quality" can be considered the method of gluing an additional reinforced concrete element in the stretched zone. This method eliminates the need to expose the tensioned reinforcement of the existing structure. Additional reinforcement is protected from aggressive media, as it is in the body of concrete. The joint work of the reinforced structure with the new one is ensured by the reliable merging of old concrete with reinforcement concrete.

Currently, a number of experimental studies of the adhesion of new concrete with the old have been carried out. New design solutions are proposed to strengthen existing buildings and structures, modern building materials are used, and a number of factors affecting the adhesion strength of elements are being studied [2, 3,

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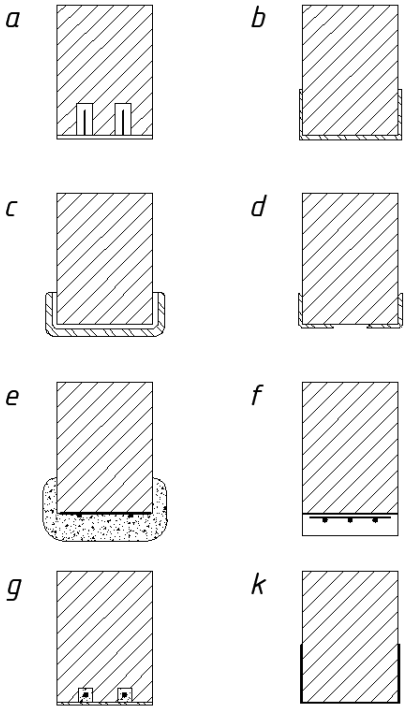
4, 5]. Due to a large number of factors that may influence the magnitude of the adhesion forces, the question remains not fully understood.



a – sheet reinforcement with vertical anchors; b – sheet reinforcement with additional anchor plates;
c, d – rolling profiles; e – sheet reinforcement with stamped reefs; f – reinforced concrete element;
g – in grooves of rod fittings; k – gummed fiberglass.
Figure 1. – Strengthening the stretched zone of structures by gluing

Lack of adhesion in the seam can lead to a complete disruption of the connection between parts of the structure. Also, poor adhesion of the new concrete with the old can lead to premature cracking, which reduces the water resistance of structures and accelerates its destruction.

Conclusion. There are many technologies for laying new concrete and preparing the surface of the reinforced structure, the observance of which in one degree or another allows to increase the adhesion strength. However, many of them are not always applicable when strengthening bending structures. Studies of the strength of adhesion of new concrete with concrete of reinforced structure are mainly devoted to the study of strengthening the compressed zone by increasing. The question of the joint work of the existing structure and additional prefabricated elements in the stretched zone has not been fully studied.

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APPLICATION OF ARMATURE FROM CARBON FIBERS DURING RECONSTRUCTION

TAISYA KAZYANINA, YAHOR LAZOUSKI
Polotsk State University, Belarus

The article discusses the main methods of strengthening bending reinforced concrete elements in the cut zone. The use of carbon fiber reinforcement construction. The main advantages and disadvantages of carbon fiber reinforcement.

Every day the issue of reconstruction and technical re-equipment of existing buildings and structures, which have been in operation for a long time, is becoming increasingly important. It is much more profitable to reconstruct existing funds than to rebuild new ones. The recoupment of capital investments in the renovation takes place several times faster, which once again speaks of its advantage in new construction.

Reconstruction of industrial buildings and structures is an integral part of the overall reconstruction of enterprises. Changing the operating conditions and functionality of building structures due to the introduction of new technologies in some cases requires additional measures for them. The installation of additional equipment leads to an increase in loads, a change in their place of application and nature, the introduction of amendments to the design schemes, which may necessitate a preliminary strengthening of the structures of building structures. In the process of reconstruction, the building structures should be brought into compliance with the requirements of the current regulatory documents in the modified operating conditions.

Civil buildings are also subject to reconstruction, among which the share of physically and morally worn-out objects is growing at a faster pace. The need to provide comfortable housing, the development of small and medium businesses require not only increasing the pace of housing construction, but also the reconstruction of old capital residential and public buildings, in some cases with the strengthening and replacement of structures [1].

The reconstruction of buildings and structures is also resorted to due to the need to restore physically worn out individual elements, parts of buildings and structures. Physical wear causes their transition to a state other than the design and leads to the need for reinforcement.

Options for strengthening building structures today, there are quite a lot. However, special attention should be paid to the strengthening of bent reinforced concrete elements in the cut zone, since in addition to combinations of bending moments and longitudinal forces, transverse forces also act here.

The main methods of reinforcement in the cut-off zone are extensions, collars, jackets, installation of additional transverse reinforcement in the form of rods or strips, normal or inclined to the longitudinal axis of the structure. Each of these methods has its own applicability and application requirements. The main task is to ensure the joint work of the old and the new sections. The joint work of build-ups, clips, shirts with concrete structures in the shear zone is provided by the arrangement of cross-links that work in shear across the structure axis in an inclined section. Cross connections are made in the form of transverse reinforcing bars, as well as cuts and dowels on the side faces of the reinforced structure.

The joint operation of the additional transverse reinforcement with the reinforced structure is ensured by: welding to the existing reinforcement; gluing to concrete in the cut zone; fixing the ends in the upper and lower zones using anchor devices. After installation in the design position, additional transverse reinforcement is concreted or coated with anti-corrosion and flame retardants.

When using the installation method of additional transverse reinforcement, the use of reinforcement from composite materials, which are more cost-effective as reinforcement for bending elements, is becoming increasingly popular. Such composite materials have found their application in construction relatively recently - the middle of the XX century. Composite materials are widely used in the aerospace industry, and later in the automotive industry and construction. [2 and others]

At present, reinforcement from composite materials based on carbon, aramid, polyester, basalt and fiberglass is used for reinforcing reinforced concrete structures in construction [3]. These types of materials differ in mechanical characteristics. Aramid and glass fibers respectively have a tensile strength of 3200 ... 3600 and 483 ... 1600 MPa with an elastic modulus of 124 ... 130 and 35 ... 51 MPa. Carbon fibers have a tensile strength from 2200 to 7200 MPa with a modulus of elasticity in the range from 200 to 785 MPa [4].

For the reinforcement of structures, the use of carbon fiber reinforcement is becoming more and more popular.

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Figure 1. – Carbon fiber reinforcement

This valve has several advantages such as [5]:
- Tensile strength is up to 5 times higher than the strength characteristics of steel reinforcement class AIII.
- The indicator strength of metal reinforcement - 390 MPa, composite - not less than 2000 MPa.
- The carbon fittings are not subject to corrosion.
- Resistant to acids, to sea water.
- Carbon fittings practically does not conduct heat.
- Radio transparent.
- Magnetoinert. Does not change properties under the influence of electromagnetic fields.
- Does not lose its strength properties when exposed to ultra-low temperatures.
- It is lighter than metal fittings 10 times.
- Durability in the environment of concrete.
- Durability prediction for a period of> 75 years.

Also, such fittings are much lighter, which reduces transport costs and weight of structures.

Table 1. – Physical and mechanical characteristics of carbon fiber reinforcement [5]

The name of indicators	Unit of ISM	Value (depending on diameter)
Diameter of CFRP	mm	4; 6; 8; 10; 12; 14; 16; 18
Tensile Modulus	GPa	not less 140
Destructive tensile stress	GPa	not less 1,6
Carbon Density	t/m^3	1,5

However, it is worth noting the existing disadvantages of carbon fiber reinforcement, such as:
- High cost, compared with traditional steel reinforcement.
- The main technical drawback is fragility, especially shock. Any slightest crack, even invisible to the eye, significantly reduces the strength characteristics.
- A narrow circle of manufacturers.
- Low fire resistance. At 600 ° C begins to soften, which leads to the need to provide protective measures in case of fire.

Another not unimportant problem is the lack of a regulatory framework in our country, which allows manufacturers to widely advertise their products using only their strength advantage.

The use of this type of reinforcement in the reconstruction is primarily due to the simplicity and ease of use, since the external reinforcement elements of carbon fiber are attached to the structure with the help of mounting glue (epoxy, epoxy polyurethane or polycomment), they effectively respond to the increment of structural deformations, and large increments of effort arise in them. It also allows for reconstruction in a short time and with significantly lower labor costs compared to traditional methods. At the same time, although the repair period is reduced several times, the lifetime of the structure also increases several times. The bearing capacity of the structure is not only restored, but also increases several times [6].

Carbon fittings have found wide application in foreign construction practice [7]. Due to a number of positive properties, such as high tensile strength with a sufficiently high modulus of elasticity, corrosion resistance, high fatigue strength, low weight, ease of installation, etc., carbon fiber reinforcement is a good alternative to steel reinforcement both in new construction and to strengthen the structures of a number of existing facilities during reconstruction.

In our country, the use of composite reinforcement has not yet found wide application and is used relatively recently, which indicates the relevance of this topic. However, based on the experience of foreign colleagues, we can

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say that this direction is worth promoting. But It is worth noting that in order to expand the possibility of using carbon fiber reinforcement, it is necessary to study it in more detail, in order to expand the possibility of using it. In the course of further work on this topic, it is planned to resolve the following issues: how to ensure the joint operation of the reinforcement elements and the old structure, how to ensure the strength of the contact, prepare a calculation methodology for selecting the number of reinforcing rods from carbon fibers.

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TECHNOLOGY, MACHINE-BUILDING, GEODESY

UDC 547.97

RATIONAL UTILIZATION OF AGRO-INDUSTRIAL COMPLEX WASTE

KATSIARYNA MAYORAVA,
SIARHEI YAKUBOUSKI, YULIYA BULAUKA
Polotsk State University, Belarus

The article presents the results of the investigation of adsorption activity of iodine and methylene blue from agro-industrial complex wastes: barley husk, radish and peanuts pericarp. It is shown, after the proposed methods for modifying, that microporous structure of the enterosorbents obtained from agro-industrial complex wastes, are close to the industrial enteric sorbents "Polifam", "Polyphepan" and activated carbon.

In conditions of high anthropogenic load on the environment, a number of harmful substances get into bodies of farm animals, and special substances called enterosorbents are used to purify their organisms.

Enterosorbents are medicines that can adsorb various chemicals and biological objects of endo- and exogenous origin in the digestive tract, without reacting with them chemically.

Enterosorbents have a porous structure, it means that there are some cavities in sorbent material in the form of channels-pores. Macropores are distinguished - with a radius of more than 200 nm, mesopores - in size from 100 to 1.6 nm and micropores - with a radius less than 1.6 nm. Micropores adsorb small molecules, while mesopores and macropores adsorb larger organic molecules.

Bonding of adsorbate by the sorbent is dynamic equilibrium process and it can be limited due to the adsorption activity of the sorbent.

Adsorption activity is a property of enterosorbents and is used to characterize adsorption capacity.

According to the chemical structure, enterosorbents are divided into carbon (activated carbon on the basis of birch wood, stone activated carbons on the basis of fruits, shells of nuts, etc.), silicon-containing (hydrogels and xerogels of methyl silicic acid, smectite dioktaedric, attapulgite, etc.) and natural organic (based on dietary fiber, for example, hydrolyzed lignin, chitin, cellulose).

Possibility of obtaining natural enterosorbents for veterinary medicine from agro-industrial complex wastes is represented in the current article.

The following samples of agro-industrial waste were used for investigation: barley husk (Hordeum vulgare), radish pericarp (Raphanus) and fruit pericarps (Arachis hypogaea).

The efficiency of the sorbent's "work" depends directly on its structural and surface properties, therefore, a promising direction in the modification of adsorption materials is to improve the microporous structure, such as grinding and extraction of ballast extractives with water and a dilute alkali solution.

The initial samples were dried to a moisture content of not more than 10% by weight and passed through several stages of crushing: primary grinding on a disk chipper, the second stage, where the particles of the samples were reground to obtain particles of a predetermined granulometric composition up to 1.0 mm, and dry mechanical grinding in a mill. After grinding the samples were subjected to dry fractionation on laboratory sieves, a fraction of 0.25-1 mm was isolated for the study. Then, the samples were processed in three ways:

1) 1 kg of raw material was loaded into an extractor with a stirrer, where distilled water was fed, massed into the raw material: water (1:50) - (1: 100). Process conditions: temperature (23 ± 2) °C and atmospheric pressure. The extraction time is 48 hours with the constant mixing. The solid residue was filtered off with a porous filter and dried at a temperature (103 ± 2) ° C to constant weight. The yield of the sorbent was 82.5% by weight. of the barley husk, 92.3% by weight. % of the radish pericarp and 95.0% of the pericarp of peanuts.

2) 1 kg of raw material was loaded into an extractor with a stirrer, jacket (electric heating) and condenser, where distilled water was supplied, the mass ratio of raw materials: water (1:50) - (1: 100). Process conditions: temperature (100 ± 5) ° C and atmospheric pressure. The extraction time is 3 hours; the mixing is constant. The solid residue was filtered with a porous filter and dried at a temperature of (103 ± 2) °C to constant weight. The sorbent yield was 81.1% by weight. of the husk of barley, 91.2% by weight. % of radish pericarp and 85.5% of peanut pericarp.

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3) 1 kg of raw material was loaded into an extractor with a stirrer, jacket (electrically heated) and reflux condenser, where 1 ... 1.5% aqueous sodium hydroxide solution was fed, the mass ratio of the raw material: sodium hydroxide solution (1:50) - (1: 100). Process conditions: temperature (101 ± 2) °C and atmospheric pressure. The extraction time is 1 hour; the mixing is constant. The solid residue was filtered off with a porous filter, distilled water was washed until neutral and dried at a temperature (103 ± 2) ° C to constant weight. The sorbent yield is 39.5% by weight. of the husks (husks) of barley, 45% of the mass. % of radish pericarp and 56.6% of peanut pericarp.

For the obtained products, the adsorption capacity of iodine (according to GOST 6217) and methylene blue (according to GOST 4453) was determined by the titrimetric method.

Results, their discussion and perspectives. The greatest potential yield of enterosorbent from the three proposed methods, was obtained by the first method. Such ballast extractives as monosaccharides, dyes, glycosides are extracted mainly with cold water. A smaller yield of the sorbent obtained by hot water extraction according to the second method was due to removing monosaccharides, glycosides, proteins, amino acids, pectic substances and mono-oligo- and polysaccharides. The enterosorbent yield is 40-57% by weight from the investigated wastes of the agro-industrial complex was obtained by the third method. By using an aqueous sodium hydroxide solution according to the third extraction method, the following substances can be isolated: resins, fats, polyphenolic acids, lignohumic substances, low molecular weight lignin, poly-saccharides.

Electron microscopic examination showed the presence of micropores measuring 0.3-1 nm, transient pores, less than 3-5 nm in size and macropores, whose size is within the range of 5-50 nm.

Table 1 presents the generalized data on the adsorption capacity of iodine and methylene blue.

Table 1. – Adsorption capacity of iodine and methylene blue

Sorbent	Adsorption capacity			
	Initial form	The first method. After cold-water extraction	The second method. After hot-water extraction	The third method. After alkali extraction
Adsorption capacity of iodine, %				
Radish pericarp	24,36	24,78	26,88	28,98
Barley husk	22,37	22,47	23,52	28,56
Peanut pericarp	17,15	19,47	21,00	24,56
Adsorption capacity of methylene blue, mg/g				
Radish pericarp	146,23	195,23	195,61	225,10
Barley husk	95,11	143,33	180,00	210,00
Peanut pericarp	62,50	71,25	159,17	174,17

Adsorption activity of iodine characterizes the volume of micropores (about 1 nm) and, accordingly, the ability to sorbitolize relatively low molecular organic substances [1-6]. From Table 1, it can be seen that, according to this indicator, these samples are approaching industrial enterosorbents, for example, Belarusian enterosorbent "Polifam" (adsorption activity for iodine is 24.16%) and Russian brand "Polyphepan" (29.63%), that indicates the development of the porous structure of the residues using the proposed methods 1-3.

The adsorption capacity of methylene blue allows us to estimate the content of the microporor in the sorbent with effective diameters of 1.5-1.7 nm. From Table 1 it can be seen that the processing of samples with distilled water and dilute alkali results in the formation of additional pores up to 1.7 nm. It should be noted that according to this indicator, the sorbents obtained by the third method from radish and barley husks are more effective than the commercially produced enteric sorbents with activated carbon (210 mg / g) and Polyphepan (125.8 mg/g).

Thus, the perspective direction of utilization of the waste of the agro-industrial complex is their use as energy sorbents for veterinary medicine.

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VARIETY OF HEAVY RESIDUAL OIL APPLICATIONS

ALENA SHULHA, NATALLIA VASHKOVA, SIARHEI JAKUBOVSKIJ
Polotsk State University, Belarus

Increase in production of ethylene and other lower olefins by thermal pyrolysis of hydrocarbonaceous raw puts forward a problem of effective schemas development to reprocess liquid pyrolysed species, in particular the fraction which is boiled out at above 180°C- heavy residual oil(HRO).

It is established that heavy residual oil which is formed during pyrolysis of different hydrocarbonaceous raw, have close characteristics – approximately identical elementary and group structures [1]. Principal components of these hydrocarbons are the bicyclic and tricyclic aromatic hydrocarbons and hydrocarbons containing a large number of cycles.

It is believed that HRO can be rationally used in two ways – as a fuel and as a chemical. In the first case HRO is a component of fuel oil, in the second case HRO serves as valuable petrochemical raw material for production of needle coke, carbon, soot, fiber-forming and electrode pitches, glass carbon, components of varnishes, impregnating, structural and other materials [2].

One of a HRO applications without its division into separate fractions is to produce softeners for concrete mixes (sulphonation reaction of concentrated sulfuric acid with the subsequent neutralization of the received sulfur weight by alkaline reagents [3]. Softeners allow to dilute concrete mix and to make further processing convenient. Use of softeners is quite universal: with their help it is possible to increase density (water tightness) and durability of concrete, having reduced the amount of water in mix when maintaining its mobility and to receive concrete with low contraction.

Surface-active substances can also be obtained from HRO by means of the reaction of alkylderivative polycyclic hydrocarbons which are contained in HRO with toxilic anhydride. For this residual oil is heated with toxilic anhydride and then the received product is sulphurized by concentrated sulfuric acid with the subsequent neutralization of sulfur weight by alkaline agents [4, 5].

Heavy residual oil is used as one of antiseptic components for wood steeping. Antiseptic impregnation compounds are used for protection against biodestructions [6].

Authors of work [7] suggested using HRO to receive oil naphthalene. For this purpose the long naphthalenic fraction which is boiled out within 205–230 °C has to be used.

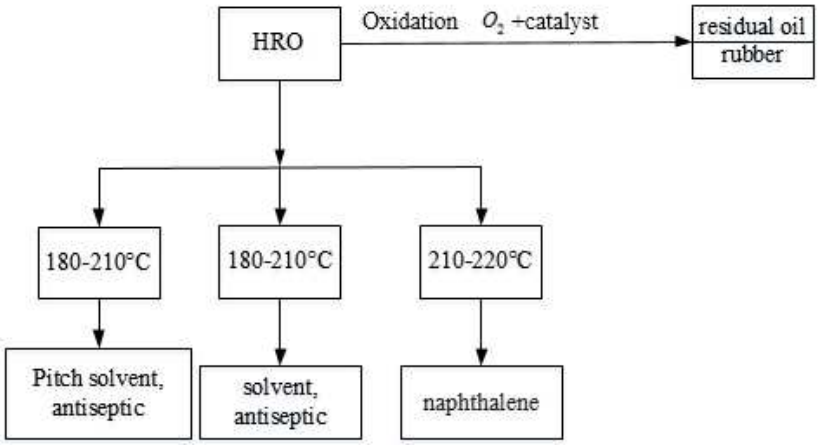

Figure 1. – At HRO distillation by Engler

Operational analysis of pyrolysis units allowed the authors of work [8] to reveal, that in a petrol column the intermediate fraction of HRO can be selected, which contains naphthalene (from 30 to 55% of mass) depending on the tapping point.

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The way of receiving naphthalene without use of larger energy-intensive and resource-intensive processes is found [9–11]. This way allows receiving naphthalene of higher quality that positively affects use of HRO as raw materials for receiving naphthalene.

One of the current problems is the deficiency of needle coke at the refineries. Its production affects the development of electrode industry. Needle coke is used to obtain high-quality graphitized electrodes. Electrodes have to have high mechanical strength, an electrical conductivity, low content of sulfur and low critical temperature of dissolution.

To obtain needle coke from HRO the fraction which is boiled out at above 230 °C is used. The received pitch is diluted with solvent. At a temperature of 120–140 °C phase separation occurs into extract and raffinate. Solvent is released from extract and coking of extract is reached at temperature of 502 °C [12].

This short review shows that heavy residual oil has a wide variety of applications in petro-chemistry, electrode industry and other areas. Use of this resource is expedient as further processing of heavy residual oil becomes profitable and efficient.

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ANALYSIS OF THE LIFE CYCLE OF EQUIPMENT OPERATING UNDER EXCESSIVE PRESSURE AT AN OIL REFINERY

KONSTANTIN KOZHEMYATOV, YULIYA BULAUKA
Polotsk State University, Belarus

In the paper results of a comprehensive analysis of the life cycle of equipment operating under excessive pressure at the Belarusian oil refinery are considered. The analysis showed that nozzles with conditional passage up to DN100, as well as the parental metal and metal of the welds of the body of various equipment are subjected at a high risk to increased wear during operation.

Every year around 20,000 major accidents occur in the oil and gas industry in the world, and in recent years there has been an increase in the accident rate in the oil refining industry. Belarus pursues a targeted state policy in the field of industrial safety [1, 2]. However, the number of accidents at work continues to be a complex socio-economic problem [3–13]. Oil refineries are among the most fire and explosion exposed objects, emergency depressurization of process equipment can cause a major accident with attendant emissions of toxic substances, destruction and damage of expensive equipment, process stops, fires and explosions.

Using retrospective methods of analysis, for the period since 2008 till 2018 specifics of repairs, defectoscopy and ways to improve reliability and maintenance-free operating time for columns, reactors and heat exchangers used at the Belarusian refineries have been studied.

With the purpose to assess the current state of equipment during shutdown repairs, as well as during technical diagnostics, to determine the suitability for further operation and to extend the life cycle of equipment that has worked for a standard period the following combination of non-destructive testing methods is used:

- visual inspection in accessible places;
- ultrasonic thickness measurement of housing elements and nozzles;
- ultrasonic defectoscopy of welds, as well as control of the continuity of the base metal;
- color flaw defectoscopy;
- Hydrostatic test and density test.

According to the data for 2018, more than 3,700 units of equipment operating under excessive pressure have been installed on the territory of the studied enterprise. And more than 3,200 units are in operation. They can be classified by type in the following way:

- heat exchange equipment (37%);
- equipment of capacitive type (41%);
- filters (7%);
- column type equipment (6%);
- separators (6%);
- reactor type equipment (2%).

The largest portion in the overall structure belongs to capacitive and heat exchange equipment.

The most common reason for the repair of column-type equipment is the replacement of unions with conditional passage up to DN100 (37% of the scope of work), replacement of internal devices (23% of the scope of work), replacement of unions with conditional passage of DN100 or more (21% of scope of work). Less often repair of the base metal and metal of the body welds (about 19% of the work) is performed.

The most common type of repair of separators is the replacement of unions with conditional passage up to DN 100 (76% of the work). A small percentage falls on other types of repairs.

The most frequent repairs on filters are replacing of unions with conditional passage up to DN100 (71% of the scope of work).A small percentage falls on other types of repairs, which is due to the low average service life of this type of equipment.

The most frequent type repairs of reactors is the repair of the base metal and the metal of the welds of the protective casing (75% of the work), 13% of the work falls on the replacement of internal reactor devices.

The most frequent are the repairs of equipment of the capacitive type, including the replacement of fittings with conditional passage up to DN 100 (70% of the work). It takes 15% of scope of work to be carried out for replacing the unions with a conditional passage of DN100.

The most frequent type of repairs of heat exchange equipment is the repair of the base metal and metal of the body welds (31% of the scope of work), replacement of unions with conditional passage up to DN 100 (30% of the scope of work) and replacement and repair of distribution chamber partitions (24% scope of work).

To minimize the number of repairs of base metal and weld metal, it is necessary to strengthen the input control for newly installed equipment, strengthen control over the selection of material for a specific working

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environment and operating parameters such as temperature and pressure, ensure strict adherence to process regulations, and apply for newly designed equipment, modern technical solutions to minimize the number of stagnant zones.

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POLYMER-MODIFIER FOR THE ROAD BITUMEN MANUFACTURE OF THE FOURTH GENERATION

YULIYA BULAUKA, TATSIANA LEBEDZEVA
Polotsk State University, Belarus

The article describes a polymer-bitumen composition based on petroleum road bitumen and a polymer modifier obtained from petrochemical wastes, which is distinguished by the use of cheaper and more accessible components compared to industrially used analogs. Moreover, it approaches the requirements for modified bitumen in terms of its basic performance indicators, ensuring their reliable operation in the composition of asphalt concrete mixtures.

In the recent years, two contradictory trends have been observed in the production of road bitumen by the method of air oxidation. On the one hand, road bitumen consumers require the manufacturer to improve the quality of road bitumen. The reason for this is the growth of the vehicle fleet and increasing load on the road bed. In this regard, a new standard GOST 33133 was accepted. It establishes stricter requirements for the quality of road bitumen. On the other hand, the deepening of oil refining at oil refineries changes the ratio of the main components in tar and creates significant difficulties in obtaining high quality commercial bitumen by direct air oxidation. All this demands modernization of the existing refinery industries to produce road bitumen that meets the requirements of the new GOST 33133, while bitumen production, unlike that of light oil products, does not make much profit for oil refineries. Therefore, such upgrades are mostly unprofitable [1-2].

From a technological and economic point of view, it is advisable to obtain polymer bitumen compositions in order to improve the operational properties of bitumen for road construction. Polymer-modified bitumens provide a high level of performance indicators, such as heat resistance, resistance to shear, long-term strength and resistance to low-temperature cracking. Currently, more than 10% of road bitumens produced in European countries contain polymer additives. However, the use of polymers is one of the most expensive ways to modify them; the introduction of a small amount of polymers into bitumen increases its cost more than twice [3].

The aim of this study is developing a polymer-bitumen composition based on oil road bitumen and a polymer modifier. The latter is obtained from petrochemical waste of polymer production, which differs by the use of cheaper and more accessible components compared to industrially used analogs. In terms of its main performance indicators it approaches the requirements for modified road bitumens, ensuring their reliable operation in asphalt concrete mixes. It has been determined that the joint influence on the bitumen structure of the components of the combined polymer-modifier additive allows to increase the softening temperature and at the same time the needle penetration depth. It also increases elasticity, lowers the brittleness temperature, ensures the plasticity interval and penetration index required by the standards, improves adhesion to the surface of mineral materials, with the satisfactory resistance of the polyethylene bitumen composition to aging. All these factors brought together will increase strength and heat resistance of the polymer EP-bitumen compositions, as well as plasticity, elasticity, frost resistance, which allows to predict high quality of the road surface.

Modification of bitumen was carried out by hashing components in metal capacity at a temperature of receiving asphalt concrete of 130-160 °C within 30 min. an anchor mixer with a speed of rotation of 60 rpm [4-7]. During the research of the modified bitumen standard methods of definition were used:

– softening temperatures on a ring and a sphere in accordance with GOST 11506;
– tensile properties at + 25 °C according to GOST 11505;
– penetration according to GOST 11501;
– temperature of fragility according to GOST 11507;
– index of penetration according to GOST 22245;
– solidification resistance at 163°C according to GOST 18180;

It has been revealed that a synergistic effect leading to an improvement in the properties of polymer-bitumen compositions occurs only after pre-mixing the components of the polymer modifier and plasticizer and their subsequent heat treatment, and at the temperature of 100-120 °C for 90...120 minutes with constant stirring. To bring the main indicators of the quality of road bitumen to modern standards' requirements, it is proposed to use a thermally prepared combined additive with a concentration of up to 3% by weight. The cost of raw components of the combined additive is equal to the cost of the commercial road bitumen itself.

PolotskSU

For industrial implementation it is proposed to use a 1% combined additive obtained by mixing 1 part of plasticizer and 2 parts of polymer production waste. This will bring the main quality indicators of road bitumen of the BND 70/100 (petroleum road bitumen) in the line with the requirements of modern standards, the actual values of the proposed polyethylene bitumen composition are given in table 1.

Table 1. – Actual quality indicators of Bitumen BND 700/100 and polyethylene-bitumen composition based on BDN 70/100

Main indicators	Requirements for BND 70/100		Actual value for BND 70/100	Bitumen composition with 1% of mass additive
	STB EN 12591	GOST 33133		
Penetration according, 0,1 mm at 25 °C (GOST 11501)	70-100	71-100	65,2	86,3
Softening temperatures on a ring and a sphere, °C (GOST 11506)	43-51	>47	44,5	46,5
Tensile properties, cm at 25 °C (GOST 11505)	не норм.	62	61,5	64,5
Temperature of fragility, °C (GOST 11507)	<-10	<-18	-15	-25
Index of penetration (GOST 22245)	-1,5… 0,7	-1…1	-1,46	-0,92
Solidification resistance at 163°C according to GOST 18180:				
changes in softening temperatures, °C	≤9	≤7	4	7
changes in the mass, %	≤0,8	≤0,6	0,06	0,03

The joint effect of the components of the combined additive on the structure of bitumen can significantly increase its strength and heat resistance, resistance to rutting at elevated temperatures, as well as plasticity, elasticity and crack resistance; improve adhesion of mineral materials to the surface, which allows to predict high quality of the road surface. Polymer production wastes are promising modifiers in polymer-bitumen materials production.

The proposed polymer-bitumen composition differs from industrially used analogs by the use of cheaper and more accessible components, and in terms of its basic performance indicators it approaches the requirements for modified road bitumens, ensuring their reliable operation in asphalt concrete mixtures.

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CONSIDERATION OF SAFETY INDICATORS IN SELECTING AUXILIARY SUBSTANCES FOR CHEMICAL-TECHNOLOGICAL PROCESSES OF OIL REFINING

DZMITRY RYMARAU, MIKHAIL SKRYPKO, YULIYA BULAUKA
Polotsk State University, Belarus

The paper gives study results on the indicators in accordance with which the selection of auxiliary substances (reagents) for chemical-technological processes of oil refining is carried out. Methods of expert assessment for decision-making based on multi-criteria parameters are proposed.

Emergency depressurization of process equipment at hydrocarbon processing plants can cause a major accident with attendant emissions of toxic substances, destruction and damage to expensive equipment, process stops, fires and explosions [1].

Currently, when selecting auxiliary substances (reagents) for chemical-technological processes of oil refining, technological parameters (flow, concentration, corrosivity, rheological properties, thermal and chemical stability, impact on the quality of the target product and its output, etc.) and economic indicators (cost, availability, etc.), almost without taking into account the indicators characterizing the impact of reagents on workers and the environment (the threshold limit value (TLV), hazardous materials (HAZMAT), toxicity, etc.). This circumstance determined the purpose of this study, which is to study the procedures and indicators in accordance with which the selection of auxiliary substances (reagents) for chemical-technological processes of oil refining and the development of expert assessment methods for decision-making taking into account the multi-criteria parameters is carried out.

Problems of choice of reagents and the need to take into account indicators characterizing safety arise at the design stage of the chemical process, for example, the choice of isobutane alkylation catalyst with olefins or concentrated sulfuric acid (2nd class HAZMAT) or hydrofluoric acid (1st class HAZMAT); solvent selective purification of petroleum oils (phenol (2nd class HAZMAT), furfural (3rd hazard class) and N-methylpyrrolidone (4th hazard class), comparative technological indicators are given in Table 1); alkanolamines for the desulfurization of hydrocarbon gases (monoethanolamine (2nd class HAZMAT), diethanolamine (3rd class HAZMAT), methyldiethanolamine (3rd class HAZMAT), the comparison of physicochemical properties is given in Table 2); hydrogen sulfide scavengers from fuel oil, etc.

An analysis of the practice of using reagents in existing plants shows that often more toxic and hazardous excipients are preferred. It should be noted that exports in the conditions of multi-criteria technological and economic parameters are difficult to make a choice in favor of one or another reagent.

Currently, various expert assessment methods are used for decision-making: operations research method, utility theory method, hierarchy analysis method, use of fuzzy set theory elements, their combination (fuzzy hierarchy analysis method) and others [2-8], method of accounting for safety indicators when choosing reagents for chemical-technological processes of oil refining using elements of the theory of fuzzy sets.

Table 1. – Comparative technological indicators of solvents for selective purification of oils

Indicators	N-methylpyrrolidone	Phenol	Furfurol
Molar mass, g·mol^{-1}	99	94	96
Density at 66 °C, g/cm^3	0.996	1.040	1.110
Kinematic viscosity at 50 ° C, mm^2/c	1,01	3,24	1,15
Digule moment, Db	4,10	1,70	3,57
Boiling point Melting point Flash point	204 -24,2 91	182 +41,1 79	162 -38,6 59
Surface tension at 20 °C, мН/м	39,9	38,2 (50 °C)	43,9
Solubility in water, %	100,0 (20°C)	100,0 (above 66°C)	100,0 (20°C)
Formation of an azeotropic mixture with boiling water	No	Yes	Yes
Heat of evaporation, kJ / kg	493,1	479,1	451,1
raw materials consumption, kg/t	0,1	0,4	0,8
TOE/t raw material	0,83-1,24	1,65	1,24

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Table 2. – Physico-chemical properties of alkanolamines

Indicators	Monoethanolamine (MEA)	Diethanolamine (DEA)	Methyldiethanolamine MDEA
Molar mass, g·mol^{-1}	61,1	105,1	119,2
Density at 20 °C, g/cm^3	1,015	1,011	1,030
Boiling point congelation	170,3 10,3	268,4 27,5	231 –21
Vapor pressure at 60 ° C, Pa	860	4,7	27
Dynamic viscosity, kPa/s (at Temperature)	18,9 (25°C)	352 (30°C)	101 (20°C)
Specific heat capacity, kJ/(kg˚C) (at 30 °C)	2,72	2,47	1,71

The following successive steps are provided: to determine the input variables of technological, economic parameters and safety indicators; to fuzz the input data by finding the values on the corresponding graphs of the term membership function; determine the degree of truth of conditions for each of the rules of fuzzy inference systems; construct the resulting membership functions for the output parameters, taking into account the degree of truth of all production rules; calculate the resulting (clear) value of the output variable by defuzzification using the center of gravity method; decide on each reagent.

The technique allows us to unify the procedure for selecting a reagent for chemical-technological processes and it is reasonable to determine the auxiliary substance that is most preferable, taking into account technological and economic parameters and safety indicators.

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METHOD TO REDUCE FREEZING AND IMPROVE DUST SUPPRESSION WHEN RECEIVING AND TRANSPORTING PETCOKE

VIKTORYIA LIAKHOVICH, YULIYA BULAUKA
Polotsk State University, Belarus

The paper describes a method for reducing the freezing point and for improving dust suppression when receiving and transporting petroleum coke, which consists of its refinement using the proposed remedy from residual refined products.

Petroleum coke (petcoke) is a solid product of the refining process. Many products are derived from a barrel of crude oil (e.g. gasoline and diesel) and petcoke is one of those products. Petcoke is a valued commodity around the world and there has been a global market for petcoke for decades. Fuel grade petcoke is an essential fuel that is used in industrial applications and manufacturing processes including the production of steel, aluminum, and other specialty products. Application of anti-dust chemical agents is normally achieved by combining the chemical into the water spray. The surfactant enhances the wetting by lowering the surface tension of the water thereby allowing the water droplets to penetrate deeper into the petcoke [1].

The use of anti-dust chemical agents may offer the following benefits: have a residual effect of up to 45 days or more for pile integrity, depending on weather conditions and type of chemical used; minimize need for reapplication of water; allow additional coke pile height, if needed; routine cleanup requirements for the coke conveyors may be reduced; maintenance needs within the coke handling facilities may be reduced.

The fight against dust generation during the receipt and transportation of petcoke and the reduction of coke freezing at negative air temperatures is an important task for the Belarusian oil refinery [2-7]. Dusty air can cause emergency situations. A person's prolonged stay in a dusty atmosphere causes occupational pulmonary diseases.

Task formulation - to develop means against freezing, sticking, for dust suppression and reduction of losses from blowing petcoke and coal, during their transportation in conditions of negative temperatures.

The input analysis of raw materials was performed in the laboratory of the Department of Technology and Equipment of Oil and Gas Processing. Compounding of light vacuum gas oil with high-molecular oil residues was performed on a laboratory setup. For the obtained prophylactic agents assumed viscosity at 50 °C (GOST 6258), pour point (GOST 20287), flash point (GOST 6356), determination of water content (GOST 2477), determination mechanical admixtures (GOST 6370) and copper strip test (GOST 6321) were determined.

A prophylactic agent for dust suppression and reducing losses from blowing petcoke upon receipt, as well as against the freezing of coke, sticking during transportation at negative temperatures has been developed on the basis of residual refined products. The process of freezing and sticking to the surface of the gondola cars when watering coal and applying anti-freezing agent is simulated at a temperature of minus 25 °C. The sequence of modeling the process of freezing and sticking of coal to the walls of gondola cars using "Sample 1" is shown in Figure 1.

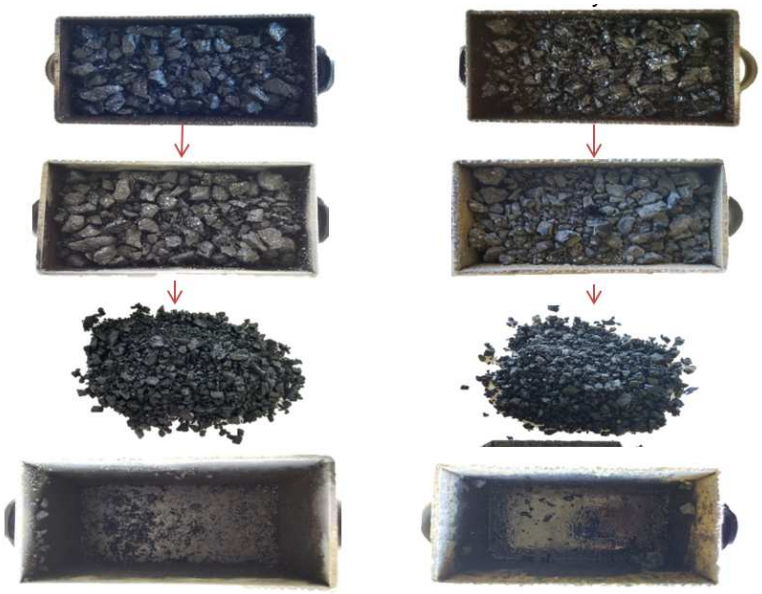

Figure 1. – The sequence of modeling the process of freezing and sticking of coal to the walls of gondola cars

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Comparison of technical and economic indicators of the proposed samples obtained from various petroleum residues (sample 1 and 2) with the industrial analogue are given in table 1.

Table 1. – Technical and economic indicators of prophylactic agents

Indicators	Niogrin PS-35S TC 0258-002-38507925-2012	Offered prophylactic agents	
		sample 1	sample 2
Assumed viscosity at 50°C, GOST 6258, °AV	within 1,0 – 3,0	1,12	1,11
Pour point, GOST 20287, °C	not higher minus 35	lower minus 65	lower minus 65
Flash point, GOST 6356, °C	not lower 40	70	70
Determination of water content, GOST 2477, % of the mass	no more 2,0	0,01	0,01
determination mechanical admixtures, GOST 6370, % of the mass	no more 1,0	trace	trace
Copper strip test, (GOST 6321	stands		
Cost $ / ton	180–200	55	54

It is established that the proposed prophylactic agents do not exhibit corrosion aggressiveness with respect to metal surfaces, do not contain mechanical impurities and water. Samples have sufficiently high flash points that meet fire safety requirements. Also samples are characterized by low pour points allowing them to be used at ambient temperatures below minus 40 °C. The proposed samples are not inferior in performance properties to the analogue "Niogrin-PS 35S" and more than three times cheaper. Prophylactic agents can be effectively used as prophylactic agents against freezing, sticking, for dust suppression and reducing losses from blowing petroleum coke and coal.

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METHODS FOR CAPTURING VAPORS OF PETROLEUM PRODUCTS IN TANK TRUCKS

TSIMAFEI HOLUBEY, ELENA SAFRONOVA
Polotsk State University, Belarus

This article discusses the problem of the environment protection from the vapors of petroleum products during transportation, the design features of tank trucks, and methods of loading.

The American Clean Air Act regulates atmospheric pollution caused by hydrocarbons from industrial enterprises in the country. Studies have shown that up to 95% of all emissions from fuel transportation can be collected for further processing. As a result, the petroleum industry has begun thorough exploration of gasoline emissions their regulation. Although there have been attempts to modify the vapor recovery system when pouring from above, the introduction of a bottom loading method proved the availability of more advanced vapor recovery technology. Today, vapor recovery technology for bottom loading dominates and is used everywhere. [1]

Vapors recovery involves preventing the release of gasoline vapors to the atmosphere during the fuel loading / unloading process. This is called the first vapor recovery stage. It requires vapors to be collected from the underground fuel tank of a maintenance station and taken to a gas station for processing. To perform this operation, some changes must be made to the design of the maintenance station, the fuel tanker truck and the filling station. These changes include the creation of a separate opening for the transfer of vapor to the underground fuel tank. This is called a "two-step" vapor recovery system requiring separate channels for fueling and for vapor collection. The "one-step" system uses one drain hose both for fueling and for vapors collection through a special coaxial crankshaft. "Two-step" systems are preferable, since they have significantly better performance in terms of fuel discharge time [2].

The second stage of vapor recovery involves preventing the release of vapor from the fuel tanker truck using special nozzles and additional changes in the design of the service station.

Fuel tankers are usually divided into chambers, each of which carries different types of fuel. A safety valve at the bottom of each chamber controls the loading and discharge of fuel to / from the chamber. A safety valve is connected via pipes to the bottom of API charging valve (for loading and unloading fuel) [3].

The hatch on the top of each chamber usually has a sampling hatch (for checking or loading "to the eyeballs") and an air vent that is connected to the vapor recovery system. At this stage, a brief overview of the traditional top loading is needed as a historical explanation of the reasons for a change to to the tank loading system from below [4, 1].

In many countries, the traditional technology of fueling tankers from above is still being used now. These gas stations usually have a lifting platform that allows operators to walk on top of the tank, open hatches and pour fuel into each of the chambers. When unloading at a service station, drivers usually have to climb on top of the tank and open the hatches of the chambers in order to:

1. measure the level with a probe;
2. to confirm the station operator that the tank is fully loaded;
3. In order to allow air to get into the chamber when draining the fuel [5, 2, 3].

Hatches are closed successively after the fuel drain operation is completed. Hatches with pneumatic vents are often used to reduce the need for the presence of an operator at the top of the tank (opening and closing hatches).

The problems that arise when pouring from top;

1. Static / dynamic sparks: bursts and turbulence of the fuel flow is formed in the case of static electricity (even if the tank is grounded). Static and dynamic sparks are extremely dangerous and when combined with fuel vapors can lead to disastrous consequences and explosions.

2. Operator safety: Operators may fall off the tank (height is about 3 meters) and be seriously injured. When pouring from the top, operators also inhale vapors that can cause health problems.

3. Fuel pollution: with the open doors of the chambers, the method of loading from above creates an opportunity for rain, snow and wind to blow off and wash the dirt into the fuel, polluting it. Aviation fuel is extremely sensitive to microscopic forms of pollution. Handles, screwdrivers, and cigarettes — all of these items may accidentally fall into the open hatch of a chamber and cause fuel contamination, damage, or malfunctioning of safety valves or other equipment located at the bottom of the tank.

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4. Loss of time: standard top-loading technology requires that only one tank chamber can be filled at a time. During the bottom loading (which will be discussed later), several chambers can be filled simultaneously. A faster discharge process reduces tanker idle time at a gas station and significantly improves delivery efficiency.

The API valve, which was developed for the oil refining industry and fuel transportation technologies with the participation of the American Petroleum Institute (API), plays a key role in tank loading at the bottom. Joint efforts have led to the creation of common technical requirements for the loading valve, as well as to the standardization of connecting elements at filling stations. API valves are located on the bottom of a tank and are connected by a piping system to each chamber. Typically, each chamber has its own API valve. Fuel is pumped through the loading hose of the filling station, through the API valve, pipeline and safety valve into the tank chamber. A safety valve is located at the bottom of each chamber and regulate the loading and unloading of fuel. When loading from the bottom, the chamber is quickly and uniformly filled with minimal turbulence. The unloading by gravity of each of the chambers is accompanied by the installation of drain hoses connected to the API valves, and from the other end to the inlet sleeve of the underground fuel tank [6, 7, 8].

When loading tanks from bottom, it is possible to eliminate all main disadvantages that are associated with loading from above, as well as to catch almost all the vapors of petroleum products while loading and unloading the tank truck [3].

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HOUSING DETAIL STANDARD-SIZED MODEL DEVELOPMENT

YEVGENIY ZHIKHOREV, NIKOLAY POPOK
Polotsk State University, Belarus

Body parts processed in the production of JSC "Izmeritel" have been considered. A standard-sized model of the housing detail for this production was compiled. It is based on the analysis of the structural elements of the details and their sizes.

One of the most important factors that should be considered while designing and creating machine-building production is the size of a product.

The standard size of a product is a product of this type of design with certain values of parameters [1]. The number of production parameters depending on it is large: from the required area for equipment placement to necessary tool. Therefore, when developing a standard model of a product, designers and technologists need to pay considerable attention to the production cost. Knowing in advance what equipment and tools are needed, you can optimize costs and use the savings for other purposes.

Housing parts is one of the types of products for which the creation of a standard-sized model is often required. The nomenclature of this type of parts is very diverse: the housing itself, covers, boxes, slats, panels, etc. In addition, the overall dimensions of body parts can vary from tens to several thousand millimeters. These two features often require a large number of diverse equipment belonging to the same type, for example, several milling machines, with different magnitude of spindle movement.

Creating a standard model is carried out in several stages:

1) analysis of the parts that will be manufactured in production (during its development), or upgrading already manufactured parts;

2) identification of common structural elements (SE) and determining their boundary dimensions;

3) creation of the model with all common SE where the dimensions are determined by the smallest and largest size for each specific element.

The use of the obtained standard-size model, as well as its change when new products appears, allows us to simplify the procedure of tools and equipment selection, as well as to reduce the time of organizing new manufacturing process for producing items included in this model.

As an example, a standardized product was developed on the basis of a body parts processed in the production of JSC «Izmeritel» analysis. The resulting model is presented in Fig. 1.

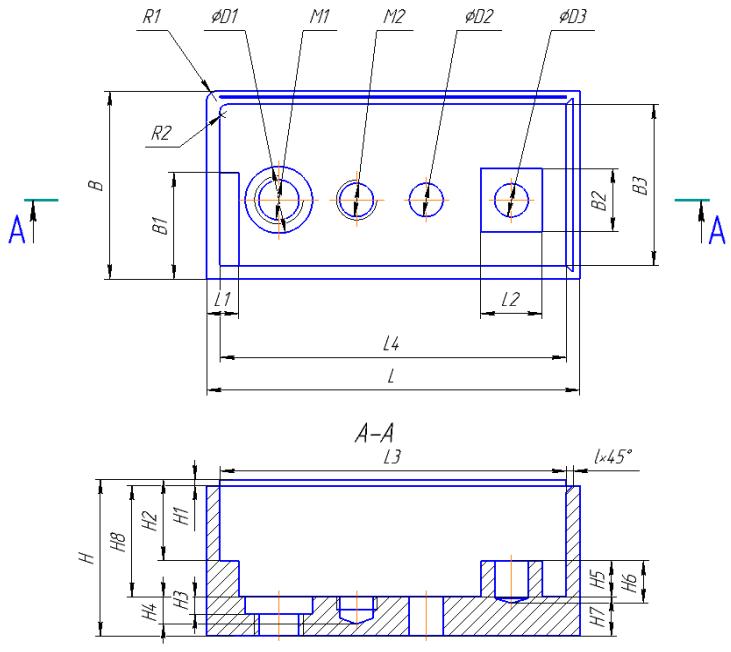

Figure 1. – Standard model of a housing detail

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As it can be seen, a standard-sized product is a housing detail, with the design including many structural elements belonging to this type of product: chamfers, pockets, roundings, holes of various types, lugs, shoulder, etc.

The boundary values of dimensions indicated in the drawing are presented in Table 1.

Table 1. – The limits of the dimensions of the CE model size

CE	Designation on the drawing	Size, mm
Main dimensions	L; B; H	100...585; 52...395; 5,5...89
External and internal rounds	R_1; R_2	0...10; 2...6
Pocket	B_3; L_4; H_8	36...560; 42...370; 3...74
Ledge	B_1; L_1; H_2	0...120; 0...60; 0...34
Boss	B_2; L_2; H_5	0...65; 0...65; 0...28
Shoulder	L_3; H_1	0...540; 0...3
Chamfer	lx45°	0...5x45°
Step hole	D_1; H_7; H_3	0...66; 0...15; 0...8
Through hole	D_2; H_7	0...28; 0...30
Blind hole	D_3; H_6	0...16; 0...45
Threaded hole	M_2; H_4	0...M8; 0...36
Threaded through hole	M_1; H_7	0...M8; 0...40

Using and analyzing this model we can decide what equipment and tools are needed for processing, mainly:

- three- and four-coordinate milling machines of horizontal or vertical type;
- face mills with a diameter of 40 ... 50 mm;
- end mills with a diameter of 1 ... 20 mm;
- spiral and centering drills;
- threaded mills and machine taps;
- in some cases cone and radius cutters.

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THE ESTABLISHMENT OF OPTIMAL CONCENTRATIONS OF NANODIAMONDS IN OIL TRIBOPARS BREAK-IN MODES

DZMITRY LAPATSIN, YURY HAS, ANASTASIYA HUSHCHA
Polotsk State University, Belarus

The article shows the studies of tribopairs with different modes of operation and in the presence of oil with different nanodiamond content, which reveal optimal concentration of nano-sized components. The most optimal mode of operation is also provided.

A life span of friction units of machines is largely determined by the performance of used lubricants. Modern development of technology is associated with an increase in speed and load on friction units, which makes it difficult to solve the problem of ensuring the desired durability of a tribo-conjugation, taking into account the interdependent parameters of the tribounit-maintenance complex technology [1].

To improve the performance properties of a friction surface, it is necessary to further increase the wear resistance of mating surfaces, which requires the development of new lubricants that have an increased load capacity and ensure low wear rates [2].

Recently, attempts to improve the properties of oils by introducing various additives into their composition have become more widespread. The use of additives in oils, and, above all, the joint introduction of additives and fillers, allows the most flexible regulation of the structure of oils. Work on the use of various kinds of nano-sized components as solid additives is becoming increasingly scientific and practical. Their use results in a new qualitative level in comparison with previously used additives. One of the promising areas is tribomodification with nanoscale diamond-containing additives.

Nanocomponents contribute to a significant decrease in the coefficient of friction and wear of the rubbing surfaces. Nanocomponents are detonation nanodiamonds 4-5 nm in size. Their properties in suspension make it possible to form a multitude of microscopic tribofilms on friction surfaces. Microfilms of nanocomponents significantly increase the shelf life and beneficial properties of lubricants used [3].

Task formulation is studying of the effect of the concentration of nano-sized components in oil and operating modes of a tribopair on the degree of wear of friction surfaces

Results and discussion Base oil I20 was used as the main oil (industrial type mineral oil with kinematic viscosity – 29-35 mm/s at 40 °C). The remaining types of oils were obtained by adding nanocomposites to the composition of the I20 oil in an amount from 0.09% to 0.9%.

The studies were carried out according to the "pin-on-disk" friction scheme. The indenter is made of steel ШХ – 15 in the form of a rod Ø 3 x 15 mm, the material was in the annealed condition (heat treatment mode: quenching - annealing at a temperature of 700 – 720 ° C; specimen hardness 25 – 27 HRC). As a counterbody, a disk Ø 70 x 6 mm from hardened steel ШХ – 15 (hardness 57 – 61 HRC) was chosen.

Tribological tests were carried out on a universal friction machine MODEL: MMW-1A of a vertical type with computer control. This model allows you to keep the load force constant with a deviation of ± 2 N. The relative error in measuring the friction force did not exceed ± 2% in the liquid lubrication mode.

Before conducting the study to reduce the surface roughness and, as a result, to improve the accuracy of the data obtained, the samples were subjected to grinding on emery paper with P600 grit.

The main mode of operation was mode with the following parameters: loading force: 212 N; unit load: 10 MPa; sliding speed: 0.2 m / s; distance traveled by samples: 3000 m.

During the tests, the values of the friction force and the friction coefficient with a frequency of once every 1 s were recorded in real time with the ability to save to a file. The obtained data were accumulated in a graphical and textual form and, after approximation, were analyzed.

The imprint method was used to measure wear. The essence of this method is to measure the size of a print before and after testing. After this, the size difference is recalculated to get absolute wear. The size of the prints was taken every 1000 m.

As a measurement equipment, a BUEHLER Model No 1105D microhardness tester was used to determine the Vickers hardness using a pyramidal indenter with an opposite angle of 136 °.

Analysis of the obtained data showed that the highest lubricating properties in this mode of operation are manifested in oils with a nanodiamond content of 0.36% – 0.45%. At lower concentrations, the maximum effect is not achieved, and an increase in the percentage does not lead to a significant decrease in the friction coefficient.

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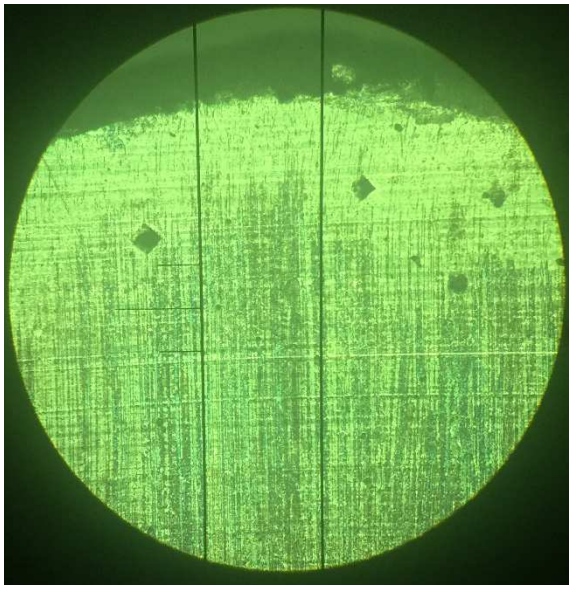

Figure 1. – Friction surface of steel samples ШХ-15 with printed prints

During the tests, the following modes of operation were also considered:

– 1st: loading force 636 N; unit load: 30 MPA; sliding speed: 0.5 m / s; distance traveled by samples: 3000 m.

– 2nd: loading force 636 N; unit load: 30 MPA; sliding speed: 0.1 m/s; distance traveled by samples: 3000 m.

Under these modes of operation it was impossible to determine the wear, because after passing 2000 m, the prints were completely erased.

In addition, in the basic mode of operation, the nature of friction was found to depend on the thickness of an oil layer. With an insufficient thickness, dark wear strips are formed on the samples.

Figure 2. – Dark wear stripes on specimens

In the zone of these dark stripes it was impossible to determine the size of the prints, and as a result, find out the degree of wear. The appearance of dark stripes is associated with a worsening of lubricant leaking into the tribocontact zone and a violation of the lubrication conditions of the friction pair due to the viscosity of the lubricant, as a result of which dry friction occurred in the contact center. The same phenomenon was observed when testing oil with a nanodiamond content of 0.09%. Moreover, in the latter case, an increase in the thickness of the oil layer did not give positive results.

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In the main mode of operation, the range of optimal concentration of nanodiamonds coincided with the data obtained in [4] with the unit load of 1 MPa and the speed of 1 m / s. This is explained by the fact that a number of oils with different concentration of nanodiamonds between successive samples of 0.09% were used for the study.

Studies of tribopairs with different modes of operation and in the presence of oil with different nanodiamond content showed that the optimal concentration of nano-sized components in the oil is 0.36% – 0.45%. The most optimal mode of operation is a mode with the specific load of 10 MPa.

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ABOUT THE APPLICATION OF THE PRINCIPLES OF THE ACCELERATION OF A LIQUID FLOW IN A HELICAOID PIPE TO THE MAIN PIPELINE TRANSPORT

RUSLAN CHARNIAUSKI, ALIAKSEI VARONIN
Polotsk State University, Belarus

This article is devoted to discovering the principles of a liquid flow in a helicoid pipe to the main pipeline transport. The main idea of a helicoid pipe was given. The advantages and the disadvantages of the applicability of such kind of pipe in the main pipeline transport were formulated. It is also proposed to learn deeper the possibility of application the helicoid pipes in the liquid environments.

Victor Schauberger (June 30, 1885 – September 25, 1958) is a great Austrian inventor, physicist, naturalist and philosopher whose works are important for hydraulic science. Working as a huntsman in a logging company, Viktor Schauberger, back in the distant 30s of the last century, received a patent that applied only to the water transport of logs, coal and ore. This scientist designed and installed water gutters with spiral notches similar to gun rifles. He showed that when rotating water decreases hydraulic resistance.

A special feature of the Schauberger's built system of rafting logs was the form of this system - most of all it resembled the natural bends of a river, and not straight segments as the shortest distance between two points. In the section of the gutter there was also a rounded shape, but not a part of the circle. According to Schauberger, observations of the natural water flows in streams and rivers prompted him to reflect on the principles of creating such a system.

Schauberger's invention is a ready-made technical solution to increase the capacity of any pipeline. According to the professor of hydrodynamics, Poppel from Stuttgart (Germany), as a result of his experiments, conducted in the 50s of the last century, in some helicoidal pipelines under certain pumping modes of ordinary water, it is possible to significantly reduce the hydrodynamic resistance of a fluid flow.

The ideas of the Austrian inventor Viktor Schauberger are extremely important for the designers of modern gas pipelines, oil pipelines, water lines of hydro stations and all other types of pipeline transport. We are talking about using the phenomenon of swirling flow in pipelines, which is still not used as a positive effect. This approach can be used to reduce the dynamic resistance of main pipelines and water lines of hydroelectric power plants. Swirling the flow along the central axis using elementary butterfly inserts or placing a curled spring inside the pipe can significantly reduce the energy costs of moving the contents of any transport pipe. The cost of upgrading the transport pipe is minimal. At the moment, a huge part of the energy, produced in the world, is used precisely for pumping oil and gas products. Reducing these energy costs through trunk transportation, even if only by a few percent, can be of immense importance.

The main parameters associated with the operation of a modern transcontinental high-pressure gas pipeline are approximately as follows: the diameter of the transport pipe is up to 1420 mm, the wall thickness is about 18 mm, the pipe is designed for a potential pressure of 75 atmospheres, the speed of the transported gas is up to 90 km per hour, the gas temperature after the compressor rises at 20 degrees, the standard distance between compressor stations is 100-200 km. When installed inside the segments of the pipeline twisting inserts butterflies can achieve an angular velocity of the axial rotation of the transported gas up to 300 revolutions per minute. Centrifugal forces provide a long central axial channel with reduced pressure and dynamic resistance. The same effect can be achieved with the help of a regular spiral inserted inside the pipe. The effect of the twist depends on the diameter of the pipe, the cross section and pitch of the helix, the viscosity of the working fluid, speed, temperature and pressure.

When a fluid or gas moves in such tubes with butterflies-inserts, a long dynamic spiral helicoid is formed inside the tube, along the axis of which an abnormal increase in the kinetic energy of the fluid or gas occurs. This profile of the pipe, called the helicoid, was first described and made by Viktor Schauberger, denoting it as a profile resembling the shape of the horns of the African antelope Kudu.

With the same cross-section of 2 pipes and the same pressure of the working fluid, they produce completely different velocity and flow rate in a laminar and turbulent-swirling axial flow, which is a helicoidal movement of the fluid. The total water flow in a pipe with a screw twisted flow will be higher, and this effect is created for the following reasons.

The first reason is that the cause of any fluid movement lies in the pressure inequality on its boundary surfaces. This pressure inequality is the driving force for the fluid. The movement itself is directed towards less pressure. There is a direct ordering of the Brownian motion of a liquid or gas in the whirl of a vortex. Chaotic

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vectors of thermal motion of molecules line up strictly parallel to the axis of rotation. For example, bullets or projectiles in the rifle barrel also behave as they move in axial rotation, so that real ammunition acquires much higher energy and in the end swirling bullets and projectiles simply fly farther.

The second reason is that centrifugal forces right in the center creates a discharge zone, where most of the working fluid has the least hydrodynamic resistance. The central axis of the vortex in the pipe is a zone of anomalous flow acceleration. The temperature of this flow in the center decreases somewhat, since this part of the thermal energy of the flow is used for its self-transportation.

Schauberger's ideas can be used to supply water from a reservoir to hydro-turbine hydroelectric power plants. According to the source [2], with a helical twist of water flow, the kinetic energy of a real water flow can be increased by about 2 times, and therefore the height of the dam can be reduced by 2 times, while maintaining the same power of the electrical units.

A mathematical model of this kind of transformation of fluid motion was first developed by a Russian scientist, prof. I.S. Gromeka (1851 – 1889) in the work: "Some cases of motion of an incompressible fluid" (1881), but was unjustly forgotten. A talented prominent Russian scientist A.Ya. Milovich devoted his entire scientific life to the study, development and promotion of hydrodynamics of a vortex motion. Professor Milovich went further, and from the complex mathematical model of a screw motion, I.S. Gromeki turned to real hydrodynamic models and calculations of physical processes.

The helical motion of a fluid is a motion in which the lines of the vortices at all their points coincide with the lines of the currents. Each fluid particle not only moves progressively along its path, but also rotates around the axis of a tangent to this path at the point of position of the particle itself. In natural phenomena, this happens literally. When changing the boundary conditions and the appearance of an obstacle or interface in the flow path of a fluid flow, the fluid tries to maintain the absolute speed of movement of its particles and at the same time ensure a zero penetration rate deep into this surface. Fluids in the literal sense of the word have to begin to twist and wriggle out of themselves in the form of spirals, forming vortex cords, rollers, along which the flow rolls along the interface. This natural mechanism of transformation of the flow when the external conditions change with the conservation of the energy of the flow is realized by a screw motion.

The result of this rotation is a shift of successive layers of fluid relative to each other in the direction normal to the translational velocity, which causes the movement of all its mass in the plane normal to the main direction. There is a rotation of the flow around its longitudinal axis, and the kinetic energy of this movement is exactly equal to the kinetic energy of the longitudinal flow.

The theory of the screw movement of a fluid gives the possibility of significant penetration into the mechanism of turbulence, as in the mechanism of overtones when considering sound, therefore there is reason to think that studying this type of motion will really bring us closer to a true understanding of the phenomena we observe in liquids.

The domination of the fluid flow in hydraulics and the reliance on the loss of pressure only viscosity and friction made the idea of the vortex motion of the fluid not fully taken into account and therefore not part of the kinetic energy of the transverse circulations of the fluid its vortex motion is used.

The idea of combining translational and rotational motion for liquid and gas is very effective and this idea is already fully applicable for wide use in any kind of modern pipeline transportation. However, the idea of real use of axial rotation of the fluid during the operation of the main pipeline transport is currently not used due to the complexity of the implementation in the manufacture of pipes, cleaning the pipe cavity from sediments, conducting intra-inspection pipe inspection and therefore at the present stage is in the theoretical plane without leaving beyond the scope of practical application.

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OPPORTUNITIES AND PROSPECTS FOR THE USE OF ALTERNATIVE ENERGY SOURCES IN TERMS OF VITEBSK REGION

ABDUL RAHMAN AL HASSAN, OKSANA KIZINA, DMITRY ANTONOVICH
Polotsk State University, Belarus

The article discusses the possibilities and prospects for the use of alternative energy sources in world practice and in Belarus. The technical and environmental aspects of the implementation of alternative energy technologies are presented. The factors affecting the spread of green energy in Belarus are also indicated.

Scientists believe that there may be a shortage of traditional energy sources by 2025. It is also predicted that during 2000-2020, the global demand for primary energy sources will increase by 50% at an average annual growth rate of 2-2.5% [1, 2]. As a result, methods for reducing energy consumption are being actively developed; obtaining energy from alternative sources, ways to minimize the negative impact on the environment are being actively developed. Belarus is a country with virtually no domestic energy reserves [3]. In this situation, such developments are of particular relevance. The goal of this work was to explore the potential of the country and the Vitebsk region in the development and implementation of alternative energy sources.

The goal implies the solution of such tasks as analysis of the state and prospects of renewable energy in the world and in Belarus, analysis of climatic conditions and factors affecting the distribution of alternative energy sources in Belarus and the Vitebsk region. The work uses the method of analyzing literary sources in combination with the methods of searching information on the Internet using general-purpose search engines and specialized search engines.

1. The state and prospects of alternative energy in the world.

Today, 1/7 of the world's electricity comes from renewable energy sources (RES) [1]. Hydropower has the highest efficiency – about 80% of all renewable energy. The lowest cost is characterized by the use of geothermal energy [1]. By 2020, global consumption of hydropower will increase by more than 50%. The use of geothermal, solar, wind energy, biomass and waste energy will grow at the highest rates, an average of 2.8% per year [2].

National programs have been created to stimulate research, development and production of wind turbines, solar panels and installations for the use of organic and wood waste in the USA, England, Canada, Germany, Russia, Denmark, Sweden, India and other countries. The greatest successes in wind energy have been achieved in the USA and Germany [1]. In Germany, the development of group accommodation of wind turbines in the coastal zones of the North and Baltic Seas is under way [1]. The cost of electricity generated from low-power wind generators is 1.7-2.0 times lower in comparison with to the cost of energy from diesel units of the same capacity [1]. A 1 MW wind generator reduces annual emissions to the atmosphere – 1,800 tons of CO_2, 9 tons of SO_2, 4 tons of nitrogen oxides. The Global Wind Energy Council estimates that by 2050, global wind energy will reduce annual CO_2 emissions by 1.5 billion tons [4].

In the city of Inko in Finland, the northernmost solar power plant in the world was created and incorporated into the country's energy system [1]. In Japan, the total power of solar stations reaches 150 thousand kW and provides 2% of the country's electricity needs [1]. Solar panels are widely used in Germany. Much attention is paid to the development of solar energy in France, USA, Spain and Italy. The World Energy Council predicts that in 2020 the cost of solar electricity will be 2-3 cents per 1 kW·h [1].

In EU countries, the amount of energy from solid biomass (mainly wood) is about 5.0% of total energy consumption. In the US, the priority of biomass use is the generation of electricity and the production of liquid fuels. Currently, there are about 500 power plants with a total capacity of 8500 MW [1].

2. The state and prospects of alternative energy in the Belarus

The main objectives of the energy policy of Belarus - reducing the cost of energy consumption, environmental protection. Based on the Concept of the National Sustainable Development Strategy, a fuel and energy balance for the period up to 2020 has been developed. According to experts, energy consumption in 2020 will increase to 41 billion kWh [4]. At the moment, the construction of the Belarussian nuclear power plant is underway, but the use of atomic energy in the future until 2021 is not envisaged. The main type of fuel for Belarus is still natural gas [5].

If in [3-6, 9] an unfavorable combination of conditions for the development of alternative energy in Belarus is noted, the authors [1, 7, 8] give very optimistic forecasts. The emphasis is on a combination of solar and

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wind energy, as well as on the possibility of small hydropower plants. In [1], this indicates the possible negative impact on the environment in the area of construction of hydroelectric power plants.

In [2], a model of a power plant with direct conversion of water energy into electricity is proposed with the possibility of using the installation in the power supply of private sector dwellings. R.N. Melenchuk, A.A. Kivshar also offers a plant using a combination of natural RES (sun, wind, rain, biomass, etc.). Consideration is given to improving the efficiency of existing elements of alternative power plants.

The authors [3, 10] propose a new approach to ensuring the energy security of Belarus - to consider consumers as active participants in the energy market with the possibility of free trade in energy surpluses, installing home and commercial energy consumption controls with the goal of aligning electrical load schedules and other economic mechanisms to encourage rational energy consumption.

In [7], the development of wind and hydropower as the priority areas of "green" energy in Belarus, with the prevalence of hydropower resources is noted. At the same time, wind generators would be the most paid back in the Vitebsk and Minsk regions, where the wind speed often exceeds 15 m/s.

At present, 17 biogas plants with a total capacity of about 34 MW, 56 wind power plants (43.2 MW), 30 photovoltaic plants (31.5 MW), 287 solar water heating plants (3.8 MW) and 51 hydroelectric power plants are operating in Belarus with capacity of 34.6 MW. There are also 3265 energy sources on local types of fuel with an installed thermal capacity of more than 6 GW, including 22 wood-fired CHP plants with 129 MW of electrical and 345 MW of thermal power. At the same time, installations operating in Belarus produce only about 0.7% of electricity. At the same time, in order to achieve the objectives set out in the program documents, it is necessary to make great efforts to improve the legislative base, eliminate stereotypes and overcome barriers in the development of renewable energy [6]. Also in [6], it is suggested that new types of high-efficiency solar and wind power plants should be created, in combination with other non-traditional energy sources in the composition of micro networks. It is noted that the simultaneous use of several alternative energy sources improves the quality and reliability of electricity generation by the power system, reduces the cost of energy production in autonomous industries and ensures the safety of the environment in rural areas [11].

Solar energy in Belarus is actively used in the agro-industrial complex when greenhouses are maintained [6], in the production of electric shepherds [1]. The first samples of silicon for solar cells were obtained at the Gomel Chemical Plant from chemical production wastes [1]. In the short term, the main areas of solar energy will be solar power plants for drying and for heating water in agricultural production [1]. Currently, the efficiency of solar installations for generating electric current is in the range of 6-17%, while in heating systems due to solar thermal energy, the efficiency rises to 30-45% [8]. [8] also notes the feasibility of using solar energy for the purposes of hot water supply and heating with the help of solar collectors, in the construction of houses of "solar architecture" and for the production of electricity using photovoltaic installations (converters). Belarus predicts a significant increase in the introduction of photovoltaic stations due to cheaper solar panels. The results of calculations showed that, provided that the current state support continues, the payback period for solar power plants is about 9 years [6].

The wind energy resources of Belarus by the electric potential amount to more than 200 billion kW·h [1]. At the same time, in [3] an estimate is made of the maximum possible potential of wind power at the level of 2.8 billion kW·h, or about 8% of today's consumption. Some Belarusian scientists believe that there are more than 300 thousand places in Belarus for the installation of small and medium-capacity wind turbines. For Vitebsk region, wind energy potential ranges from 1 MW to 4 MW [8]. By wind energy potential, Belarus complies with the requirements of commercial expediency of introducing wind engineering [12, 1].

The efficiency of wind power plants (WPP) increases by two or more times in the cold period compared with the warm period [1]. The correct choice of the location of wind turbines and the development of new installations that ensure maximum energy removal with relatively weak winds will allow starting large-scale development of wind energy in the conditions of the republic and save 2 million tons of standard fuel (tons of diesel fuel) per year [1, 12] .

Under the conditions of Belarus, it is recommended to use wind turbines with a capacity of 1-2.5 MW with a tower height of at least 80 m. Taking this into account, the electricity generation in these areas will amount to 9 billion kW·h and will allow replacing 1,100 thousand tons of fuel equivalent in year. The cost of electricity can be 5-7 cents / kWh, and the payback period of installations does not exceed 6 years [5]. The issue of using low-power wind generators (100–150 kW) in the agricultural sector is being considered. [12]. To date, the total installed capacity of wind power plants in Belarus reaches 43.2 MW. [10, 12].

Sanitary standards set the minimum allowable distance from individual wind turbines and wind farms to populated areas. When wind farms are located, the established migration routes of migratory birds are taken into account. Despite bright prospects, there is still no legal basis in Belarus that will contribute to the develop-

PolotskSU

ment of renewable energy [12]. The results of calculations for the territory where the average wind speed exceeds 4 m / s showed that installing a wind generator for daily electricity generation up to 200 kWh will be cheaper than using a diesel generator, expanding the grid or installing photovoltaic systems [12].

Hydropower. The economically viable hydropower potential of the rivers of Belarus is about 250 MW, or 2% of the total energy consumption [3]. It is most concentrated in the Grodno, Vitebsk and Mogilev regions in the areas of the Neman, Zapadnaya Dvina and Dnieper river basins. According to the State program of construction in 2011-2015 of hydroelectric power stations in the Republic of Belarus, on the Zapadnaya Dvina, a cascade of four hydroelectric power stations was planned: Verkhnedvinsk, Polotsk, Beshenkovichi and Vitebsk. On the Neman River - the construction of a cascade of two hydroelectric power stations: Grodno and Nemnovskaya. A cascade of three hydroelectric power plants was planned on the Dnieper River: the Orsha, Shklov and Mogilev stations with a capacity of about 5 MW each [6]. In 2012, the Grodno hydropower plant with a capacity of 17 MW was commissioned, in 2017, the Vitebsk hydropower plant with a capacity of 40 MW and the Polotsk hydropower plant (HPP) with a capacity of about 22 MW. It is planned to build another hydroelectric station near Beshenkovichi. Work is underway to implement the project Nemnovskaya HPP with a capacity of 20 MW [3].

During operation of hydroelectric power station there are no emissions of pollutants into the atmosphere. Of the possible environmental consequences, consideration should be given to flooding and flooding of lands adjacent to hydroelectric power plants, changes in the thermal and ice regimes of rivers, soil and vegetation of coastal areas, habitat conditions of amphibious animals, birds, fish. At the same time, the approximate amount of reduction of emissions of pollutants into the atmosphere due to the construction of new hydropower plants with a total capacity of 102.2 MW with an annual electricity generation of about 460 million kW·h compared to emissions from thermal power plants using fossil fuels of similar capacity is 230 700 tons, including sulfur dioxide – 850 tons, nitrogen dioxide – 210 tons, carbon monoxide – 229 640 tons [7].

Bioenergy. In Belarus, the list of bioenergy resources mainly includes wood, canola, peat, woody biomass. Recently, the processing of municipal solid waste (MSW) [1, 3, 6, 7] is gaining momentum.

According to Belneftekhim concern, diesel biofuel obtained from rapeseed processing conforms to EURO-4 standard. It has been proven that out of 3 tons of rapeseed seeds, about 2 tons of rapeseed oil cake used for the production of animal feed and 0.9 tons of diesel biofuel are extracted [7]. The use of peat can grow to 2.0-2.5 million tonnes of coal equivalent. by 2020. Thanks to the use of peat and wood, the country can satisfy 25% of the total energy demand [3]. At Postavskiy flax factory, they mastered the Japanese technology for producing fuel from flax processing waste - castrobriquettes, which are not inferior to coal in terms of heat transfer [1].

The total area of forests in the country is 8 676.1 thousand hectares, the timber stock is more than 1100 million m^3. The annual increase is 32.37 million m^3, the average increase minus litter is 25 million m^3. Extensive use of woody biomass as a fuel can provide up to 15% of its own energy potential versus 5% in the energy mix today [1].

Over the past 15 years in Belarus, the indicator of the formation of MSW has increased to 1.5 kg / person. in a day. Taking into account the country's population, it is about 13.5 thousand tons of MSW per day. The energy potential of biogas generated from MSW in Belarus is estimated at 480 thousand tons of fuel equivalent. in year. But its use is difficult due to a number of factors. In most places of storage of MSW, there is no "purge", impervious screens and external insulation, i.e. safe conditions for their processing are not provided [6].

3. Climatic conditions of Belarus in the context of solar and wind energy.

The last 30 years in Belarus there has been a change in climate towards an increase in air temperature, compared to the accepted climate-wide norm. The greatest deviations in the positive direction are observed in winter. In percentage terms, this anomaly is maximum in the Vitebsk region [13]. The territory of the country receives more solar radiation and can count on realizing the potential of solar power.

The amount of solar radiation arriving on the earth's surface depends on the time of year and day, the latitude of the place, the cloudiness and transparency of the atmosphere, the closeness of the horizon, and the time the sun stays above the horizon. An important energy indicator of solar radiation resources is the duration of sunshine, which characterizes the flow of direct sunlight in hours with the sun disk open. This indicator decreases in cities due to the dustiness of the atmosphere and the shading of urban buildings [1, 8]. On the territory of Belarus, the duration of sunshine for the year increases from north, northwest to south, southeast from 1750 to 1870 hours [8]. In the annual course, the maximum duration of sunshine is in June (from 265 to 290 hours), the minimum - in December (from 25 to 35 hours) [1, 8]. The warm season accounts for 80% of the annual sunshine duration. The number of days without the sun decreases from north to south from 100-115 to 93-100 [1]. The average annual arrival of total radiation varies from 4,100 MJ/m^2 in the south of the republic to 3,500 MJ/m^2 (85-97 kcal/cm^2) in the north [1]. The intensity of total solar radiation varies from 165 kW/m^2 in the Vitebsk region to 185 kW/m^2 and higher in Gomel region [8].

PolotskSU

Taking into account all factors, experts believe that to cover all the needs of the republic in electricity, it is enough to use the total land area equivalent to a square with a side of 18 km, or 0.5% of the total area of the country. To do this, the roofs of houses, farms, land unsuitable for agriculture must be used [1].

For wind power plants, average wind speeds, annual and daily wind speeds, repeatability of speeds (year or period) and wind directions, distribution of wind periods and calm periods by duration are of great importance [8]. The mode of wind speeds is determined by atmospheric circulation and the physical-geographical conditions of the area. Surface wind is closely dependent on the conditions of the underlying surface [1].

Hills occupy about 30% of the territory of the surface of Belarus, the plateau – 10%, and the remaining 60% are lowlands. Winds are stronger on elevations or open convex forms of relief than on flat terrain and lowlands. In the northern part of the country, south-west and south wind directions have a high frequency, in the south part – west wind directions. From June to August the northwesterly and westerly winds prevail. In the winter period – south-western and western with a frequency of 40% [1]. The variability of the average annual wind speed is small, the standard deviation is 0.3-0.4 m/s. Continental winds prevail in Belarus at an average speed of 4-6 m/s [12]. The maximum wind speeds are characteristic for the autumn-winter periods, the minimum ones are observed at the end of the summer. Differences in wind speed in the winter and summer months are 1.0-1.5 m/s [12]. In the Vitebsk region, the average monthly wind speed ranges from 3.3 m/s in August to 4.8 m/s in December. The recurrence of these speeds in winter is 80-85%, in the summer – 70-75% [1]. Moderate winds (6-9 m/s) are noted in the republic up to 25% of the time of the year [1]. The most favorable for the placement of wind turbines are hilly-moraine hills (Novogrudskaya, Minsk, Vitebsk, Gorodok, Orshanskaya), occupying the north-eastern and central parts of the country. The maximum values of the specific power of the wind flow here exceed 150 W/m² [1].

The minimum starting wind speed at which it is advisable to use wind turbines is 2 m/s. According to [15] for Belarus, the minimum average annual wind speed at a height of 10 m is 2.9 m/s. For the Vitebsk region – from 3.0 m/s to 3.8 m/s, which exceeds the threshold value [8] and indirectly confirms the prospects for the development of wind energy in the Vitebsk region.

The main factors hindering the development of alternative energy sources in Belarus are the following [3, 11, 13, 14]: the lack of an exhaustive legal and regulatory framework [6, 12]; climatogeographical limitations [3, 4-6, 9]; the stereotype of economic thinking of the main actors of the power system; lack of a developed infrastructure, in particular, in the sphere of processing of MSW [6], technical difficulties in realizing the potential of renewable energy sources.

Based on the results of the work, it is possible to formulate the following conclusions:

1) The elaboration of alternative energy sources is a global practice, acquiring particular relevance in the context of increasing demand and the projected shortage of primary energy sources. The most actively used resources are hydropower and biomass. The latter makes a significant contribution to the reduction of polluting emissions into the atmosphere.

2) Belarus is actively working on the development of alternative energy sources, along with a policy of rational energy consumption. The country has enough potential for the development of hydro and wind energy, biomass energy; hybrid energy based on a combination of solar and wind energy.

3) Vitebsk region, compared with other regions of Belarus, is more promising for the development of wind turbines. Also it is of practical interest for the development of hybrid installations, in the summer months using mainly the energy of the sun, in the winter – the wind. It is preferable to use wind turbines with a capacity of up to 150 kW with a starting wind speed of 2 m/s.

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PolotskSU

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THE PLASMA SOURCE FOR THE FORMATION OF HIGH-ENERGY FOCUSED BEAMS OF CHARGED PARTICLES

EVGENY MALYUSCHENKO, DMITRY ANTONOVICH
Polotsk State University, Belarus

The results of the research on the formation of high-energy charged particle beams for the implementation of beam technologies on various materials are presented in the article.

Currently, there are quite a number of ways to process and modify the surfaces of materials in vacuum using streams of charged particles. Electron-beam, ionic, and combined methods of influence on the surfaces of materials have received the greatest development. This stimulates the development of sources of charged particles with a wide range of technological parameters that differ in power, current density, modes, and gas-dynamic working conditions. For solving specific technological problems, electronically focused beams of high brightness, electron beams of a large cross section of circular or other shape, ion beams can be used. The diversity of requirements imposed on technological beams cannot be realized in sources of the same type, although a number of fairly universal systems have been developed [1]. One of the rather promising tools for the implementation of such technologies are plasma sources of charged particles, operating at elevated pressures and having a high resource [1, 2].

In such systems, the formation of a beam of charged particles is carried out using plasma formations and presented in the fact that plasma is usually formed using a low-voltage anomalous glow discharge in an electronic structure with a small volume [3, 4]. The exit of plasma particles (electrons or ions) to the region of acceleration and beam formation, as well as the gas-dynamic coupling of the plasma formation and beam acceleration regions, is carried out through an orifice of small diameter (on the order of a millimeter). This provides a significant pressure drop between the areas of plasma formation (1 … 10 Pa) and beam acceleration and allows maintaining sufficiently low pressure in the areas of acceleration (10^{-2} … 10^{-1} Pa) and the technological use of a beam of charged particles (10^{-2} … 1 Pa). Under these conditions, the effect of gas separation and pressure increases in the technological area, accompanying the process of radiation exposure, on the parameters of the formed plasma and the beam of charged particles turns out to be insignificant. The pressure difference between the areas of formation of the discharge and the beam is determined by the geometrical dimensions of the emission channel, the rate of pumping of gas from the vacuum chamber and the inlet of the plasma-forming gas, which is carried out into the gas-discharge structure. The uniqueness of such structures lies in the possibility of the formation of both electron and ion, as well as combined beams of charged particles depending on the polarity of the accelerating voltage [5].

The geometric dimensions (diameter, length) of the orifice connecting the regions of plasma formation and electron acceleration are usually chosen so that the plasma penetrates into this orifice, called the emission channel. On the other hand, an accelerating field penetrates the emission channel. The depth of penetration of the plasma into the emission channel depends on its concentration and the potential difference between the plasma and the walls of the emission channel. The depth of penetration of the accelerating field into the channel depends on the intensity of the accelerating field at the entrance to the emission channel on the side of the accelerating field and on the diameter of the channel.

As a rule, the potential of the walls of the emission channel is lower than the potential of the plasma penetrating it. This leads to the possibility of the emergence in the emission channel of two different situations, which are common for the formation of a plasma surface (plasma boundary) in the channel separating the plasma and space charge regions in an electric field, to which the concept of plasma is not applicable. The difference in situations is due to the distribution of the electric field at the plasma boundary [4, 6]. Through plasma surface formed in the emission channel (plasma boundary) plasma particles due to thermal velocities go into the space charge region and the interval of their acceleration. In this, a certain analogy with the known emission-optical structures based on thermal emitters [7].

Therefore, it seems possible to consider a plasma surface forming in the emission channel (and in some cases outside it) as a plasma emitter of charged particles (electrons and ions) with physical properties and characteristics inherent only in it. However, despite the presence of specific properties of the plasma emitter, the method for analyzing the construction of electron-optical systems based on it turns out to be in many ways similar to that used for electron-optical systems with thermal cathodes [8].

The source for the formation of high-energy focused beams of charged particles. To produce beams with current density and brightness required for technological applications, plasma must be formed in the discharge, providing a high emission current density (~100 A/cm^2) [9], which is possible either due to a high electron concentration of about 10^{18} m^{-3} in the region emission channel, or due to processes in the discharge, ensuring the effective switching of electrons from the entire plasma volume into the emission channel [4, 10]. When forming focused electron beams, it is impractical to provide high plasma concentrations in the entire volume of the discharge chamber, since the efficiency of the source of charged particles decreases and the thermal loads on the

PolotskSU

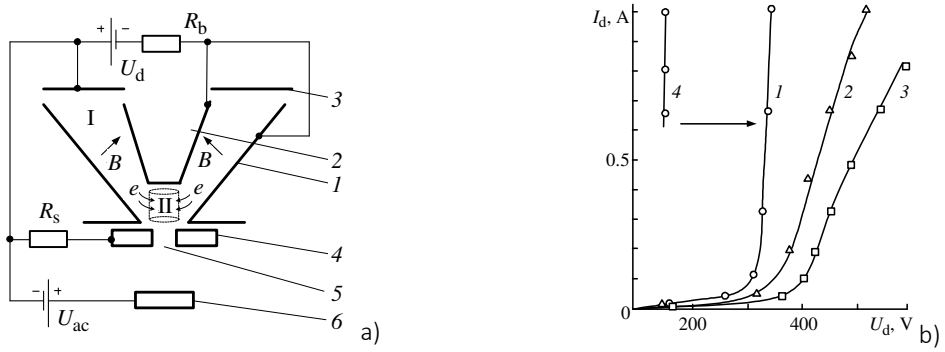
electrodes increase. In this case, it is preferable to use discharges with a high degree of inhomogeneity of the plasma concentration distribution in the discharge with a maximum concentration on the axis of the emission channel. The most common are gas-discharge structures with a hollow cathode [11].

Another variant of the plasma generator is gas-discharge structures in which switching of the electron current from the entire plasma volume into the emission channel takes place — with a different hollow cathode shape and using E×H crossed fields [1], which have several advantages compared to hollow cathode structures.

In Figure 1a, an electrode structure and a current–voltage characteristic (CVC) of a modified gas-discharge structure with crossed E×H fields. The discharge is excited in the space between cathodes 1 and 2 (region I, Figure 1, a), where, as in the reflective discharge with a hollow cathode, the main ionization processes are realized. Plasma-forming gas is fed into the space between the cathodes, and the pressure drop is provided by the geometry of the emission channel. The plasma formed in the discharge between the cathodes diffuses into the region of the emission channel. This contributes to the additional electrode 4 (anode), which acts as an emitter electrode. The presence of a magnetic field in almost the entire volume of the discharge structure contributes to the effective ionization of the gas.

In such an electrode structure, the stage of discharge initiation is excluded, which is reflected in the shape of the CVC (Figure 1, b). In the region of the emission channel (region II, Figure 1, a), the magnetic field has the direction of the induction in the longitudinal axis of the channel and does not prevent the emission of electrons. Electrons are extracted through the emission channel in the emitter electrode with an anode (or close to it) potential. Diffusion of electrons to region II from region I of plasma generation (region I) occurs in a magnetic field with a significant transverse component of the induction vector, which to some extent restricts the movement of electrons to the emission channel region and makes it difficult to implement unwanted full switching of the electron current from the plasma to the emission channel.

When a discharge is excited, the emitter electrode plays the role of an auxiliary anode, and the value of its potential is not so critical for the formation of a gas-discharge plasma as the potential of the emitter electrode in a discharge with a hollow cathode. Therefore, to increase the resource, extraction efficiency and stability of the emission current in a plasma emitter of this type, the potential of the emitter electrode can vary in the range from anode to almost cathode, which is regulated by the choice of bias resistance (Figure 1, a), or have a floating potential. The emitter electrode can be manufactured single-piece or sectioned with different potentials of parts [12]. The possibility of a significant reduction in the potential drop in the near-wall layer at the emitter electrode in such a plasma generator allows a significant increase in the emission channel resource.



a - electrode system [1] (1 - external cathode; 2 - internal cathode;
3 - anode; 4 - emitter electrode; 5 - emission channel; 6 – accelerating (removing) electrode; U_d is the discharge burning voltage; U_{ac} – accelerating voltage;
R_s is the bias resistance; R_b - ballast resistance; B - magnetic field induction);
b - current-voltage characteristics (CVC) (gas (air)): 1 - 2.8 mPa·m³/s (100 atm·cm³/h);
2, 4 - 1.7 MPa·m³/s (60 atm·cm³/h); 3 - 1.25 mPa·m³/s (45 atm·cm³/h)
Figure 1. – The discharge in the modified structure with crossed E × H-fields

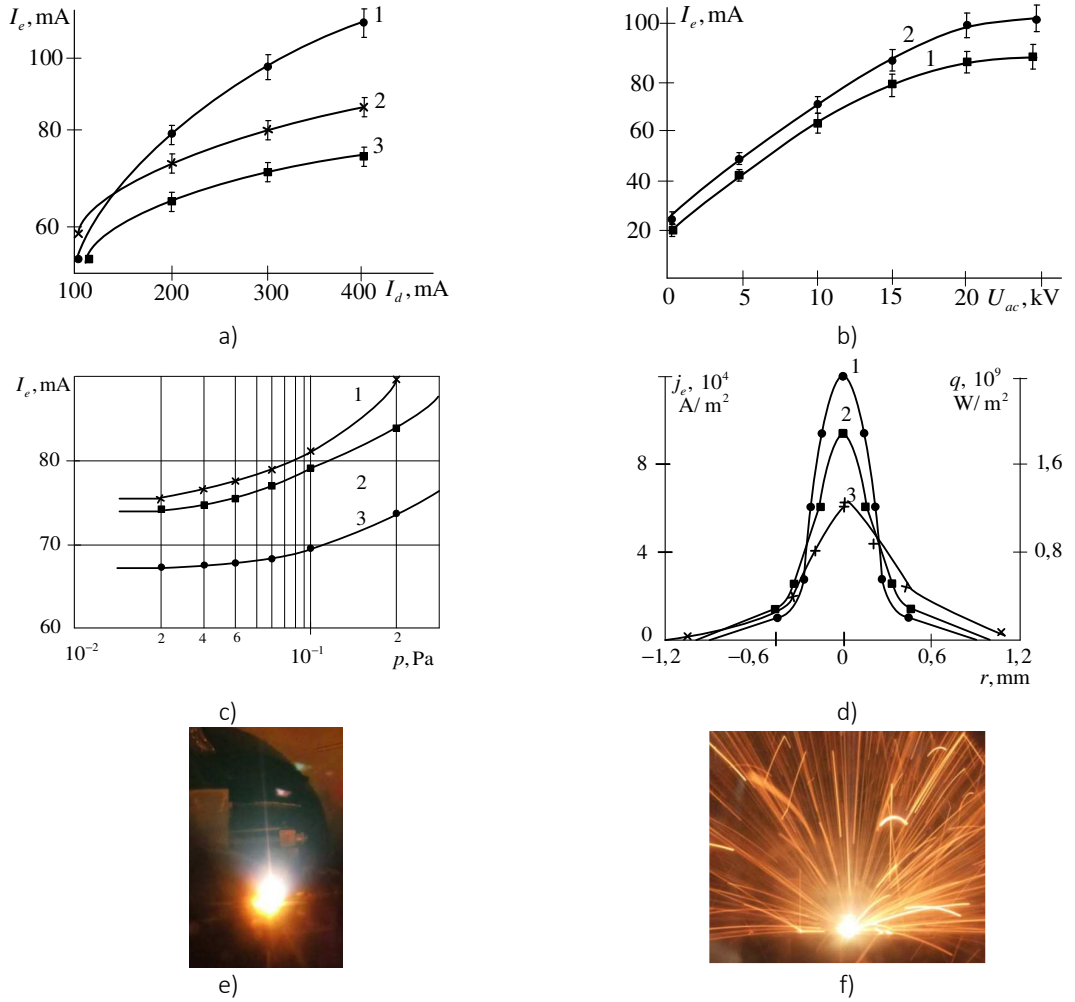
In the range of operating values of the discharge currents, the form of the current – voltage characteristics (Figure 1, b) is close to the form of the corresponding characteristics for a discharge with a hollow cathode. This allows the use of the same type of power source of the plasma generators considered.

In [13] there is a detailed description of the source of high-perverse beams of charged particles developed taking into account the principles presented. In a plasma emitter of this type, the following methods are possible to control the extraction efficiency and stability of the emission current, which are not realizable in plasma electron sources based on a hollow cathode. The first method is to create conditions for the redistribution of currents between the emitter electrode and the emission channel by changing the parameters of the space charge layer near the emitter electrode. This can be provided both by automatic displacement of the potential of the emitter electrode by the bias resistance in the circuit of the corre-

PolotskSU

sponding electrode, and through the use of inserts into the emitter electrode in the region of the emission channel under the floating potential [4, 12]. The second method is implemented by creating electric fields in the emitting plasma, which ensure the formation of electron fluxes to the emission channel region. The intensity of such flows is determined by the configuration of the magnetic and electric fields (the displacement of the potential of the anode relative to the emitter electrode) in the gas-discharge structure and the gas pressure (the amount of gas inlet into the discharge chamber) [2, 4].

In Figure 2 the typical characteristics of this source is shown. The main advantage of this source is the weak dependence of the emission current on pressure up to 0.3 Pa (Figure 2, c). This feature is realized both due to the configuration of the discharge chamber electrodes and due to the additional autostabilization of the electron beam parameters by including resistance R in the emitter electrode circuit relative to the anode. In Figure. 2, d, the distributions of the current density and the electron beam power density over the cross section are presented. The maximum value of the power density $q_{max} \approx 10^9$ W/m^2 and the effective diameter of the electron beam (which is determined at a level of 0.1 q_{max}) corresponds to typical values of the power density of the electron beams used for electron beam welding [2, 4]. This, as well as the type of gas characteristics, indicate the possibility of using this source for welding, including materials with increased gas separation in the heat treatment process.



a - emission characteristic: accelerating voltage 18 kV;
gas inlet 1.5 mPa·m^3/s; pressure, Pa: 1, 2 - 0.04; 3 - 0.1; R_{bi}, kΩ: 1 - 0; 2, 3 - 1;
b - current-voltage characteristic: gas inlet 1.5 mPa·m^3/s; discharge current 0.2 A;
gas pressure, Pa: 1 - 0.04; 2 - 0.1; c - gas characteristic: accelerating voltage of 16 kV; gas inlet 1.5 mPa·m^3/s; R_{bi}, kΩ: 1 - 0; 2 - 0.5; 3 - 1; d - current density and power density distribution over the beam section:
accelerating voltage 18 kV; gas inlet 1.5 mPa·m^3/s; discharge current 0.2 A;
emission current 0.08 A; R_{bi}, kΩ: 1 - 1; 2 - 0.5; 3 - 0

Figure 2. – The main characteristics of the plasma electron source (a, b, c, d) and the photo beam in the process of welding various materials (e, f):

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The results obtained correspond to the typical characteristics of plasma sources of charged particles and show how these can be used to develop new technologies for radiation exposure of materials and the implementation of existing ones.

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PLASMA SOURCE FOR THE FORMATION OF LARGE CROSS SECTION CHARGED PARTICLES BEAMS

EVGENY HOMICHENOK, DMITRY ANTONOVICH
Polotsk State Universitys, Belarus

This article presents the results on the formation of beams of charged particles of large cross section for the implementation of technologies for modifying the surface properties of various materials. The structure, design sketch and the main characteristics of the developed source are given.

For the implementation of plasma-chemical and strengthening technologies, it is advisable to use beams of charged particles of large cross-section with an area corresponding to the area of the treated surface. In the structures of plasma sources of charged particles with a large cross-section beam, the accelerating electrode is usually absent and the accelerating potential is applied to the workpiece (surface), the focusing system of the electron beam is also absent. Therefore, to obtain electron or ion beams of large cross section in a plasma generator, it is necessary to form a plasma emitting surface corresponding to the beam cross-sectional area, providing an emission current density sufficient for technological purposes. During the formation of a developed emitting plasma surface, it is impossible to ensure a significant pressure drop between areas of plasma generation and electron beam formation. Therefore, if it is necessary to ensure a low gas pressure in the region of the beam acceleration and the technological region, additional gas-discharge structures are usually used to inject electrons or plasma into the region of the formation of the emitting plasma. When an increased gas pressure is required in the process area, in order to form a process plasma, and the required density of the emitting plasma is achieved without auxiliary gas-discharge structures, it is usually necessary to ensure the stability of the emitting plasma surface. This is achieved by the method of grid stabilization of the emitting plasma surface [1-3]. This paper presents a source of charged particles capable of forming beams of charged particles of large cross section for the implementation of technologies for modifying the surface properties of various materials. The data on the grid stabilization of the emitting plasma surface are presented. The structure, design sketch and the main characteristics of the developed source are given.

The source for the formation of large cross section charged particles beams. The essence of the grid stabilization method is as follows. The emitter electrode is made in the form of a grid electrode (with geometric mesh transparency ξ) that prevents the emitting plasma from penetrating into the accelerating gap (the mesh cell size should not exceed twice the thickness of the wall layer) and the accelerating electrode restricting the field penetration into the discharge chamber. However, the electrical transparency of the grid (D) for the field of the accelerating electrode is a quantity that depends not only on the geometric transparency, but also on the field strength in the accelerating gap. With an increased gas pressure, when a secondary plasma [4, 5] is formed in the acceleration gap, at the surface being treated with a potential close to the potential of the accelerating electrode, the field strength at the grid emitter electrode increases, which increases the permeability of the accelerating field through the grid electrode. To ensure the stability of the emitting surface, in this case it is necessary to use either grid electrodes of lower geometric transparency, which reduces the efficiency of the plasma emitter, or double grid electrodes made of two grids with the maximum possible geometric transparency and separated by equipotential space. One of the grids ensures stability of the plasma surface, the other limits the penetration of the field into the discharge chamber. As a result, stable emission characteristics are ensured both at elevated pressure and at significant fluctuations.

When using charged particles with a large cross section of additional plasma injectors in plasma sources, a large plasma surface is usually formed in a special cylindrical electrode having an anode potential (hollow anode) [1, 5].

Figure 1 shows the electrode structure and the current-voltage characteristics (CVC) of the discharge in a modified structure with an expander electrode for forming a developed plasma surface. Plasma is formed in the space between the cathodes and, expanding, fills the volume of the expander electrode. Plasma penetration into the expander takes place mainly through peripheral areas, where the escape of charged particles is the most intense. This ensures a high degree of homogeneity of the plasma distribution over the cross section of the expander. In addition, in the expander, as in the main region of the discharge, ionization processes occur due to the ionization ability of plasma electrons.

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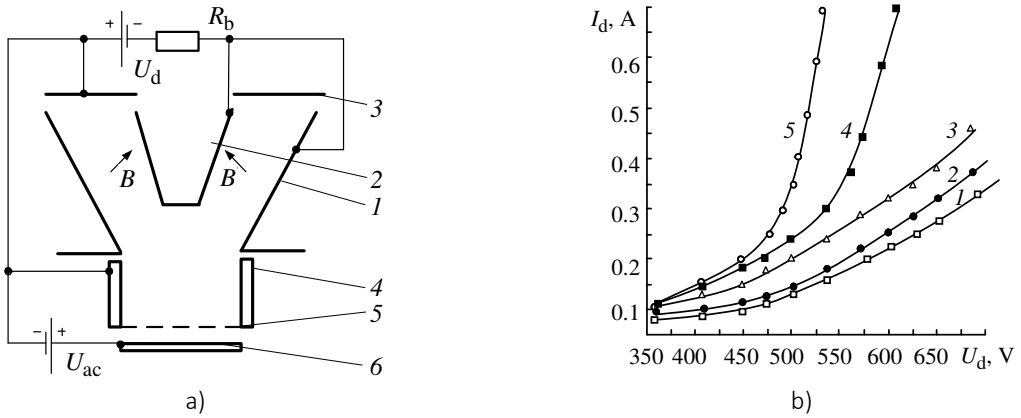
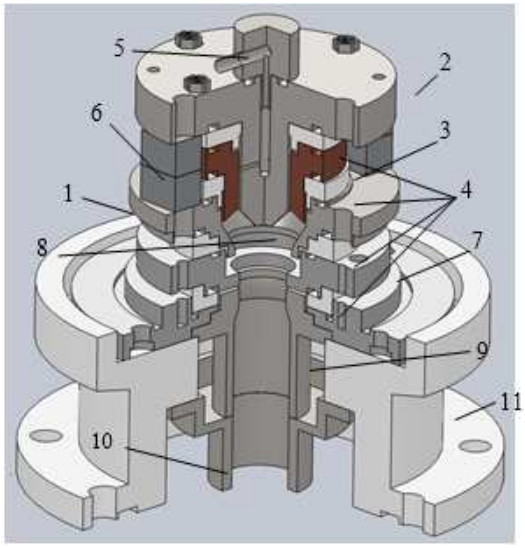


a - electrode system [1, 2] (1 – external cathode; 2 – internal cathode; 3 – anode;
4 – hollow anode (expander); 5 – emitter (grid or perforated) electrode;
6 – accelerating (extracting) electrode-the processed surface; U_d is the discharge burning voltage;
U_{ac} – accelerating voltage; R_b – ballast resistance; B – magnetic field induction;
b – CVC: 1 – system with an open emitter electrode, without grid; 2 – grid ξ = 0.64; 3 – double grid ξ = 0.64;
4 – grid ξ= 0.44; 5 – emission channel in the form of a single hole 3 mm diameter;
1–3, 5 – 4.2 mPa·m^3/s; 4 – 3.3 mPa·m^3/s
Figure 1. – Discharge in a modified structure with crossed E × H-fields

Therefore, under certain conditions (plasma concentration, gas pressure in the discharge, the size of the output aperture of the external cathode 1) the intensity of the ionization processes in the main discharge and the expander are comparable, that is, the expander switches to the "active" mode, performing the role of a hollow anode.

The CVC (Figure 1, b), regardless of the geometry of the emitter electrode, are similar, and their difference is explained by a change in the gas-dynamic parameters of the emitter structures, which leads to a difference in pressure in the region of the discharge initiation and the formation of the emitting plasma, because the effect of grids transparency ξ on the current-voltage characteristics of the discharge is significant. Curve 5 corresponds to the maximum pressure in the gas-discharge structure. Curve 1 corresponds to the minimum pressure that is realized in the electrode structure with the expander fully open (no grid electrodes) with all other conditions being equal. The "active" mode of the expander is realized in the range of the laps values corresponding to curves 2 - 4.

Figure 2 shows the discharge structure for the formation of low-energy beams of charged particles, also developed on the basis of a modified gas-discharge structure with crossed E×H fields, and both Figures 3 and 4 show its main characteristics and photos of the charged particle beams formed in it. In this source, the main gas ionization processes occur in the region bounded by the external and internal cathodes 1 and 2, and the anode 3.



1 - external cathode; 2 - internal cathode; 3 - anode;
4 - insulators; 5 - fitting for plasma gas inlet;
6 – permanent magnets; 7 – additional electrode;
8 – gas inlet; 9 – plasma expander electrode;
10 – accelerating electrode; 11 – flange
Figure 2. – The discharge structure for the formation of low-energy charged particle beams

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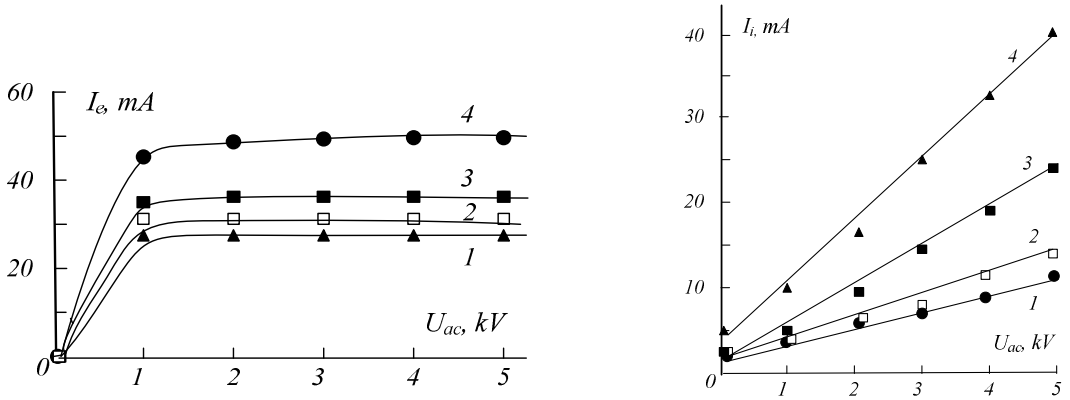
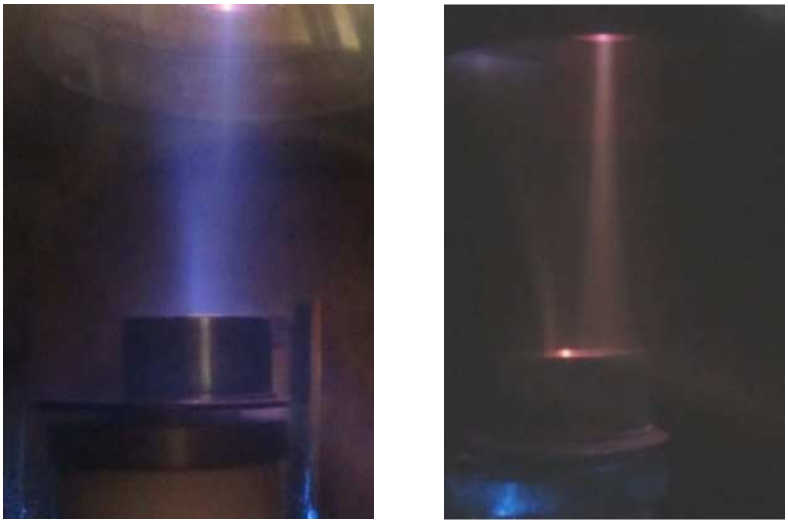
The magnetic field is formed with the help of permanent magnets 6 located between the cathodes. Moreover, a necessary condition for the operation of the structure is the direction of the magnetic induction vector. It should have a perpendicular direction relative to the working surface of the cathodes, since due to this, there is a restriction of the electron mobility from the plasma to the anode, leading to an increase in the plasma density in this region. Through the upper opening in the expander, the plasma penetrates into the expander 9. Plasma-forming gas into the discharge structure is fed through channel 8 in choke 5 and cathode 1. The use of an additional electrode 7 located between the inner cathode and the expander improves the extraction efficiency and stability of the emission current [6, 7].



a) b)

1, 2 – anodic, 3, 4 – cathodic; discharge current: 250 mA

Figure 3. – Characteristics of the extraction of electrons a) and ions b) for different potentials of the expander electrode [7], potential of the expander electrode



a) b)

Figure 4. – Appearance of electron (a) and ion (b) charged particle beams

Since the plasma emitter is able to emit both ions and electrons, depending on the polarity of the accelerating voltage, and the frequency of change of the accelerating voltage is determined mainly by the time of formation of conditions on the target for the formation of microarcs, and, depending on the material being sprayed, range from one to tens of kilohertz. This method can be implemented on the basis of this single ion-electron optical structure. In addition, such a structure is promising for the implementation of such plasma-chemical technologies as electron beam dispersion, ion-plasma nitriding, electron-beam sputtering of dielectric materials, lithography and the application of multilayer coatings where low-energy beams of charged particles with energy up to 5 keV and impact on a large surface.

These characteristics indicate the possibility of using the presented source for the implementation of existing technologies for modifying the surface properties of materials and developing new technologies.

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ANALYSIS AND DESIGN OF CUTTING INSERTS WITH MICROMETRIC BLADE ADJUSTMENT FOR BORING PRECISION HOLES

NNADI CHRISTIAN CHIMEZIE, NIKOLAY POPOK, ALIAKSEI SIDIKEVICH
Polotsk State University, Belarus

In an automotive and machine-tool industry are widely used body parts with surfaces obtained by boring. There is a problem processing such parts on CNC machines with the required accuracy at the lowest possible production costs. Machine-building enterprise "JSC" "Minsk Automobile Plant" is no exception. In the production of the beam of the front axle of the MAZ family of vehicles, it is necessary to obtain the maximum number of surfaces of the part for a single installation at the integrated CNC operation, (Figure 1).

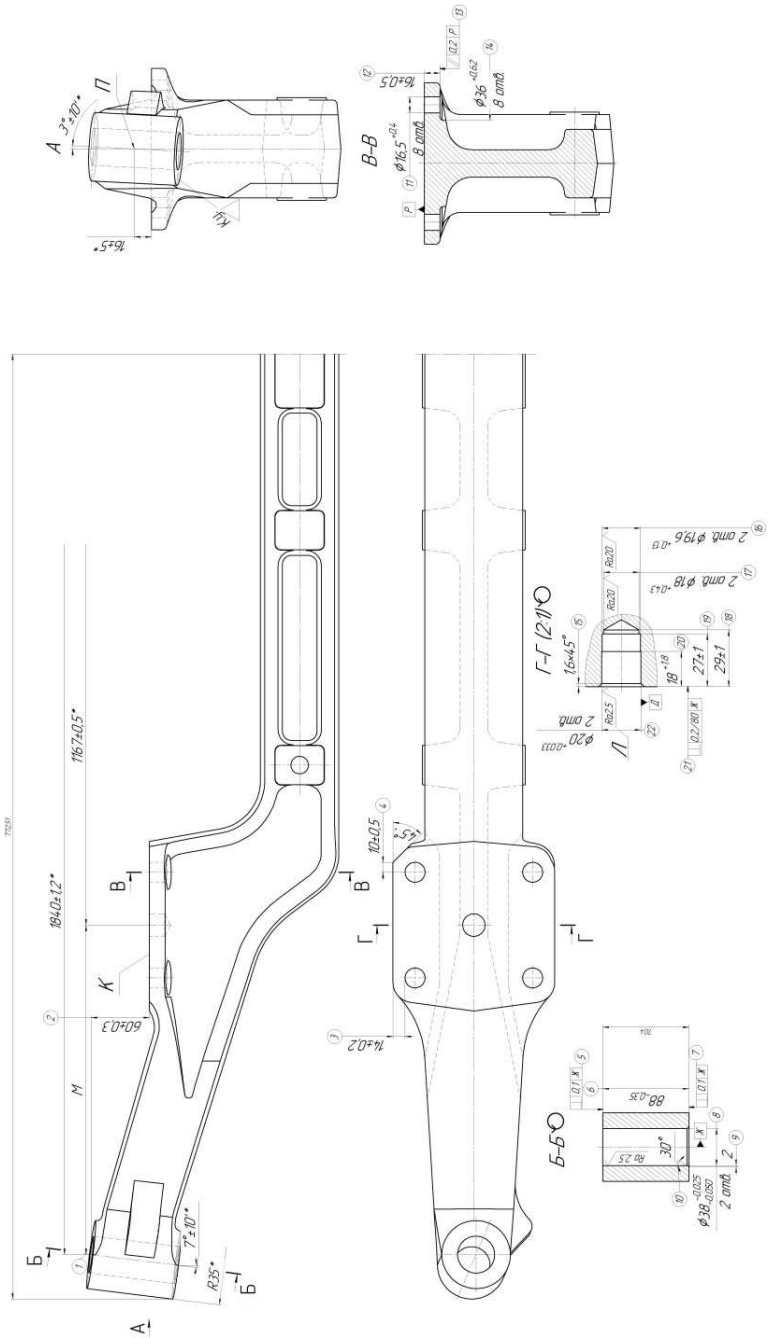

Figure 1. – Sketch map of the integrated CNC operation for processing front axle beams

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When machining a hole $\varnothing 38^{-0,025}_{-0,050}$ an auxiliary tool-body, manufactured at the tool section of the enterprise (figure 2), and a tool insert with a micrometric blade setting, which is purchased abroad, is used.

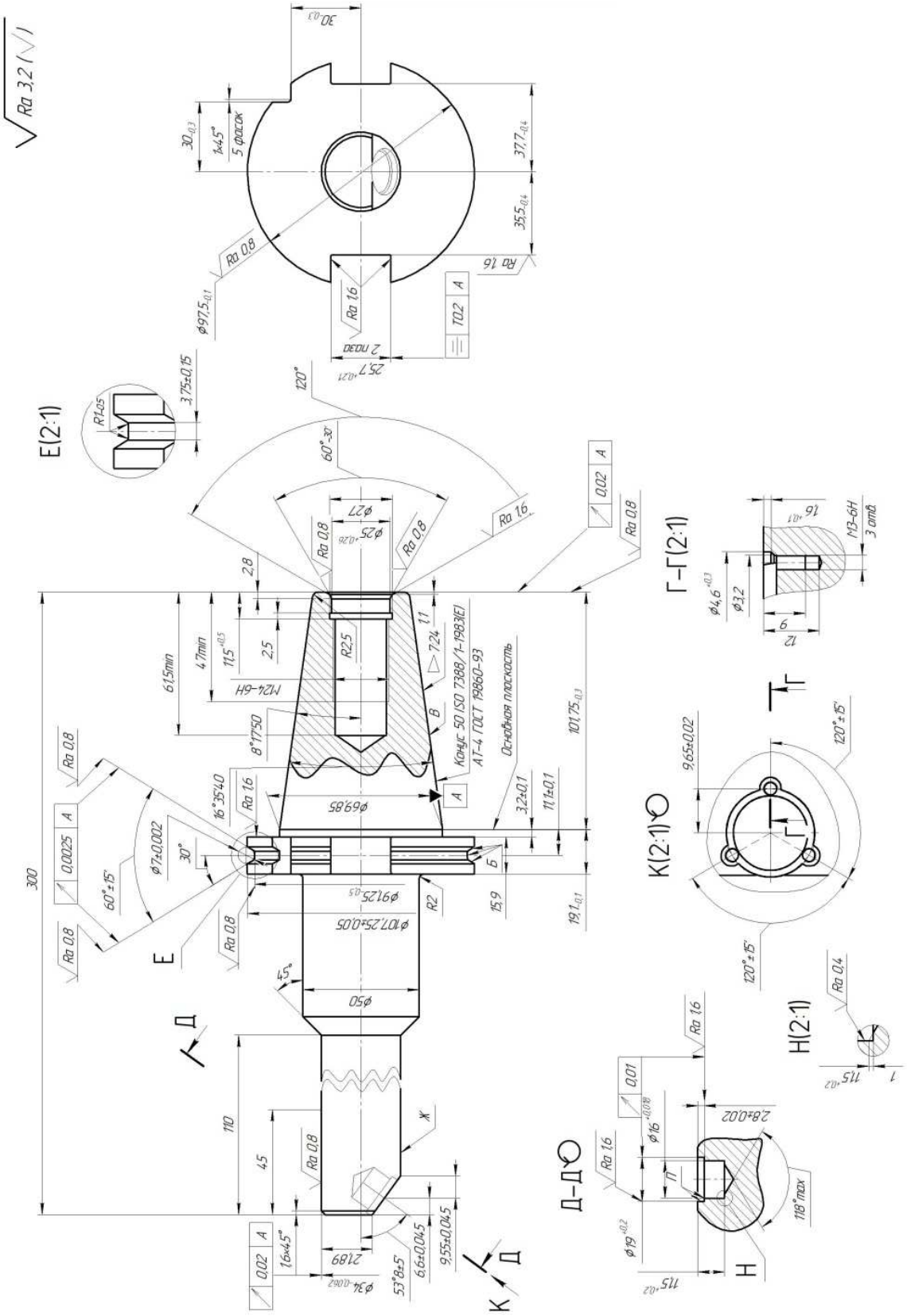

Figure 2. – Sketch auxiliary tool housing

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The analysis shows that at domestic enterprises the production of tools with micrometric blade adjustment is not serially adjusted, and the use of foreign boring tools is expensive. In addition, the boring tools of various tool companies have different interchangeable elements, which makes it difficult and expensive to use them. Therefore, the creation of boring tools with micrometric adjustment of the blades, which would have interchangeable blocks and modules in a wide range of diameters of bore holes, ensured the manufacturability of the design and the required machining accuracy, and unified cutting inserts with micrometric blade settings for machining surfaces of parts on metal-cutting CNC machines is relevant. At the same time, special attention is paid to the structures of the mechanisms for moving and micrometric adjustment of the cutting blades in the tool inserts.

The development and use of cutting inserts with micrometric adjustment of the blade for surface treatment of parts on CNC machine tools will provide the following advantages compared to the analogues currently used [1].

1. Reduce the range of cutting tools;
2. Design and manufacture easily customizable cutting tools that will provide rational cutting and cutting allowance schemes in each particular case of processing.
3. Rigid design of the cutting inserts with micrometric adjustment of the blade will increase the resistance of the cutting plates by 1.5 times and the quality of processing up to 20%.
4. The process of equipment changeover is simplified, less qualification of service engineers is required.
5. The cost of new cutting inserts with micrometric blade adjustment for domestic consumers will decrease in comparison with foreign analogues.

The tool insert can be attributed to the classification of the cutting tool to the assembled tools. The composition of the insert may contain:

1. Cutting blade;
2. The installation mechanism of the cutting blade;
3. Cutting blade adjustment mechanism;
4. Housing
5. The installation mechanism of the housing in the base boring mandrel
6. Other mechanisms

In the assembly cutting tool as a cutting blade can be used [1,2,3]:

replaceable polyhedral plates (RPP);

replaceable sharpened plates (RSP);

interchangeable composite inserts with superhard tool materials consisting of a holder and a cutting blade fixed by soldering or gluing.

The tool insert can be installed in a basic boring mandrel - with a radial scheme (figure 3,a); at the angle of 53°8′(figure 3,b).

Based on the analysis of the use of various RPP as a cutting blade, it should be noted that the plates with the original marking according to GOST 19042 are most often used, these are triangular plates with a back angle of TPUN. TEGN, TPMR plates are also available. In the design under development, plates TPUN-110304 and TPMR-110308 can be offered. Plate TPUN-110304 has a back angle of 11 °, but does not have chip breakers. Plate TPMR-110308 has a back angle of 11 ° and chip breaker grooves.

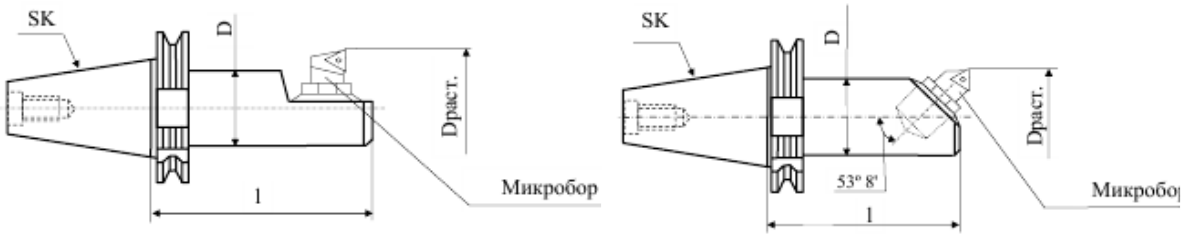

Figure 3. – Installation diagrams of the cutting inserts in the base boring bar: a - radial; b-angled

The installation mechanism of the cutting blade (plate) in the holder includes an exact groove closed on both sides, which ensures that the plate is precisely oriented in space relative to the axis of the base mandrel. This is achieved by having a contact at three points on the plate and a groove of the plate mounting mechanism.

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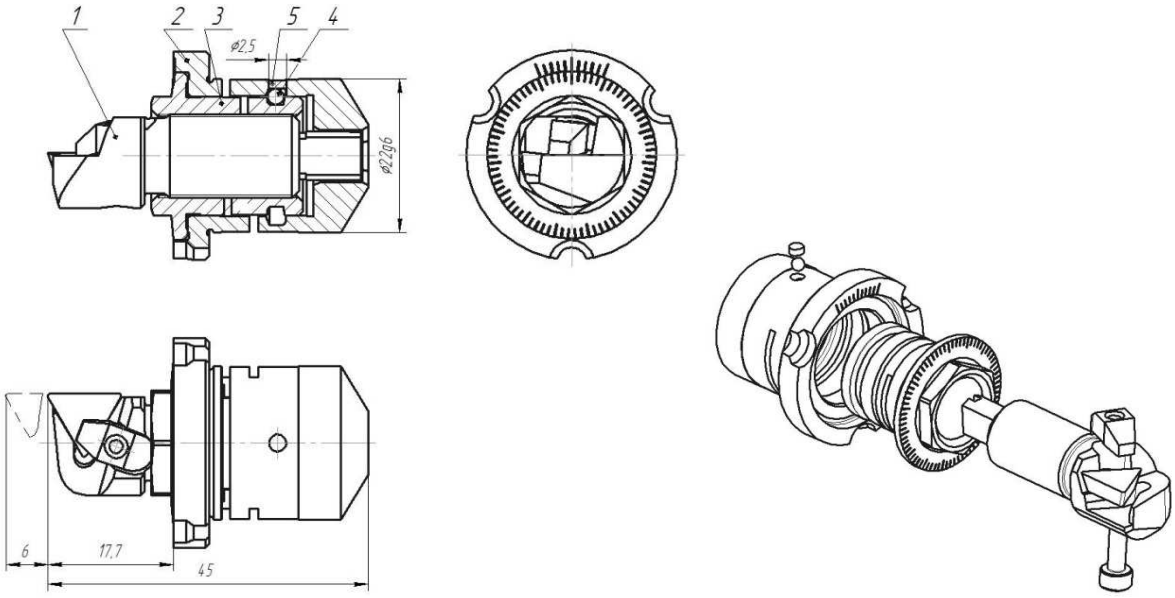
The tool insert must have minimal dimensions, which leads to the complexity of the structures of its individual elements. It is proposed to combine the mechanism for the installation of the RPP and the screw entering the mechanism for adjusting the cutting blade. The screw has an exact chassis thread, made in 4 degrees of accuracy with a tolerance field g. This accuracy is due to the accuracy of the movement of the plate when adjusting the cutting insert itself on the size.

It is also proposed to combine two functions - movement and installation in one detail: the reciprocal internal threaded surface of the plate movement adjustment mechanism, a dial with a vernier and the presence of a surface serving as the main design base in the body (cup) of the tool insert. Structurally, this detail has many complex surfaces and is the most non-technological. Leading manufacturers of tool inserts go to this consciously, having high-tech equipment. The main problem of the interaction of the threaded sleeve and the threaded insert is the need to sample the gaps in the thread, due to possible inaccuracies in the manufacture. This opportunity should be laid constructively. For this purpose, a preload of the threaded connection is realized, considering various materials in a screw-nut friction pair, and the stiffness of the split nut. The variability of ensuring the accuracy of such a compound is very large and can only be determined by experimental methods and additional calculations.

The installation mechanism of the cutter insert in the base boring mandrel is combined with the preload mechanism of the threaded pair in the "cup" part. The installation mechanism in the base mandrel includes the presence of a cylindrical surface, as the most technologically advanced in manufacturing, and three radius slots for fastening on the base mandrel with screws. The preload mechanism contains a split bushing with a counter internal groove in which hardened balls of a certain size are installed when the bushing is compressed in a glass. Balls rolling in the grooves of the sleeve and the glass transfer elastic force from the glass to the sleeve. This leads to the displacement of the sleeve so that the gap in the thread between the threaded insert and the sleeve disappears. The second positive point in the use of hardened balls is the transition of sliding friction to rolling friction and the emergence of a rolling bearing, which makes it possible to reduce the friction that occurs with considerable preload forces to eliminate the gap in the thread. In Polotsk State University at the department "Technology and equipment for machine-building production" designs of tool inserts for radial installation and installation at an angle were developed. The variability of the designs also included various methods of fastening the plate: with a clamp on top for plates without a hole (Figure 4), a screw for plates with a hole (Figure 5).



1 – assembly "threaded insert"; *2* – cup; *3* – bushing; *4* – ball; *5* – lead, used as cork from balls falling out
Figure 4. – Sketch of the insert with the fastening of the plate with the clamp on top

The "threaded insert" assembly (Figure 6) contains four elements - holder 1, tack 2, screw 3, plate, cutting 4.

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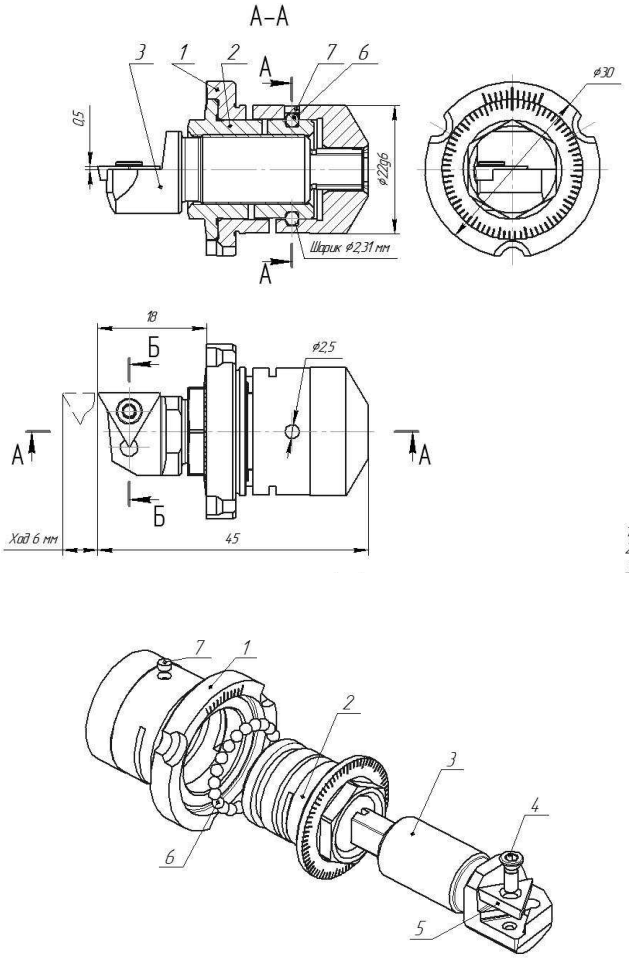

1 – cup; *2* – sleeve; *3* – holder; *4* – screw special; *5* – plate hard alloy;
6 – ball; *7* – lead, used as cork from balls falling out
Figure 5. – Sketch of the insert with screw fastening of the plate

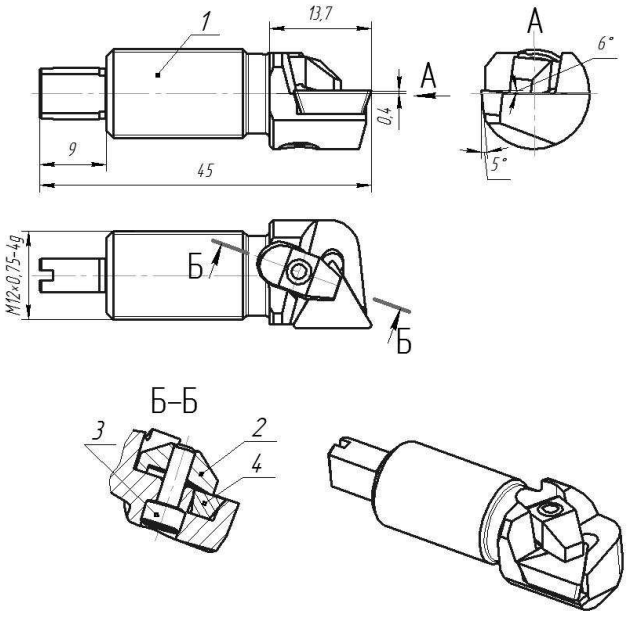

Figure 6. – Sketch of the threaded insert

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The most complex part is the threaded insert holder. To improve the accuracy of manufacturing the groove for the plate and tacking, it is necessary to use a milling cutter made of hard alloy after quenching the entire threaded insert. Before processing, it is necessary to grind the outer diameter under the thread, and to grind the thread with special single-thread circles from elbor.

The "bushing" part 2 contains a non-technological element — an internal threaded surface, which involves the use of special master taps and final grinding of the coils to obtain the desired roughness.

Details "sleeve" 2 and "glass" 1 contain radial grooves. They are low-tech due to the size of their length and width. However, they are necessary from the point of view of obtaining a "spring" for preload when sampling a gap in a threaded connection.

The company Sandvik Coromant (Sweden) separately, on request, delivers a special tool for pre-loading the thread of the tool insert and replacing the thread insert in case of damage by the insert plate of the thread insert.

The analysis carried out and the developed designs of the cutter inserts with micrometric adjustment of the blade for boring precise holes allow to modernize the existing technological process, which will ensure a reduction in the price of the prefabricated cutting tool used and, accordingly, a decrease in the price of the product. The use of standardized inserts with micrometric blade settings with standardized elements of the installation will reduce the range of cutting tools in the enterprise as a whole, followed by import substitution of an expensive assembly cutting tool.

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UDC 621.793

COLD METAL OXIDATION

EVGENI PUIMAN, DMITRI BASHLACHEV, NIKOLAI POPOK
Polotsk State University, Belarus

The methods and results of studies of cold metal oxidation are presented

In mechanical engineering oxidation or burnishing - the formation of oxide films on the metal surface [1] are widely used to protect products against corrosion and to give them more attractive appearance. Metal Oxidation is carried out in several ways: chemically, thermally, electrochemically, by flame or arc [2]. Each of these methods has advantages and disadvantages concerning oxidation process technology, used equipment and accessories. This paper discusses the possibility of using a single and small-scale production of parts by two oxidation methods: chemical oxidation, cold blackening, and thermal or "hot" oxidation.

Comparison of cold blackening and hot oxidation shows that the first method has a number of advantages (Table 1):

Table 1. – Comparison of cold and hot oxidation

COLD blackening (chemically pure) – "INSTA-333 BLACK"	HOT OXIDATION
guild temperature	The bath temperature> 140 ° C
Low cost and ease of bath use	The high cost and complexity of the bath operation
Bath KhCh is always ready to use	It takes a lot of time to warm up
No warping	Perhaps buckling of parts
You can blacken iron	Problems with cast iron
Low equipment cost, easy to manufacture, self-sustaining	The high cost of sophisticated equipment
KhCh line can be installed almost everywhere, in any shop	Installation is allowed only in special rooms
simple ventilation	Need a powerful extractor
Security of service	Increased OSH requirements

– The process is applicable to the oxidation of various steels: carbon and alloy, structural and tool, cold-hot rolled, after forging or stamping, as well as cast iron and powder metals.

– Cold blackening solution is universal and parts from steels and cast irons of different brands and types can be subjected to blackening in the same tub.

– High decorative properties of the coating – the item acquires a deep rich black color, which improves its appearance and presentation.

– High efficiency of the process is characterized by the absence of costs for heating and maintaining the bath at a given temperature. The process is carried out at the shop floor temperature.

– Coating is recommended for mating parts. In the case of mating parts coating is not painted, does not crack, does not peel off. At the initial contact and during the subsequent lapping, the black oxide layer friction surfaces are produced, with simultaneous formation of the scuffed surfaces.

– The properties of the cutting tool are improved; its service life is increased.

– Landing size and hardness retained.

– There is no easily removable dark smearing plaque inherent to other blackening processes at room temperature.

– High corrosion protection. Cold oxidation technology provides excellent corrosion resistance of parts, up to 150 hours in the salt spray chamber.

– Dimensional stability-dimensions increase by 0.12-0.25 μm. This means that the surface properties of the oxidized part are maintained: the polished surfaces remain shiny, and the hardness of the heat-treated parts does not change. Dimensions of precision parts-stored "deformation, which may occur during hot oxidation – no".

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– High performance - the duration of the cold oxidation process is 50-55 seconds, as opposed to 25-30 minutes with hot oxidation.
– Processability-the process is insensitive to variations in the concentration of the main drug.
– Blackening can be made on pendants, in bulk baskets or buckets, drums.
– The process is easily controlled due to the ease of control and adjustment of the working solution.
– Low capital costs-no expensive equipment, heating devices, instrumentation, powerful supply and exhaust ventilation is required.
– Safety of the solution – for the preparation of cold blackening non-aggressive, water soluble concentrate "Insta-black 333" is used; it is odorless, in contrast to the hot oxidation solution, where caustic substances are used with the presence of odors and harmful fumes with a high probability of emission and spraying of a hot caustic solution.
– Long service life of the bath-the solution can be replenished by adding a fresh drug.

Depending on the grade of steel, surface condition and whether the surface is jet-abrasive or not, the number of operations in cold blackening and, accordingly, the number of baths in the line can vary from 5 to 9

The maximum number of operations is nine.

1. Chemical degreasing-contaminants such as cutting fluids, emulsions, lubricants and corrosion inhibitors must be removed. Contamination can slow down or inhibit subsequent processes, negatively affecting the adhesion and appearance of the black film. For effective (guaranteed) degreasing it is recommended to use branded alkaline preparations "E-Wedge 148 E" or " E-Wedge 196»

2. Washing in the bath with bottom feed, top drain. Poorly washed alkaline degreasing film will quickly contaminate the bath in the next activation or blackening operation, which will lead to deterioration of adhesion of the black film and the appearance of spots on the surface

3. Etching in HCl solution (200-300 g/l) for the purpose of oxide film removal.

4. Washing in the bath with bottom feed, top drain

5. Activation by immersion for 0,5-3 min in 20 % aqueous solution of the drug "E-Prep 258" at 18-30° C

6. Washing in the bath with bottom feed, top drain.

7. Blacking – dip for 3-4 min at room temperature in acidic solution (pH of 1.8), containing ~ 20 ml/l of the drug "Instable 333 5X".

8. Washing in the bath with bottom feed, top drain.

9. Compaction by immersion of parts for 2 minutes in one of the film-forming inhibited hydrophobizing compounds called anticorrosive "E-Tech". Anti-corrosion quickly displaces moisture from the surface of the part and absorbed by the pores of the coating, providing long-term protection against corrosion. In cases where there is no need for pickling, stages 3 and 4 are excluded, and the treatment is carried out in seven stages: 1-2-5-6-7-8-9. A line of 7 baths of 75 liters is shown in the photo on the next page.

Black simple mild steel often requires even less operations – five: 1-2-7-8-9.

And in the case of applying jet-abrasive cleaning (CAO), provided that measures have been taken to prevent contamination of the surface of the products with oil, also requires five operations. Immediately after CAO the part should be cold flushed, and then immediately immersed in a blackening bath. The stage of degreasing and activation is passed (after CAO, the metal surface does not need additional activation). The sequence of operations in this case will be as following: CAO-6-7-8-9.

The black coating formed on the surface treated with jet-abrasive method will be matte.

When the processed products are immersed in a blackening solution the ions of the black compound are deposited on their surface instead of part of the iron ions passing into the solution. There is an autocatalytic reaction. The consequence of the accumulation of iron ions in the solution is the appearance of white flake particles, a mixture of amorphous iron oxide with other reaction products. This colloidal phase should be removed by continuous cyclic pumping of the solution through a filter with a retention pore diameter of 5 to 50 microns, at a rate of 2-3 bath volume per hour. The speed can be less-it is only important to ensure that the solution is constantly transparent (the bottom of the bath should be examined). Cleaning the solution from loose sludge will increase the service life of the solution to 10 years or more, improve the quality of treatment and reduce its cost.

Flushing – the most important operation of the process, which directly affects the quality of the coating. It is recommended to thoroughly rinse product in cold running water in the bath with a drain pocket, the water supply is provided from the bottom; water consumption: ~ 4 l/min flushing Time 1-2 min.

Taking into account the previously considered recommendations cold blackening of samples of different steels was carried out: 40X, R6M5, 45 steel in the research laboratory of the Department "technology and

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equipment of machine-building production" of Polotsk state University. The appearance of the samples before and after blackening is shown in figure 1.

1

2

3

1 – appearance of the steel R6M5 sample before and after oxidation;
2 – appearance of the steel 45specimen before and after oxidation;
3 – appearance of the 40x steel specimen before and after oxidation.
Figure 1. – The appearance of the samples before and after blackening

As the results show, the samples after oxidation have a more attractive appearance; samples do not corrode long time and in humid atmosphere; the oxide film has sufficient adhesion to the metal. Taking into account the achieved technological effectiveness, this method of cold oxidation is recommended for the processing of parts made of carbon, alloy and high-speed steels in small-scale production.

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3D MAKING OF TEAM CUTTING TOOLS FOR HIGH-SPEED PROCESSING

S. PARTSIANKA, NIKOLAI POPOK
Polotsk State University, Belarus

The results of work on improving the constructions of block-modular face milling cutters, taking into account the analysis, the use of 3D modeling and rapid prototyping are presented.

Currently, more than 50% of cutting tools used in machine-building production are prefabricated, due to their well-known advantages compared to composite and solid [1]. However, due to the intensive development of high-speed machining, characterized by the rotational speed of the cutting tool from 10000 to 40000 min-1, the extensive use of prefabricated structures is constrained by their large size, inertia of the masses and, as a result, the cutting power [2].

Requires modern design and technological solutions to improve the aerodynamic parameters (properties) of cutting tools through the use of a rational form of buildings, balancing mechanisms, etc.

In the manufacture of modular cutting tools used various methods, such as pressure treatment and machining, powder metallurgy techniques and 3D printing. For each of these methods requires the construction of such a design of the cutting tool, which would take into account the functional purpose of the cutting tool, for example, for high-speed milling or boring, and features of its manufacturing technology (processing and assembly). The solution of this technologically complex tasks is possible with an integrated approach to design, involving mathematical modeling of a 3D design, prototyping (manufacturing) an experimental sample using three-dimensional technologies, physical modeling of cutting conditions of a material with a cutting tool model, and optimizing cutting tool parameters. cutting tool [1].

An analysis of the constructions of precast cutting tools shows that many foreign firms use a streamlined shape of cutters. And balancing mechanisms in the form of screws (Figure 1, a). In boring precast cutting tools, the body most often has a cylindrical shape and a balancing mechanism in the form of two rings. A 3D layout of the face milling cutter of a streamlined shape formed by two mating tori and balancing screws obtained on a 3D printer is proposed (Figure 1, b).

a) b)

Figure 1. - Flowing milling cutter (a), milling cutter with balancing screws (b)

In the model of the face milling cutter according to Figure 2, a balancing mechanism in the form of two rings with spiral grooves is proposed (Figure 2, b).

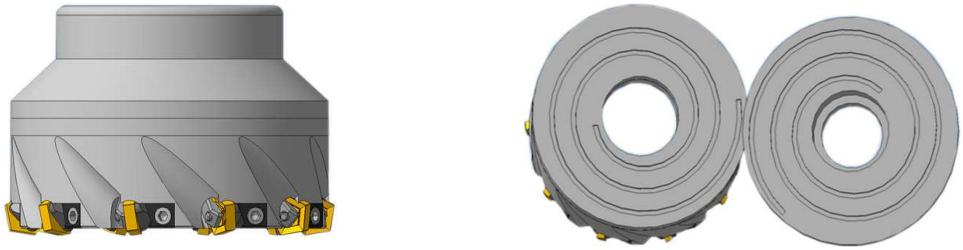

Figure 2. - 3D model of a face milling cutter of a streamlined shape formed by two mating tori and balancing screws (a)

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The 3D layout of the boring tool has a cylindrical body and a balancing mechanism in the form of two rings, made in the shape of an Archimedes spiral (Figure 3).

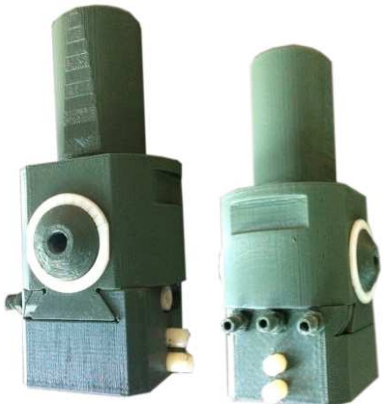

Figure 3. - Layout boring chuck with a balancing mechanism in the form of two rings

A feature of this construction of two balancing rings is the ability to change the corrective mass in anti-phase to the cutter imbalance added by moving a load (ball) of a certain mass in a groove in the spiral of Archimedes. Creation of a universal balancing mechanism to correct the imbalance in the different types of cutting tools involves the further development of 3D models, modeling prototypes and their testing.

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ICT, ELECTRONICS, PROGRAMMING

UDC 004.05

HYPERTEXT TRANSFER PROTOCOL SECURE. SECURITY WEB SERVICES

DZMITRY TATARYN, IRYNA BURACHONAK
Polotsk State University, Belarus

The features of the HyperText Transfer Protocol Secure Protocol (HTTPS) and the problems that can be encountered when using it are considered. Conclusions are made on the necessary measures to ensure complete security when using the HTTPS protocol.

When you enter the site name, everyone is accustomed to seeing the http: // or HyperText Transfer Protocol (HTTP) links at the beginning – the Hypertext Transfer Protocol – the standard data transfer protocol from the server hosting the site to the user. However, despite its popularity, more and more websites prefer to use a more advanced protocol, HTTPS, since it protects transmitted data from being intercepted by attackers by encrypting it. In the present article we will consider this protocol in more detail: how it works, who is recommended to use it and what is needed to connect it to the site.

HTTPS is a protocol that ensures the confidentiality of data exchange between a site and a user device. Information security is ensured through the use of cryptographic protocols SSL (Secure Sockets Layer) – a layer of secure sockets and its predecessor TLS (Transport Layer Security) – a transport layer security protocol, further SSL / TLS, having three levels of security:

– data encryption - allows you to avoid their interception;

– data integrity - any change in data is recorded;

– authentication - protects against user redirection.

SSL can be compared with the "candy wrapper" in which HTTP data is wrapped to hide it from outsiders. The SSL / TLS protocol helps two unfamiliar with each other Internet users to establish a secure connection through a normal, non-secure channel. Using mathematical algorithms, both users – the client and the server – agree on the secret key without transferring it directly through the connection. Even if someone manages to connect to the connection and intercept all transmitted data, it will not be able to decrypt it.

SSL uses a multilayered environment: on the one hand, it is the client program protocol, for example, (Internet Message Access Protocol (IMAP) – an application layer protocol for access to e-mail, File Transfer Protocol (FTP) – file transfer protocol and HTTP), and on the other, TCP / IP transport. The name TCP / IP comes from the two most important protocols of the family – Transmission Control Protocol (TCP) / Internet Protocol (IP) or Transmission Control Protocol / Internet Protocol. For SSL encryption, symmetric and ac-symmetric keys obtained using various mathematical models are used [1].

Next, we will conduct a comparative analysis of the use of the HTTPS and HTTP protocols.

For HTTPS connections, TCP port 443 is commonly used. HTTPS is widely used to protect information from interception, and also, as a rule, provides protection against man-in-the-middle attacks – if the certificate is verified on the client, and at the same time, the private key of the certificate was not compromised, the user did not confirm the use of the unsigned certificate, and the certificates of the malefactor's certificate were not implemented on the user's computer. The man-in-the-middle attack can be seen in Figure 1.

Currently, HTTPS is supported by all popular web browsers.

Mandatory use of a secure data transfer protocol requires all information relating to making payments on the Internet: payment for goods in online stores in any way (individual payment card, online payment systems, etc.), payment for services through Internet banking, making payments online services (casino, online courses, etc.) and many more. The use of the HTTPS protocol is also recommended on sites that request user data for access to certain content, for example, a passport number – such data must be protected from being intercepted by hackers.

If your site uses something similar, then you should seriously consider switching to HTTPS. Therefore, we will consider below what is necessary for this.

The operation of the HTTPS protocol is based on the fact that the user's computer and the server select a shared secret key with which the transmitted information is encrypted. This key is unique and is generated for each session. It is believed that it is impossible to fake it, because it contains more than 100 characters. In order to avoid data interception by a third party, a digital certificate is used – this is an electronic document (ED) that

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identifies the server. Each owner of the site (server) must have such a certificate to establish a secure connection with the user. This ED specifies the owner and signature. With the help of a certificate, you confirm that:

– the person to whom it is issued, really exists,

– it is the owner of the server (site) that is specified in the certificate.

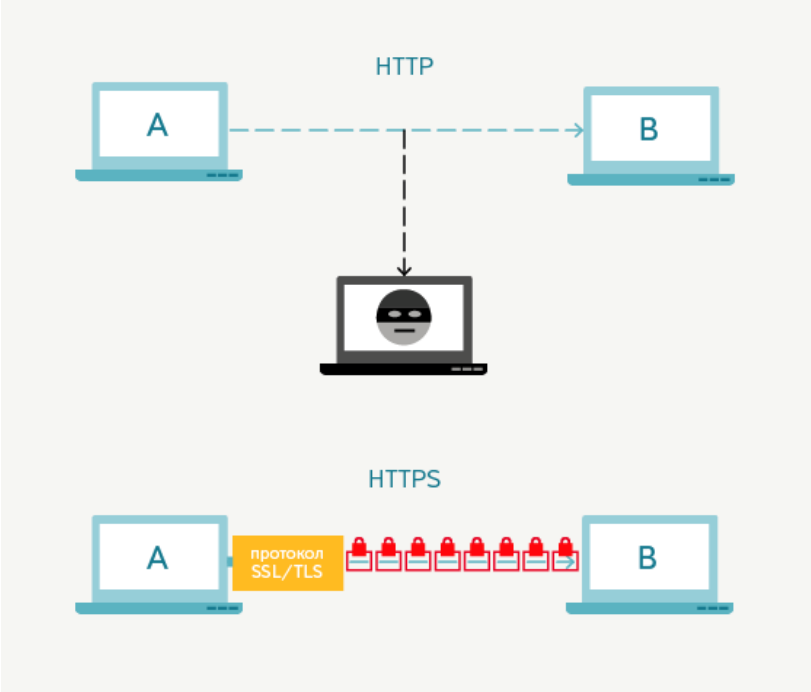

Figure 1. – Comparison of HTTP and HTTPS

The first thing that the browser does when establishing a connection via the HTTPS protocol is to check the authenticity of the certificate, and only in the case of a successful response, data exchange begins.

More details on the problems that can be encountered using HTTP:

1 Sharing HTTP and HTTPS. When sites use mixed HTTP and HTTPS functionality, this potentially leads to an informational threat to the user. For example, if the main pages of a certain site are loaded using HTTPS, and Cascading Style Sheets (CSS) and JavaScript are loaded via HTTP, then the attacker, at the time of downloading the latter, can load his code and get the HTML page data. Many sites, despite such vulnerabilities, download content through third-party services that do not support HTTPS. The HSTS mechanism allows you to prevent such vulnerabilities by forcing the use of HTTPS connections even where the default is HTTP [2].

2 Attacks using traffic analysis. In HTTPS, traffic analysis vulnerabilities were discovered. An attack with traffic analysis is a type of attack in which properties of protected channel data are displayed by measuring the size of traffic and the transmission time of messages in it. Traffic analysis is possible because SSL / TLS encryption alters the content of the traffic, but has a minimal impact on the size and time it takes to pass traffic. In May 2010, researchers from Microsoft Research and Indiana University found that detailed confidential user data can be obtained from non-essential data, such as package sizes. The traffic analyzer was able to get a history of diseases, data on used medications and user operations, data on family income, etc. All this was done despite the use of HTTPS in several modern web applications in the field of healthcare, taxation, etc. [3].

3 The man in the middle of https. When a man-in-the-middle attack is used, the HTTPS server sends a public key certificate to the browser. If this certificate is not trustworthy, then the transmission channel will be vulnerable to the attack of the malicious user. Such an attack replaces the original certificate certifying the HTTPS server with a modified certificate. The attack succeeds if the user neglects double checking the certificate when the browser sends a warning. This is especially common among users who often encounter self-certified certificates when accessing sites within a network of private organizations.

As a result of the study, it can be concluded that the HTTPS protocol is quite flexible and easy to use, it ensures the confidentiality of data exchange between the site and the user device. Thanks to the HTTPS proto-

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col, it has become possible to keep confidential information secret. To communicate with the client, HTTPS uses SSL / TLS for encryption with a fairly high level of security.

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UDC 534.781

PROTECTION OF INFORMATION STORED IN DATABASE MEANS MS SQL SERVER (TRANSPARENT DATA ENCRYPTION)

ALEXANDER POPOV, IRYNA BURACHONAK
Polotsk State University, Belarus

With the development of computing tools and information transfer systems, the problem of ensuring its security, preventing unauthorized access to information, physically destroying or modifying protected information is becoming increasingly urgent.

Under the threat to the security of information means an action or event that can lead to the destruction, distortion or unauthorized use of information resources. In order to increase the security of stored data, humanity is constantly inventing various algorithms to prevent unauthorized access to information.

Moreover, the choice of methods and means of protection is determined not only by the importance of the information being processed, but also by the composition of the data storage system, its structure, methods of information processing. At present, among the developers of modern software applications, client-server architecture is popular. It allows you to distribute the load on the solution of tasks among several machines, thereby increasing the speed of data processing. In this article we will look at the option of building a system using MS SQL Server as a data warehouse and using Transparent Data Encryption (TDE).

Encryption of a database file is carried out at the page level. Pages in an encrypted database are encrypted before being written to disk and decrypted when read into memory. Transparent data encryption does not increase the size of the encrypted database. When using transparent data encryption, SQL Database automatically creates a server-level certificate stored in the master database. To move a TDE encrypted database, you need to decrypt it, move it, and then re-enable TDE in the target SQL server. This way data is protected when physical media is stolen, since without a certificate, the attacker will not be able to access the encrypted data [1].

Next we directly consider the encryption process using TDE. Special hierarchy of keys is used to increase the reliability of cryptographic protection and reduce the load on the system. Each database table is encrypted with a special symmetric Database Encryption Key. Database Encryption Key is encrypted by a certificate that is created in the database. The copy of this certificate is placed in the Master database. The master database certificate is encrypted with its master key. The master key of the master database is encrypted with the master key of the Service Master Key (SMK) service. The service master key is the top of the MS SQL Server encryption hierarchy. It is created automatically when it is needed during encryption. However, to enhance security it is also encrypted by the operating system data protection service.

As a result, we have the following chain: Service master key -> Database master key -> Keys and certificates in the database. Accordingly it is not possible to decrypt the data without having one of the components. Therefore it is necessary to make backup copies of keys [2]. The user application that interacts with the database server receives all the necessary data in decrypted form at the stage of encrypting the master key of the master with the master key of the SMK service.

This scheme uses both symmetric encryption algorithms and asymmetric ones. Symmetric encryption is less demanding on system resources, but more vulnerable. The asymmetric method, on the contrary, is protected at the key management stage. For the same reason it requires significantly more computational resources. Using a combination of both methods allows you to neutralize the shortcomings of each of them and to improve security and performance; compared to if all the time used one of the types of encryption. Thus, the database is protected by faster symmetric encryption, which is preferable when taking into account large amounts of information. In turn, base encryption keys are subjected to asymmetric encryption, the size of which is incommensurably small, but the criticality of their protection is higher. Using this approach on servers with low I / O, low CPU consumption and enough RAM to store large amounts of information affects the performance by 3-5% when you turn on TDE. Servers with a smaller amount of RAM, whose applications load the CPU and I / O system, will produce a load of 28% more, the reason being asynchronous execution of procedures in SQL.

Thus, this algorithm provides encryption of the user database for which TDE encryption was enabled, the transaction log of this database, as well as the common temporary database tempdb. But unlike full encryption of the user base, the transaction log and tempdb are encrypted from the moment TDE is enabled — the previous entries in them remain open. Therefore, after encryption is enabled, it is necessary to re-create these files.

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The main disadvantage of this scheme, despite the fact that it ideally opposes the theft or seizure of the database itself, is the vulnerability of data at the network level. That is, during the transfer between the client and the server, data can be stolen or replaced. Additional organization of encrypted channels using TDE would entail additional performance costs. With large amounts of data and the number of requests it could seriously affect the performance of the system as a whole. In order to encrypt all information via the client-server-client channel, it is necessary to issue the root trusted certificate to the server, import it to the client stations and configure the cryptographic algorithm interaction scheme. One of the most effective schemes will be traffic encryption using a symmetric method, while the keys are protected by open certificates.

By combining these two approaches, you can fully protect the data stored in the database.

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UDC 004.05

ARCHITECTURAL DESIGN PATTERN ENTITY-COMPONENT-SYSTEM

DZMITRY SUSCHEUSKI*, *IRYNA BURACHONAK
Polotsk State University, Belarus

In the presented article, the architectural design pattern Entity-Component-System is investigated. It describes its main features that improve the architecture of the game application and solve problems related to the performance and flexibility of the software.

One of the main problems of the present time is the ever-increasing complexity of software. This leads to an increase in the probability of making a mistake. To solve these problems, new approaches to writing software, design patterns and rules to facilitate system support are created. Games, like other applications, should work quickly, and their design should allow easy expansion of functionality.

In the presented article we will take a closer look at one of the interesting approaches of the Entity Component System (ECS) which is based on composition. ECS is an architectural pattern that is mainly used in game development. ECS adheres to composition, not inheritance, which allows for greater flexibility in defining objects. Objects consist of one or more components that add additional behavior or functionality. Therefore, the behavior of an object is easy to change at run time by adding or removing components [1]. Many large companies, such as Unity, Epic, Ctytek use this template. This approach is data-oriented and reduces the number of cache miss [2].

The component approach is increasingly recognized in game development. The main idea of the approach is to divide the functional into separate components, which are mostly independent of each other. Standard deep inheritance hierarchies are not used. Instead of traditional hierarchies of objects, collections are created, collections of independent components. Each object has only those functions that it needs. Any new functionality is easily implemented by adding new components.

The cache controller manages the contents of the cache, retrieving data from the RAM, transfers it to the processor, and returns the results of the calculations to RAM. When the processor core accesses the controller for data, the controller checks if this data is in the cache memory. If the data is contained in the cache, then it is given to the processor. If the data is not found, the kernel must wait for the moment when this data will be loaded from RAM, which is a very resource-intensive process. The situation when the cache does not have the necessary data is called a cache miss. The controller tries to keep the cash misses to a minimum. Processor cache size is very small compared to RAM. Usually it stores a small part of the data taken from the RAM. As a rule, all modern processors have caches of different levels (Figure 1); the higher the level, the less memory it has and the more efficient the data acquisition rate is. If the data is not found in the uppermost level of L1, then there is an appeal to the level that is below L2 and the necessary data is searched, if this data is not there, then the last level of L3 is accessed, if no data is found in it, then the controller accesses the RAM. Such complex architectural solutions for working with memory were chosen for the reason that usually the bottleneck in programs is working with memory. Therefore, it is very important to work with memory as efficiently as possible. To do this, the program should be as cache-friendly as possible to achieve maximum performance.

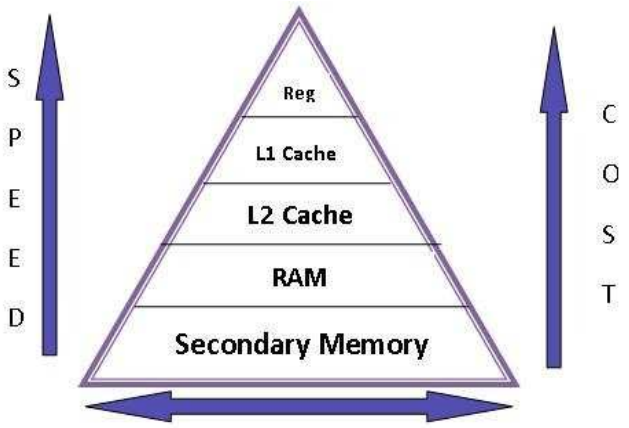

Figure 1 – Computer memory levels

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The pattern can be divided into three parts.

1. Entities are container objects that do not have properties that act as storage for "components". An entity is an implicit aggregation of components. Storage is usually a simple data container. Usually, an approach is used in conjunction with entities, called object pooling (of the object pool). This reduces the cost of allocating and redistributing memory, which is a resource-intensive process. The idea of this approach is to allocate a large memory size, and if necessary, take it from the reserve and use it to create objects, and after the object is not needed, you need to return it back.

2. Components are data blocks that define the possible properties of any game objects or events. All this data is grouped and processed by a certain logic. They are objects with a simple data structure (plain old object, POD). Each type of component can be attached to an entity to determine its characteristics. Components contain no logic, sometimes they are empty markers for processing the system. The component can be compared with the structure in the C programming language, it has no methods and is capable of storing data. Each component describes a specific aspect of an object and its parameters. The components themselves make little sense, but when combined with entities and systems, they become an extremely powerful tool for solving development problems. For example, entities can be assigned the "health" property, which is a regular integer or fractional value in memory. The component should not have a large size, because this will cause problems in processing speed.

3. System is responsible for the processing of components, in which the work of all logic takes place. The system has a list of components with certain types, where it scans them and processes them. As a rule, the system never has one element, it deals with a collection, and processes the elements in turn, but this does not mean that the collection cannot be empty or have only one element. This approach eliminates the problems if in the future it will be necessary to add, for example, a new character. For example, the system can work with position, speed. Each system will be updated in a logical order.

Intersystem communication can be done in a variety of ways. For example, the way to send data between systems is to store certain data in components. In the game, the position of the object can be constantly updated. However, this approach is not always good when events occur rarely and it is necessary to somehow keep the current state. The most common are status flags, but this has a big drawback. Systems at each iteration will read the flags and check the availability of the event, which may be ineffective, one of the reasons may be the branch prediction.

The branch prediction is a mechanism that is a part of microprocessors, with a pipeline architecture, where the prediction is carried out whether a conditional transition will be performed in an executable program. The reason is that modern processors perform many operations in parallel, which allows to reduce the downtime of the conveyor due to preloading and execution of instructions that must be performed after the conditional transition. Branch prediction plays a critical role [3]. This can be a problem in ECS, since the components are treated as a continuous pipeline with low latency. For example, in Unity, the Fixed Update method runs 50 times per second. There is also an Update method, the speed of which can vary from the power of the computer, i.e. maybe both 100 and 10 calls per second. In this case, the problem may be critical. Therefore, as a rule, there are several subsystems in the system that update entities. To solve this problem, a design pattern can be used - an observer. All systems that depend on an event subscribe to it. Thus, the action from the event will be executed only once at the moment when it happens and does not require constant polling with checks.

The Entity-Component-System approach solves the problem with multiple invocations of update methods that surround all gaming applications. A good example is the Unity game engine. Native calls of programming language C ++ occur in it. There is a performance test of one of the Unity developers, in which he showed how native calls affect performance. In these tests, the Unity developer made 10,000 calls to the Update method and called the update method, which is not native. Links to components were added to the collection, where they were called in turn [4]. Table 1 presents the results of performance measurements.

Table 1. – Measurements of the performance of native and non-native methods in Unity

Mono

Methods	**iPhone 6**	**iPhone 4s**
Update	2.8ms	
Manager	0.52ms	2.1ms

IL2CPP

Methods	**iPhone 6**	**iPhone 4s**
Update	5.4ms	10.91ms
Manager (Dynamic Array)	1ms	2.52ms
Manager (Array)	0.22ms	1.15ms

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As a result of the study, it can be concluded that the use of the ECS approach not only reduces code connectivity, but also significantly increases program performance. The proposed approach allows us to simplify further support and provide a simple way of connecting the game components to each other.

The advantages of the ECS approach include: flexibility, scalability, efficient memory use, easy access to objects, and ease of testing.

In the future, it is planned to introduce this approach into the development of a casual multiplayer gaming application. Since Unity is initially used is not fully implemented in ECS approach, because of which there are certain performance problems, with a large number of objects.

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UDC 005

BIG DATA DEVELOPMENT TRENDS, RISKS AND PROSPECTS

STEPAN KUZNETSOV, SERGEI SURTO
Polotsk State University, Belarus

Management of the structured and unstructured data with the help of new technologies and instruments of their processing – a subject, now relevant both at the level of the concrete enterprises, and at the level of the state. Big Data is even more often discussed at various actions.

Big data is designation of the structured and unstructured these huge volumes and considerable variety which are effectively processed by horizontally scalable program tools which appeared at the end of the 2000th years and alternative to traditional database management systems and solutions of the class Business Intelligence [6].

The IDC company predicts growth of the market of technologies of processing of big data and business analytics by 12% a year till 2020. First of all, growth of the analytical Big Data platforms using machine learning and the systems of artificial intelligence on the basis of neural systems that is demanded by business for the analysis of data on consumers and forecasting of their behavior is expected. The concept of the Internet of Things (IoT) has a great influence on the market. In 2016 the largest volumes of world investments were directed to the Internet of things in the sphere of production, cargo transportation, power supply systems, a consumer segment. The most rapid growth of the Internet of things is expected in insurance area, the sector of consumption, health care and retail trade.

The international analytical agency Gartner predicts increase in demand for experts in the field of data management and increase in number of departments in this area as it is expected that it will lead to maximizing profit. More and more popular is a position of Chief Data Officers (CDO) [2]. Initiatives in the field of analytics, data management, development of strategic tasks and integration of analytics and data in strategy and also ensuring information security at the enterprise have to become its main objective.

Recently many researches are conducted in the field of so-called big social data. A number of experts considers this direction as separate science. Here it is possible to allocate four significant subareas — social computing, Big Data science, data analytics and computational social science(CSS) [5].

The problem of big data covers methods of classification, processing, storage, search, exchange, the analysis and visualization of data. Big data usually have to be processed on crossing of four requirements characteristics known as "requirements of four V":

– the volume of data (Volume), is supposed that and to methods of their processing refer to category of big data only massifs from several terabytes. Quite often monthly accumulation of data array the required volume is characteristic of large enterprises. These data demand the appropriate means of safety relating to the Big Data Security applications;

– speed of data processing (Velocity) if to consider concerning the organization of methods of safety, is meant detection of anomaly and prevention of invasion in real time. The analysis of data, the deep analysis of packages allows to minimize damage of the attack or unauthorized leak from accounts of users;

– variety. Big massifs have to not only correspond on volume to big data, but also turn out from different sources. Concerning cyber security, a variety of data sources and their vulnerabilities is at the same time estimated. Logs can be analyzed, be estimated on the structured and unstructured data, different network streams. For example, going from e-mail, a set of coherent mobile devices of users, by means of capture and the deep analysis of packages, at the same time to be monitored vulnerabilities and to be prevented invasions.

– objectivity (Veracity). Accuracy and reliability of data is meant, from the point of view of the organization of safety – the corporate data belonging to the category big have to be provided with the security aids providing their confidentiality, integrity, availability of sources, such as logs and external channels of data. The relevance of these requirements grows especially when using methods of anonymization of traffic which mean, first of all, destruction of structure of messages and chaotic processing of IP packages.

In connection with the processing of social data, users of various resources have legitimate concerns about the use of their data: where and how they will be stored, who and how can access them, how long they will be stored. Experts confirm the existence of imaginary and real dangers associated with Big Data. To the imaginary can be attributed the effect to the polls. As an example, we can bring the recent scandal with Cambridge Analytica. The company gained access to data analysis of nearly 50 million users of social services.toils. First, a small psychological test was

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held by a small group of users, they even paid for it. They gave their consent to the processing of the data, thus, formally did not violate the privacy of the user. But then from their profiles pulled profiles of friends — and on it explicit permission wasn't any more. The data was processed, and the person began to receive commercials designed specifically for him about the candidate. It is difficult to assess the extent to which concerns about big data and its use may have an impact on elections, as many factors play a role. But some research in this area can serve as a theoretical justification for these fears. Research by the famous scientist from Stanford graduate school of business Mikhail Kozinski. One of his studies is devoted to the field of psychometry-the science at the intersection of psychology and sociology, which allows to attribute a person to a particular type of behavior and predict his actions on the basis of sociological data. The scientist M. Kozinski and his colleagues developed a method that allowed analyzing likes on a social network. The method could determine with very high probability the skin color of the user, his sexual orientation, commitment to the party. There are opinions that this technology was applied by Cambridge Analytica to preparation of personal political advertizing during the election of the president of the USA.

The question of the use of certain technologies is associated with the goals of their use and with those in whose hands they fall. Here you can draw an analogy with nuclear development: you can "use the atom" for peaceful purposes - nuclear energy, and you can make an atomic bomb. Similarly, processing and analytics technologies for big data can be used to prevent abnormal situations and transport disasters, to reduce equipment breakdowns, identify customer preferences, and determine the need for medical services. And the same technologies allow filtering people for some purposes, for example, for hiring. Real dangers include the use of Big data for commercial purposes. But what really develops at a rapid pace and has all chances to become one of the main investment targets in the future is the Internet of Things (IoT) [4].

According to experts, there are four important aspects of the use of big data: the data itself, analytics, people, tools [1]. Structured and unstructured data can be distinguished, and human-generated data (texts, office documents, manual input data) and machine-generated data (operational data, satellite images, scientific data, photo and video) can be extracted in both types of data. Now interest has shifted to unstructured data.

There is a number of problems in the field of big data, in particular:

1. Question of quality of unstructured data. It is possible to face a fair share of counterfeited content in the Internet. For example, there are people and programs of artificial intelligence for writing of responses both positive, and negative.

2.Big Data is not only unstructured information. So Banks of the world, except tasks of the analysis of addresses of citizens, identifications of affiliates on the Internet, passes to collecting and processing of financial micro data and operational data from credit institutions that will demand use of Big Data technologies.

The greatest prize from use of Big Data will be received by predictive analytics and operational analytics. But the new direction in business analytics of data discovery continues development. There is an opinion that Data scientist has to have knowledge in many areas, often on a joint of different disciplines. In fact, experts combine on several roles.

Application areas for Big Data technology.

Large and medium-sized companies from the trade and service industries show great interest in using Big Data technologies. These technologies are actively used by banks, mobile operators. In addition, they are used by large manufacturing companies to analyze data on equipment breakdowns and reduce downtime, which allows to reduce costs. For example, in the field of flight control, the analysis of data arrays can increase the reliability of equipment and reduce the number of failures.

But scope of Big Data is much wider.

For example, business purchase can be one more of scopes of Big Data technology. It is about the broadest coverage of various information on the company. It and analysis of ordered data: physical characteristics of objects; financial data. Can be sources of information: file tables, traditional DBMS, accounting systems. It is necessary to analyze also the disordered data: customer reviews; applications for service; IT infrastructure. Here can be sources of information: tables, schemes, social networks, estimates of experts. The so-called passport of an object including data on arrangement, the area, number of storeys, allowing documentation, inventory data, a competitive environment, historical financial data, a seasonal factor of sales can become result of the analysis of such data.

But, as we know, the cost of the company is not equal to the simple sum of cost of its tangible assets. Collecting and the analysis of information on Big Data technology will allow to estimate the cost of intangible assets. It is possible to carry to them: human resources; knowledge and abilities; information resources; organizational and administrative structure; potential of workers; brand; reputation; developments; bases of clients.

Big Data and digital economy:

Abroad already became a norm when at medium-sized and large enterprises the position of Chef Data Officer is entered. Most often he submits directly to the top management. For our enterprises, even large, such

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position still remains a big rarity. There is a deficiency of experts in the field of management of big data and the corresponding analytics. The universities in principle practically do not train such experts. Young specialists from the IT sphere should be finished learning, retrained, besides, that they often very overestimated requirements for starting salaries taking into account insufficient qualification.

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UDC 004.9

CODING BY VOICE AS A STAGE OF PROGRAMMING EVOLUTIONARY PROGRESS

ADAM PARFIANOVICH, ANATOLIY NADOLSKIY
Belarusian State University of Informatics and Radioelectronics, Minsk

Summary: The article researches the pros and cons of coding by voice. This mode of programming can become a useful tool for routine coding and it can also help people, especially handicapped, to control their electronic devices easily.

The main goal for a programmer is not just simply write a program suitable to fulfill the task by means of any language structures. The main goal is always a set of interesting solutions how to implement these structures. In fact, a programmer needs to translate the tasks to a computer in the most laconic and appropriate form.

Programming as a task can be divided into four stages:

1) Writing
2) Debugging
3) Compilation
4) Performance

A programmer usually writes a short section to solve a concrete task. Then this part of code is compiled and, in case the compilation is successful, it starts and is tested with debugging tools. When the code performs correctly it is expanded to solve a bigger task. The process is repeated till the code solves the whole task. Thus coding is followed by correcting, testing and debugging. A programmer usually works with mediums that offer tools to fulfill all four actions, e.g. Microsoft Visual Studio.

Rather logical question can be brought up as the following: are so various programming languages too necessary to use and to learn without approaching to the direct communication with a system. To answer this question we should as soon as possible make at least several steps in our way to the "dream." Coding by voice is one of these steps.

How coding by voice works. Handicapped people and those who would prefer to code from their smartphones should become the main consumers of coding by voice. For example, Carpal tunnel and repetitive strain injuries can prevent programmers from typing for month at a time. Clearly, that smartphones have been being popularized for long by February 2019. Even cars can be controlled by voice commands through smartphones, and more and more ideal artificial intellects to search information or to communicate with other people are appearing.

So, what is the reason for the coding by voice not to be developed yet? There is an opinion that a lot of people are afraid of such simplifying of coding because it will lead to deterioration of coding quality (that will cause speed reduction of programs performance) and wage declines subsequently. One more crucial factor is a very small opportunity to make profits when coding commercial software. Also there is an existent horrible factor that thieves do not even need to crack your computer to steel the code, if necessary; they will just listen to your voice for some period of time. It is, certainly, simplify the task for them and complicate it for honest citizens: because the techniques to defend it will naturally subject to material and spiritual resources of humanity. It is understandable now that the idea to code some secret projects by voice even sounds rather horrible.

Software. Code by voice is fortunately possible by replacing the keyboard with speech recognition, for example, as David Williams-King writes Linux systems. The key is to develop a voice grammar customized for programming. A community has evolved around hacking the commercial Dragon NaturallySpeaking to use custom grammars, but this method suffers from fragmentation, a steep learning curve, and frustrating installation difficulties. In an attempt to make voice coding more accessible David Williams-King created a new speech recognition system called Silvius that is built on open-source software with free speech models. It can run on cloud servers for easier setup, or locally for the best latency. David Williams-King and his collaborators have also prototyped a hardware dongle which types Silvius keystrokes using a fake USB (Universal Serial Bus) keyboard, and requires no software installation. They hoped that Silvius would lower the bar for experimentation and innovation in this field, and encourage ordinary programmers to try coding by voice, instead of waiting until a crippling injury throws them in at the deep end. The idea was that the technique would become more handful for the whole process of programming and controlling different devices.

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VoiceCode is an Open Source initiative of Institute for Information Technology (IIT) within National Research Council Canada [1]. The task is to develop tools for compliant components to support current best practices in programming in voice using main mediums.

ShortTalk and EmacsListen is a development of a special spoken language for a human-computer interaction [2].

Voice Grip is an additional macros for Emacs editor that has been created to simplify the usage of commercial software for speech recognition by programmers [3].

Java by voice is a series of macros for Emacs editor that have been created to simplify the Java language code input [3].

Cache Pad is macros for Emacs editor for caching recent function names and variables for subsequent re-usage.

Emacs VR Mode is macros for editor that adding Select and Say [3].

Common coding in Microsoft Visual Studio, with the help of Speech Recognition in Windows, can become a good example.

Recently-developed program Code by voice can be offered as an example.

The steps of work are as follows:

1) Signal processing: finding features in sound signals;

2) Acoustic modeling: recognizing phonemes;

3) Language modeling: valid sequences of words [4].

And if the signal processing is easy, the other steps could not be the same. To recognize phonemes we need to train with hundreds of hours of speech. Learn individual phonemes, for example, by the GMMs or DNNs. And even with 24-core server with 48GB RAM you can lose several days to fulfill it and get some results.

To go through Step 3 we even need sometimes to model a new language.

The final work means dictating necessary language constructions by a programmer to a computer while the program is coding itself. The only inconvenience for a programmer will be the necessity to correct mistakes and to hand-type variables. The reason why typing becomes an inconvenience of the presented technique is evident – it will be necessary to dictate a simple variable "GetInfoFromMas" as "Get, no space, big letter, info, no space, big letter, from, no space, big letter, mas, no space," as it is offered in one of the most well-known style of coding "CamelCase" [5].

Google has issued Android program "Voice Access" to use in smartphones and applications for them that can help handicapped people to use their smartphones. This fact proves the possibility to code by this program.

Acceleration of the modern world requires new approaches in a lot of spheres. Coding by voice is a tool that offers new opportunities for ordinary users of the software. The spheres of our life, where this technique can be used, are numerous. Of course, as it was mentioned above it will not be used in different secret services like state secrets, military, accounting, keeping some personal data and others. But the development of this technique is being waited by people who are involved in hand-typing and hand-coding of ordinary codes along with people who are handicapped or unable to type by any reason.

Coding by voice can make our routine life easier. And as a part of the whole evolutionary process of programming this stage is important. In this case we need to try to promote this technology by any means. We should not be afraid of all minuses and disadvantages which have been mentioned in this work above.

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UDC 004.658

PECULIARITIES OF DESIGNING THE DATEBASE FOR CREATING AND MARKETING VIRTUAL TOURIST TRIPS

ULADZIMIR MAHERAU, VLADIMIR PITOLIN
Polotsk State University, Belarus

The object of development is a system for creating and marketing virtual tourist trips. The aim of the research is to create an interactive information system for the distribution and visualization of virtual tourist trips. The issues of designing a database for the creating and marketing of virtual tourist trips are considered in this paper.

Before creating a client application that will work with the database, you should first create the database itself. For the convenience of the follow-on development, the designed database should be easy to understand and normalized.

To design a database, you should select the entities that will be used in the information system. During the analysis of the subject area, which is determined by the largeness of all information about tourism, tourist routes and methods of commercialization, we distinguish the following main entities:

- users (user);
- tourist routes (route);
- travel companies that can organize routes (route seller);
- route point (the route consists of several points) (point).

and additional entities, which include:

- feedback on the route (feedback);
- the visual component of the route points (photos).

To construct a database schema, it is necessary to determine the set of relations between the entities that will be used in the database. It is also important that the entities meet the condition of integrity and the condition of link integrity. The condition of entity integrity is as follows: every tuple of any relationship must be different from any other tuple of this relationship, that is, any relationship must have a primary key, and the condition of reference integrity is as follows: for each value of a foreign key that appears in a child relation, in the parent respect, there should be a tuple with the same primary key value [2].

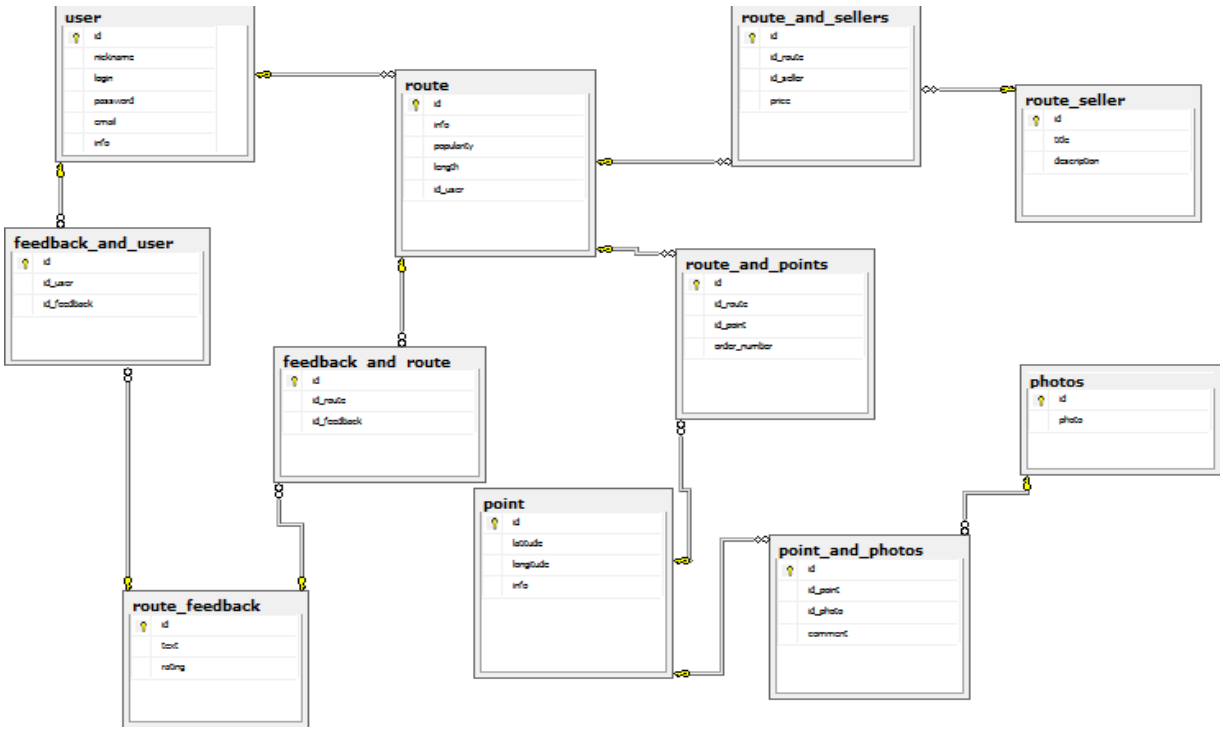

Figure. – The scheme of designed database

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The choice of DBMS is one of the most important stages of system development. Among the variety of available DBMSs, the choice was made in favor of MySQL - one of the most common DBMS (database management system) in the Internet. It will not work with large amount of information, but its use is ideal for Internet sites, both small and large enough. MySQL has good speed, reliability and flexibility. Working with it, as a rule, does not cause great difficulties. An important factor is its free distribution to the terms of the GNU General License (in other words, it is free) [1].

For proper operation and preservation of referential integrity for the entities in the database, add / delete / edit triggers were developed. They prevent the addition of identical records to the database and organize cascade deletion without leaving irrelevant links.

As a result of the work done, the information database of the system for the creation and marketing of virtual tourist routes was designed. The designed base can be the basis for the further development of the system.

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ICT, Electronics, Programming

UDC 004.021

IMPROVING THE PERFORMANCE OF UNITY 3D MOBILE GAMES

ALEXEY KARPOVICH, DMITRY PYATKIN
Polotsk State University, Belarus

This article presents ways to create high-performance applications on Unity 3d. Describedways to improve the performance of applications for mobile platforms and architectural design patterns that are most often used when programming mobile games.

Unity3d [1] is one of the most popular game engines for mobile platforms. Many developers use it to create and release games. When developing games for mobile devices, it is important to consider their limited technical capabilities. There are weak and powerful phones in performance. New generations of mobile GPUs can be 5 times more productive than their predecessors. Despite this, it is important to optimize the application on time in order to achieve maximum performance on most devices and reach a greater number of users. Also of great importance is the architecture of the gaming application. Properly chosen architecture allows us to greatly simplify and speed up the process of developing a game, as well as improve the overall performance of the application as a whole.

To create high-performance applications that will work equally well on any device, good optimization of the program code and graphics rendering is necessary.

Optimization [2] - modification of the system to improve its effectiveness.

Optimization requires finding a bottleneck: a critical part of the code, which is the main consumer of the necessary resource. Improving about 20% of the code sometimes entails a change in 80% of the results, according to the Pareto principle [3]. A resource leak (memory, handles, etc.) can also lead to a drop in the speed of program execution.

However, optimizing code from the very beginning of game development can be a pretty bad idea. Premature code optimization can cause many problems and slow down development. Since the optimized code is less flexible and harder to read. In addition, it is most likely that most of the optimizations that you are going to do at the initial stage of the project will most likely not affect the final project as a whole. Therefore, the best solution is to optimize the application only if necessary at the final stage of game development.

However, there are a couple of exceptions to this rule, which are especially important when developing for mobile devices, because this rule is more suitable for PC projects and they are less limited in resources. Optimization can be carried out immediately:

– If there is a code, or a construction that is already known to write better, with less memory / processor cost, and so on, and this will not damage the overall perception of the program code.

– If there is an action that will be repeated many times, and from the very beginning it can be optimized. Then everything will go automatically, and you will not need to correct the same thing several times.

Before you begin to optimize the code, you need to determine what exactly needs to be optimized. In Unity there is a convenient tool for finding places needing optimization - profiler [4].

A profiler is a tool that allows a programmer to see how much time a program takes to perform each function and rank them in order. When the top function takes 3% of the time, this means that if you can halve the time for its execution, the overall program performance will accelerate by 1.5%.

Optimization mainly focuses on single or repeated runtime, memory usage, disk space, bandwidth, or some other resource.

Most of all, the performance of the game is affected by graphics rendering, so you should pay more attention to it. Usually the best way to increase graphics rendering performance is to reduce the number of draw calls [5].

Draw-call is a drawing API command (for example, OpenGL or Direct3D) for drawing. The graphics API does significant work for each draw-call, which greatly affects the CPU performance.

For mobile devices it is recommended to have up to 100 draw-calls, for older devices it is better that the number of draw-calls does not exceed 40. There are many ways to reduce their number:

– Use batching [6] for drawing objects of the same type using the same material for one approach.
– Use atlases to combine multiple textures into one large one.
– Try to ensure that objects with different materials do not overlap each other.
– Do not change Transform->Scale

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– Try to use fewer particle systems. Each particle system gives 1 Draw Call

Another factor affecting the performance is the so-called performance jumps. Performance jumps are short-term game hangs. Here is a list of rules for reducing performance jumps:

– Try not to use Instantiate (), especially for complex objects.

– Minimize the number of calls Destroy (), gameObject.SetActiveRecursively (), Object.Find (), Resources.UnloadUnusedAssets () and GC.Collect () functions, as they require a large amount of resources.

Unity supports several types of audio; by default, it will import audio clips for use with the Decompress On Load [7] download type along with Vorbis compression [8]. Sound effects are usually short and, therefore, have small memory requirements. For them, the setting of Decompress on Load will work best, but the type of compression should be either PCM or ADPCM [9]. PCM provides higher quality, but comes with a large file size, which is great for a very short but important sound effect. ADPCM has a compression ratio of 3.5 times less than PCM, and is best used for audio effects that are used very often.

Were considered the most common ways to increase productivity, but also to simplify the development of the game and improve performance, it may be important to choose the right game architecture.

The architecture of a computer game [10] is a system for organizing a program that defines the internal logic of building code, the choice of structural elements and the definition of connections between them.

A complex gaming application system consists of several subsystems - functional modules, services, layers, subroutines, connected in a specific sequence. With this functional partitioning, developers get not very connected code, but a set of clear elements that interact according to simple rules.

It is important in the development process to follow the signs of a good architecture:

– It is easy to make edits. New fragments do not require rewriting existing ones.

– The system is effective. The code solves the tasks and works in any conditions.

– Development time can be reduced by increasing the team. Tasks are easily shared between developers.

With an incorrectly written architecture, the game will turn out to be poorly scalable and inefficient in terms of performance.

One of the simplest architectural patterns used in games, as well as one of the oldest, is considered the Game Loop [11]. This template is used in almost every game.

Game Loop (Game Loop) - this is a general flow control for the entire game program. Each iteration of the game loop is known as a frame. Most real-time games are updated several times per second: 30 and 60 are the two most common intervals. If the game runs at 60 frames per second, then the game loop completes 60 iterations every second.

Game Loop works throughout the game. At each iteration, the game loop processes user input without blocking, updates the state of the game, and renders the game.

Another frequently encountered architectural solution in game programming is the Model-View-Controller (MVC) [12]. It is often used in applications with a graphical user interface (GUI) [13]. MVC divides the program into Controllers, Views and Models:

– The model provides data and responds to controller commands, changing its state.

– The view is responsible for displaying model data to the user, responding to changes in the model.

– The controller interprets the user's actions, notifying the model of the need for changes.

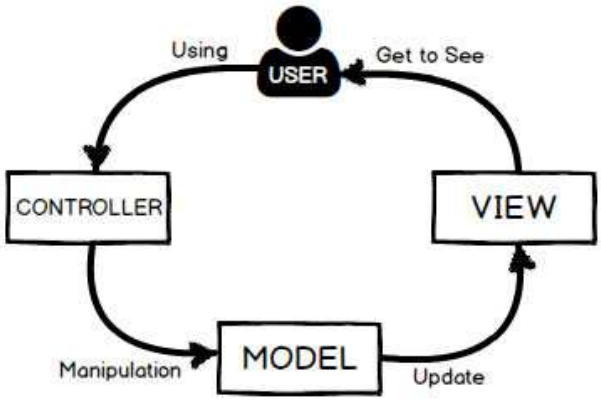

Figure 1. – MVC Chart

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The main purpose of the application of this concept is in the separation of business logic (model) from its visualization (presentation, type). Due to this separation increases the possibility of code reuse. Also this separation allows a programmer who develops business logic to work independently of theGUI developers.

However, MVC is usually not fully utilized. The role of the Controller in controlling the flow of data can be assumed by the game cycle and the set of Systems, and the number of different Components is much larger and is not described by simply dividing into Model and View. In addition, many components are optional. In spite of all this, MVC pattern is the most popular among mobile application developers, simple and efficient applications are created with its help.

This article has reviewed the main ways to develop high-performance mobile games. Optimization recommendations were given to help improve application performance. Architectural design patterns of games optimal for the development of mobile applications were also considered.

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UDC 004.432

NAMEKO LIBRARY

ALIAKSANDR VOITAU, ARKADZI OSKIN
Polotsk State University, Belarus

In this article I want to describe some of the features of Nameko, the problems I encountered, and their solutions, as well as some useful extensions.

Nameko is a python library for building microservices. The Nameko service is just a Python class, some of whose methods are labeled with @rpc decorator. RPC is a remote procedure call which means you can call these methods from other Nameko services. Also you can call service methods from non-Nameko services. For example, if you build a web application and you need to perform some background logic you can call this RPC method.

Nameko RPC implementation works on top of the AMQP protocol. That means you need a AMQP broker. One of them is a RabbitMQ. Briefly, when you start the Nameko service, RabbitMQ creates queues, and when you call the RPC method, Nameko sends it to the queue. And when the service is not busy, it executes this method. In the example below you can see how it works [1].

```
#service.py
from nameko.rpc import rpc, RpcProxy
class ServiceY:
    name = "service_y"
    @rpc
    def append_identifier(self, value):
        return u"{}-y".format(value)

class ServiceX:
    name = "service_x"
    y = RpcProxy("service_y")
    @rpc
    def remote_method(self, value):
        res = u"{}-x".format(value)
        return self.y.append_identifier(res)


#app.py
from nameko.standalone.rpc import ClusterRpcProxy
config = {
    'AMQP_URI': AMQP_URI  # e.g. "pyamqp://guest:guest@localhost"
}
with ClusterRpcProxy(config) as cluster_rpc:
    cluster_rpc.service_x.remote_method("hello") # "hello-x-y"
```

Normal RPC calls block until the remote method completes, but proxies also have an asynchronous calling mode to background or parallelize RPC calls:

```
with ClusterRpcProxy(config) as cluster_rpc:
    hello_res = cluster_rpc.service_x.remote_method.call_async("hello")
    world_res = cluster_rpc.service_x.remote_method.call_async("world")
    # do work while waiting
    hello_res.result()  # "hello-x-y"
    world_res.result()  # "world-x-y"
```

In some cases this code may have problems. For example, if the service doesn't start, the ClusterRpcProxy will wait forever. And it is very difficult to understand when your backend is not responding. The solution is to use the timeout parameter when creating a ClusterRpcProxy. And when the time is out it raises an exception which you can catch and say your frontend about the problem and also log it. Here is the example:

```
try:
    with ClusterRpcProxy(config, timeout=3) as cluster_rpc:
        cluster_rpc.service_x.remote_method("hello")
except RpcTimeout:
    logger.error("service is not responding")
```

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There is no possibility to set a timeout inside the service in Nameko by using RpcProxy. But Nameko uses eventlet library to do multithreading. And you can use eventlet's timeout to limit waiting [2].

```
with eventlet.timeout.Timeout(3):
    try:
        self.y.append_identifier(res)
    except eventlet.timeout.Timeout:
        logger.error("service is not responding")
```

One cool thing is that Nameko has extensions support which you may find useful when developing your own Nameko services. One of them is nameko-sqlalchemy. SQLAlchemy is the Python SQL toolkit and Object Relational Mapper that gives application developers the full power and flexibility of SQL. To use it with Nameko you need to create YAML config file and describe databases and services. Then you need to declare the database using the "Declarative_base" function and set the name constructor parameter as in the config file. After that you can create a service field using "DatabaseSession" with declared database as a constructor parameter [3].

```
#config.yaml
DB_URIS:
    "service_x:first_base": "mysql://user:pass@host:port/firstbase?charset=utf8"
    "service_x:second_base": "mysql://user:pass@host:port/secondbase?charset=utf8"
    "service_y:other_base": "postgresql://user:pass@host:port/otherbase"
```

```
#service.py
from nameko_sqlalchemy import DatabaseSession
from sqlalchemy.ext.declarative import declarative_base

FirstBase = declarative_base(name="first_base")
SecondBase = declarative_base(name="second_base")
OtherBase = declarative_base(name="other_base")

class ServiceX:
    name = "service_y"
    first_base = DatabaseSession(FirstBase)
    second_base = DatabaseSession(SecondBase)
class ServiceY:
    name = "service_x"
    other_base = DatabaseSession(OtherBase)
```

Ok, now you can declare a database session and what can you do with it? How to request some data and transfer it between other services? The main problem is that the sqlalchemy object is not serializable. A serializable object means that it can be represented, for example, as json. It is necessary to transfer objects through a message broker. It is used when calling the RPC method or when you want to return the result. A simple way to create a serializable object is to create a python dict or list. It is easy to do because they have a similar structure with JSON.

The marshmallow-sqlalchemy library can serialize the SQLAlchemy object very easily. To do it the first thing you need is to create a table class and declare the table fields, then you need to create a shema object, where you can declare the Meta SQLAlchemy object. And that's all, now you can do the serialization [4].

```
Base = declarative_base()
class Author(Base):
    __tablename__ = 'authors'
    id = sa.Column(sa.Integer, primary_key=True)
    name = sa.Column(sa.String)
def __repr__(self):
        return '<Author(name={self.name!r})>'.format(self=self)
class AuthorSchema(ModelSchema):
    class Meta:
        model = Author
author_schema = AuthorSchema()
author = Author(name='Chuck Paluhniuk')
session.add(author)
session.commit()
dump_data = author_schema.dump(author).data
# {'id': 321, 'name': 'Chuck Paluhniuk'}
author_schema.load(dump_data, session=session).data
# <Author(name='Chuck Paluhniuk')>
```

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UDC 004.4

USING CLOUD COMPUTING CAPABILITIES ON THE EXAMPLE OF IMPLEMENTING A NEWS APPLICATION-FUNCTION

OLGA MIKHNOVICH, OKSANA GOLUBEVA
Polotsk State University, Belarus

The possibilities of cloud computing technologies are considered on the example of the application implementation, which is a function that receives a news feed through the NewsApi service. The cloud computing model FaaS (Function as a Service), the Microsoft Azure cloud platform and the Azure Functions solution are used for implementation.

Cloud computing technologies represent computing services such as databases, servers, network equipment, software, and many others provided via the Internet. The implementation of various tasks on low-power computers is inefficient due to the low processor performance, lack of memory, as well as the low speed of data transmission and exchange with external devices. Users can use the large number of readily available computing resources provided by cloud computing services instead of investing in hardware upgrades and new software, which are not used at full capacity to store and process information and to provide information technology services. The user gets the necessary resources through his computer in accordance with their needs.

Today, there are various cloud computing models. The main ones are IaaS (Infrastructure as a Service), PaaS (Platform as a Service), SaaS (Software as a Service). To select the optimal service, it is necessary to determine what work will be performed by the user, and what is given for maintenance. SaaS model allows you to work with ready-made programs via the Internet. The IaaS model allows the user to use virtual servers, data warehouses, operating systems and network resources as a connected service. Using the PaaS model, the user has the opportunity to rent a computing platform, «assembling» a computer of the required power and installing applications on it, as well as connect advanced artificial intelligence services, analyzing large amounts of information from Google, Microsoft, Oracle.

The advantages of using cloud computing technologies consider the example of a news web application implementation that will request information on certain criteria (keyword, category, country) with the ability to use a range of dates and receive news feed through NewsApi ["https://newsapi.org"].

To implement this task, a cloudless model of serverless computing was chosen, also called FaaS (Function as a Service). Functions as a Service (FaaS) are one of the new services offered by cloud service providers. The qualitative difference between FaaS and PaaS lies in the fact that the subject of the service is not some kind of monolithic complete web application, but a loosely coupled cloud-based system of components that allows you to create architectures whose work is subject to events [1]. Prior to FaaS, the Application was the smallest unit of scale. PaaS providers will allow developers to scale their applications by deploying multiple instances of their application. With the introduction of FaaS, developers can break their application down into functions and scale each function independently. There is nothing smaller than a function. A function takes a set of inputs and may return a set of outputs. It is possible to abstract a complex set of functions into simpler functions [2].

There are different providers of cloud platforms such as: Amazon web services, Google Cloud Platform, Microsoft Azure, IBM Open Whisk. Microsoft Azure provides the ability to subscribe to Azure for Students Starter. The offer is an ideal solution for students who want to get acquainted with cloud technologies. Therefore, the news web application, which is a function, will be implemented using the Microsoft Azure cloud platform and the Azure Functions solution. Azure features are a way to quickly launch code snippets in the cloud. To implement the function, the Visual Studio 2017 development environment and the C # programming language were chosen. It should be noted that Azure Functions provides the ability to write program code in other programming languages such as F #, Node.js, JavaScript.

The implementation of class with logic includes sending a request to the API (application programming interfaces) with parameters and getting a list of news. The implementation of the method of obtaining a list of news is presented in the listing below.

```
public static string GetNews(string query)
    {
      var newsApiClient = new NewsApiClient(ApiKey);
```

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```
        var articlesResponse = newsApiClient.GetEverything(new EverythingRequest
        {
          Q = query,
          SortBy = SortBys.Popularity,
          Language = Languages.EN,
          From = new DateTime(2018, 1, 25)
        });
        string html = @"<html>
                        <head>
                            <title>News API Example</title>
                        </head>
                        <body>";
        if (articlesResponse.Status == Statuses.Ok)
        {
          foreach (var article in articlesResponse.Articles)
          {
            html += $"<h4>{article.Title}</h4>";
            html += $"<p>{article.Author}</p>";
            html += $"<p>{article.Description}</p>";
            html += $"<a href=\"{article.Url}\">Learn more</a>";
          }
        }
        html += "</body></html>";
        return html;
      }
```

The implementation of the function that will return the list of news according to the specified criteria is presented in the listing below.

```
    public static class Function1
      {
        [FunctionName("News")]
        public static HttpResponseMessage Run([HttpTrigger(AuthorizationLevel.Anonymous, "get", "post",
Route = null)]HttpRequest req, TraceWriter log)
        {
          log.Info("News API HTTP trigger function processed a request.");
          string q = req.Query["q"];
          if (q != null)
          {
            string html = Util.GetNews(q);
            return Util.GetOKResponce(html);
          }
          else
            return Util.GetBadResponce();
        }
      }
```

The result of testing this function is shown in fig.1.

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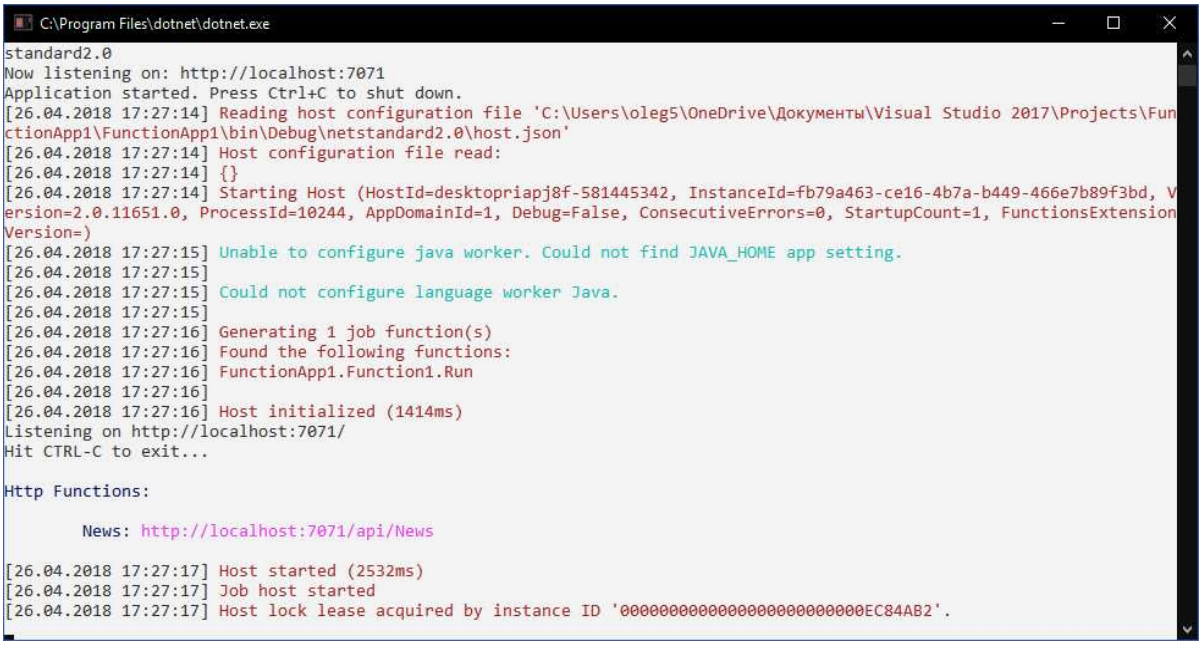

Figure 1. – Test result

The result of the Get request with the Apple parameter at http://localhost:7071/api/News and the resulting list of news are presented in fig. 2.

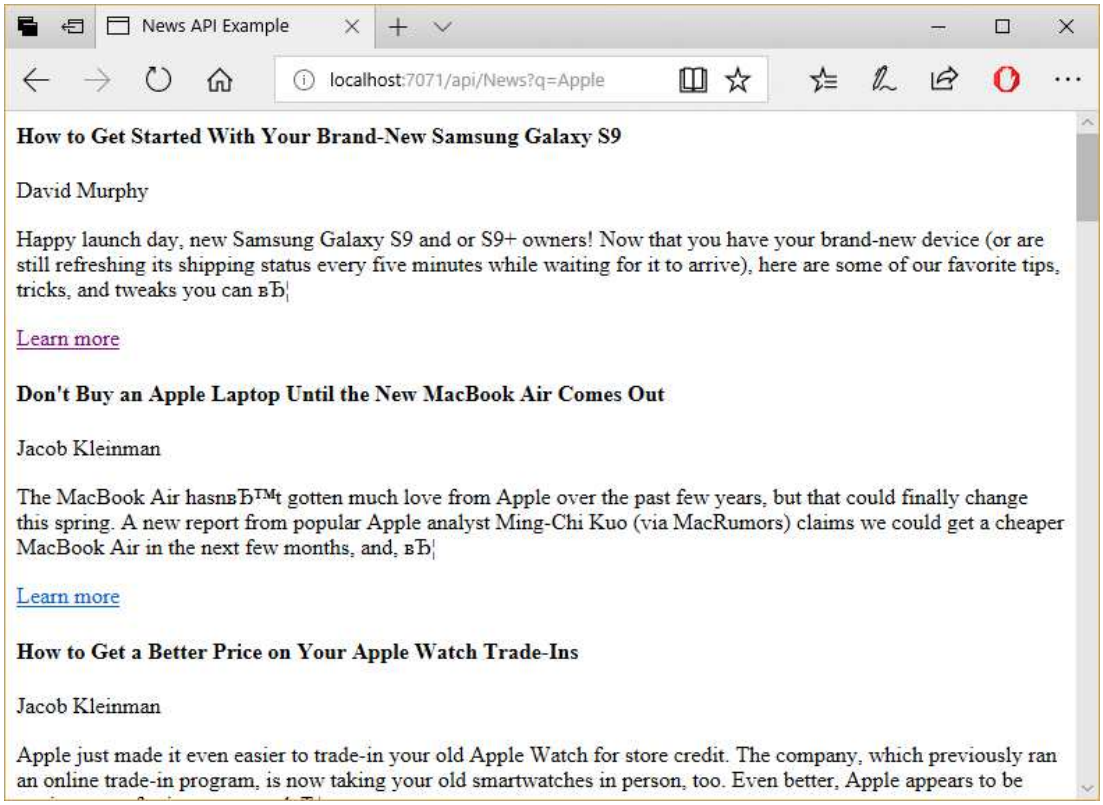

Figure 2. – Result of the news application-function

As a result of the cloud computing technologies use, the time spent on developing application functions has decreased, since the use of serverless architecture has allowed us to abstract away from setting up and managing the server, focusing solely on writing code. Servers are managed by cloud service providers through

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automated systems. Updating an application-function is a simple task, as it is carried out through a web portal with the possibility of publishing «in one click». The system is not limited in terms of scaling; resources are allocated and released as needed. The exploitation of provider resources is terminated when the application is not running.

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UDC 004.438Lua

LUA MULTIPARADIGM PROGRAMMING LANGUAGE: APPLICATION AND OPPORTUNITIES

VITALY GAVRILOV, ARKADZI OSKIN
Polotsk State University, Belarus

Lua is one of the most popular embedded programming languages. This language is used in many different applications. It combines a small amount of memory, high speed, ease of use and great flexibility.

The effectiveness of a programmer's work depends largely on the correct choice of tools in relation to the problem being solved. The choice of programming language is a key position which the success of the implementation of a ready-made software system essentially depends on.

Today the total number of developed programming languages is estimated at several thousands. When classifying them, various selection criteria (applicability to the subject area, performance, scalability, etc.) are distinguished, grouping them together (according to the programming paradigms used, the method of execution, the principles of memory organization, etc.). Modern information technologies use only dozens of the most commonly used programming languages [1]. This article discusses one of the popular embedded programming languages – Lua [2].

Quite often, when developing a software product, you have to simplify the work of writing end user applications as much as possible. One of the possible solutions in such cases is the use of simple scripting programming languages, such as Lua. Script languages allow you to think less about specific data types, byte order and other internal features of the platform. Typically, this code is less cumbersome and easier to perceive.

This script language has a simplified syntax and provides language learning in the shortest possible time, it also has a small interpreter size, relatively high execution speed and easy extensibility. This language allows you to pay special attention to the algorithm and logic of work, and minimize the dependence of software on the architectural features of the platform used.

The authors of the language Luiz Henrique de Figueiredo, Waldemar Celes and Roberto Ierusalimschy from the very beginning – the year of its creation is 1993 – developed it for integration with software written in C / C++ and other common languages [3, 4]. This integration has many advantages. Lua is a small and simple programming language that complements C / C++ well. This is an interpreted language, which means that programs written in it are converted into bytecode directly during execution, without prior compilation. It has a safe environment, automatic memory management and good capabilities for working with strings and other resizable data types. In C / C++, a compiled language with static typing, various software components are created, and Lua is used to connect them. Lua, being a full-fledged programming language, gives a final form to the application, with the help of which adaptation and dynamic adjustment of these components is carried out, and completely new application components are created.

Despite the fact that the language is procedural and does not support the principles of object-oriented programming, some features of OOP (for example, inheritance) are fully performed by standard means of the language [5, P. 138].

Lua is an embedded scripting language, flexible and fast, easily portable, combining simple procedural syntax with powerful descriptions of data structures. Due to the fundamental concept of the language, Lua is a multiparadigm language and it can implement object-oriented and functional approaches to programming [6, P. 60].

One can extend the capabilities of Lua by writing their own libraries, which is one of the basic principles laid down during the language creation phase. Even the basic functionality is implemented as a set of standard libraries, for example, working with strings. There are also various third-party libraries. Lua was designed to be easily integrated into other applications. A well-designed interface allows the Lua code to fully interact with external code, so it integrates with a large number of languages, such as C / C++, Java, C#, Smalltalk, Fortran, Ada, Erlang, Perl and Ruby.

The Lua engine is written in pure C and all that is required to run Lua programs is the presence of a C compiler to build an interpreter. Due to this, high portability of the code to various platforms is achieved.

Lua is not the only scripting language. There are other languages that can be used for the same purpose. Nevertheless, Lua provides a whole range of features that make it the best choice for many tasks:

— *Extensibility*. Lua's extensibility is so remarkable that many people regard Lua not as a language, but as a kit for building domain-specific languages. Lua was designed from scratch to be extended, both through Lua code and through external C code. As a proof of the concept, Lua implements most of its own basic functionality through external libraries. It is really easy to interface Lua with C / C++, and Lua has been used integrated with several other languages as well, such as Fortran, Java, Ada, C#, and even with other scripting languages, such as Perl and Python.

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— *Simplicity.* Lua is a simple and small language based on a small number of definitions. It has few (but powerful) concepts. This simplicity makes Lua easy to learn and contributes to its small size. The size of the Lua kernel version 5.2.3 along with the standard libraries is about 182 KB [6, P. 61].

— *Efficiency.* Lua has quite an efficient implementation. Independent benchmarks show that Lua is one of the fastest languages in the realm of scripting languages [7, P. 13].

— *Portability.* Starting Lua is possible on all platforms: different versions of UNIX and Windows, PlayStation, Xbox, Mac OS X and iOS, Android, Kindle Fire, NOOK, Haiku, QUALCOMM Brew, IBM mainframes, RISC OS, Symbian OS, Rabbit processors, Raspberry Pi, Arduino, and many others. The source code for each of these platforms is virtually the same. Lua does not use conditional compilation to adapt its code to different machines; instead, it sticks to the standard ANSI (ISO) C. It does not need to be adapted to the new environment, it can simply be compiled ANSI C. [7, P. 14]

The use of Lua usually belongs to one of three broad groups: a) those that use Lua already embedded in an application program, b) those that use Lua stand alone, c) those that use Lua and C together.

Many people use Lua embedded in any application, such as Adobe Lightroom, Nmap, Wireshark, VLC media player, and computer games, such as World of Warcraft, Angry Birds, Diablo 3, Far Cry and S.T.A.L.K.E.R. (in 2003, Lua was recognized as the most popular scripting language for game development according to the GameDev.net community) [8, P. 1159]. These applications use the Lua-C API to register new functions, to create new types, and to change the behaviour of some language operations, configuring Lua for their specific domains. Frequently, the users of such applications do not even know that Lua is an independent language adapted for a particular domain.

The capabilities of Lua as an independent language are not limited to text processing and small programs, but also apply to medium and large size projects. For such use there is a wide range of additional libraries. Lua Rocks, a system for building and managing modules for Lua, now has more than 150 packages.

Although Lua is an interpreted language, it always precompiles the source code into bytecode before it is executed. If necessary, the developer can also create bytecode using the luac compiler, and the interpreter can execute the file both as bytecode and as a source file. For time-critical tasks, there is a Lua JIT compiler – LuaJIT.

A large number of programmers use Lua as a library for C / C++. They write various applications in C / C++, and use Lua, a well-integrated programming language, to create simple and lightweight interfaces. An example of this is the AutoPlay Media Studio application designer from Indigo Rose Software. Application components are created in C / C++, and their adjustment, adaptation and dynamic changes are carried out using Lua [9].

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UDC 004.21

LOGICAL STRUCTURE DEVELOPMENT AND TESTING TASK FOR THE VIRTUAL TRAINING SIMULATOR AT THE GAS-CONTROL POINT START

IHAR PERELYHIN, IRYNA BURACHONAK
Polotsk State University, Belarus

The requirements have been formed for the testing task algorithm of the virtual reality while training gas supply facility specialists. Possible ways for logical structure construction of the testing task have been considered. Problems connected with these ways have been analyzed. Concepts of the expert systems and neural networks have been considered. The way of projecting the algorithm has been justified. The conclusion has been made concerning the effectiveness of this way.

The virtual reality application for training gas supply facility specialists has been developed. It allows getting practical skills on the starting and expulsion the gas-control point (GCP). The customer has pointed the task during the project realization. According to this task it is needed to project the logical structure of the program, which covers the possibility of starting and expulsion of the GSP in different ways. GCP is the type of construction that can differ by configuration facilities and the way of plugging in the gas supply pipeline network.

All this factors can significantly affect the algorithm of the producible works. Consequently it is needed to develop the logics of the program with the possibility to adopt the algorithm to complete the tasks in the new GCP and new equipment in the short periods of time. One of the most important conditions to realize the algorithm is the task of the particular accordance of the technological instruction about the starting and the expulsion of the GCP. Even small mistakes that are made during the execution of these operations can lead to the serious consequences.

The requirement list that was presented to the algorithm was formed according to the earlier pointed conditions. First of all, the possibility of the algorithm to adapt easily to the different GCP configurations and its absolute accuracy by definition of the user's actions correctness. The requirements for the computational resources of the system should be minimal on the condition of using the virtual reality technologies and hardware limits of the equipment possibilities.

Traditional programming methods for achieving set goals are not suitable. The algorithm which is based on such a way is very hard to adapt to the different types of GCP. Its development takes a lot of time.

The algorithm creation on the base of graphs of the conditions is also not appropriate. It is necessary to anticipate and to describe all the possible options in the matrix, according to which an error was made. In this case it is necessary to make up such a graph for every GCP. According to this way there is a high probability of an error. This way also doesn't confirm the algorithm adaptability requirement and is not rational in the way of temporal expense.

It is necessary for this algorithm to imitate the course of reasoning the real expert in this activity area for the high-quality algorithm creation. In this case the algorithm should partly suit for the concept of "artificial intelligence". It is possible to point two ways for the developing the artificial intelligence, in particular, descending and ascending. Descending way means creation of the symbol systems, which design high-level physical processes such as thinking and reasoning. According to this way, the system should reproduce the logical reasoning course of the specialist in the particular subject area. Ascending way means learning the human's neural networks and creation of the similar models, which imitate intellectual behavior on the base of smaller "intellectual" elements.

The possibility of using the neural networks has been considered. Artificial neural network (ANN), which is more frequently called just neural network, is a mathematical or computer model. It was created by the principles of the biological neural networks work. In most cases ANN appeared as adaptive system that changes its structure on the base of incoming and outgoing informational handling, which is given at the time of learning phase. The popularity of ANN has reached huge success recently. They are used almost in every sphere of the human management.

In the case of high-quality training of the neural network, it could be appropriate to solve the pointed task. Unfortunately, the area that should be described by the algorithm is narrow and there is no data for ANN training. Consequently, neural networks training will require more temporal expense. Also algorithm adaptation for different GCP is made to face the problems that appeared while the overfitting of the neural networks. Overfitting is one of the deep neural network's problems. It consists of: the model that illustrates only examples from

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the educative selection, and adaption to the training examples, instead of train to classify the examples, that are not in the training (with losing the ability to summarize). In the fact that neural networks do not make the logical conclusions, but just memorize regularities, it is not possible to guarantee what will be defined, and if the user made a mistake while starting the expulsion of the GCP or not.

This term appeared in the 1970-s because of expert systems as the alternative direction of the neural networks. Now neural networks and expert systems have been related to the artificial intelligence. This is absolutely different direction in the artificial intelligence sphere that is based on completely different principles and ways. Expert system (ES) is the program resource that uses expert's knowledge, for high-effective tasks solution in the subject area. [3]. ES was made for solving the important applications in the narrow knowledge areas. The main components of the ES are knowledge base and "tasks solver". Knowledge base contains data (facts) and rules (knowledge). Expert systems use rules to accept the solutions on the base of facts. Success of many projects that were based on this approach testifies that this approach is viable.

This approach has one more plus in the creation of algorithm. It is possible to follow the way of solving the particular ES by contrast with neural network, which appears as a black box. The use of ES lets adopt algorithm fast and easily for different configurations of the GCP. Main work principles should be described in the rules during the adaptation of the algorithm to the new GCP configuration. It is needed to describe rules only for different nodes. The description of work rules of the GCP and ES will help to define mistakes in the user's actions. It is thought that training the neural networks is a faster process than creating the ES. But in the conditions of the highly tailored area that needs data collecting and structuring, ES creating need the same temporal expense as neural networks, and maybe even better.

That's why the decision was made to divide the logical structure of the program on the knowledge base and ES. Knowledge base is constructed in the same way as the expert systems. It is divided into 2 sections: data (facts) and rules (knowledge). The fact has the form of the line in which all conditions have been listed. The last rule to write is a rule which should be completed in the presence of all requirement conditions. For example the rule: "if the gas before the regulator, regulator grip is lead up, crane on the impulse is closed, the mistake is done". Such rules are simple and understandable, that's why the system can easily show the user which mistake he made. The rule is a method that completes particular actions. After all actions ES verifies all the facts and stars suitable rules. If the fact was used it becomes inactive. If the condition from the fact disappears, the fact will become active again. All the facts have equal priorities except the facts that are connected with errors. Such facts have higher priority.

As a result of the analysis about different ways of creating the logical structure of testing task, we have come to the following conclusions. According to the requirements of the algorithm, the optimum way is to use the model of the logical structure that is based on the realization principles of the ES. Positive results have been received while testing the program product with the adjusted structure of the testing task. Speed work of algorithm conforms to the adjusted requirements. It completes on the control computer with the minimal speed of 0,001 second.

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THE DEVICE FOR DETERMINING THE DIRECTION OF ARRIVAL OF THE INFRARED RADIO WAVES FROM A BRIGHTLY CONTRASTING OBJECT

ALEKSANDR CHERNYAVSKY, VIKTOR YANUSHKEVICH
Polotsk State University, Belarus

The analysis of radar methods. Various ways of viewing are mentioned by moving the directional beam of a radar antenna. A review of the main physical phenomena directly affecting the radar. An assessment of the most promising parts of the device to accomplish the goal of the study. The characteristic of the main parameters of the key elements of the device is shown. The proposed parameters for the technical performance of this device. The results of the study can be used to develop a device for determining the direction of arrival of infrared radio waves from a brightly contrasting object.

Determining the direction of arrival of physical quantities is one of the most important aspects in radar systems. Radiolocation is a field of science and technology that combines methods and means of locating (detecting and measuring coordinates) and determining the properties of various objects using radio waves. Radio navigation is a close and somewhat overlapping term, but in radio navigation an object plays a more active role, the coordinates of which are measured, most often this is the definition of its own coordinates. The main technical device radar - radar station (radar). Distinguish active, semi-active, active with a passive response and passive radar. Radars differ in the range of radio waves used, the type of the probing signal, the number of channels used, the number and type of measured coordinates, the installation location of the radar.

There are two types of radars:

1. Passive radar is based on receiving the object's own radiation;

2. With active radar, the radar emits its own probing signal and receives it reflected from the target. Depending on the parameters of the received signal, the characteristics of the target are determined.

Active radar is of two types:

With an active response - the facility assumes the presence of a radio transmitter (transponder), which emits radio waves in response to a received signal. The active response is used to identify objects, remote control, as well as to obtain additional information from them (for example, amount of fuel, type of object, etc.);

With a passive response - the request signal is reflected from the object and is perceived at the receiving point as a response one.

To view the surrounding space, the radar uses various ways of viewing by moving the directional beam of the radar antenna:

- circular;
- sector;
- overview of the helix;
- conical;
- in a spiral;
- "V" review;
- linear.

In accordance with the type of radiation radar are divided into:

- radar continuous radiation;
- pulsed radar.
- Radar is based on the following physical phenomena:
- radio waves are scattered by electric inhomogeneities (objects with other electrical properties that differ from the properties of the propagation medium) encountered on the path of their propagation. In this case, the reflected wave, as well as the radiation of the target itself, makes it possible to detect the target;
- at large distances from the radiation source, we can assume that the radio waves propagate in a straight line and at a constant speed, due to which it is possible to measure the distance and angular coordinates;
- the frequency of the received signal differs from the frequency of the emitted oscillations due to the mutual displacement of the receiving and emission points (the Doppler effect), which makes it possible to measure the radial velocities of the target moving relative to the radar;
- Passive radiolocation uses the radiation of electromagnetic waves by the observed objects, it can be thermal radiation characteristic of all objects, active radiation created by the technical means of the object, or spurious radiation created by any objects with working electrical devices.

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The purpose of this work is to develop a device for determining the direction of arrival of the infrared radio waves from a brightly contrasting object [1-4].

The diagram contains 4 infrared receivers, they work in pairs. Thus, each pair is responsible for turning the motor on its axis. With the passage of IR radiation through the lens, it will be focused at a certain point. If the spot does not uniformly illuminate all the plates, then a potential difference will occur and pulse is generated at the receiver output, which is fed to the motors. If it is positive, then the motor moves in one direction, and if it is negative, then in the other. By the same principle, the second pair of the receiver and the motor works, the only difference is that each pair drives the motor moving along its axis, one along the X axis, and the second along Y.

Simultaneously with the work of the motors, the circuit responsible for the derivation of coordinates works. The MPU6050 chip is the main element of the GY-531 module. It has an accelerometer, a gyroscope and a temperature sensor. During the movement of the gyroscope and accelerometer, the information received is stored in the registers of the chip. The transfer of the value to the microcontroller is carried out via the I2C interface.

The microcontroller is used to control and transmit signals to other parts of the circuit. After receiving information from the sensors, the microcontroller displays data on a liquid crystal display, which has 4 lines of 20 characters each. The screen displays information received and converted from the MPU6050 chip. The first line contains the values along the three axes of the accelerometer, the second values along the three axes of the gyroscope, the third temperature, the fourth line on the left, the deflection angles according to the accelerometer and the right rotation of the Z axis according to the gyroscope. The values of the fourth row are calculated by the microcontroller itself. Also on the diagram there are 6 LEDs that light up depending on the position of the GY-531 module on the Y axis.

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UDC 374.1

THE WEB APPLICATION DEVELOPED FOR THE EXCHANGE OF INFORMATION AND FILES FOR A RESTRICTED NUMBER OF USERS

PAVEL MAKHANKO, YURIY KRAVCHENKO
Polotsk State University, Belarus

This article discusses the main goals and principles of database modeling, building a fast, user-friendly API for a web application. The main database entities were considered. Addresses for accessing the client part of the web application to the server part are designed.

The creation of graphical interfaces is currently based mainly on the use of:

1. HTML – hypertext markup language;
2. CSS – cascading style sheets;
3. multi-paradigm JavaScript programming language

Page layout is carried out by means of HTML language. With this language, the basic elements of the page with which the user interacts are created. Using CSS stylesheet you can achieve a certain style of the page, as well as describe the animation and changes to the page, in the process of using it. The basis is the JavaScript programming language (Angular 5). It is Javascript that allows pages to interact with each other, make HTTP requests to the server and dynamically change the content of the page.

This article gives a detailed description of the interface building technologies in a web application.

Typically, applications in Angular 5 are built using the MVC pattern (Model-View-Controller or model-View-Controller). The idea of this template is simple and based on distribution of responsibilities: the task of the controller-processing user actions (clicking on the buttons, processing requests to the server, etc.); the model provides the controller with the data requested by the user; the view, in turn, provides a view of the data obtained from the model.

File with the extension HTML is a markup file generated in HTML using tags. A tag is a named label or descriptor that contains information about an element of an HTML page and its location on that page.

Stylistic features are written in files with the extension .css. You apply certain styles to specific markup elements in html files by using classes and identifiers. The CSS stylesheet allows you to encapsulate the styles of specific tags by nesting CSS selectors and allows you to create functions that can be called in different selectors, making it much easier to understand the code.

Files with the extension .ts are used as controllers. Ts files are written in TypeScript, which extends the capabilities of JavaScript. One of the main advantages of TypeScript is static typing (implementation of OOP in the classical form, more understandable for most programmers).

The interaction of html markup and controllers occurs using:

1. The attribute directives
2. Structural directives
3. Data binding

In Angular, there are four forms of data binding:

1. Binding a DOM element to component values
2. The binding properties of the html element to the value of the component
3. Binding a component method to an event in DOM
4. Two-way binding when a DOM element is bound to a value in a component, and changes at one end of the binding immediately result in changes at the other end.

NgIf, ngSwitch and ngFor (by analogy with the structures of programming if, for, and switch) are used as structural directives.

Attribute directives change the behavior of elements by changing their attribute. For example, the ngClass Directive allows you to set a certain class at certain events.

Nowadays it is difficult to imagine a good web application without a developed database and fast, optimized API. The database allows you to conveniently store large amounts of information not on the user's device, but on a remote server, and the API allows you to process web application requests, differentiate access rights and issue data from the database to any device where the main purpose of API development is to create an in-

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termediate link between the client part of the web application and the database. This is a great way to protect user data, as well as to provide quick access to information without loading the user's device.

JSON Web token is used as protection. This is an open standard for creating access tokens based on json. At the time of user authorization, the server generates hash keys that are sent to the client side of the web application. In the future, each request to the server must contain a hash key to confirm access rights to resources.

As points for requests, the server provides the web application with the end addresses to which the web application receives certain data. Requests pass through the standard HTTP Protocol using the GET, POST methods. Chat and file sharing are implemented using socket technology (Websocket Protocol). Socket is a real-time duplex communication protocol between the client and the server. In this case, the web application subscribes to new messages when it successfully logs on to the application. Then, when you receive a new message, it will be instantly sent to the user.

A document-oriented MongoDB database was chosen as the database. The MongoDB syntax is similar to the json format, which in turn does not specify a rigid data storage framework, which makes it convenient to expand the stored data. The entire database consists of collections, and the data stored in it are documents. A document is a json object in the form of key/value pairs, where strings, numbers, binary data, arrays, or other nested objects can be stored as a value.

A relational model is a database in the form of a set of interrelated relations (tables), which are used to store information about the objects represented in the database.

This article discusses the main goals and principles of database modeling, building a fast, user-friendly API for a web application. The main database entities were considered. Addresses for accessing the client part of the web application to the server part are designed.

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UDC 004.9

ECONOMIC COMPONENT OF THE DEVELOPMENT OF AN EDUCATIONAL APPLICATION FOR LEARNING ENGLISH

VLADIMIR ROGULEV, ARKADY OSKIN
Polotsk State University, Belarus

In the following article the stages and components of the development of an educational application for learning English are being shown and observed.

Software tools like other industrial products have a certain life cycle. The life cycle of computer software means the period from the beginning of the development of a new software tool to its decommissioning by the consumer. The life cycle includes three stages: development (design), production (creation) and use (maintenance of software). Each stage in turn is divided into phases or stages.

The software development stage can be divided into the following steps:

1 *Design*. The "Design" stage includes the analysis of a technical task for development and design. At this stage, a significant period is allotted, as a high-quality design allows reducing the time spent on the subsequent stages of development.

2 *Implementation*. The stage "Implementation" refers directly to the development of a software product. This stage is the longest and requires from 40 to 60% of the total time.

3 *Testing*. At the stage "Testing", the compliance of the result of the implementation stage with the results obtained at the design stage is checked. This stage takes up about 20% of the total development time.

4 *Revision*. At the stage "Revision", final acceptance tests are carried out, if necessary, minor corrections to the software product are made, and the final chapters of the explanatory note are drawn up.

The following graph displays the above-mentioned program development stages:

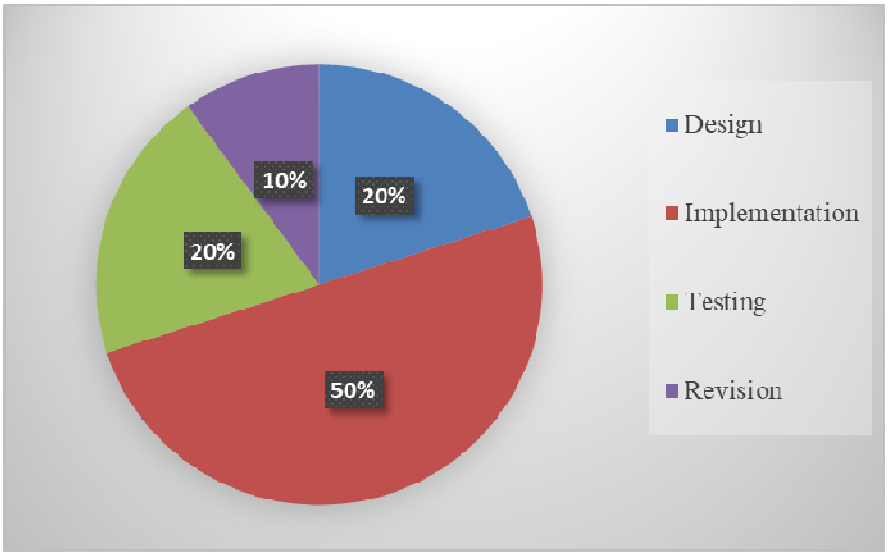

Figure 1 – Working time distribution in project development

Types of jobs

In addition to dividing the PS life cycle into stages and phases, there are eight types of work that can be performed in the process of creating a software product:

1 *Requirements analysis and planning*. It includes the development of specifications, analysis and modification of functional, technical, interface requirements.

2 *Designing products*. It includes the definition, specification, analysis and modification of the hardware and software architecture of the program design and database.

3 *Programming*. Detailed design, coding, autonomous debugging and integration of individual program components, as well as planning the work of programmers, developing a database, documenting individual components and organizing programming at the component level.

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4 *Planning debugging*.

5 *Verification*. The process of checking the correctness of requirements, debugging products and acceptance tests.

6 *Project Management*. Planning and control of the project, monitoring and regulation of contracts, communication with users.

7 *Quality control*. Development and control, standard and technical checks of software and development processes.

8 *Documentation*. Development and adjustment of user guides and operators.

The division of the life cycle of software into stages, phases and stages, as well as a more detailed description of the work performed in the process of their development, production and operation, is necessary for a detailed determination of the costs required for these purposes.

Calculating the cost of the product

The cost of any product includes the cost of its creation. In this case, software.

The product is an educational application. The cost calculation should consider the following:

Expenditures:

1 Materials and components - consumables spent to create the product;

2 *Electricity* - since the product is an application, it uses computers that consume electricity;

3 *The basic salary of performers* - the cost of issuing salaries to employees working on the project;

4 *Additional salary* - the cost of paying premiums, risks, vacations, and so on;

5 *Deductions for social needs* - the cost of tax collection, in the fund for the protection of the population, insurance, etc.;

6 *Depreciation* - the cost of unforeseen circumstances;

7 *Spending on special equipment* - the costs associated with the acquisition of specialized equipment;

8 *Overhead costs* - expenses for general business needs;

9 *Other direct costs* - the cost of preparing and acquiring various kinds of information.

The impact of cost items on the final cost of the product can be seen in the diagram presented in Picture 2.

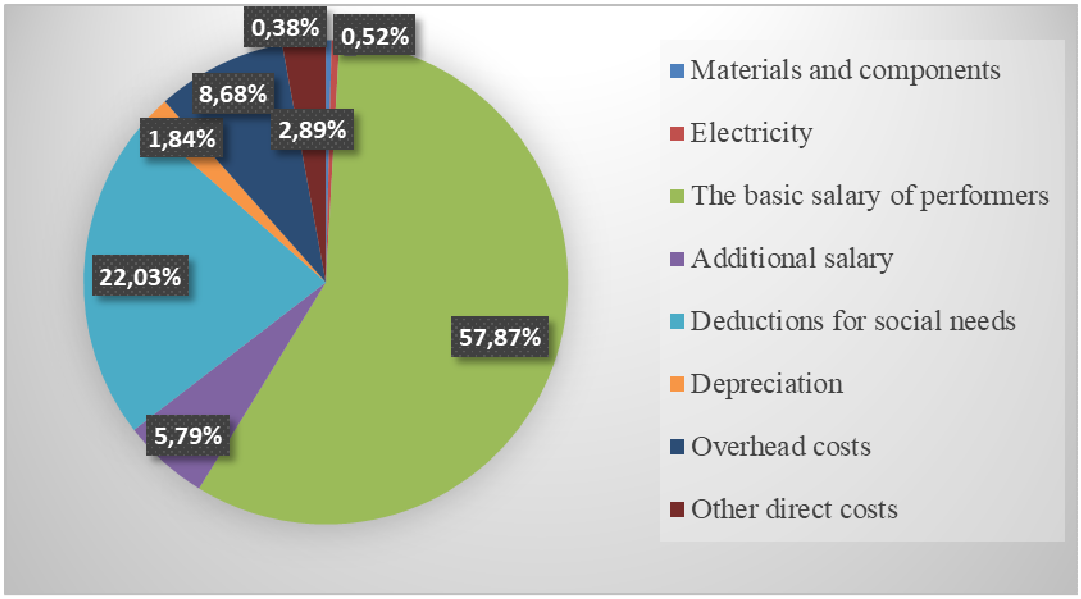

Figure 2 – The cost structure for the development of the training application

Looking at the diagram, we can conclude that the main costs of the product being developed, regardless of the development time, are related to the issuance of salaries to employees.

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UDC004.514

MANAGING APPLICATIONS IN PRODUCTION WITHOUT MANAGING SERVERS

MIKITA TORAPAU, SIARHEI SURTO
Polotsk State University, Belarus

This article is about deployment and managing applications without managing server instances using AWS Fargate.

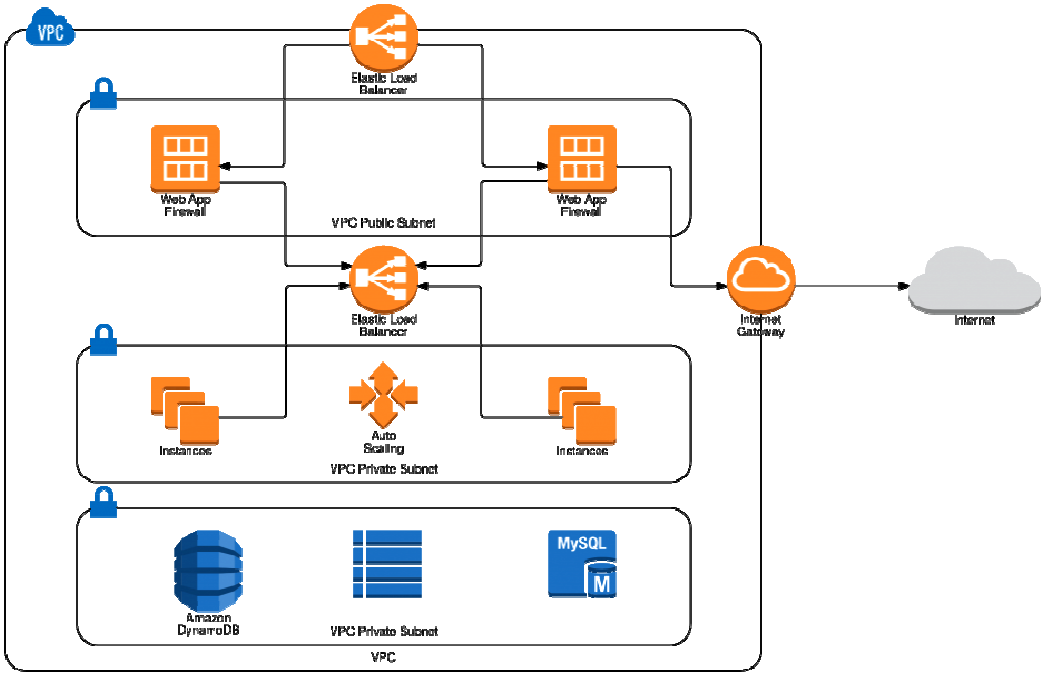
Nowadays AWS is one of the most powerful and popular on-demand cloud computing platform, that is used by millions of companies for delivering theirs products to end users. Generally, each application hosted in AWS is deployed to EC2 instance inside private subnet and exposed by special security group. Of course, such deployment scheme requires servers managing. In other words, you need a specialist or even an operation team with good knowledge of such systems and cloud deployments. And even that does not guarantee, that your system will be enough secure, fast and reliable.

By the end of 2017 Amazon introduced AWS Fargate for running applications without having to manage servers or clusters. It was irrelevant till 2019 because of extremely high pricing. Currently Fargate has almost the same price as EC2 instances, so this service gives opportunity for deploying applications fast and secure without of managing application servers.

Let's imagine production infrastructure of microservice application deployed in a cloud according to AWS best practices [2]. Generally, it consists of the following resources:

- virtual private cloud (VPC);
- public and private subnets, route tables;
- NAT and internet gateways;
- application instances (EC2) hosted in private subnet;
- bastion instance hosted in public subnet for accessing application instance via SSH;
- autoscaling group, autoscaling policies and alarms for triggering autoscaling;
- container server, cluster and docker containers;
- load balancers and firewalls;
- security groups.

Building such infrastructure requires a lot of time, incorrect configuration can lead to different problems such as security holes or high billing.



Figrure 1. – General application infrastructure (without bastion host)

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It takes a lot of time to configure all these resources. If you need SSH access to the application instance you have to add additional instance hosted in public subnet and called "bastion instance". This gives a lot of vulnerabilities. For example, AWS users in account which have access to AWS EC2 service can edit security group and log into application server and break something on production environment.

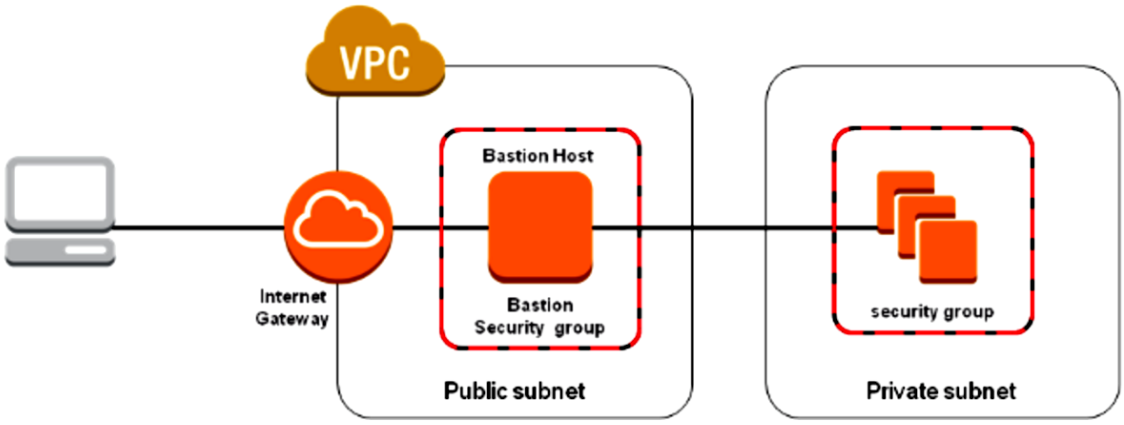

Figure 2. – Infrastructure for SSH access to application instance

This is required minimum to protect application server from attacks from the internet, but it does not protect from internal attack.

What if nobody has access to application servers even administrators? AWS Fargate allows you to run containers without having to manage servers or clusters. It removes the need for you to interact with or think about servers or clusters. Fargate lets you focus on designing and building your applications instead of managing the infrastructure that runs them.

With AWS Fargate you can get rid of EC2 instances, autoscaling groups, security groups for EC2 instances, alarms, it makes you infrastructure much easier and secure. Besides, it makes deployment faster.

Generally, monitoring is an important part of application production. With instance application servers you have to set up monitoring for instances and docker containers to know about CPU and memory consumption both on instances and application containers. It takes additional time, resources and gives potential vulnerabilities. With AWS Fargate you should setup monitoring only for containers, no application servers – nothing to monitor.

Speaking about scaling, with Fargate you don't have to setup autoscaling groups, policies, alarms. You don't need to scale instances, you can scale your application only by tasks (applications).

But what if your application uses additional software that should be installed on instance? No problems with that, AWS Fargate uses new network mode called "awsvpc". With this mode all application containers communicate with each other via isolated local network. All additional software can be installed in additional docker container and mounted to other application containers.

And the most important question is pricing. Of course, AWS Fargate is a little bit more expensive comparing to EC2 instances (20% more expensive for most of regions). But this is about empty EC2 instances, if we take into account monitoring, alarms, scaling and additional bastion instances for SSH access, it can be even cheaper, all depends on your system requirements. So, the best solution is to use cheap t2 instances for development purposes, and AWS Fargate for production.

Managing application servers adds a lot of problems for development and operation teams. It requires a lot of knowledge, time and resources. AWS Fargate solves these problems, it has a lot of advantages over EC2 deployment, it faster, easier, more secure and reliable. It can be used for almost all applications.

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UDC 004.021

GRAPHIC INTERFACE DESIGNING FOR AUTOMATED INFORMATION ACCOUNTING SYSTEM FOR GOODS TO PROMOTE SMALL BUSINESS OF THE "GRANDDECOR" COMPANY UNDER THE OPERATING SYSTEM OF WINDOWS

MAKSIM TRASHCHANKA, IRYNA BURACHONAK
Polotsk State University, Belarus

This article discusses the principles of building a graphical user interface in the AIS accounting for goods to promote small business of the company "GrandDecor" under the Windows operating system.

Different technologies are used to create graphical interfaces using the .NET platform – Window Forms, WPF, applications for the Windows Store (for Windows 8 / 8.1 / 10). However, the most simple and convenient platform is still Window Forms or forms. This article focuses on the description of technologies for creating graphical interfaces using Windows Forms technology.

A Windows Forms application is an event-driven application supported by the Microsoft .NET Framework. Unlike batch programs, most of the time is spent waiting for the user to take any action, such as typing text in a text field or clicking a button.

A form is a visible surface on which information is displayed to the user. Typically, a Windows Forms application is built by placing controls on a form and writing code to respond to user actions, such as mouse clicks or keystrokes. A control is a separate user interface element for displaying or entering data.

When a user performs an action with a form or one of its controls, an event is created. The application responds to these events with a code and handles events as they occur.

The big drawback of Windows Forms was that the programming and design teams had to work very closely to make a great project. That is, the designer drew the interface, gave it to the programmer, and the programmer, in turn, implemented it (aside from his immediate task - he had to adjust the buttons to fit the dimensions, insert pictures, etc.) rather than implement the logic of the program.

To get rid of this lack of Windows Forms, the Windows Presentation Foundation technology WPF was included in the .NET Framework, a big step towards improving interface design. Compared to Windows Forms - the following was done (roughly speaking) - the programmer was completely immersed in the development of the program logic, and the designer could immediately create the program design, almost independent of the programmer.

The popularity of Windows Forms is fading. But it continues to be used in simple, not requiring great interfaces, programs. Also in all versions of the .NET Framework there is support for Windows Forms, and some additions and improvements are included there.

Despite the fact that in Windows Forms, the entire interface can only be built using the mouse, the program code markup is also available for the programmer, and can be changed if desired.

Sample code for a WF designer is shown in listing 1.

Listing 1 – Sample WF Designer Code

```
namespace HelloApp
{
  partial class Form1
  {
    private System.ComponentModel.IContainer components = null;
    protected override void Dispose(bool disposing)
    {
      if (disposing && (components != null))
      {
        components.Dispose();
      }
      base.Dispose(disposing);
    }
    #region Windows Form Designer generated code
    private void InitializeComponent()
```

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```
    {
        this.SuspendLayout();
        this.AutoScaleDimensions = new System.Drawing.SizeF(6F, 13F);
        this.AutoScaleMode = System.Windows.Forms.AutoScaleMode.Font;
        this.ClientSize = new System.Drawing.Size(284, 261);
        this.Name = "Form1";
        this.Text = "Hello world!";
        this.ResumeLayout(false);
    }
    #endregion
  }
}
```

Using the special Properties window on the right, Visual Studio provides us with a convenient interface for managing the properties of an element:

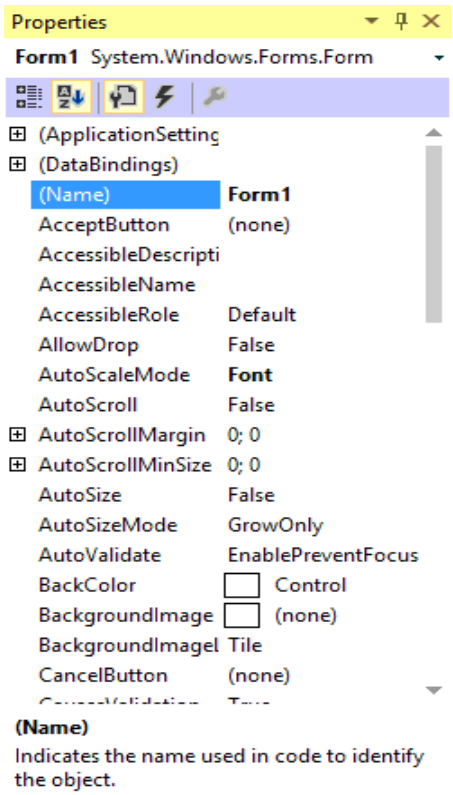

Figure 1. – Properties window

Most of these properties affect the visual display of the form. We analyze the basic properties:

– Name: sets the name of the form - or rather the name of the class that inherits from the Form class

– BackColor: indicates the background color of the form. By clicking on this property, we can choose the color that suits us from the list of suggested colors or the color palette.

– BackgroundImage: indicates a background image of a form

– BackgroundImageLayout: determines how the image specified in the BackgroundImage property will be placed on the form.

– ControlBox: indicates whether the form menu is displayed. In this case, the menu refers to the top-level menu, where the application icon, the form header, and the form minimization buttons and the cross are located. If this property is false, then we will not see either the icon or the cross, which usually closes the form

– Cursor: determines the type of cursor that is used on the form

– Enabled: if this property is false, then it will not be able to receive input from the user, that is, we will not be able to click on the buttons, enter text in text fields, etc.

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– Font: sets the font for the entire form and all controls placed on it. However, by setting the font of the form elements, we can thereby override it.
– ForeColor: font color on the form
– FormBorderStyle: specifies how the form border and title bar will be displayed. By setting this property to None, you can create the appearance of a free-form application.
– HelpButton: indicates whether the form's help button is displayed.
– Icon: sets the shape icon
– Location: determines the position relative to the upper left corner of the screen when the StartPosition property is set to Manual
– MaximizeBox: indicates whether the maximize window button will be available in the form header
– MinimizeBox: indicates whether the minimize button will be available
– MaximumSize: sets the maximum size of the form
– MinimumSize: sets the minimum size of the form
– Opacity: sets form transparency
– Size: defines the initial size of the form
– StartPosition: indicates the initial position from which the form appears on the screen
– Text: defines the form header
– TopMost: if this property is true, then the form will always be on top of other windows
– Visible: whether the form is visible, if we want to hide the form from the user, then we can set this property to false
– WindowState: indicates the state in which the form will be on startup: normal, maximized or minimized

This article discusses the positive aspects of using Windows Forms, the possibilities for a fast and flexible interface development, and discusses the basic properties of graphic elements.

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UDC004.056

PROTECTION OF THE DATA OF THE APPLICATIONS DEVELOPED ON UNITY 3D

ARTSEMI KARNILOVICH, DMITRY PASTUHOV
Polotsk State University, Belarus

This article discusses how to obtain unauthorized access to thesaving data and resources of applications developed on Unity3d, as well as possible ways to solve this problem.

Unity3D is a cross-platform game engine from Unity Technologies. Unity allows you to create applications that run on more than 20 different operating systems. The engine supports many popular formats of models, sounds, materials and textures.

The project in Unity divided into scenes (levels) - separate files containing their game worlds with their own set of objects, scenarios, and settings. Scenes can contain both, in fact, objects (models) and empty game objects - objects that do not have a model. Objects, in turn, contain sets of components with which scripts interact.

All these data must be protected from copying, illegal use, pirated distribution, professional analysis and hacking.

When compiling a project Unity creates an executable game file, and in a separate folder - game data (including all game levels and dynamic link libraries).

Source code. For Windows builds, Unity compiles and saves the source code of all game scripts in the Managed directory. The code is in the libraries: Assembly-CSharp.dll, Assembly-CSharp-firstpass.dll and Assembly-UnityScript.dll. For decompiling and viewing managed code of .NET libraries there are quite convenient and at the same time free utilities: IlSpy and dotPeek.

The data approach is especially effective for our purposes: Unity very sparingly optimizes the source code of game scripts, practically without changing its structure, and does not hide the names of variables. This makes it easy to read and understand decompiled material.

In such cases, developers have to worry about the security of their code. For such purposes, usually use obfuscators.

The code obfuscation is a mechanism for hiding the original algorithm, data structures or the logic of the code, or to harden or protect the code from the unauthorized reverse engineering process. In general, code obfuscation involves hiding a program's implementation details from an adversary, i.e. transforming the program into a semantically equivalent (same computational effect) program, which is much harder to understand for an attacker. None of the current code obfuscation techniques satisfies all the obfuscation effectiveness criteria to resistance the reverse engineering attacks. Therefore, the researchers as well as the software industries are trying their best to apply newer and better obfuscation techniques over their intellectual property in a regular process. But unfortunately, software code is not safe, i.e. still it can be cracked. In especially unpleasant circumstances, obfuscator can make the program completely unsuitable for execution, in less severe cases new errors may appear in the program. Therefore, obfuscation should be applied with maximum caution.

In AssetStore there are many ready-made solutions, but most of them are paid. Free versions, as a rule, are limited or have low efficiency.

Project resources. Most Unity project resources packaged in proprietary format files with the .assets and .resources extensions. Despite the closeness of the formats, there are tools for unpacking such files. For example, Unity Assets Explorer is able to extract most textures and shaders from the game. The resulting textures will be in DDS format, which can be opened using the Windows Texture Viewer. Shaders extracted in the already compiled form and there are no solutions for their decompilation. However, this circumstance does not prevent the import and use of the resulting shaders in another Unity-project.

Three-dimensional models in the Unity assembly are located in various resources, and some of them can be generated at all during the game. You can get this data straight from the GPU memory. When the game is running, all the information about the textures and models visible on the screen is in the memory of the video card. Using the 3D Ripper DX utility, you can extract all this information and save it in a format understandable to 3D editors.

Stored data. PlayerPrefs is a class from the standard Unity library that allows you to save data in the long-term memory of the device. It is a pair of key - value. Developers to store various settings, achievements, player progress, and other information about the state of the game often use it. On Windows, this data is stored in the system registry. Other operating systems, data is stored on the device in the local folder of the application in a

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special file. In most cases, they can be easily accessed and modified using a text editor. For example, in Windows it is enough to use the built-in utility RegEdit to modify any values of PlayerPrefs, thereby changing the configuration and status of the game.

The easiest way to counteract is to encode the stored data, for example, base 64. This method is not very effective, but can provide initial protection against viewing. Checking whether the data was changed without the knowledge of the hash functions will help: by comparing the checksums of the stored data, we can make sure that nobody and nothing except our code has changed this data.

It is necessary to use encryption or various combinations of the listed methods for more reliable protection.

You can also implement your own save format. Thanks Mono Unity supports work with the file system. Thus, you can serialize all the necessary data, apply strong encryption and save in a safe place.

RAM. Cheat Engine - a well-known program for hacking memory. It finds the area of RAM that belongs to the process of the running application and allows you to arbitrarily change it. Over several iterations of screening, you can easily find the location of most game variables and arbitrarily change them.

This program takes advantage of the fact that developers rarely protect variable values. Protection from such programs is quite simple - you need to encrypt the values in the application's memory. Encrypt each time you write and decrypt each time you read. Since the operation is quite frequent, we need a very fast algorithm. For this, for example, an encryption algorithm based on XOR and base 64 may be suitable. Since there will be work with data in RAM, there is no need to save the key, for this you can use the session key generated just before the operation.

However, a more effective method would be to store critical values immediately in the long-term memory of the device. Playerprefs allows you to do this quite quickly and simply, but, again, you need to take care of the safety of this data.

Digital rights protection. Digital Rights Management or DRM is a scheme that controls access to copyrighted material using technological means. It may refer to the usage of proprietary software, hardware, or any type of content: music tracks, video files, ebooks, games, DVD movies, emails, documents, etc.The purpose of DRM is to prevent unauthorized redistribution of digital media and restrict the ways consumers can copy content they have purchased. DRM products were developed in response to the rapid increase in online piracy of commercially marketed material, which proliferated through the widespread use of peer-to-peer file exchange programs. Typically, DRM is implemented by embedding code that prevents copying, specifies a period in which the content can be accessed or limits the number of devices the media can be installed on.

Although copyright laws protect digital content, policing the Web and catching law-breakers is very difficult. DRM technology focuses on making it impossible to steal content in the first place, a more efficient approach to the problem than the hit-and-miss strategies aimed at apprehending online poachers after the fact.

Unfortunately, there are not so many ways to protect the game from hacking. Being installed on the user device, it actually reveals all the textures, models and source code. If someone wants to decompile the application and steal resources - it is only a matter of time.

Despite this, there are effective methods that will seriously complicate the lives of hackers.

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UDC 004.42

DESIGN OF COMPUTER 3D GAME WITH POSSIBILITY OF CONSTRUCTION BY BLOCKS

PAVEL SILUKOU, DZMITRY HLUKHAU
Polotsk State University, Belarus

In this article, we will look at the process of designing a computer 3D game in the sandbox genre with the possibility of construction by blocks. The aim of the game is to develop spatial thinking and creative skills among the players.

Now there are many educational games in the sandbox genre with construction elements. However, in such games there is a large number of game mechanics which distract from the construction process (quests, survival mechanics, etc.), or provide a small set of tools for construction without the possibility of creating their own tools. There was a need for a computer game, aimed only at construction and having a large set of tools for construction.

To solve the problem you must define the required set of features for the game by domain analysis and research of similar projects. The feature set is as follows:

– auto generation of the surrounding world;
– infinite world;
– smoothed landscape and objects of the surrounding world;
– realistic lighting;
– manual adjustment of world generation parameters: selection and changing of seasons, time of day, various biomes, selection of elevation (from plain to mountains);
– a set of various pre-installed construction blocks, including plants, light sources, special items, etc.;
– ability to add your own blocks;
– ability to add and delete objects on the landscape;
– ability to add and remove landscape blocks (terrain).

After the domain analysis, it is necessary to determine the requirements for the game as a product:

– fast landscape generation;
– saving and loading the previously generated world and all objects on it;
– seamless world;
– user-friendly interface;
– low requirements for computer resources;
– cross-platform (Windows, MacOS, Linux).

Based on the requirements and feature set for the game, it is necessary to determine the set of tools for the project implementation. The selection is made of three sets of: Unity + CSharp, C++ and OpenGL, Java + OpenGL. All three sets allow you to complete the task, but C ++ and OpenGL have more advantages, including:

– the highest performance among than the rest;
– OpenGL has a large set of methods for implementing a 3D game with landscape generation;
– cross-platform.

Next, you need to develop an interface and control in the game. Control will be carried out using a keyboard and a mouse. The interface will be the following:

– window with the Game Menu with settings and game mode selection;
– window of the game;
– first-person view;
– window with editing available objects (add, delete);
– window with a selection of construction blocks.

To implement the generation of the landscape, we chose the formal language of generator description of the three-dimensional landscape based on the compositions of harmonic functions [1]. This method of generating a landscape based on compositions of harmonic functions and the formal language descriptions of the landscape generator have expressiveness and allow creating optimized performance generators of unlimited reproducible terrain.

Figure 1 shows changing the time of day in the game.

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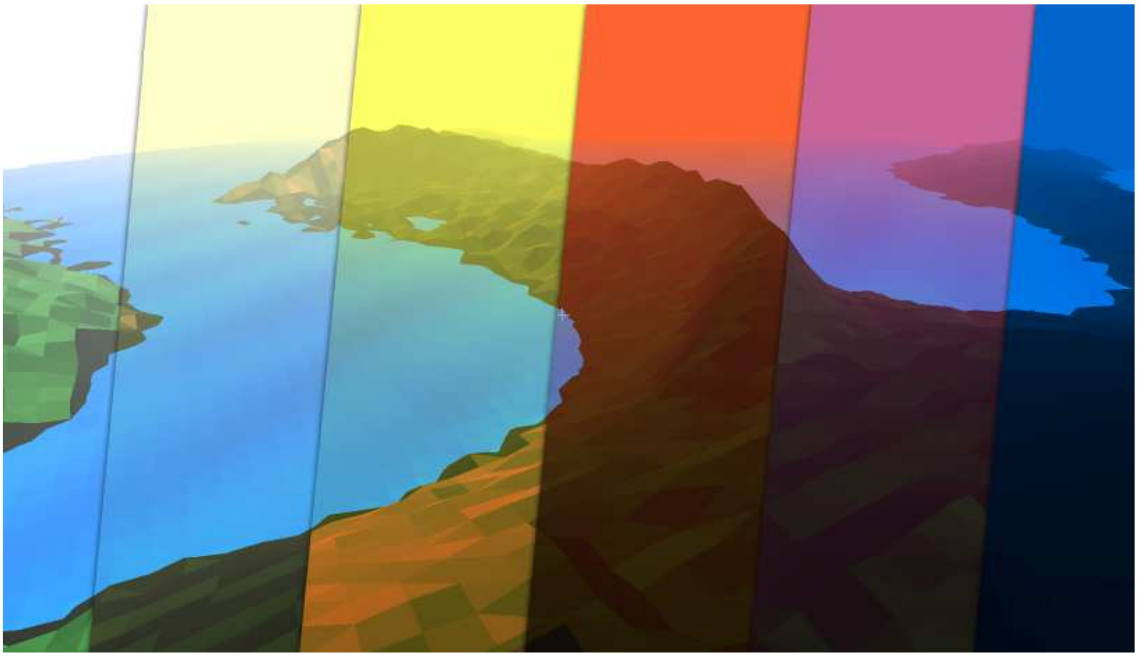

Figure 1. – Change of time of day in the game

Figure 2 shows the generated cave.

Figure 2. – Generated cave

This computer 3D game will allow players to develop their creative abilities by providing a wide range of construction tools and excellent graphics.

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UDC 004.2

ANALYSIS OF APPROACHES TO IMPLEMENTATION OF A MOBILE APPLICATION FOR ANDROID OS

ALIAKSANDR MOROZOV, RICHARD BOGUSH
Polotsk State University, Belarus

In this article we are going to review the architecture and general approaches to implementing a mobile TV- and video-viewer application for the Android platform. We are going to list the major functions of the software required to develop the mobile application.

In this article we are going to review the architectural approach that may be used for developing a mobile application intended for the Android operating system. We describe the advantages and the drawbacks of that approach, giving explanations and analyzing the chosen architecture [1].

The project development process involves adding a great number of code lines. If we work with a single development pattern the code become hard to work with, as the developer has to check constantly where a certain function begins and keep in mind the constant code replications. [2] To make that work easier, various application architectures were developed.

There are quite a few approaches to developing complex systems with robust architectures. Despite some insignificant differences, those approaches have a lot in common. Of course, all of them establish the methods to divide the application into separate modules. As a minimum, each system has modules containing the application's business rules and data display modules. In the end, each approach may be used to develop a system that meets the following requirements:

– Architecture must be independent of various frameworks;
– The system must be tested;
– The application must be independent. [3]

Independent of Frameworks. The architecture does not depend on the existence of some library of feature laden software. This allows you to use such frameworks as tools, rather than having to cram your system into their limited constraints.

Testable. The business rules can be tested without the UI, Database, Web Server, or any other external element.

Independent of UI. The UI can change easily, without changing the rest of the system. A Web UI could be replaced with a console UI, for example, without changing the business rules.

Independent of Database. You can swap out Oracle or SQL Server, for Mongo, BigTable, CouchDB, or something else. Your business rules are not bound to the database.

Independent of any external agency. In fact, your business rules simply don't know anything at all about the outside world. [4]

The schematic approach to organizing a mobile application code is presented on Figure 1.

The Dependency Rule. The concentric circles represent different areas of software. In general, the further in you go, the higher level the software becomes. The outer circles are mechanisms. The inner circles are policies.

The overriding rule that makes this architecture work is The Dependency Rule. This rule says that source code dependencies can only point inwards. Nothing in an inner circle can know anything at all about something in an outer circle. In particular, the name of something declared in an outer circle must not be mentioned by the code in an inner circle. That includes, functions, classes. variables, or any other named software entity.

By the same token, data formats used in an outer circle should not be used by an inner circle, especially if those formats are generating by a framework in an outer circle. We don't want anything in an outer circle to impact the inner circles.

Entities encapsulate Enterprise wide business rules. An entity can be an object with methods, or it can be a set of data structures and functions. It doesn't matter as long as the entities could be used by many different applications in the enterprise. If you don't have an enterprise, and just write a single application, then these entities are the business objects of the application. They encapsulate the most general and high-level rules. They are the least likely to change when something external changes. For example, you would not expect these objects to be affected by a change to page navigation, or security. No operational change to any particular application should affect the entity layer.

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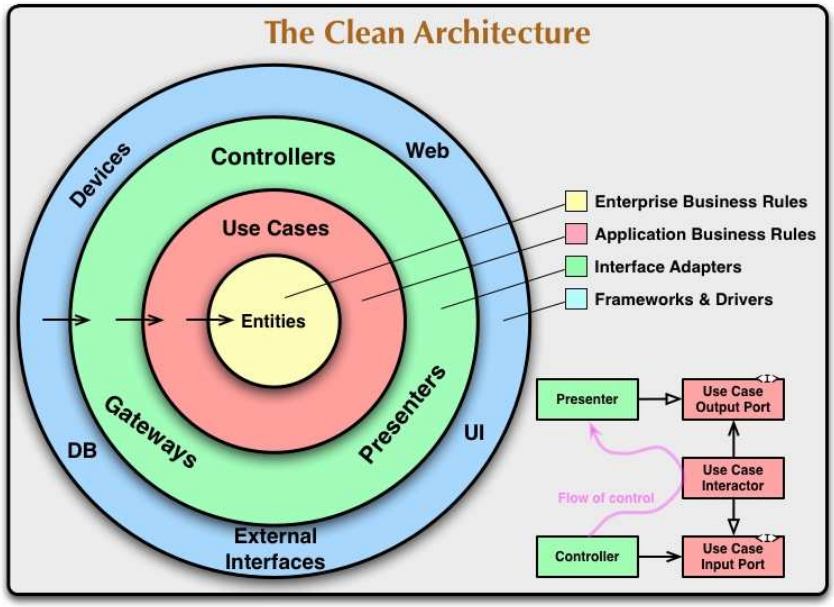

Figure 1. – Clean Architecture Diagram

Use Cases. The software in this layer contains application specific business rules. It encapsulates and implements all of the use cases of the system. These use cases orchestrate the flow of data to and from the entities, and direct those entities to use their enterprise wide business rules to achieve the goals of the use case.

We do not expect changes in this layer to affect the entities. We also do not expect this layer to be affected by changes to externalities such as the database, the UI, or any of the common frameworks. This layer is isolated from such concerns.

We do, however, expect that changes to the operation of the application will affect the use-cases and therefore the software in this layer. If the details of a use-case change, then some code in this layer will certainly be affected.

Interface Adapters. The software in this layer is a set of adapters that convert data from the format most convenient for the use cases and entities, to the format most convenient for some external agency such as the Database or the Web. It is this layer, for example, that will wholly contain the MVC architecture of a GUI. The Presenters, Views, and Controllers all belong in here. The models are likely just data structures that are passed from the controllers to the use cases, and then back from the use cases to the presenters and views.

Similarly, data is converted, in this layer, from the form most convenient for entities and use cases, into the form most convenient for whatever persistence framework is being used. i.e.

The Database. No code inward of this circle should know anything at all about the database. If the database is a SQL database, then all the SQL should be restricted to this layer, and in particular to the parts of this layer that have to do with the database.

Also in this layer is any other adapter necessary to convert data from some external form, such as an external service, to the internal form used by the use cases and entities.

Frameworks and Drivers. The outermost layer is generally composed of frameworks and tools such as the Database, the Web Framework, etc. Generally, you don't write much code in this layer other than glue code that communicates to the next circle inwards.

This layer is where all the details go. The Web is a detail. The database is a detail. We keep these things on the outside where they can do little harm. [5]

Application architecture is one of its most important characteristics, defined in the very beginning of an application's development. Changing architecture is a complex and long operation involving the already existing code which may lead to many new bugs negatively impacting the application's functions. Therefore, one has to be careful when choosing architecture back at the application design stage.

In this article we reviewed one of the approaches to the mobile application design, namely the Clean Architecture approach, defining the layers separating the mobile application's components, which, in turn, improves the code's testability. The modules become independent from one another, thus giving the developers

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an opportunity for their independent development and reuse, as well as simplifying introductions of new features to the project.

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UDC 004.02

ANALYSIS OF FUNCTIONAL OPPORTUNITIES OF AN ELECTRONIC TRADING SITE

PROKHOR ZIAZIULYA, TATYANA RUDKOVA
Polotsk State University, Belarus

The article presents a theoretical justification of an electronic trading platform, scope of this functional and gives analysis of its core functional capabilities.

More and more people want to start their own business. There can be different reasons, among them are dissatisfaction with the job, senior officials, working conditions and wages, or it can be just a wish to cardinally change one's life. The changes are possible because the start-up budget is quite low. Personal savings, government grants, loans from friends and relatives – these can be enough to start a small business.

A small business is entrepreneurship based on the activity of small firms, small enterprises, officially not aligned in associations [1].

The state tends to help small firms and numerous programs of motivation, such as soft lending, provision of gratuitous financial aid, free of charge advisory services, are initiated. By the year 2020 the proportion of small and mid-sized business in GDP (gross domestic product) of Belarus will have risen up to 40%. Taras Nadolny, the First Deputy Chairman of the National Bank's Board, told about it at the opening ceremony of the International Conference "Modern Instruments of SME Finance".

Due to new technologies development anyone who wishes can start their own business. More and more people all over the world use web based applications to seek and buy goods and to start their business. The popularity of such web applications lies in the fact that it is possible to find practically everything one needs, including various products at wholesale prices, on the Internet.

An electronic trading platform is in the first place a website directed at the search, purchase, making transactions and holding auctions between suppliers and an organizer. Along with that users are provided with an access to the section "Products Catalogue", where they can make bargains without participating in an auction, just purchase products at a fixed price specified to each product.

An auction is a public sale of financial credit documents, corporate assets, works of art and other commodities, which has clearly defined rules. Common for all auctions is the competitive principle among potential buyers. The winner is defined through a competition among the buyers to obtain the products. The winning bidder is the person who has won the auction according to its rules. In this case the object is bought from the winning bidder [2].

Functional structure of an electronic trading platform. The functional structure of the system under development can be presented as a set of subsystems, each of which in its turn consists of separate modules or is presented as a single module. The following subsystems can be singled out in the electronic trading platform structure:

– Organizing an auction subsystem in the system under the user account "Organizer";

– Editing an auction subsystem (is responsible for editing the existing auctions under the user account "Organizer");

– "Company Catalogue" subsystem (stores the information about all the clients and companies registered on the trading website);

– "Products Catalogue" subsystem (stores the list of products which were created by the users on the trading website as well as the information about completed and declined transactions, creating and editing products);

– "Forms of Participating in an Auction" subsystem (allows the users to join an accessible auction and submit a bid under the account "Participant");

– "User Profile" subsystem (allows to set the system parameters under the user accounts "Organizer" or "Participant" according to users' preferences and ease of handling the system).

Having created an auction and having added participants (suppliers) the organizer can make sure that they buy the commodity at wholesale prices, the suppliers in their turn can find new partners to dispose products.

Furthermore, the user can add partners and organizers to their account in order to include them in new auctions. There will be "Products Catalogue" on the website where the users (an organizer and a participant) can upload products and execute transactions on targeted products at wholesale prices without taking part in the auctions.

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The website users will have an opportunity of user profile management where they can change their private information and update functional images on the website (switch off sound columns on the auction form, not make reports about auctions, not receive notification from those users who are not in partnership relations with them, etc.).

In the Republic of Belarus small business plays an important role in the social and economic development of the country. It promotes the establishing of competitive environment, provides an increase in consumer products manufacturing, and encourages the growth of service sector. Besides, the nation's economy gets additional stability. The importance of small business is defined by such characteristics as susceptibility to consumers' demand and ability to keep up with it in a timely manner, to respond to changes in the market and to demonstrate high flexibility. Among other matters it must be noted that small business creates new jobs in all functional areas, which in its turn leads to the decrease in the number of the unemployed. With regard to the above-said it is possible to make a conclusion that this issue is of current concern as it helps users to acquire necessary products in no time, which facilitates the development of small business.

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UDC 004.021

INTERFACE DESIGN THE AUTOMATED INFORMATION SYSTEM "COMMISSION SHOP" ON THE PLATFORM 1C: ENTERPRISE 8.3

VLADISLAV GONCHAROV, ARKADY OSKIN
Polotsk State University, Belarus

This article discusses the principles of designing the user interface in the automated information system "Commission shop" on the platform 1C: Enterprise 8.3.

Each automated information system has its own principles of interface design. 1C: the Company has a number of advantages of building application solutions, the main of which is the ability to adapt to the peculiarities of a particular field of activity, i.e. configurability – the ability to configure the system to the characteristics of a particular enterprise and the class of tasks in which it is used. This article is aimed at a detailed description of the technologies of building the user interface on the 1C platform.

The user interface is all the Windows, menus, buttons, etc., with which the user works directly in the program [1]. Running the configuration in managed mode starts from the desktop. On the desktop information relevant to the user should be provided – user tasks, ongoing operations, etc. Desk is customizable, without the means of configuration. The form editor is used to create and edit forms of application solution objects. Object forms are used by the system to visually display data during the user's work. Form parameters are edited in the list. The developer has the ability to add, remove form parameters and set their properties using the properties palette. To edit the form module, the Configurator calls the text and module editor. This editor provides the developer with a wide variety of options to create and modify the module text. [2]

This platform has its advantages:

– "Trehdverka" – load balancing
– Database openness
– No restrictions
– Universal configuration code
– Platform is installed very simply.

However, there are disadvantages:

– Price: have to buy separate CALs for each client computer separately – one server license 1C, a separate license for SQL server unless you use free
– Also sometimes it has difficulties in the work database. They are solved much faster due to the availability of data and the availability of external tools to work with the database [1]

The main menu of the application is shown in Figure 1.

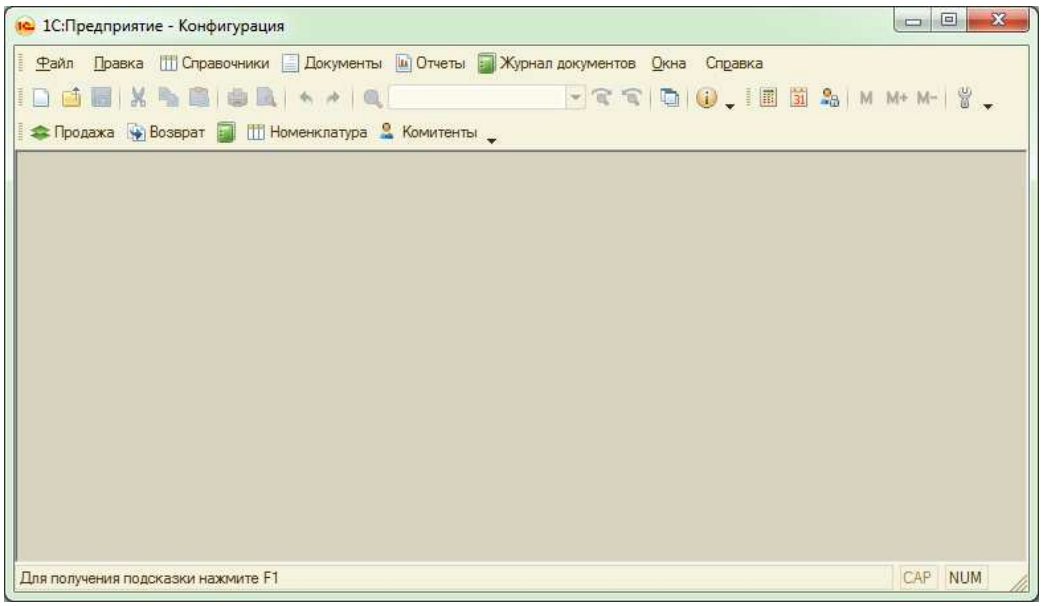

Figure 1. – Main application menu

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As you can see from picture 1, all the main modules are on the screen, including settings and actions. In this menu you can access to all components: directories, documents, reports etc. Working with directories is to save the data. Also, the details (the Commission, the division and the Commission) have two-way filling: manually enter or select from the appropriate directory. If the dictionary does not yet have the required element – you need to add it. Working with documents is to create reports and print the required list of documents.

When you run the program in the background, the documents are automatically checked for the need for revaluation or return of goods. The constants store the dates after which you want to revalue or check in. If it is necessary to mark the goods, the document "Markdown of goods" is created, which is filled in with data from the document of arrival of goods, which is the document-basis for markdown. In the panel "Service message" notification is displayed to the user on every markdown. The document "Sale of goods" is created for the sale of goods. In the document window, fill in the required fields and specify the goods to be sold. After conducting your data is stored in the accumulation register "goods" and information register Sales. For the necessary clarity and ease of perception of printed documents in the modules increases the program code with the necessary distribution of data on the print.

The user interface configuration is shown in Figure 2.

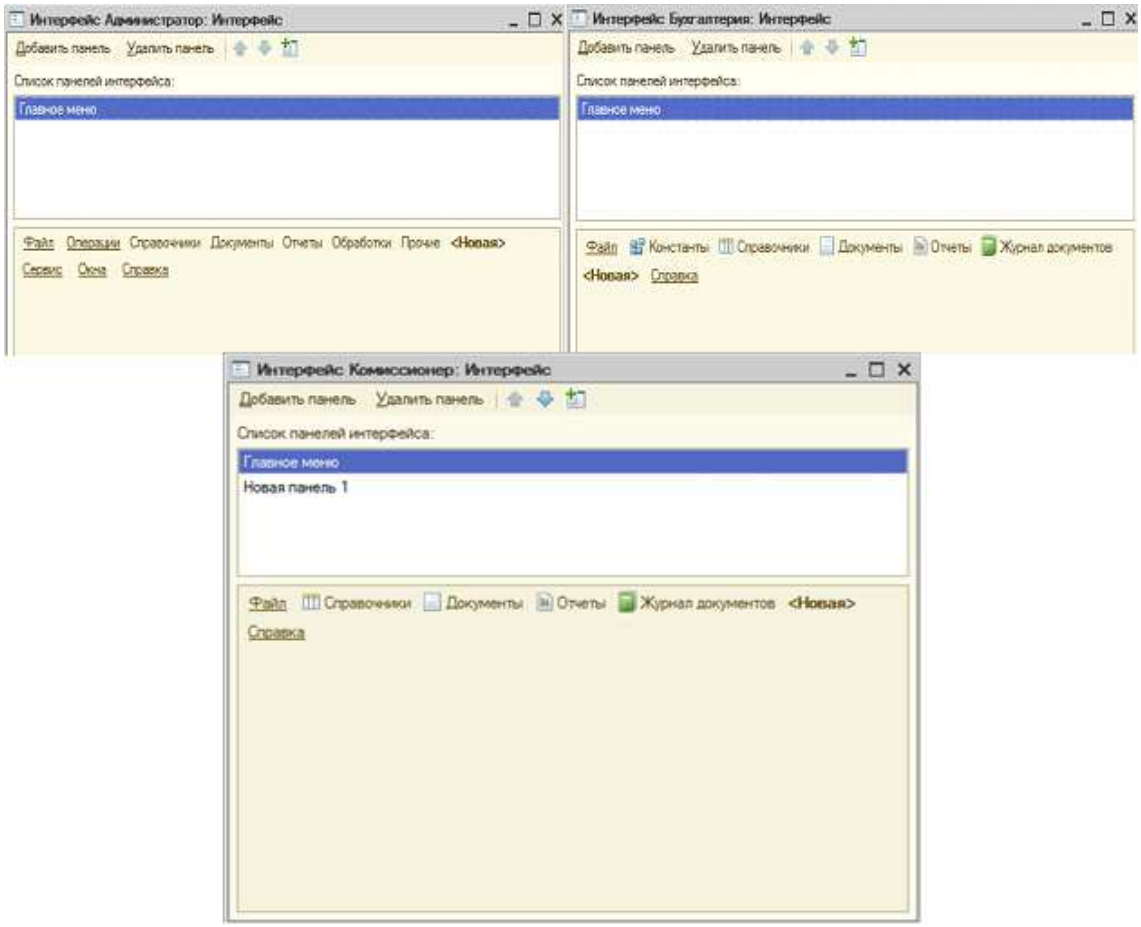

Figure 2. – User interfaces

This article describes the construction of the user interface on the platform 1C: Enterprise 8.3, as well as their pros and cons. User interfaces of work with the system are presented.

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UDC 004.223.2

CLIENT-SERVER WEB APPLICATION ON ENCRYPTION MESSAGES IN THE CHAT NETWORK ON THE BASIS OF HMAC-SHA256 AND AES ALGORITHMS

VLADISLAV PETYUKEVICH, DMITRY PASTUKHOV
Polotsk State University, Belarus

This article discusses the design of the secure data transfer scheme between users using peer-to-peer scheme, as well as the protection of this data. The analysis of technology most suitable for the development of this scheme has been done.

Some means of transferring information between users, such as Viber and Telegram, use message encryption, but transmit messages through their own servers. Thus, it turns out that all user messages can be stored on the server and transmitted to someone.

This problem can be solved using a peer-to-peer connection.

A peer-to-peer network is an overlaying computer network based on equal rights of participants. There are often no dedicated servers in such a network, and each node (peer) is both a client and acts as a server. Unlike the client-server architecture, such an organization allows the network to remain operable with any number and any combination of available nodes. Members of the network are peers. [1]

Benefits from using peer-to-peer:

1. Protection against server data leakage;
2. Reducing the load on the application server, because the server will cease to participate in the process of sending messages.

None of the popular messaging tools use message protection at the highest possible level. Viber and Telegram use end-to-end encryption, but their common problem is control of the entire message passing process by the servers of these services.

End-to-end encryption is a data transfer method in which only users participating in communication have access to messages. Thus, the use of pass-through encryption does not allow access to the cryptographic keys by third parties. [2]

The topic of combining end-to-end encryption and peer-to-peer connections is not well developed. Only one article in English was found on the Internet. But only theoretical issues were considered in this article without considering the options of the technologies used.

This article deals only with the case of the text data transfer. However, the technologies used in this scheme can be applied to transfer other types of data.

End-to-end encryption in the peer-to-peer network will avoid the problem of intercepting the data being sent. This application should also work in the browser so that the user does not have to install anything.

In connection with the requirements to install peer-to-peer connections between clients using WebRTC:

WebRTC is an open source project designed to transfer streaming data between browsers or other applications supporting it using peer-to-peer technology. [3]

At the API level, technology is standardized by the W3C consortium, and at the protocol level - by the IETF community. Its inclusion in the W3C recommendations is supported by Google Chrome (and others based on it), Mozilla, and Opera.

Technology benefits:

1. Conducting a conference in a browser greatly simplifies the process of holding a conference — the user does not need to install separate applications for this;
2. Used codecs provide good quality of communication;
3. The ability to implement any interface elements using HTML5 and JavaScript;
4. Open source gives you more options.

The technology defines only the general standard of data transmission (video and sound), but individual solutions of different browsers regarding the subscribers addressing and other control processes are not compatible with each other. Therefore, even calls between a pair of different browsers present a separate complexity.

For end-to-end encryption, Diffie – Hellman protocol is used.

Diffie – Hellman protocol is a cryptographic protocol that allows two or more parties to obtain a shared secret key using an unprotected communication channel. The resulting key is used to encrypt further exchange using symmetric encryption algorithms. [4]

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Description of the message transmission scheme:

1. According to the Diffie-Hellman protocol clients generate their public / private key pair during authorization and send the public key to the server;
2. Before sending messages clients receive each other's public keys through the server and exchange messages to establish peer-to-peer connections via WebRTC. To reduce server load, setup messages for peer-to-peer connections are transmitted via the WebSocket protocol;
3. As a result of receiving public keys customers can generate a common key using the Diffie-Hellman protocol;
4. After establishing peer-to-peer connections, clients can exchange encrypted shared key messages.

Algorithms used in this scheme:

1. To create a public / private key pair the Diffie-Hellman protocol is used;
2. To generate the private key the HMAC-SHA256 algorithm is used with a block size of 64 bits. The HMAC-SHA256 algorithm hashed the user name and a random number. It is done for the purpose of making different key for each new session;
3. The AES algorithm with a key (length of 256 bits and a block size of 64 bits) is used for messages encryption. The key for encrypting / decrypting messages is the shared key of two users, which is obtained using the Diffie-Hellman protocol.

Establishing a peer-to-peer connection between two clients:

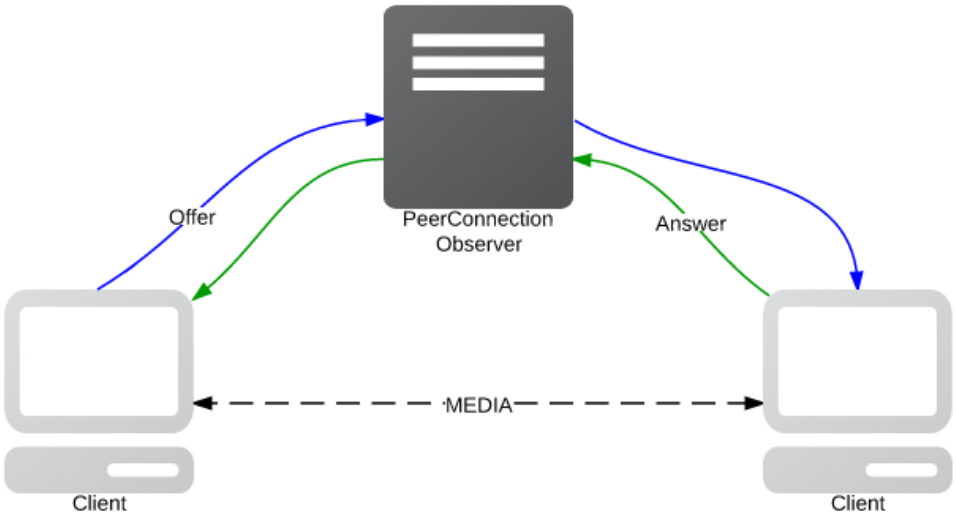

Figure 1. – A peer-to-peer connection between two clients

Simplified connection steps between two clients:

1. The first client sends the so-called Offer to the second client via server;
2. The second client sends a response through the server to the first client;
3. A peer-to-peer connection is established between clients.

For quick transfer of messages to the server, the WebSocket protocol is used. WebSocket is a full-duplex protocol over TCP connection designed for real-time messaging between a browser and a web server. [5] Compared to HTTP, WebSocket sends much less service information with each request.

The scheme for secure data transfer between users using end-to-end encryption in a peer-to-peer network was designed in the course of this study. End-to-end encryption was implemented using Diffie-Hellman protocol using the HMAC-SHA256 and AES algorithms. WebRTC was used to set up peer-to-peer connections in the browser. The developed scheme leaves the possibility for the refinement and introduction of additional remedies.

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UDC 004.02

DESIGNING AN INTERNET SHOP OF TELEGRAM CHANNELS

MAKSIM POTAPOV, TATYANA RUDKOVA
Polotsk State University, Belarus

The article presents a statement of need to make a web application which can help Telegram channels acquire various contents. The key requirements to the designing of both functionality features and web resource interface are considered.

These days online stores are convenient resources for users as they make it possible to order products and services quickly and easily with their personal computers without leaving their homes. It can therefore be concluded that they are likewise lucrative for the owners of stores.

Having analyzed the current trends on the contemporary market one can deduce that developing an online store which can perform effective sales on Telegram channels, is of immediate interest because at the moment there are no complete analogs of such a resource. Thus, the unique character in this segment is demonstrated.

Since an online store performs the functions of a display-window presenting available goods and services, it seems appropriate to develop a web application which will make it possible to place the products, accordingly grouping them by their types and prices.

Therefore based on the subject area analysis the key requirements to developing an online store of Telegram channels were specified:

- Viewing the news on the homepage with references to the website domain;
- Viewing feedback on the online store;
- Viewing the video content on the homepage of the website;
- Choosing channels according to categories;
- Channels filtering;
- Channels purchase;
- Contacting the website administration through the section "About Us";
- Choosing channels according to the topic;
- Channels search on all pages of the website;
- Website administering;
- Possibility to update (updatability) the news content on the homepage;
- Products catalogue changing;
- Animated design;
- Breadcrumbs;
- Pagination.

The resource for development of functionality configuration can be presented as a set of subsystems:

- viewing, editing and creating the news subsystem (it enables to view the latest news on various topics on the homepage of the online store: five pieces of the news can be placed on the online store homepage; the online store administrator is the only person who can edit and create the news);
- viewing, editing and creating the feedback on the online store subsystem (it enables to scan the feedback on the online store homepage: seven feedbacks can be placed on the homepage; a feedback includes a text, a client's photo and a link to social media where the feedback was made);
- viewing, editing and creating the categories subsystem (a user can choose a category on their preference; the administrator is able to edit the categories; every category has a name and its own unique URL);
- ordering options subsystem (every user can buy products through the online store, you should just press the "BUY" button under the item and fill in your personal data).

The process of developing an online store interface begins with the homepage, where the following elements must be placed:

- drop-down menu, which enables users to choose a catalogue of Telegram-channel categories;
- news carousel, which enables users to look through all the news independently of the user, the change of the news takes place automatically, there is also an opportunity to change the news by making use of a computer mouse;

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– search bar is a search of a channel by its title (a prompt message with possible hits appears during the searching);

– feedback carousel, which enables users to look through the opinions of the clients, who have already used the website services (the automatic feedback are moved automatically, there is also a function of feedback).

On the page with the list of channels the following elements must be placed:

– drop-down menu which will make it possible to choose the sorting;

– "SORT" button which will make it possible to perform the sorting;

– search bar is a search of a channel by its title and category (a prompt message with possible hits appears during the searching);

– "BUY" button which makes it possible to do the shopping, when you press it a page with a form appears;

– "Breadcrumbs" element which makes it possible to pass to the preceding pages;

– Telegram-channel logo;

– online store logo, when users press it they are forwarded to the website homepage;

– price of a Telegram-channel.

On the Telegram-bot page all the standard elements of Telegram messenger will be placed.

As can be seen from the above, the page templates presented demonstrate the design process of this web-resource main functionality. An online store of web-channels will not only be able to replace the search of channels through dubious Internet forums or websites, but also guarantee a transparent and safe purchase.

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UDK 004.62

ANALYSIS MODEL MAPREDUCE TECHNOLOGY «BIG DATA»

ANTON STANOVOY, SERGEI SURTO
Polotsk State University, Belarus

Although they have existed for several years big data have not previously been of great value, because their processing and analysis were difficult. This required substantial computing power, long time and financial costs. Everything changed when the technology of processing multi-gigabyte arrays of information in fast RAM appeared. A breakthrough in this area is associated with the launch of the free Hadoop platform, including libraries, utilities and frameworks for working with Big Data. Hadoop components are used today in most commercial platforms and systems of companies such as SAP, Oracle, IBM, and so on. Today, the term Big Data, as a rule, is used to refer not only to the data arrays themselves, but also to tools for their processing and the potential benefits that can be obtained as a result of painstaking analysis.

Introduction. The widespread introduction of the term «big data» is associated with Clifford Lynch, the editor of Nature magazine, who prepared a special issue for September 3, 2008 with the topic «How can technology influence the future of science, opening up opportunities for working with large amounts of data?» about the phenomenon of explosive growth in the volume and diversity of the processed data and technological perspectives in the paradigm of the likely jump «from quantity to quality»; The term was proposed by analogy with the «big oil», «big ore» metaphors in the business English-speaking environment. Despite the fact that the term was introduced in an academic environment and, above all, the problem of growth and diversity of scientific data was understood, since 2009 the term has been widely spread in the business press, and by 2010 the appearance of first products and solutions related exclusively and directly to the problem of processing big data. By 2011, most of the largest suppliers of information technology for organizations in their business strategies use the concept of big data, including IBM, Oracle, Microsoft, Hewlett-Packard, EMC, and the main analysts of the information technology market devote dedicated research concepts. In 2011, Gartner noted big data as trend number two in the information technology infrastructure (after virtualization and as more significant than energy saving and monitoring). At the same time, it was predicted that the introduction of big data technologies would have the greatest impact on information technologies in manufacturing, health care, trade, government, as well as in areas and industries where individual movements of resources are recorded [1].

Since 2013, big data as an academic subject has been studied in new university programs on data science and computational sciences and engineering.

In 2015, Gartner eliminated big data from the maturity cycle of new technologies and stopped releasing a separate maturity cycle of big data technologies in 2011-2014, motivating this by moving from the stage of hype to practical application. The technologies that figured in the dedicated maturity cycle, for the most part, moved into special cycles on advanced analytics and data science, on BI and data analysis, corporate information management, resident computing, and information infrastructure. One of the main big data models is Mapreduce [2].

Main part. MapReduce is a distributed data processing model proposed by Google for processing large amounts of data on computer clusters. MapReduce is well illustrated by the picture (Figure).

MapReduce assumes that data is organized in the form of some records. Data processing occurs in 3 stages:

1. Stage Map. At this stage, the data is processed using the map () function that the user defines. The job of this stage is to pre-process and filter the data. The operation is very similar to the map operation in functional programming languages — a user-defined function is applied to each input record. The map () function applied to a single input record and produces a set of key-value pairs. The set - i.e. can give only one record, can give nothing, and can give several key-value pairs. What will be in the key and in the meaning is up to the user, but the key is a very important thing, since the data with one key will fall into one instance of the reduce function in the future.

2. Stage Shuffle. It passes unnoticed by the user. At this stage, the output of the map function is "sorted into baskets" – each basket corresponds to one output key of the map stage. In the future, these baskets will serve as an input for reduce.

3. Stage Reduce. Each "basket" with values, formed at the shuffle stage, goes to the input of the reduce () function. The reduce function is set by the user and calculates the final result for a single «basket». The set of all values returned by the reduce () function is the final result of the MapReduce task [3].

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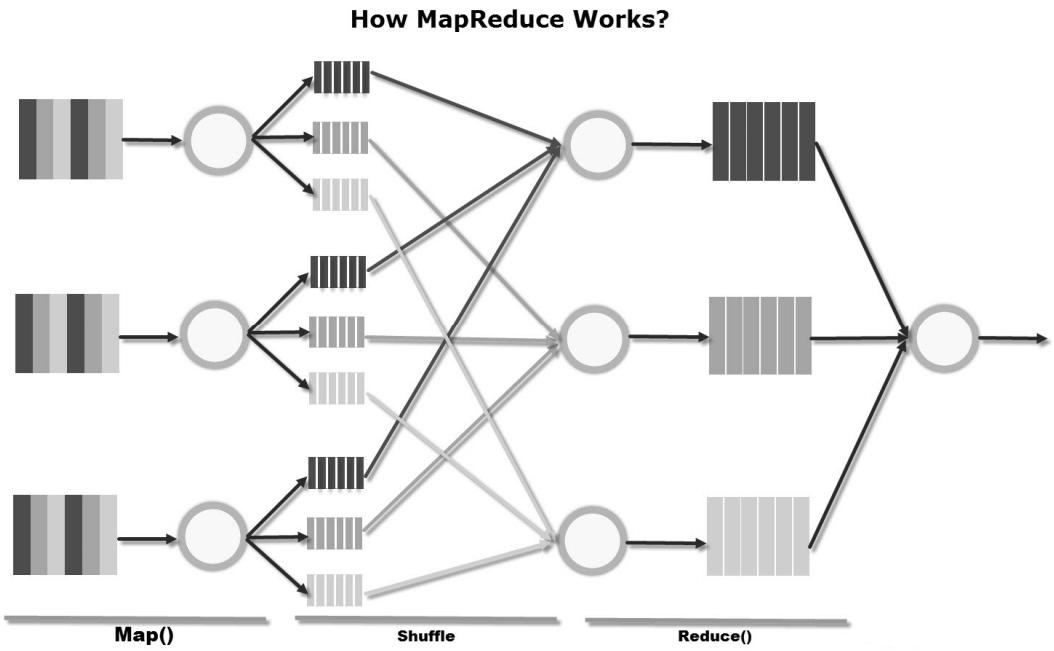

Figure 1. – Model MapReduce

Some additional facts about MapReduce:

1) All launches of the map function work independently and can work in parallel, including on different cluster machines.

2) All launches of the reduce function work independently and can work in parallel, including on different cluster machines.

3) Shuffle inside represents parallel sorting, so it can also work on different cluster machines. Items 1–3 allow you to perform the principle of horizontal scalability.

4) The map function, as a rule, is used on the same machine on which the data is stored - this reduces the transmission of data over the network (the principle of data locality).

5) MapReduce is always a full scan of the data, there are no indices. This means that MapReduce is poorly applicable when a response is required very quickly [4].

Conclusion. Currently, enterprises have to work with large amounts of information, which is often updated and comes from different sources. With the help of Big Data technology, enterprises can analyze huge amounts of data and identify useful patterns that give them competitive advantages.

For easier perception and quick decision-making, it is necessary to present the results of data analysis visually. At the moment there are several types of data arrays. But existing visualization methods are still underdeveloped and need improvement.

Companies that have already implemented Big Data technologies will have a great competitive advantage in the future.

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UDC 004.223.2

POSSIBLE OPTIONS FOR INFORMATION STORAGE, ANALYSIS AND SELECTION OF THE OPTIMAL STORAGE FOR FURTHER IMPLEMENTATION

JEKATERINA DENISOVA, YURY PASTUHOV
Polotsk State University, Belarus

The article discusses various options for storing information. The result of the analysis is choosing the best option for storing information. Design of a system for storage and transmission of information is discussed, as well as issues of these data protection. There is also provided research on the relevance of this system development.

In the modern world, users of personal computers, smartphones and other devices with access to the world wide Web have a large amount of information (photos, videos, music, various documents, etc.) that has to be stored somewhere. To store information, there are a large number of different resources. Consider the possible options for storing information:

– disk drives can either be housed internally within a computer or housed in a separate box that is external to the computer. They are found in PCs, servers, laptops and storage arrays, for example. They work by rotating very rapidly around a head or heads, which read and write data. They differ from solid state drives (SSDs), which have no moving parts and offer greater performance, but also cost more and generally offer less capacity. Today they are used in most desktop PCs, and have also found application as portable data storage. Usually, such a device works properly for 3-10 years and its service life depends on many external factors and the quality of production;

– an SSD drive is a type of nonvolatile storage media that stores persistent data on solid-state flash memory. Two key components make up an SSD: a flash controller and NAND flash memory chips. The architectural configuration of the SSD controller is optimized to deliver high reading and writing performance for both sequential and random data requests. SSDs are sometimes referred to as flash drives or solid-state disks. Such devices, on average, work properly for about five years. Many flash drives can break even much earlier, because they cannot tolerate a voltage surge or static discharge at the time of connection to the PC;

– an optical disc is an electronic data storage medium that can be written to and read from using a low-powered laser beam. This is, perhaps, one of the longest-time ways to save information, in some cases, such a disk will reliably store all recorded data for more than 100 years, but optical disks can occupy a large number of physical space, which is not very convenient for the user;

– cloud storage is a service model in which data is maintained, managed, backed up remotely and made available to users over a network (typically the Internet). The use of cloud media is very popular nowadays. It is a very convenient option to provide information to any person, being anywhere in the world, with any multimedia device and access to the Internet.

Based on the mentioned above options, one can conclude that in the age of modern technology and the availability of the Internet, users increasingly "trust" their data to cloud services, which is sufficient and convenient, because the service does not take any physical space, unlike other possible options for storing information.

The relevance of the development of a cloud storage: the basis of the developed system is the ability to store, store and process data, as well as the ability to share files with third-party people. When developing our own cloud storage, we have the opportunity to make encryption "for ourselves", that is, to choose the algorithms that we need and, if necessary, modify them. At this stage, a two-key mathematical model of the cryptosystem based on two types of encryption (AES+RSA) is implemented in such a way that we can change/add the encryption algorithm at any time. This makes our system flexible to develop and more secure against intentional information theft.

The principle of information security. Based on the fact that this system is designed to store sensitive data of users, it is necessary to develop a system of authentication and cryptographic protection of data.

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For secure data transmission over the Internet there are the following technologies:

– Hypertext Transfer Protocol Secure (HTTPS) is a variant of the standard web transfer protocol (HTTP) that adds a layer of security on the data in transit through a secure socket layer (SSL) or transport layer security (TLS) protocol connection. HTTPS enables encrypted communication and secure connection between a remote user and the primary web server. When using HTTPS, the traffic between the browser and the web server is encrypted. This prevents anyone who happens to have access to any of the many wires that your data will traverse as it crosses the Internet from looking at what you are sending to the server, or what the server is sending to you. This is why HTTPS is used for sending passwords and other login credentials. This is one reason, why websites dealing with banking and other matters that require privacy, use HTTPS. This is why you probably want to use HTTPS if you are reading your webmail from a public wi-fi connection.

– SRTP (Secure Real-Time Transport Protocol or Secure RTP) is an extension to RTP (Real-Time Transport Protocol) that incorporates enhanced security features. Like RTP, it is intended particularly for VoIP (Voice over IP) communications.

SRTP was conceived and developed by communication experts from Cisco and Ericsson and was formally published in March 2004 by the Internet Engineering Task Force (IETF) as Request for Comments (RFC) 3711. SRTP uses encryption and authentication to minimize the risk of denial of service (DoS) attacks. SRTP can achieve high throughput in diverse communications environments that include both wired and wireless devices. Provisions are included that allow future improvements and extensions.

– SSL (Secure Sockets Layer) is a standard security technology for establishing an encrypted link between a web server and a browser. This link ensures that all data passed between the web server and browsers remain private and integral. SSL is an industry standard and is used by millions of websites for the protection of their online transactions with their customers.

– Advanced Encryption Standard (AES) algorithm is one on the most common and widely symmetric block cipher algorithms used worldwide. This algorithm has its own particular structure to encrypt and decrypt sensitive data and is applied in hardware and software all over the world. It is extremely difficult for hackers to get the real data when it is encrypted by AES algorithm. For the time being, there is no case of craking this algorithm. AES has the ability to deal with three different key sizes such as AES 128, 192 and 256 bit, and each of these ciphers has a 128 bit block size. This paper will provide an overview of AES algorithm and explain several of its crucial features in details, and as well as demonstrate some previous researches that have been done on it in comparison to other algorithms, such as DES, 3DES, Blowfish etc.

– The RSA algorithm is the basis of a cryptosystem - a suite of cryptographic algorithms that are used for specific security services or purposes -- which enables public key encryption and is widely used to secure sensitive data, particularly when it is sent over an insecure network such as the Internet. RSA derives its security from the difficulty of factoring large integers that are the product of two large prime numbers. Multiplying these two numbers is easy, but determining the original prime numbers from the total – or factoring – is considered infeasible due to the time it would take even using modern supercomputers.

After analyzing the above, we can conclude that cloud storage is one of the best options for storing information at the moment. Developing cloud storage, it is necessary to learn the methods of encryption and their relevance, and choose the most versatile protection methods.

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UDC 004.422

APPROACHES TO THE DESIGN OF THE GRAPHIC WEB INTERFACE ON THE EXAMPLE OF THE WEB APPLICATION

MIKITA BOBKOV, SERGEI SURTO
Polotsk State University, Belarus

In this article we analyze the technologies used for implementation of the interfaces of web applications and give the example of the web interface implementation within a page of the application.

Introduction. With the development of Internet technologies, more and more web applications with various subjects began to appear.

Web application is a client-server application in which a client is a browser, and a server is a web server. The logic of the web application is distributed between a server and a client, data storage is carried out, preferentially, on a server, information exchange happens on a network.

The web application consists of client and server parts, thereby realizing client-server technology. A client part realizes the user interface, creates server requests and processes responses from it. [1]

Development of web applications is a powerful tool, which allows to realize business ideas and to create successful software products. Web applications help to automate process of operation with large information streams (a client basis, goods directory, a branch network, documents and so on).

Front-end and back-end are terms in program engineering which are distinguished according to the principle of division of responsibilities between external representation and internal implementation respectively. Front-end is an abstraction, which provides a user interface. For example, in design of the software, the architecture provides to Model-View-Controller front-end and back-end between the database, components of data handling and users [1].

Development of web applications on the front-end and back-end system implies hierarchical division of creation process of a resource into two parts, into development of a user interface (frontend) and its program and administrative part (backend).

Now web applications are already comparable by their advantages to classical applications. But at the same time they can be available in any place and at any time on a computer, a pad or a mobile device and often have smaller cumulative possession costs. These features do web technologies very attractive to the solution of a wide range of tasks.

Task cures.

Let's consider fixed assets of implementation of a frontend of the web application on the basis of noncommercial transportations of passengers.

Front-end development is an operation on creation of a public part of the application, which a user contacts with, and functionality, which is usually beaten on a client side directly, contacts (in the browser). The frontend is a component of the application, which is responsible for an output of certain information to a user and upon making, to them, any actions in the web application, its interpretation in a look clear to the programs relating to a backend.

In operation Bootstrap – CSS/HTML a framework for creation of web applications which contains a row of advantages thanks to which it is considered to be the most popular of similar used. In other words, it is a tool kit for imposition.

Let's consider primary benefits of Bootstrap:

– operation speed – thanks to a set of ready elements imposition with bootstrap takes much less time;
– scalability – adding of new elements doesn't break the general structure;
– easy adjustability – editing styles is made by creation of new css-rules which are executed instead of standard;
– large number of templates;
– huge community of developers;
– wide scope of application – Bootstrap is used in creation of subjects for almost any CMS (OpenCart, Prestashop, Magento, Joomla, Bitrix, WordPress and any other), including one-page appendices. [3]

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Bootstrap uses the modern practices in the field of CSS and HTML therefore it is necessary to be attentive with assistance of old browsers.

Main Bootstrap tools:

– grids – in advance the given sizes of columns which can be used at once for example width of a column 140px belongs to the class .span2 (.col-md-2 in the third version of a framework) which can be used in CSS a document description;

– templates – the fixed or rubber document template;

– typographics – Descriptions of fonts, determination of some classes for fonts, such as a code, quotes and so on;

– media – are represented by some control of images and video;

– tables – means of design of tables, up to adding of functionality of sorting;

– forms – classes for design of the forms and some events happening to them;

– navigation – design classes for tab, tabs, pageness, the menu and a toolbar;

– alerty-design of dialog boxes, hints and pop-up windows [1].

Also in case of implementation of the web application JSP (JavaServerPages) – the technology allowing creating contents, which have both static and dynamic components, was used. The JSP page contains the text of two types: static basic data, which can be issued in one of the text HTML formats, SVG, WML, or XML, and JSP elements, which construct dynamic contents. Besides libraries of JSP tags and EL (ExpressionLanguage), for implementation of Java code in static contents of JSP pages can be used [1].

JSP is the platform independent, portable and easily expanded technology for the development of web applications. The main idea of JSP is very simple – the page is a template with already prepared HTML tags between which it is necessary to insert the necessary data.

JSP pages have extension of .jsp and are placed in the same place where normal web pages. The structure of such pages can consist of five constructions: HTML, comment, scripting elements, directives and actions. The JSP page in case of compilation will be transformed to a servlet with static contents, which go to the output stream connected to the service method. Therefore, in case of the first request this process can cause a small time delay. Scripting elements allow specifying a code in the Java language, which afterwards will become a part of a finite servlet, directives give the chance to control all structure of a servlet, and actions serve for the job of the existing used components, and also for control over behavior of an engine of JSP. For simplification of operation with scripts there are in advance defined variables, such as request, response, page Context, session, out, application, config, page, exception [1, 2].

The code of the JSP page is broadcast in servlet Java code by means of the compiler of JSP pages Jasper, and then compiled in byte code of the virtual machine Java (JVM). The containers of servlets capable to execute JSP pages are written in the Java language. JSP pages boot on the server and cope from structure of special Javaserverpacket which is called Java EE WebApplication. Usually pages are packed into file archives.

Nowadays web technologies are quickly developing, they give to developers more and more opportunities, and their productivity is growing. As a result advantages of native applications decrease, and development goes to the web environment more and more. Web applications were strongly included into our life, and we use many of them even without thinking – the same search of Google or a mail service of Gmail.

During the development of web interfaces it is necessary to take into consideration not only good design which helps to concentrate on tasks of the user, but also to consider that any interface shall be intuitively clear for a user – he shall understand instantly which following step he can make. The web interface shall have such qualities as a crossp platform, adaptivity for different sizes of screens, dynamism and incorrect operation in different browsers.

It is obvious that there are more pluses from the use of web applications than minuses, and use of different frameworks and technologies allows reducing considerably time of implementation of web applications without loss of their quality.

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UDC 512.7

CHARACTERISTIC AND MINIMAL POLYNOMIALS IN PROBLEMS

YANA KAZAK, STEPAN EHILEVSKY, NINA GURIEVA
Polotsk State University, Belarus

In linear algebra, the minimal polynomial of an n-by-n matrix A over a field F is the monic polynomial p(x) over F of least degree such that p(A)=0. Any other polynomial q with q(A)=0 is a (polynomial) multiple of p. The following three statements are equivalent: λ∈F is a root of p(x), λ is a root of the characteristic polynomial of A, λ is an eigenvalue of A. The multiplicity of a root λ of p(x) is the geometric multiplicity of λ and is the size of the largest Jordan block corresponding to λ and the dimension of the corresponding Eigen space. The minimal polynomial is not always the same as the characteristic polynomial.

The minor of the k[th] order of a matrix of size (m×n), built on its rows with numbers $i_1 < i_2 < \cdots < i_k \leq m$ and columns with numbers $j_1 < j_2 < \cdots < j_k \leq n$ is called the main minor of the k[th] order, if $i_1 = j_1, i_2 = j_2, \ldots, i_k = j_k$. Among all the main minors of a square matrix, its successive main diagonal minors are distinguished.

The sum of the diagonal elements of a square matrix A is called its trace and is denoted by *SpA*. The characteristic matrix of a square matrix $A(a_{ij})$ of the n[th] order is called the matrix $(A - \lambda E)$ with variable λ, taking any values. The determinant $|A - \lambda E|$ is called the characteristic polynomial of the matrix A, and its roots $\lambda_1, \lambda_2, \ldots, \lambda_n$ – the characteristic roots or characteristic numbers of the matrix A.

Note that the characteristic polynomials of similar matrices are the same.

The characteristic polynomial of the matrix A of order n is a polynomial of the n[th] degree of λ and has the form:

$$|A - \lambda E| = (-1)^n(\lambda^n - p_1\lambda^{n-1} + p_2\lambda^{n-2} - \cdots \pm p_n), \quad (1)$$

where p_m - the sum of the principal minors of the k[th] order of the matrix A, in particular, $p_1 = SpA$, $p_n = |A|$, E – unit matrix.

Let us consider the following problem of calculating the characteristic polynomial of the matrix

$$A = \begin{pmatrix} 1 & 2 & 0 \\ 0 & 2 & 0 \\ -2 & -2 & -1 \end{pmatrix}.$$

By the definition of the characteristic polynomial, we get:

$$|A - \lambda E| = \begin{vmatrix} (1-\lambda) & 2 & 0 \\ 0 & (2-\lambda) & 0 \\ -2 & -2 & (-1-\lambda) \end{vmatrix} = -\lambda^3 + 2\lambda^2 + \lambda - 2 = -(\lambda - 1)(\lambda + 1)(\lambda - 2).$$

Let us find p_1, p_2, p_3, using the formula (1):

$$p_1 = SpA = 2, \quad p_2 = \begin{vmatrix} 1 & 2 \\ 0 & 2 \end{vmatrix} + \begin{vmatrix} 1 & 0 \\ -2 & -1 \end{vmatrix} + \begin{vmatrix} 2 & 0 \\ -2 & -1 \end{vmatrix} = -1, \quad p_3 = \begin{vmatrix} 1 & 2 & 0 \\ 0 & 2 & 0 \\ -2 & -2 & -1 \end{vmatrix} = -2.$$

So we have

$$|A - \lambda E| = (-1)^3(\lambda^3 - p_1\lambda^2 + p_2\lambda^1 - p_3) = (-1)^3(\lambda^3 - 2\lambda^2 - \lambda + 2) = -\lambda^3 + 2\lambda^2 + \lambda - 2.$$

Let us display the way of D.K. Fadeev to calculate the characteristic polynomial:

$$|A - \lambda E| = (-1)^n(\lambda^n - k_1\lambda^{n-1} - k_2\lambda^{n-2} - \cdots - k_n). \quad (2)$$

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This method consists in applying the following formulas:

$$\begin{gathered} A_1 = A,\ k_1 = SpA_1,\ B_1 = A_1 - k_1E, \\ A_2 = AB_1,\ k_2 = \frac{1}{2}SpA_2,\ B_2 = A_2 - k_2E, \\ A_{n-1} = AB_{n-2},\ k_{n-1} = \frac{1}{n-1}SpA_{n-1},\ B_{n-1} = A_{n-1} - k_{n-1}E, \\ A_n = AB_{n-1},\ k_n = \frac{1}{n}SpA_n,\ B_n = A_n - k_nE = 0. \end{gathered} \quad (3)$$

Equality $B_n = A_n - k_nE = 0$ is used to control computing.

The main problem will be solved by the Fadeev method. To solve the problem, we consistently find all the matrices included in formulas (3):

$$A_1 = A = \begin{pmatrix} 1 & 2 & 0 \\ 0 & 2 & 0 \\ -2 & -2 & -1 \end{pmatrix},\ k_1 = SpA_1 = 2,$$

$$B_1 = A_1 - k_1E = \begin{pmatrix} 1 & 2 & 0 \\ 0 & 2 & 0 \\ -2 & -2 & -1 \end{pmatrix} - \begin{pmatrix} 2 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 2 \end{pmatrix} = \begin{pmatrix} -1 & 2 & 0 \\ 0 & 0 & 0 \\ -2 & -2 & -3 \end{pmatrix},$$

$$A_2 = AB_1 = \begin{pmatrix} 1 & 2 & 0 \\ 0 & 2 & 0 \\ -2 & -2 & -1 \end{pmatrix} \cdot \begin{pmatrix} -1 & 2 & 0 \\ 0 & 0 & 0 \\ -2 & -2 & -3 \end{pmatrix} = \begin{pmatrix} -1 & 2 & 0 \\ 0 & 0 & 0 \\ 4 & -2 & 3 \end{pmatrix},\ k_2 = \frac{1}{2}SpA_2 = 1,$$

$$B_2 = A_2 - k_2E = \begin{pmatrix} -1 & 2 & 0 \\ 0 & 0 & 0 \\ 4 & -2 & 3 \end{pmatrix} - \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} = \begin{pmatrix} -2 & 2 & 0 \\ 0 & -1 & 0 \\ 4 & -2 & 2 \end{pmatrix},$$

$$A_3 = AB_2 = \begin{pmatrix} 1 & 2 & 0 \\ 0 & 2 & 0 \\ -2 & -2 & -1 \end{pmatrix} \cdot \begin{pmatrix} -2 & 2 & 0 \\ 0 & -1 & 0 \\ 4 & -2 & 2 \end{pmatrix} = \begin{pmatrix} -2 & 0 & 0 \\ 0 & -2 & 0 \\ 0 & 0 & -2 \end{pmatrix},\ k_3 = \frac{1}{3}SpA_3 = -2,$$

$$B_3 = A_3 - k_3E = \begin{pmatrix} -2 & 0 & 0 \\ 0 & -2 & 0 \\ 0 & 0 & -2 \end{pmatrix} + \begin{pmatrix} 2 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 2 \end{pmatrix} = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}.$$

Therefore, according to the formula (2), we get:

$$|A - \lambda E| = (-1)^3(\lambda^3 - 2\lambda^2 - \lambda + 2) = -\lambda^3 + 2\lambda^2 + \lambda - 2.$$

If in an arbitrary polynomial from λ

$$P(\lambda) = a_0\lambda^n + a_1\lambda^{n-1} + \cdots + a_{n-1}\lambda + a_n$$

instead of λ, put a square matrix*A* of order n, then matrix

$$P(A) = a_0A^n + a_1A^{n-1} + \cdots + a_{n-1}A + a_nE.$$

where*E* – unit matrix, is called the value of the polynomial P(A) at λ=A. If P(A)=0, than matrixA is called the matrix root of the polynomial, and P(λ) is called the polynomial, which is annulled by the matrix A.

Every square matrix A serves as the root of some nonzero polynomial.

The polynomial ϕ(λ) of the least degree with the highest coefficient equal to one, annulled by the matrix A, is called the minimum polynomial of this matrix.

Every polynomial P(λ), annulled by the matrix A, is exactly divisible by minimum polynomial ϕ(λ) of this matrix.

The characteristic polynomial $|A - \lambda E|$ of the matrix A and its minimum polynomial ϕ(λ) are related by the term

$$\varphi(\lambda) = \frac{(-1)^n \cdot |A - \lambda E|}{D_{n-1}}, \quad (4)$$

where D_{n-1}– the greatest common divisor of all (n-1)-order minors of the matrix $(A - \lambda E)$.

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The roots of the minimal polynomial ϕ(λ) are all the different roots of the characteristic polynomial $|A - \lambda E|$.

Let's find the minimal polynomial for the matrix A. The characteristic polynomial for the matrix A it's:

$$|A - \lambda E| = -\lambda^3 + 2\lambda^2 + \lambda - 2.$$

The greatest common divisor D_2 of all second-order minors of the matrix

$$(A - \lambda E) = \begin{pmatrix} (1-\lambda) & 2 & 0 \\ 0 & (2-\lambda) & 0 \\ -2 & -2 & (-1-\lambda) \end{pmatrix}$$

is equalto one, since its minors

$$\begin{vmatrix} (1-\lambda) & 2 \\ -2 & -2 \end{vmatrix} = 2(\lambda + 1), \quad \begin{vmatrix} 0 & (2-\lambda) \\ -2 & -2 \end{vmatrix} = 2(2 - \lambda)$$

are mutually simple. So,

$$\varphi(\lambda) = \frac{(-1)^3 \cdot |A - \lambda E|}{D_2} = \lambda^3 - 2\lambda^2 - \lambda + 2 = (\lambda - 1)(\lambda + 1)(\lambda + 2).$$

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UDC 004.021

USING DOCKER AND JENKINS IN MODERN SOFTWARE DEVELOPMENT

PAVEL TALAIKA, IRYNA BURACHONAK
Polotsk State University, Belarus

In this article, we discuss complete software development lifecycle and the role of such tools as Docker Container Platform and Jenkins for Continuous Integration.

In the process of software development, it is essential to delineate the stages the project is going through before being deployed in a real life production environment. Modern software engineering tools facilitate building and deployment of the projects. We will demonstrate the lifecycle of our project from writing source code to its deployment using Docker and Jenkins.

Docker is a lightweight, autonomous and executable software suite that includes all the necessary tools to run and deploy your projects, it provides source code editing, execution environment, system tools and various libraries. Using this suite, one can easily manage architecture components of the application [1]. Docker solves multiple problems relating to configuring execution environment to interact with a database, setting up application server and GUI. Configuring execution environment locally may be tedious and time-consuming and may also lead to unexpected and hard to tackle problems. If you are developing a project in a team, using Docker is a must.

Jenkins is an open source automation server [2]. Jenkins provides the programmer with hundreds of plugins that facilitate deployment and automation of any project.

The project was developed using Java 1.8, Spring Boot and Spring Data. The database layer is represented by PostgreSQL, the project was build using Maven.

At this point, we have all the tools we need. The first step is project configuration, as a prerequisite one needs to have basic knowledge of Docker and terminal commands of the required operating system. Downloading the image with Jenkins and Docker Store is also a requirement. After having downloaded the image, the container can be started by issuing the *docker run* command and specifying options like ports, container names and the path to the image itself. If it is necessary to use additional programs, one can write a Dockerfile.

During initial stages of the development, a need for additional configuration has arisen, so the Docker file had to be written, moreover having written the Dockerfile allowed for automatic loading of the required plugins for the project. Using plugins is one of the necessary conditions for building and deploying the project. In order to automatically download all the necessary plugins into the project's root directory, one needs to create the *plugins.txt* file that specifies the necessary plugins in the following format *plugin_name:version*, each new plugin needs to be specified on the new line. Commands that need to be added to Dockerfile are described below:

```
COPY ./plugins.txt /usr/share/jenkins/ref/plugins.txt
RUN /usr/local/bin/install-plugins.sh</usr/share/jenkins/ref/plugins.txt
```

After starting the built image, plugins specified in plugins.txt will be automatically downloaded at start-up.

Next we have to create Tomcat and PostgreSQL image for deployment and data storage which is built using .war file generated by Maven. Maven plugin that is installed in Jenkins is responsible for building the project. One should also bear in mind that all containers should create the interconnected system for controlling the building and deployment processes, in order to achieve that you need to forward the ports from Tomcat to PostgreSQL and bind Jenkins by using common volume which can be done by running the Jenkins container with *--volumes-from=tomcat:rw* option and running Tomcat with *–v=tomcat-data:/usr/local/tomcat/webapps:rw* option [3].

Let's create the container with PostgreSQL by issuing the command as described below:

```
docker run -p 5432:5432 --name postgres -e POSTGRES_PASSWORD=postgres -d postgres
```

The next step is to create Tomcat container which is done by running the command as described below:

```
docker run -it -p 8080:8080 --name tomcat -v tomcat-data:/usr/local/tomcat/webapps:rw --link postgres:postgres -d tomcat:latest
```

--link option lets us connect Tomcat and PostgreSQL which also allows volume tomcat-data to be available in Jenkins [4].

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Command for running Jenkins are as follows:

docker run -p 8888:8080 -p 50000:50000 --name=jenkins-master --mount source=jenkins-log,target=/var/log/jenkins --mount source=Jenkins-data,target=/var/jenkins_home --volumes-from=tomcat:rw -d jenkins-artteam

As you can see in the code above, data storage and backup volumes are also created. After start-up, Jenkins will be available at http://localhost:8888/.

After having configured the container system, one needs to configure spring.datasource and application.properties and pom.xml to be able to build the project as a .war file.

For more flexibility, VCS is used. When building the project using VCS one needs to specify what changes are affected and what branch needs to be built. Under "Project management" we specify git repository and credentials such as user and password, credentials are needed to log in to Jenkins and configure the build item. Under "Build" we specify the plugin that will build the project. Under "Add build stage" we specify the location of the script which will copy the generated .war file into the volume tomcat-datastartup directory if the build was successful (Figure).

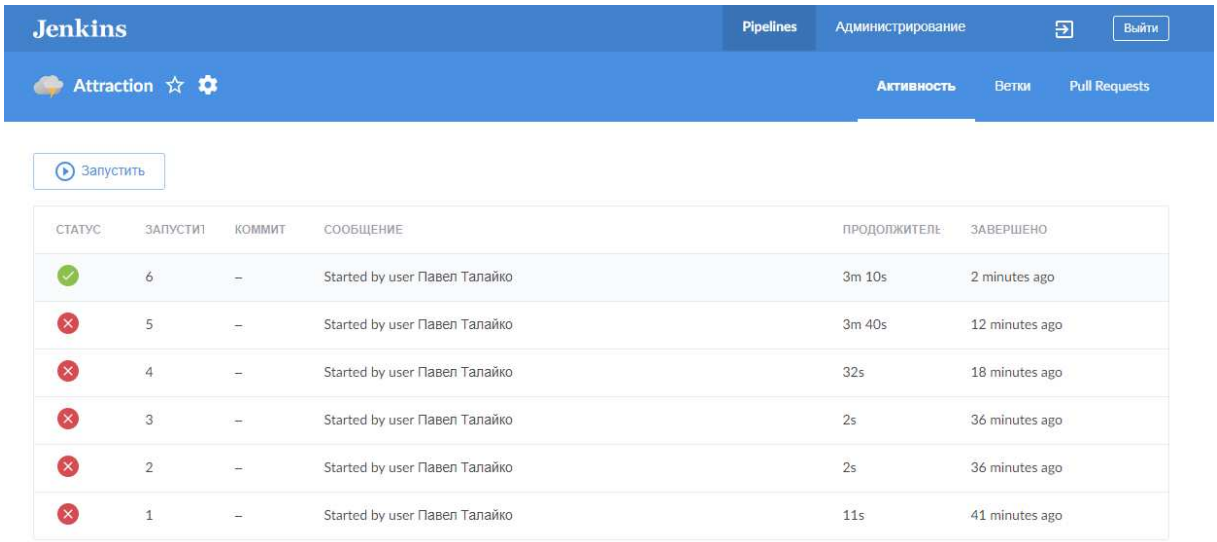

Figure. – List of builds in Jenkins dashboard

Conclusion. The final product of this work is a full-fledged automated docker-container system that facilitates control over project building and deployment, its VCS system allows to track changes that can potentially lead to failed builds. Jenkins also allows for project testing; users of the system can create certain stages that need to be completed in the lifecycle of the project build before being released.

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UDC 004.514

SERVERLESS ARCHITECTURE

RAMAN KHRAPAVITSKI, DMITRY GLUKHOV
Polotsk State University, Belarus

This article is about serverless architecture using AWS services as an example.

Introduction. Deployment a software application on the Internet typically involves managing some kind of server infrastructure. This typically means the virtual or physical server that you want to manage, and the operating system and other web server hosting processes that are required to run the application. Using a virtual server from a cloud provider such as Amazon means Troubleshooting physical hardware, but still requires a certain level of management of the web server's operating system and software processes. Theserverless architecture [1] focuses on individual functions in the application code. Services such as AWS Lambda [3] functions provide management of all physical hardware, virtual machine operating system, and web server software. You only need to worry about your code.

Main part. Serverless – peer-to-peer application architecture. The architecture is based on microservices, or functions (lambda) that perform a specific task and run on logical containers hidden from prying eyes. That is, the end user is given only the interface for loading the function (service) code and the ability to connect event sources (events) to this function. Using serverless architecture will significantly help developers focus more on their core product. If not for serverless, developers would still be worrying about managing and operating servers or runtimes, whether managing them on the cloud or on-site. This way, the developer's focus will solely be on individual functions in their application code.

Considering the example of Amazon service, the source of events can be many of the Amazon services:

1. S3 storage - generate many events on almost any operation, such as adding, deleting, and editing files in buckets.
2. DynamoDB - allows to generate events on adding or changing data in a table.
3. Cloudwatch is a system similar to cron.
4. API Gateway [4] - software emulator of the HTTP Protocol that allows you to abstract the queries to a single event micro service.

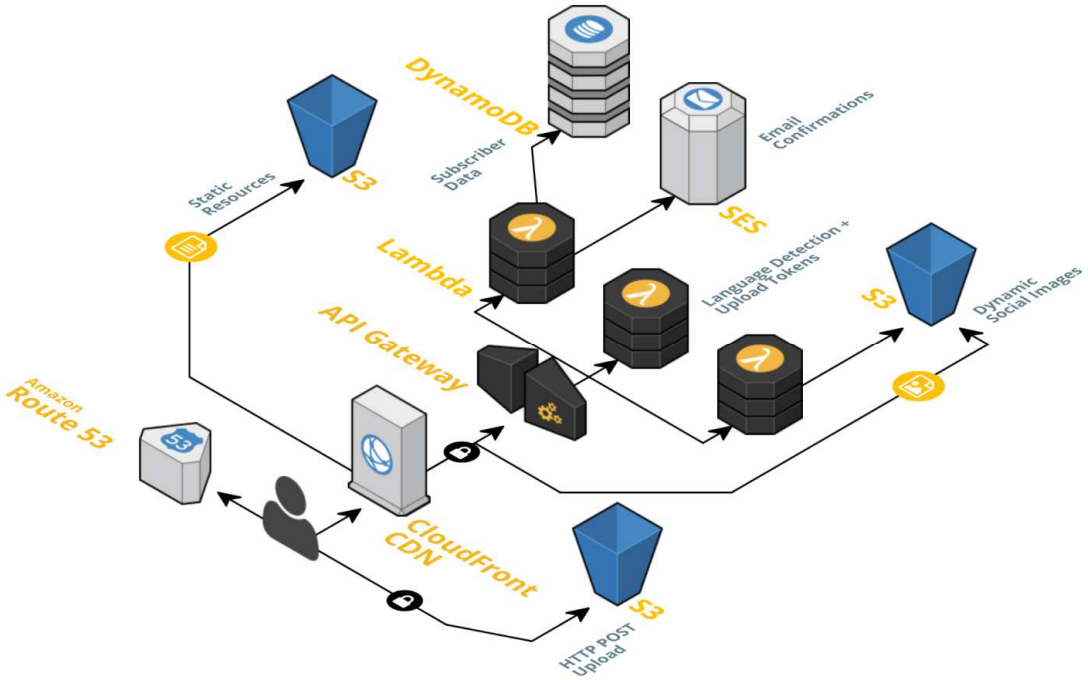

Figure. – General architecture structure

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When you load the function code into Amazon, it is stored as a package on an internal file server (like S3). When the first event is received, Amazon automatically runs a mini-container with a specific interpreter (or virtual machine, in the case of Java) and runs the resulting code, substituting the generated event body as an argument. As it is clear from the principle of microservices, each such function can not have a state , since there is no access to the container, and its lifetime is not defined. Due to this quality, microservices can grow horizontally depending on the number of requests and load. In fact, based on the practice, balancing resources in the Amazon performed well and the function is quickly replicated even if the load is not stable.

On the other hand, another advantage of such a stateless startup is that payment for the use of the service can usually be made based on the execution time of a particular function. Such a convenient payment method makes it possible to launch startups or other projects without initial capital. After all, there is no need to buy out hosting for code placement. Payment can be made in proportion to the use of the service (which also allows you to calculate the necessary monetization of your service).

The advantages of this architecture include the following:

1. The lack of a hardware part – servers;
2. Lack of direct contact and administration of the server part;
3. Virtually limitless horizontal growth of your project;
4. Payment for used CPU time.

The disadvantages include:

1. Lack of clear container control (you never know where and how they run, who has access) - which can often cause paranoia.
2. The lack of" integrity " of the application: each function is an independent object, which often leads to a certain dispersion of the application and difficulties to put everything together.
3. The cold start of the container leaves much to be desired (at least in the Amazon). The first launch of a container with a lambda function can often slow down for 2-3 seconds, which is not always well perceived by users.

Conclusion. Serverless technology, in practice, the range of applications of this technology is almost limitless. From simple portals (executed as a static page using React or Angular) with backend and logic on lambda functions to processing archives or files through S3 storage and quite complex mathematical operations with load distribution.

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UDC 004

SOLAR COLLECTOR CONTROL SYSTEM

VADIM KOVALEVSKY, VIKTOR YANUSHKEVICH
Polotsk State University, Belarus

Flat and vacuum collectors of solar energy, their types and design and technical features are considered. The characteristic of basic parameters of basic elements of the device are presented. The main advantages and disadvantages of various types of solar energy collector designs are highlighted. The existing control system of the solar collector is analyzed. The prospects for the development of alternative sources of electrical energy, including wind, solar and water are considered. The article provides statistics on different countries and data from various sources on the current state of this area. The necessity of changes in the production of electricity is shown. The research results can be used to develop a solar collector control system.

Introduction. In connection with the development of production technologies and a significant deterioration of the ecological situation in many regions of the globe, humanity faced with the problem of finding new sources of energy. This formulation of the question led to the search for so-called alternative energy sources that meet the above requirements. Through the efforts of world science many such sources have been discovered. At the moment most of them have already been used more or less widely.

There are the following types of alternative energy sources:

– Energy of sun;
– Wind energy;
– Bioenergy;
– Tidal energy;
– Thermal energy of the Earth;
– Energy of atmospheric electricity and thunderstorm energy.

Helioenergetics is a branch of economy associated with the use of solar radiation for energy. Solar energy uses an inexhaustible source of energy, does not cause harmful waste and is environmentally friendly. There are various ways to convert solar radiation into heat and electricity. One such method is the use of a solar collector.

A solar collector is a device for collecting solar thermal energy carried by visible light and near- infrared radiation. By type of design, flat and vacuum solar collectors are most common in solar heating systems. Each of them has certain advantages and disadvantages that must be considered when designing control systems. Simple and cheap to make flat collectors consist of an element that absorbs solar radiation (absorber), a transparent coating and a heat-insulating layer. A collector of this type is capable of capturing direct and diffuse radiation and is usually installed permanently on the roof of a building.

Advantages of a flat solar collector:

– a large area of the absorber;
– low cost, ease of manufacturing;
– the possibility of implementing the mode of despotic defrosting of fallen snow by passing a hot heat carrier through a solar collector for several minutes;
– the ability to capture both direct and diffuse radiation;
– stationary installation without the use of solar tracking devices;
– the cost of solar installation can be significantly reduced by combining the roof structure with a flat solar collector.

Disadvantages of a flat solar collector:

– the fragility of the translucent sheet coating;
– low efficiency at high temperatures of the absorber;
– the possibility of coolant freezing in winter;
– low operating temperature (maximum operating temperature of the coolant (without stagnation) does not exceed 100 ºC);
– corrosion.

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A vacuum solar collector consists of so-called heat pipes and resembles a thermos in its structure.

The outer part of such a tube is transparent, and on the inside of the tube a highly selective coating is applied effectively capturing solar energy. Between the outer and inner glass tube there is vacuum. Inside the tube there is a low boiling liquid or coolant.

Advantages of a vacuum tubular solar collector:

– high operating temperature;
– high efficiency;
– no probability of freezing (for condensed steam);
– the ability to capture both direct and diffuse radiation;
– stationary installation without the use of solar tracking devices;
– no conditions for corrosion.

Disadvantages of a vacuum tubular solar collector:

– the fragility of the translucent sheet coating;
– small absorber area;
– the ratio of the aperture area to the total area of a flat solar collector;
– high price;
– the impossibility of implementing the mode of despotic defrosting of fallen snow without the introduction of additional systems.

The principle of operation of the solar collector control system. Control systems are applied to increase efficiency and improve solar collector's work. A solar thermal microcontroller is a mandatory element of a solar system with despotic circulation of a coolant. The main purpose is to control the process of heating the coolant from the sun and the state of the solar heating system. The controller receives information from temperature sensors installed at the output of the solar collector in the storage tank and regulates the operation of the circulation pump.

There may be two or more temperature sensors. In addition to the standard functions, the controller can control the heating system. The efficiency and safety of the solar system largely depends on the controller: the correctness of the inherent algorithms of the solar system, the reliability of the elements.

The main advantages of microcontrollers are:

– Automatic control of the flow rate of the circulating pump: regulation of the flow rate of the coolant in the system circuit depends on the temperature difference between the solar collector and the storage tank.

– Stable operation of the solar system and a rapid achievement of set temperatures. By increasing the operating time of solar systems in morning and evening hours and in cloudy weather, additional heat energy generation is provided.

– Minimization of solar system electricity consumption by reducing the power consumption of the circulating pump.

– The possibility of using in systems for various purposes (heating, pool heating) due to versatility of controllers.

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UDC 004.5

THE USAGE OF VIRTUAL REALITY TECHNOLOGIES IN THE TRAINING OF GCP SPECIALISTS

ALIAKSEI ANANENKA, OKSANA GOLUBEVA
Polotsk State University, Belarus

This article considers ways to use virtual reality technologies in different spheres, and also this article describes the virtual reality application for the GCP specialists training.

In the last years of its developing, virtual reality technologies have been used both in the videogames industry and in the other different spheres of the human's activity, for example: in architecture, computer visualization of future buildings, it allows customers and executors to travel around the virtual buildings before the foundation's erection; in the education schoolboys and students can work in the unique experimental labs, create volume diagrams and perform chemical experiments; in the marketing and advertising spheres while the buying some product clients can hardly imagine the product that they bought. In this cases marketing experts use virtual reality. This is a nice opportunity to demonstrate the product from different sides, including hard technical details and constructions; in the auto-building industry virtual reality used to perform crush-tests, in the knots and the aggregate's assembling; civil engineers define an optimal distributions of the domestic communication, they analyze difficulties of the erecting works in the lodgments, they virtually place an equipment [1].

A lot of big companies already successfully use virtual reality to train specialists' process of production. For example Volkswagen concern instills special virtual reality applications to perform the logistics operations [2]. Siemens set up systems and software of the virtual reality on the developing and making the gears with the controllable rate for the motors [3].

Undoubtedly, for the industry sector facilities, the usage of virtual reality for the staff training is one of the most interesting areas to learn. The usage of the virtual reality in this direction is irreplaceable, because it opens new opportunities and allows to exclude the difficulties with the staff trainings, that appear with the usage of traditional training methods, which are temporarily expensive. According to this the virtual reality application for the GCP staff trainings has been developed, because GCP equipment tuning is difficult and requires high-level accuracy. Mistakes, that can be made while the GCP start, can lead to the gas closure at users houses, which is inadmissible. Also in the case with an accident on the gasification areas, needs instant and high-quality prevention, while that, the specialist, who prevents an accident, has a risk to harm his health (works with gas are dangerous).

Framed application is an exact copy of the real GCP, this application allows to walk around the facility and perform an act of starting and expulsion (fig. 1). If the specialist's actions, which are made in the application, do not conform the instruction, the specialist gets a notification about the mistake and repeat the training.

Figure 1. – Copy of the real GCP

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The application also has the accompanying sound, which is fully conform the GCP sounds, which make the presence in the virtual GCP more realistic. One more attribute that makes this presence more realistic is that interaction with virtual objects is analogous to interactions in the reality. It is achieved with the help of recreation the 3D-model of the hand and its movement physics; it is illustrated on the figure 2.

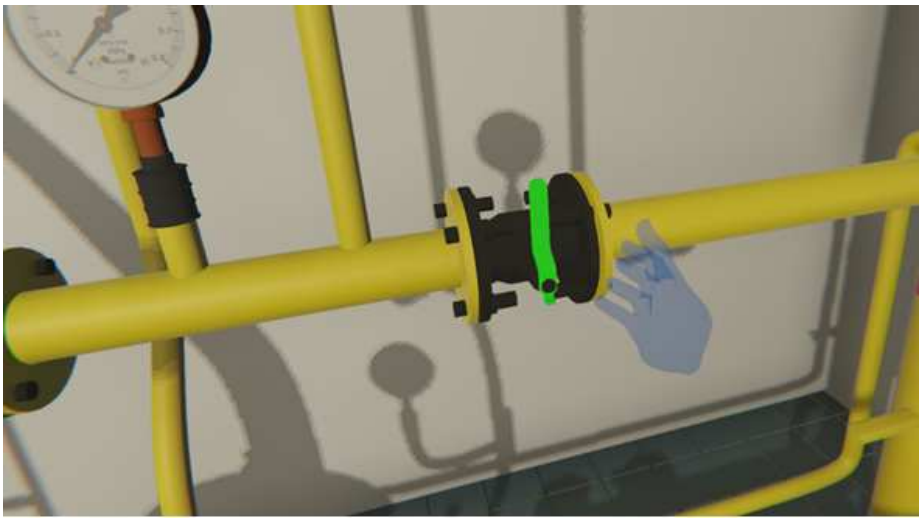

Figure 2. – 3D-model of the hand

The application has two modes: the exam and the training. During the training mode, the user perform an operation of starting the GCP according to the hints, which describe the sequence of actions, which are necessary to reach a successful complete of work. The exam mode means self-dependent actions to complete the starting of the GCP. An examinee has only one attempt to complete the task.

The application works with such virtual reality display systems as Oculus Rift CV1 and HTC Vive. For the creating the 3D-models of GCP equipment, 3D- modeling environment Blender were used. Blender is the most convenient and understandable modeling environment among other free options on the market. For the developing the main functional, the game engine Unity3D were used.

The immersion in the virtual reality allows users fully concentrate on the training without derivation on external stimuli. It is possible to recreate different situations, with the help of which the user will get the particular skill without any harm for the health.

The main merit of the using the virtual reality technologies while training is obviousness. While using the 3D-graphics, it is possible not only to describe the phenomenon, but to demonstrate the phenomenon with all kinds of detailing. Safety is also very important merit. Training the particular situation without harm is important. Virtual reality which is everywhere around the user will allow him concentrate on the training without derivation on external stimuli [4].

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UDC 004.021

DEVELOPMENT OF A HYBRID CRYPTOSYSTEM FOR USER DATA PROTECTION

ARTYOM SUBBOTIN, YURY PASTUHOV
Polotsk State University, Belarus

The most important requirement for the encryption system is its durability. Unfortunately, increasing durability using any method usually leads to difficulties in encrypting data and decrypting it. Therefore, the formation of a deeply thought-out cryptosystem is a very important task.

Introduction. The level of knowledge in the field of data encryption is quite high. Every year a lot of programmes and literature, which are dedicated to cryptographic systems, are created. A cryptographic system is a family of cipher transformations and a keys collection. There are symmetric and asymmetric cryptosystems.

Main section. Symmetric cryptosystems (with a secret key) - cryptosystems, which are built on the basis of keeping the encryption key secret. The encryption and decryption processes use the same key. The secrecy of the key is a postulate.

Asymmetric cryptosystems (open encryption systems with public key) - the meaning of these cryptosystems is that different transformations are used for encryption and decryption. One of them - encryption - is absolutely open to all. The other, decoding, remains secret [1].

At the moment quite resistant systems are used more often, systems with a rather complex encryption algorithm. Because of the need for various objects to encrypt secret data and cryptographic systems do not stand still and are constantly being improved.

Selection of encryption algorithms. Based on the analysis of the most crypto-stable algorithms, the following conclusions were made:

– encrypting information using the symmetric algorithm AES: despite the shortcomings, to crack the information protected by this algorithm is almost impossible. The essence of AES is that any "frontal attack" on protected data — that is, the selection of all possible passwords — is very stretched out in the future. If we imagine that a hacker has vast resources, that is, a whole collection of supercomputers, then he could get access to encrypted data in decades.

– Encryption of the session key using the asymmetric RSA-OAEP algorithm: it is not only involution modulo a large number. It is also the addition of redundant data which allow additional protection of your information. [2]

Flowchart of the communication protocol. Let the two subscribers agree to exchange data. The scheme, which is shown in Picture 1, assumes that each participant in the information exchange has two keys: a public PK and a private SK. Let's have a look on the process of sending a document M. The sender (subscriber A) generates a secret key — a random number, which is used only once and therefore called a one-time or session key. This key is used to encrypt the M document using a symmetric cryptoalgorithm. The session key is encrypted in the recipient's public key (subscriber B) and attached to a previously encrypted document. The generated message is sent to the recipient. This person, received the message, repeats the same procedure, but in reverse order. Using his private key, the recipient recovers the session key, and then decrypts the document with it.

Selection of the length of the session key. The second step is to select the session key length. The number of encryption rounds depends on the key size:

– 128 bits length – 10 rounds;
– 192 bits long – 12 rounds;
– 256 bits length – 14 rounds.

As an example, let's take a key length of 128 bits. Input data for encryption operations is an array of 16 bytes. Before encryption starts, the bytes of this array are placed sequentially in the matrix columns. Inside the algorithm, operations are performed on a byte matrix, called the state matrix. The final value of the state matrix is the output of the algorithm and is converted into a sequence of ciphertext bytes. Similarly, 16 bytes of the cipher key fall into the columns of the original matrix. The dimension of all matrices is 4 × 4. Four bytes in each column of the state matrix or key can be considered as one 32-bit word. Therefore, the state matrix

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is an array of 4 words. The matrix that arrives at the input of each round is called the input state matrix, and the output matrix of the output state is formed at the output of the round. [3]

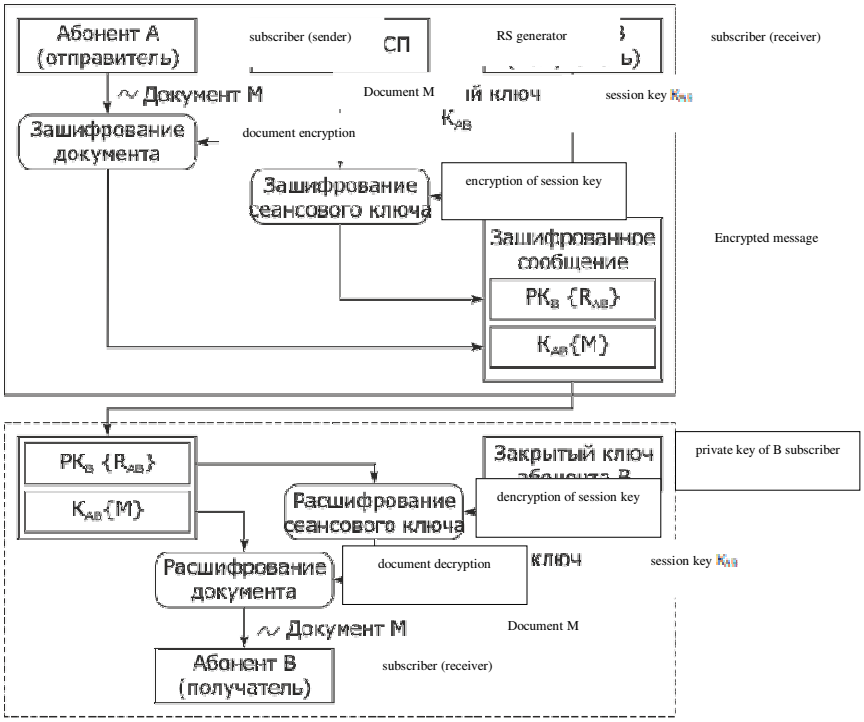

Figure. – Exchange scheme of 2 keys

Conclusion. After analysing what was said above, we can conclude that the encryption algorithm developed can successfully compete with analogues at the moment. At the same time, the developed scheme provides a great opportunity to implement additional functions and settings.

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UDC 004.032.04

QUANTUM COMPUTER

DENIS PETRISCHE, KARINA IVANOVA
Polotsk State University, Belarus

This article is about quantum computers, shows its advantages over classical computers and prospects for their use.

Over the past few years, almost all people have heard the name «quantum computer»,however, only few people imagine how this works and why it is needed.A quantumcomputerisadevice that uses quantum effects to process and transfer data.Forexample, in classical computer information is encoded using a binary code and bit, as the minimum unit of information, has two basic states: 0 and 1. A quantum computer uses qubits (quantum bits), capable of accepting not only states 0 and 1,but the superposition of both numbers, i.e. 0 and 1 at the same time [1].

Figure 1 shows the representation of a bit and a qubit:

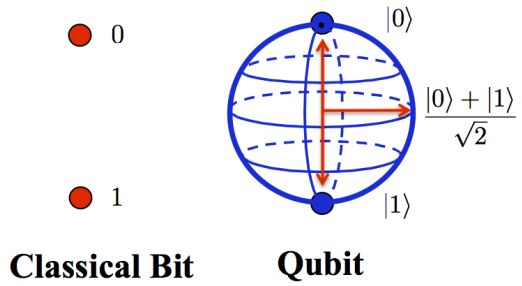

Figure 1. – Bit and Qubit

Objects of the real world capable of realizing qubits may be elementary particles. Due to the superposition of qubits, quantum computers can perform parallel computations, which will lead to a significant increase in computation speed.Therefore, it is believed that a quantum computer consisting of several dozen qubits in computing power will be equal to a supercomputer operating with a performance of tens of teraflops (trillions of operations per second), while the power of modern classic computers does not exceed billions of operations per second.Another important physical phenomenon that can be used to create quantum registers and help in reading information from qubits is quantum entanglement. If you apply external force to two atoms, you can establish a connection between them - "entangle" together in such a way that one atom will start to have the properties of the second one and, when measuring the spin of one atom, the second atom immediately changes its spin to the opposite one. This property of particles will allow you to read information from qubits without measuring them directly [2].

However, a number of problems stand in the way of creating quantum computers, the main one is the phenomenon of decoherence [3], in which quantum uncertainty disappears, without which a quantum computer will be no different from the classical one. Also, the work of quantum computers depends on external interference. One of the methods of dealing with these problems is the isolation of a quantum system.

If you still manage to overcome all these problems, then we can expect a breakthrough in technology and various fields of science, it is already assumed that quantum computers will be able to bring cryptography to a new level, since they will be able to quickly decompose large numbers into simple factors. This rapid decomposition of numbers into simple factors will create a security risk for the RSA encryption system, which is widespread today. Other applications for quantum computers: research in the field of artificial intelligence, molecular modeling, which will help to simulate chemical reactions and theoretically help in the creation of drugs [4].

Despite the fact that science has made a step far in the field of creating quantum computers and the leading companies can boast not only a few units but dozens of entangled qubits, their computing power is not enough to outrun classic computers. Leaders in the field of construction of quantum computers are IBM, D - Wave, Google, Microsoft.

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The IBM quantum computer came out under the name Q System one in January 2019. It is a 20 qubit machine operating at temperatures close to absolute zero. To isolate and counteract external interference, the computer is enclosed in a sealed glass cube. As the manufacturer says, the computer has a modular design, which makes it relatively easy to modify and maintain. However, it is not yet possible to buy this computer, but it will be available for IBM partners. IBM has staked on the development of quantum computers capable of performing a wide range of tasks.

The quantum computer of Google has 72 qubits and has the original architecture. In Google's quantum computer, qubits are not connected in a chain, but form two square arrays, which makes it possible to achieve extremely high accuracy and reliability of computations.

Figure 2 shows an architecture of a Google computer:

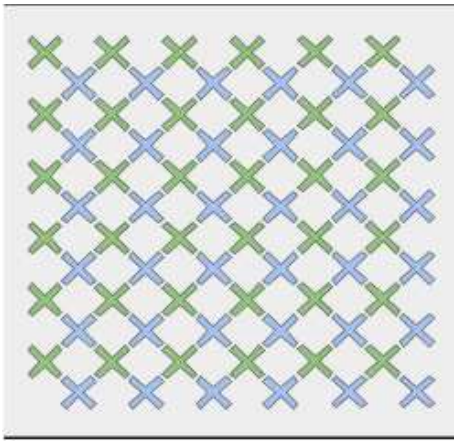

Figure 2. – Google architecture of a quantum computer

Google has relied on high accuracy of calculations, which will allow to scale quantum systems and soon it is possible to get a quantum computer consisting of hundreds of connected qubits. [5]

Company D - Wave was one of the first to create quantum computers incorporating many dozens of qubits. To date, the latest D-Wave computer models contain 2000 qubits and are capable of decomposing a six-digit number into simple factors, but this machine is not a full-fledged quantum computer, as it can perform only a limited range of tasks.

Microsoft has been researching quantum computers since the mid-2000s, but so far it boasts the idea of creating a quantum computer using an elementary particle — Majorana fermion, which, according to Microsoft, is more suitable for solving real-world problems.

Conclusion: quantum computers are promising computing systems that can be used in any field of science and eventually force out classic computers. Quantum computing can change our world forever. However, the leading technology development companies do not have a single view on a quantum computer, each manufacturer sees its own unique way of creating the final product. Therefore, on the way of their creation, there are still certain difficulties that can be solved in the next decades.

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ITERATIVE SIMULATION PROCEDURE ISOLATING RESPIRATORY APPARATUS

TATSIANA RUDZKOVA, STEPAN EKHILEVSKIY, SERGEI OLSHANNIKOV
Polotsk State University, Belarus

In the simulation of dynamic sorption activity, the equations of mathematical physics are used and the skipping expressions are written in the form of double series in powers of time and coordinates. For a multiple increase in the rate of numerical experimentation, this article proposes an alternative approach to the description of dynamic sorption activity that is not based on the ideology of equations of mathematical physics.

The simulation of the air regeneration process is a classic task of the dynamics of sorption [1], within which the evolution of impurity penetration through the absorber layer is tracked. It is usually solved by methods of mathematical physics in the presence of stationary boundary conditions at the entrance to the filter [2]. However, in an insulating breathing apparatus, a leakage of carbon dioxide is added to the constant component of the concentration of carbon dioxide molecules given by the mode of operation of the apparatus, monotonously increasing as the regenerative cartridge resource is exhausted. In other words, there is a variable concentration of sorbtiv at the entrance to the layer of the absorber. The corresponding formalism analytically describing the dynamic sorption activity in the presence of a variable concentration of the sorbent at the filter inlet is proposed in [3] and reduces to a system of equations:

$$-\omega_{\xi}'(\xi,\tau)=e^{-\tau}\left[e^{-\xi}\omega_0(0)+\int_0^{\tau}e^{\tau}d_{\tau}\,\omega(\xi,\tau)\right],\qquad \tau>0, \tag{1}$$

$$u(\xi,\tau)=e^{-\tau}\int_0^{\tau}e^{\tau}\omega(\xi,\tau)d\tau,\qquad \tau>0, \tag{2}$$

where τ and ξ – dimensionless time and, respectively, the coordinate (depth of penetration into the layer of the absorber), $\omega(\xi,\tau)$ – reduced concentration of CO_2, $\omega_0(0)$ – its initial value at the filter inlet, $u(\xi,\tau)$ – the proportion of waste product.

Solution (1) can be written as a series

$$\omega(\xi,\tau)=e^{-\xi-\tau}\sum_{n=0}^{\infty}\frac{f_n(\tau)}{n!}\xi^n, \tag{3}$$

which coefficients are connected by a recurrence relation

$$f_{n+1}(\tau)=\int_0^{\tau}f_n(\tau)d\tau, \tag{4}$$

allowing by known

$$f_0(\tau)=e^{\tau}\omega_0(\tau) \tag{5}$$

consistently calculate all $f_n(\tau)$ to any number. Expression (5) for $f_0(\tau)$ follows from the form of the series (3) and the boundary condition

$$\omega(0,\tau)=\omega_0(\tau). \tag{6}$$

Relations (1) - (6), involving computer calculations, allow one to quantitatively describe the CO_2 chemisorption in regenerative cartridges of breathing apparatus with a circular scheme of the airway part. For this in (6) instead of $\omega_0(\tau)$ as previously outlined, substitute

$$\omega_0(\tau)=1+\omega(\eta,\tau), \tag{7}$$

where η – dimensionless length of the cartridge.

The result is a self-consistent task of determining the desired function $\omega(\xi,\tau)$. To solve it, an iterative procedure with a small parameter is used $\omega(\eta,\tau)$. To obtain a zero approximation in (7), slip should be completely neglected $\omega(\eta,\tau)=0$. In this case, we return to the stationary boundary condition $\omega(0,\tau)=1$, for which the solution of the recurrence relation (4) can be written in an analytical form

$$f_n(\tau)=e^{\tau}-\sum_{k=0}^{n-1}\frac{\tau^k}{k!} \qquad (n=1,\,2,\,\ldots)\cdot \tag{8}$$

Substituting (8) into (3), we get

$$\omega 0(\xi,\tau)=e^{-\xi}\left[1+\sum_{n=1}^{\infty}\frac{\xi^n}{n!}\left(1-e^{-\tau}\sum_{k=0}^{n-1}\frac{\tau^k}{k!}\right)\right]. \tag{9}$$

The next step of the iterative procedure, corresponding to the first approximation $\omega 1(\xi,\tau)$, is the substitution of (9) into (7) and the numerical implementation of the recurrent procedure (4). To this end, a special program was written in the MathCAD package environment (figure).

$$\eta := 4 \qquad \xi := 0, 0.1 .. \eta \qquad N := 30 \qquad \beta := 1 \qquad \tau := 0, 0.05 .. \eta + 5$$

$$\omega 0(\xi,\tau) := e^{-\xi}\cdot\left[1+\sum_{n=1}^{N}\left[\frac{\xi^n}{n!}\cdot\left(1-e^{-\tau}\cdot\sum_{k=0}^{n-1}\frac{\tau^k}{k!}\right)\right]\right]$$

$$f0(\tau) := (1+\omega 0(\eta,\tau))\cdot e^{\beta\cdot\tau} \qquad N1 := 80 \qquad k := 0 .. N1 \qquad x_k := 0.05\cdot k$$

$$y1_k := \beta\cdot\int_0^{x_k} f0(\tau)\,d\tau \qquad S1 := \mathrm{cspline}(x,y1) \qquad f1(\tau) := \mathrm{interp}(S1,x,y1,\tau)$$

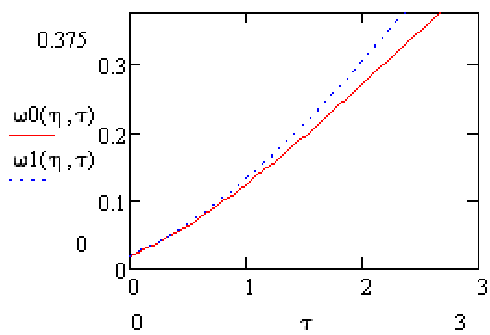
$$y2_k := \beta\cdot\int_0^{x_k} f1(\tau)\,d\tau \qquad S2 := \mathrm{cspline}(x,y2) \qquad f2(\tau) := \mathrm{interp}(S2,x,y2,\tau)$$

$$y3_k := \beta\cdot\int_0^{x_k} f2(\tau)\,d\tau \qquad S3 := \mathrm{cspline}(x,y3) \qquad f3(\tau) := \mathrm{interp}(S3,x,y3,\tau)$$

\- -

$$y35_k := \beta\cdot\int_0^{x_k} f34(\tau)\,d\tau \qquad S35 := \mathrm{cspline}(x,y35) \qquad f35(\tau) := \mathrm{interp}(S35,x,y35,\tau)$$

$$\omega 1(\xi,\tau) := e^{-\beta\cdot(\xi+\tau)}\cdot\left[f0(\tau)+f1(\tau)\cdot\beta\cdot\xi+f2(\tau)\cdot\frac{(\beta\cdot\xi)^2}{2!}+f3(\tau)\cdot\frac{(\beta\cdot\xi)^3}{3!}+\ldots+f35(\tau)\cdot\frac{(\beta\cdot\xi)^{35}}{35!}\right]$$



$$\tau := \eta \qquad \tau(\eta) := \mathrm{root}(\omega 0(\eta,\tau)-0.375,\tau)$$

$$\tau 1 := \eta \qquad \tau 1(\eta) := \mathrm{root}(\omega 1(\eta,\tau 1)-0.375,\tau 1)$$

$$\tau(\eta) = 2.666 \qquad \frac{\tau 1(\eta)}{\tau(\eta)} = 0.884$$

$$\tau 1(\eta) = 2.358$$

Figure. – Program for calculating the evolution of CO_2 leakage through a regenerative cartridge of a breathing apparatus on chemically bound oxygen with a circular pattern of the airway part

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Built for $\eta = 4$ using this program, the time dependence of the leakage permits reasonable interpretation. At the beginning, when the CO_2 leakage is insignificant, the dependences constructed for the open (solid) and circular schemes (dashed lines) of the airway part are almost the same. However, as the cartridge's resource is exhausted, the breakthrough in the circular pattern grows faster, as it should be, because the CO_2 molecules that have avoided chemisorption return to inhale, increasing the carbon dioxide content in the exhale. Developing in the specified direction, the process is increasingly moving away from having a place in the open circuit. As a result, the time $\tau_{кр}$ of the onset of the critical CO_2 $\omega_{кр} = 0{,}375$ leakage decreases by 11,6%.

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DEVELOPMENT OF ENCRYPTION ALGORITHM BASED ON THE ALGORITHMS OF RUBIK'S CUBE

EUGENE IVANENKO, YURI PASTUKHOV
Polotsk State University, Belarus

The article deals with the design of encryption algorithm based on Rubik's cube algorithms. A generalized algorithm for solving the problem is presented.

Data encryption and decryption algorithms are widely used in computer technology to hide confidential and commercial information from malicious use by third parties. The main principle in them is the condition that the transmitter and the receiver know in advance the encryption algorithm, as well as the key to the message, without which the information is just a set of characters that do not make sense.

The Rubik's cube-based encryption algorithm is a permutation cipher. The method of permutation is that the characters of the encrypted text are rearranged according to certain rules within the encrypted block of characters, that is, transformations lead to a change only in the order of the characters of the original message.

In 1991, V. M. Kuzmich proposed a permutation scheme based on the Rubik's cube. According to this scheme, the open text is written to the cells of the cube faces by rows. After the implementation of specified number of specified turns of the layers of the cube to read the ciphertext is carried out by columns. The complexity of decryption in this case is determined by the number of cells on the cube faces and the complexity of the layer rotations. A permutation based on the Rubik's cube is called a volume (multidimensional) permutation. [1]

This encryption algorithm based on the Rubik's cube algorithm has been changed to work not with the characters of the encrypted text, but with an array of bytes, which is obtained by converting the encrypted text. This algorithm is a symmetric encryption algorithm.

The encryption algorithm based on the Rubik's cube algorithm works with encryption keys of different lengths. The algorithm can use the keys 16 bytes (128 bits), 32 bytes (256 bits), 64 bytes (512 bits), 128 bytes (1024 bits) and 256 bytes (2048 bits). The key length determines the number of rounds that will be used to encrypt or decrypt the characters of the original message.

A generalized algorithm for solving the problem.

The encryption algorithm includes the following steps:

1. An encryption key of the required length is generated or set for the algorithm.
2. The characters of the original message are converted to an array of bytes.
3. From the obtained key is generated by an array of keys.
4. The data array is divided into blocks of 6 bytes (48 bits). If there is not enough data to form the whole block, the block is supplemented with "0".
5. Each byte in the data block is replaced with the corresponding byte in the constant table shown in figure 1.

		y															
		0	1	2	3	4	5	6	7	8	9	a	b	c	d	e	f
x	0	52	09	6a	d5	30	36	a5	38	bf	40	a3	9e	81	f3	d7	fb
	1	7c	e3	39	82	9b	2f	ff	87	34	8e	43	44	c4	de	e9	cb
	2	54	7b	94	32	a6	c2	23	3d	ee	4c	95	0b	42	fa	c3	4e
	3	08	2e	a1	66	28	d9	24	b2	76	5b	a2	49	6d	8b	d1	25
	4	72	f8	f6	64	86	68	98	16	d4	a4	5c	cc	5d	65	b6	92
	5	6c	70	48	50	fd	ed	b9	da	5e	15	46	57	a7	8d	9d	84
	6	90	d8	ab	00	8c	bc	d3	0a	f7	e4	58	05	b8	b3	45	06
	7	d0	2c	1e	8f	ca	3f	0f	02	c1	af	bd	03	01	13	8a	6b
	8	3a	91	11	41	4f	67	dc	ea	97	f2	cf	ce	f0	b4	e6	73
	9	96	ac	74	22	e7	ad	35	85	e2	f9	37	e8	1c	75	df	6e
	a	47	f1	1a	71	1d	29	c5	89	6f	b7	62	0e	aa	18	be	1b
	b	fc	56	3e	4b	c6	d2	79	20	9a	db	c0	fe	78	cd	5a	f4
	c	1f	dd	a8	33	88	07	c7	31	b1	12	10	59	27	80	ec	5f
	d	60	51	7f	a9	19	b5	4a	0d	2d	e5	7a	9f	93	c9	9c	ef
	e	a0	e0	3b	4d	ae	2a	f5	b0	c8	eb	bb	3c	83	53	99	61
	f	17	2b	04	7e	ba	77	d6	26	e1	69	14	63	55	21	0c	7d

Figure 1. – Constant replacement table

6. The data block is converted to a 6 by 8 bit matrix.
7. The resulting matrix is mixed according to the Rubik's cube algorithm.
8. The matrix obtained after mixing is modulo two with a round key.
9. Each block is shifted 1 byte to the left.

Round keys are generated from the key of the cipher K by means of the key expansion procedure, as a result of which an array of round keys is formed, from which the necessary round key is then directly selected.

Each round key has a length of 128 bits (or 4 four-byte words w_i, w_{i+1}, w_{i+2}, w_{i+3}, and the length in bits of all round keys is 128 bits). The first four words w_i, w_{i+1}, w_{i+2}, w_{i+3} in the key array are filled with the cipher key,4 words for the round key are selected from the remaining 44 words. The choice of words is simple: the first four words (they match the cipher key) are the key with number 0, the next four words are w_4, w_5, w_6, w_7 – round key for the first full round, etc.

New words w_{i+4}, w_{i+5}, w_{i+6}, w_{i+7} next round key are determined from words w_i, w_{i+1}, w_{i+2}, w_{i+3} previous key based on equations:

– w_{i+5} $w_{i+4} \oplus w_{i+1}$;

– w_{i+6} $w_{i+5} \oplus w_{i+2}$;

– w_{i+7} $w_{i+6} \oplus w_{i+3}$.

The first word w_{i+4} in each round the key is modified differently:

– $w_{i+4} = w_i \oplus g(w_{i+3})$.

Here, the action of function g is reduced to the sequential execution of three steps, displaying word for word:

1 Cyclic shift of a four-byte word to the left by one byte.

2 Replace each byte of the word obtained in step 10 according to the constant substitution table used in encryption.

3 Mod summation of 2 bytes received in step 2, with a round constant $R_{con}[i] = (RC[i],0,0,0)$, unclassified and unique for each round key. The right-most three bytes of this constant is zero, and a non-zero left bytes varies according to the known law of recursion: RC[1] =1 , RC [i] = 2 * RC[i-1] , i 1,2,...11 .

The purpose of summation with round constants is to break any symmetry that can occur at different stages of key expansion and lead to the appearance of weak keys, as in the DES algorithm.

The operation of the key expansion algorithm is shown in figure 2.

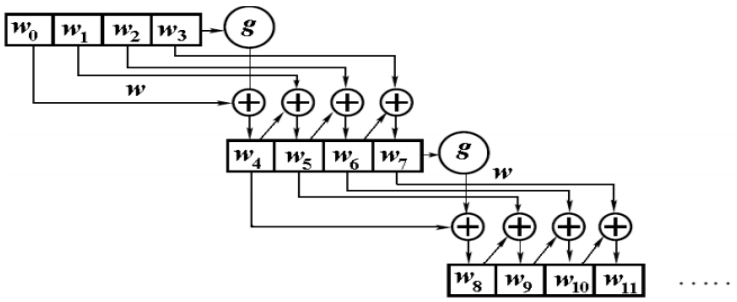

Figure 2. – Key expansion Algorithm

In the course of this study, an encryption algorithm based on the Rubik's cube algorithm was designed. At the same time, the developed algorithm leaves the possibility for further development and introduction of additional security features.

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UDC 004.223

DESIGNING THE MOBILE GAME APPLICATION "CUBE" UNDER THE ANDROID OPERATION SYSTEM

IVAN LARIONOV, YURY KRAVCHENKO
Polotsk State University, Belarus

This article describes how to store data for a mobile gaming application running the Android operating system, as well as how to protect them.

Introduction. Unity3D is a cross-platform game engine produced by Unity Technologies. Unity allows you to create applications that run on more than 20 different operating systems. The engine supports many popular formats of models, sounds, materials and textures.

The project in Unity divided into scenes (levels) - separate files containing their game worlds with their own set of objects, scenarios, and settings. Scenes can contain both, objects (models) and empty game objects - objects that do not have a model. Objects, in their turn, contain a set of components which scripts interact with.

All these data must be protected from copying, illegal use, pirated distribution, professional analysis and hacking.

Main section. When compiling a project Unity creates an executable game file, and in a separate folder - game data (including all game levels and dynamic link libraries).

Data storage methods. Information objects, the relationships between them, as well as the ways of their influence on the system should be represented in the final software product using a data model. It means that the data model is a set of data structures and operations for their processing.

The developed application will include a large amount of information prepared for the user in advance, and it is necessary to select a convenient and efficient way of its storage and processing.

Let us point out the main categories of data that need to be stored for further interpretation by the game:

- information about game levels;
- information about prices in the in-game store;
- predefined settings.

Two options are suitable for storing the above data: XML storage and binary serialization.

The ideal option would be not to choose among the proposed technologies, but to use both options, taking the best from each and applying the situation that is ideally suited for the current task.

The big advantage of binary serialization is the small size of the output files. Data is very compactly folded into files and compressed by the most efficient algorithms, but there is one drawback: the inability to read data without special software.

Binary serialization is great for storing a wide variety of settings, prices, and other configuration parameters.

The way the levels are stored requires transparency and easy access to the data. The data should be easily readable using the selected programming language and at the same time be obvious when you simply view the document. That is why the use of documents in XML format was chosen to store game levels.

Data protection. For Windows builds, Unity compiles and saves the source code of all game scripts in the Managed directory. The code is kept in the following libraries: Assembly-CSharp.dll, Assembly-CSharp-firstpass. dll and assemblyunityScript.dll. There are quite convenient and at the same time free utilities for decompiling and viewing the managed .NET code libraries. They are: IlSpy and dotPeek.

The data approach is especially effective for our purposes: Unity optimizes the source code of game scripts quite poor, practically without changing its structure, and also does not hide the names of variables. This makes it easy to read and understand decompiled material.

In such cases, developers have to worry about the security of their code. For such purposes obfuscators are usually used.

Obfuscation is a process due to which the program code takes on a form that is difficult to analyze. Obfuscation is carried out in order to protect the program code and the algorithms it implements from the eyes of others. But in most cases, obfuscation has a lot of side effects. In especially unpleasant circumstances obfuscator

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can make the program completely unsuitable for execution, in less severe cases new errors may appear in the program. Therefore, obfuscation should be applied with maximum caution.

In AssetStore there are many ready-made solutions, but most of them are commercial. Free versions, as a rule, are limited or have low efficiency.

Most Unity project resources are packaged in proprietary format files with extensions. assets and.

resources . Despite the closeness of the formats, there are tools for unpacking such files. For example, Unity Assets Explorer is able to extract most textures and shaders from the game. The resulting textures will be in DDS format, which can be opened with Windows Texture Viewer. Shaders are extracted in the already compiled form and there are no solutions for their decompilation. However, this circumstance does not prevent the import and use of the resulting shaders in another Unity project.

Three-dimensional model in Unity build is arranged in different resource, and some of them can be generated at all during the game. One can obtain such data directly from the memory of the graphics accelerator. When the game is running, all the information about the textures and models visible on the screen is in the memory of the video card. Using the 3D Ripper DX utility, you can extract all this information and save it in a format understandable to 3D editors.

PlayerPrefs is a class from the standard Unity library that allows you to save data in the long-term memory of the device. It is a pair of key - value. Developers often use it to store various settings, achievements, player progress, and other information about the game progress. For Windows, this data is stored in the system registry. For other operating systems, data is stored on the device in the local folder of the application in a special file. In most cases, they can be easily accessed and modified using a text editor. For example, in Windows it is enough to use the built-in utility RegEdit to modify any values of PlayerPrefs, thereby changing the configuration and status of the game.

The easiest way to counteract is to encode the stored data, for example, base 64. This method is not very effective, but can provide initial protection against viewing. Checking whether the data was changed without the knowledge of the hash functions will help: by comparing the checksums of the stored data, we can make it sure that nobody and nothing except our code can changed this data.

For more reliable protection, it is necessary to use encryption or various combinations of the listed methods.

You can also implement your own save format. Thanks to Mono Unity keeps working with the file system. Thus, you can serialize all the necessary data, apply strong encryption and save in a safe place.

Conclusion. In this article we examined the methods of data storage for a game application running the Android operating system, as well as some ways to protect them.

Unfortunately, there are not so many ways to protect the game from hacking. Being installed on the user device, it actually reveals all the textures, models and source code. If someone wants to decompile the application and steal resources - it is only a matter of time.

Despite this, there are effective methods that will seriously complicate the lives of hackers.

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UDC 004.021

ANALYSIS OF THE MOST COMMON PHP FRAMEWORKS

VLADISLAV RADCHENKO, DMITRY PYATKIN
Polotsk State University, Belarus

In this article we review the pros and cons of PHP frameworks using.

PHP Framework Review. Currently, PHP is one of the most popular scripting programming languages that allows you to create a large number of different Internet projects: from simple websites to large high-loaded e-commerce projects. Fast Internet development has led to the creation of numerous sites: business cards, corporate sites, promotional sites, portfolios, blogs, catalogs, portals, forums, online stores, large individual projects.

To facilitate the development of sites, programmers begin to reuse pieces of code, grouping them into various modules and components, and combining into special sets of ready-made tools, which are called frameworks.

Framework is a ready frame with a set of modules, components, extensions for quick, simple and high-quality software development.

PHP frameworks allow you to:

- accelerate the development of web applications;
- write simple and high-quality code;
- reuse code in projects;
- scale projects easily;
- use modern programming practices;
- test software code effectively;
- ensure project safety.

In this article we will consider PHP Laravel framework and Yii framework and analyse their pros and cons.

Laravel. Laravel is a free open source PHP framework created by Taylor Otwell for developing web applications using the MVC architectural pattern.

We can say that the rest of the PHP frameworks have affected Laravel's emergence.

Laravel is based on the components of Symfony framework (which will also be described below).

The Laravel framework is very popular among Western web application developers.

With the help of the Composer package manager, Laravel framework makes it easy to install and connect various components for use in a web application.

The implementation of the ActiveRecord - Eloquent ORM template allows you to establish relations between database objects of a web application and build convenient queries for data manipulation.

The class auto-loading mechanism allows you to load class files when they are needed without explicitly loading or including them. This gives you ease in running your application by loading those files automatically which are needed every time.

A convenient migration system helps simplify the deployment and updating of a web application.

Laravel has built-in support for the Blade template engine, with the help of which you can make simple representations of a web application using a special syntax.

When creating an application, you can use Artisan, a command line interface for entering embedded commands, as well as creating your own.

Laravel has many useful features that allow you to make the process of developing web applications quick, simple and of high quality.

Regarding these functions we can highlight dd () which is a convenient analogue of the standard PHP function var_dump (). The function displays the variable information in a more understandable form, dividing the data into a tree of attributes and values, with the ability to search and navigate through them.

Pros:

- Fairly good and understandable documentation.
- A powerful ecosystem has been created around the framework. Various courses, conferences, training materials allow you to gather around the framework a large number of developers and sponsors who are interested in developing the tool and are taking part in it.

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– One of the most obvious advantages of Laravel is a flexible routing system, which provides you with a great number of ways to check the route of a web application. You can allocate routes to special groups, use a namespace, specify route parameters, use regular expressions, configure subdomain routing, etc.

– There is a lot of syntactic sugar in Laravel. The framework API syntax is fairly simple and straightforward. There are no long and complex structures, but only brief and thought-over names of functions.

– Laravel provides a convenient mechanism for handling errors and exceptions.

– The framework includes built-in user authentication and authorization mechanisms, which can be reconfigured to fit your needs.

– Laravel provides out-of-box mechanisms for caching a web application using Memcached and Redis. In addition, there are convenient features for using simple file data caching.

– Laravel provides a clean and simple API over the popular SwiftMailer library with drivers for SMTP, Mailgun, SparkPost, Amazon SES, and sendmail to send mail through a local or cloud service according to your choice. Besides there is a mechanism for building mail sending queues.

– Laravel Cashier provides an expressive, free interface to Stripe and Braintree subscription billing services.

Cons:

– For Russian-speaking developers, whose English language skills are limited, a small number of articles, code samples, official documentation translations can be attributed to the cons of the framework. For those who can read documents in technical English, this one can be omitted.

– Syntactic sugar in Laravel can be both a plus and a minus. It is very easy to get used to it and forget how clean requests and functions are written.

– Backward compatibility violation between versions of the framework.

– The illogical location of directories and files. For example, by default, the User.php model is located directly in the / app directory, which it would be more logical to place in the / app / Models directory. The resources directory with presentation files is located in the application root, although it would be more logical to place it in / app / resources.

Yii framework. Yii is a free object-aimed component full-stack PHP framework. Yii is based on PRADO framework, written in ASP.NET and later transferred to PHP. Shortly after building a new architecture, PRADO framework was renamed Yii. The name of the framework is an abbreviation of the word "Yes It Is!". The progenitor of the framework is a Chinese developer Qiang Xue.

Yii can be used to develop any kind of web application. Due to its component base, architecture and complex caching support, the framework is suitable for developing large-scale projects such as portals, forums, content management systems (CMS), e-commerce systems, RESTful web services, etc.

Yii implements an architectural template for using MVC (Model-View-Controller) and contributes to organizing code based on this template.

Yii is a full-stack framework, providing many proven and ready-to-use functions: query builder and ActiveRecord for relational and NoSQL databases, RESTful API, support for multi-level caching, etc.

Yii is an extremely extensible framework in which you can replace almost every piece of code and develop the necessary extensions.

Yii provides Gii, a visual interface for automatically generating controllers, models and mappings.

Pros:

– For Russian-speaking developers, a great advantage of the framework is good documentation. There are many articles with code examples and the community.

– Yii is not an indicator of one person, the framework is supported by a strong team of core developers, as well as a large community of professionals who constantly contribute to its development.

– Yii facilitates rapid prototyping of a web application. It is a RAID development tool.

– Built-in mechanisms for creating presentation widgets, for example, for placing various blocks on a site: recent posts, categories, navigation, blocks of advertising, etc.

– The i18n application component allows automatic translation of web application messages.

– Built-in support for automatic form validation and error reporting based on data from web application models.

– Active Record mechanism for building relational database query processing.

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– Many ready-made extensions on Github and their installation via Composer
– Built-in widgets for displaying data: DetailView (rows in a table), ListView (List), GridView (tables)
– Built-in authentication, authorization, user registration mechanisms
– Contains a built-in and very convenient debug panel.

Cons:

– Weak ecosystem: the community is scattered across different places (several forums with little activity, stackoverflow, etc.)

– The framework allows you to make the code simple, but it is far from elegant. Its syntax is inferior to Laravel framework.

– Yii lags behind language, standards and other frameworks. New updates with really useful features are released not so often.

– The backend and frontend parts of Yii2 are too interconnected. The framework implies using the jQuery library and Bootstrap, which are built in by default into the framework. This minus is planned to be corrected in the new version of the framework Yii 3, making its components less connected.

– Not very flexible routing system: there is no possibility to group routes.

Conclusion. Laravel is currently the most promising PHP framework and is suitable for creating both small and large web projects.

We can still develop new projects on Yii2, just as we can continue to manage existing projects. Version 3 is still in development, so Yii is in the span and it is better to take another framework for this, for example, Laravel.

A very important aspect in the development of frameworks is the commercial side around the framework. If it has no sponsors, then sooner or later, the development team will simply lose all interest in participating in the framework development. A significant role in the framework development belongs to marketing. If there is no popularity and PR around the framework, there will be no developers interested in the framework development.

PHP frameworks are an indispensable tool for building the foundation of any site quickly. They will help to speed up the development process and make a quality project, avoiding programming all parts from scratch.

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DESIGNING THE GRAPHIC INTERFACE OF THE SYSTEM FOR COVERING INFORMATION BASED ON DISCRETE TRANSFORMATIONS BY MEANS OF KOH AND ZHAO ALGORITHM

KLAUDZIYA STANKEVICH, DMITRY PASTUKHOV
Polotsk State University, Belarus

This article discusses the design of a graphical interface system for hiding information based on discrete transformations using the Koch and Zhao algorithm. The degree of suitability of the container for modification, modeling attacks and determining resistance to them have been analyzed.

The development of computer technology in the last decade has given a new impetus to the development of computer steganography. There are many new applications. Messages are now embedded in digital data, usually having an analog nature.

The program interface must have a number of properties: naturalness, consistency, friendliness, the principle of 'feedback', simplicity, flexibility, aesthetic appeal.

Any application should be properly designed and divided into separate modules, which should be relatively independent of each other. This separation greatly facilitates not only the implementation of the application, but also its possible modifications. This is the principle of object-oriented programming modularity.

The application "KochZhao" is an application to hide information in images. To hide the message, you will need to select the container (supported formats: bmp and png), select the hidden file and specify the settings: P and the size of the segments (blocks).

For further extraction of the message it is necessary to remember the key, which will be displayed in the corresponding field, and the size of segments (blocks).

To determine the optimal container, we will use different images with predominance of one RGB color component.

As a result, it was found that the most suitable for the container are images with the predominance of blue and green components.

To determine the stability of the steganosystem, several types of attacks (passive intruder, active intruder) have been carried out.

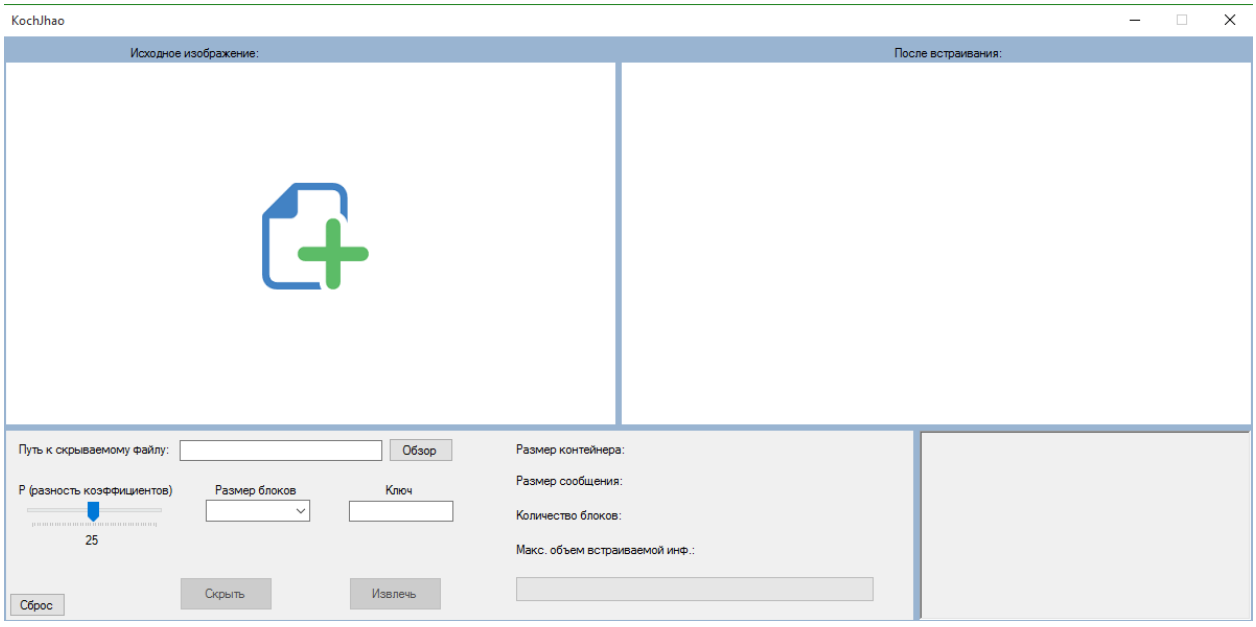

Figure 1. – Program interface

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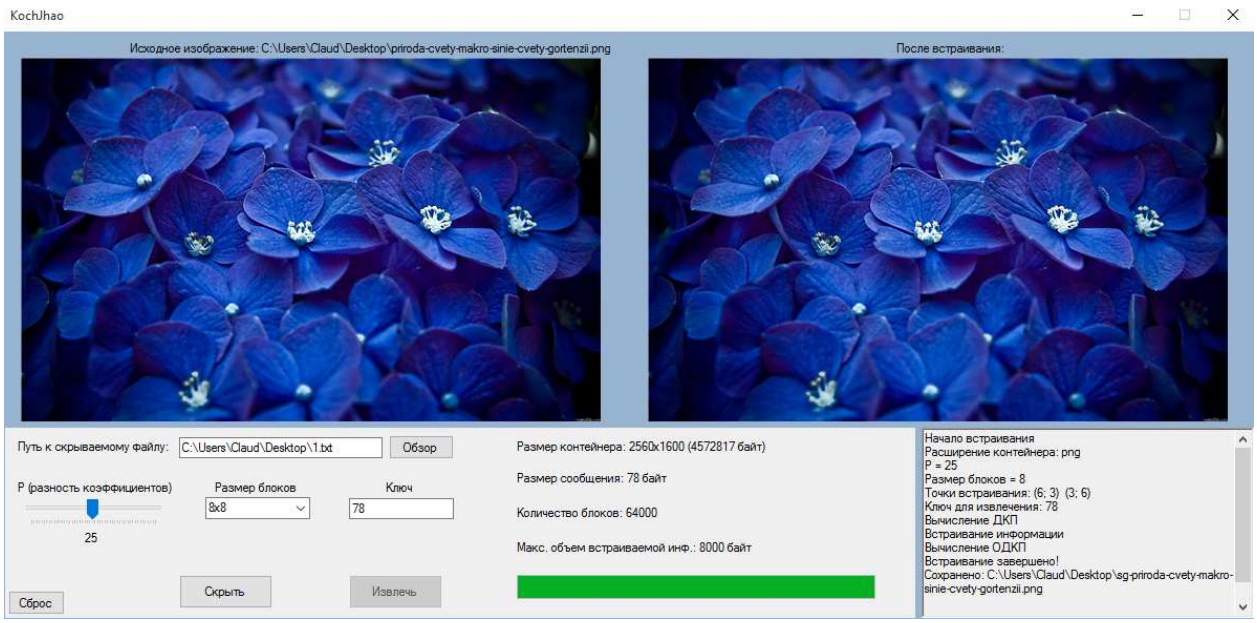

Figure 2. – Encryption interface

A passive attack is an attack when the enemy is not able to modify the transmitted messages and insert its messages into the information channel between the sender and the recipient. The purpose of a passive attack can only be listening to the transmitted messages and traffic analysis.

An active attack is an attack when the enemy has the ability to modify the transmitted messages and insert its messages. There are the following types of active attacks:

– denial of service DoS-attack (Denial of Service);
– modification of the data stream;
– the creation of a false stream (falsification);
– reusability.

When trying to determine the presence of a hidden message in the container, using the function of Adobe Photoshop channel levels, it was noticed that some pixels had a blue channel, which indicates the presence of a hidden message.

During active attacks it was revealed that the algorithm is resistant to most known steganacin, including attack, compression, affine transformation, geometric attacks.

As a result, the tests found out the following:

– change the color of the model before the DKT has significantly worsened the result of the ratio signal/noise;
– embedding in the high frequency region of the spectrum slightly improved the result;
– embedding in the low-frequency region of the spectrum has significantly worsened the result, reduced resistance to compression;
– reducing the block to the 4x4 dimension slightly improved the result, reducing the compression resistance;
– embedding 2 bits per unit in midrange and high-frequency region improved result.

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DESIGNING GUI SYSTEM FOR HIDING INFORMATION BASED ON A CONSISTENT ALGORITHM OF STEGANOGRAPHY

IVAN ANDREYEU, DMITRY PASTUKHOV
Polotsk State University, Belarus

This article discusses designing the GUI system for hiding information based on a consistent algorithm of steganography. The degree of suitability of containers for modifications is analyzed. The description of modeling scams, resiliency and determination of algorithm's efficiency is done.

The development of mankind, due to his desire to secure and safe life, always was generally sustained. Progress broadened their horizons and knowledge gradually improved the quality of life of people, their capabilities, and increased the growth of their needs and requirements. For this simple reason, nowadays people try maintain the desired level of security. It became a key issue. A lot of money, time and effort are spent to reach this goal. One of the security methods stored and transmitted files is to convert them into stegocontainer.

Any application must be competently designed. It is divided into separate modules, which should be relatively independent from each other. This separation greatly facilitates not only the implementation of applications, but also its possible modification. This is the principle of modularity of object-oriented programming.

LSB application is a program to hide information in images. For the correct operation of the program, you must select a container (one of the following formats: bmp, png, jpg, jpeg), select the file and enter as the special key (which would be necessary to extract).

On the basis of the study, taking into account all factors of the development and operation of the finished software product the best programming language for the implementation to Java programming language has been selected. To detect errors, verify implementation of functional and non-functional requirements to the program have tested developed automated system. In tests was activated personal computer on which you have installed the required list of software products, and meets the requirements to the composition of the hardware. Based on this document were tested.

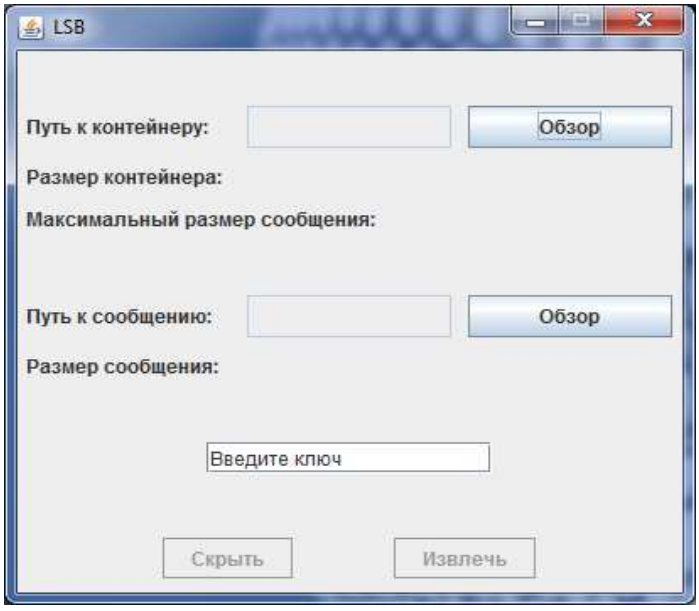

Figure 1. – Program interface

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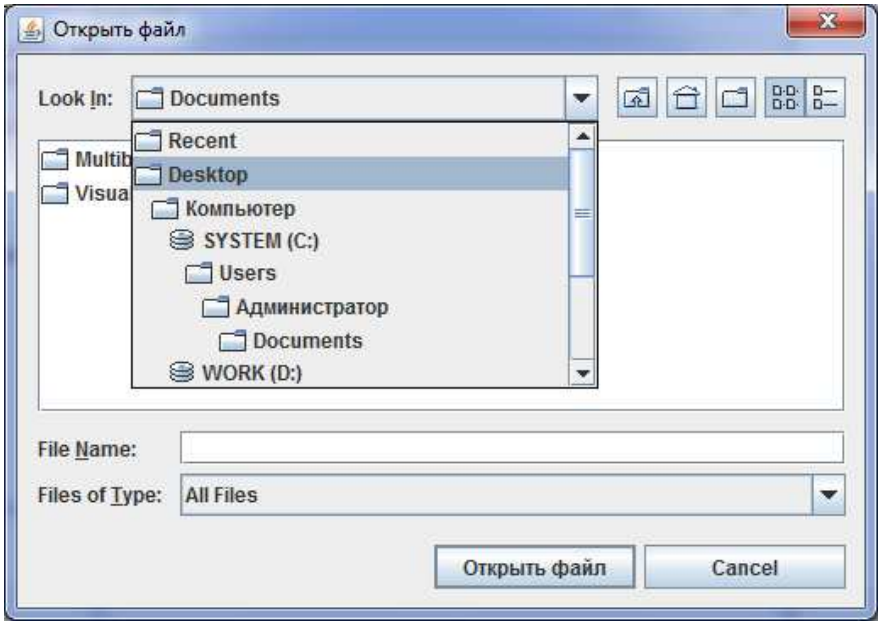

Figure 2. – Select a file to encrypt

When it was revealed that the algorithm has resistance to most known steganoatak, including compression attack to affine transformations, geometric attacks.

During the research, it was determined that the human eye is more sensitive to noise at low intensity colors.

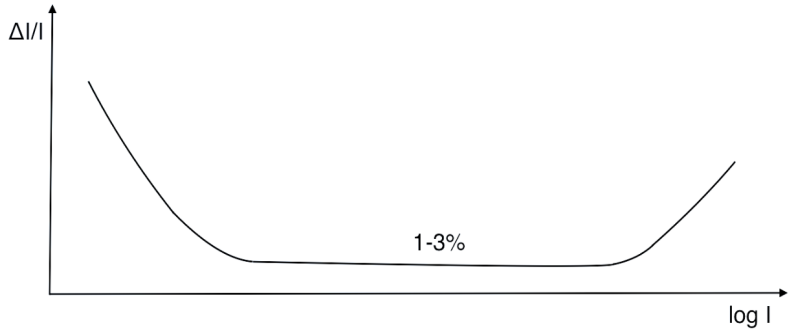

Figure 3. – The dependence of the contrast of brightness

During testing it was found that the proposed method enables to produce graphic compression up to 10%. The same detailed study was conducted to select the development Wednesday. On the basis of the facts submitted for the design chosen Eclipse Wednesday, as a wrapper for the rapid development of high-quality interface.

In this article, you learned how to build a graphical interface to hide information system based on sequential algorithm of steganography, the analysis of the degree of suitability of a container for modifications, modeling and identification resistance to them.

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UDC 004.021

DESIGNING GUI SYSTEM FOR HIDING INFORMATION USING HYPERBOLIC FUNCTIONS

ALIAKSEI SMALIAK, DMITRY PASTUKHOV
Polotsk State University, Belarus

This article discusses designing the GUI system for hiding information using hyperbolic functions. The analysis of the degree of suitability of a container for modifications, modeling and determination of resistance to them.

Need for hiding information from mankind appeared very long ago. However, with the advent of the need for hiding information, and the need for breaking ciphers. The Cryptology, the science of creating and breaking ciphers.

The interface of the program should possess a number of characteristics: naturalness, consistency, friendliness, simplicity, flexibility, aesthetic appeal.

«ExponentLog» is an application to hide information. In the interface presented 3 encryption key for each key has 2 functions, parameter 3 to choose from: hyperbolic cosine (1) and hyperbolic sine (2).

To hide messages you will need to type in the text for encryption in the fieldInputtext, choose the encryption keys and 9 function k, click Coding. After clicking filling status bar appears and the text will be encrypted.

When the buttonDecoding is clicked, decoding the message occurs.

However, if you change at least 1 of 9 decryptedkey message will be changed.

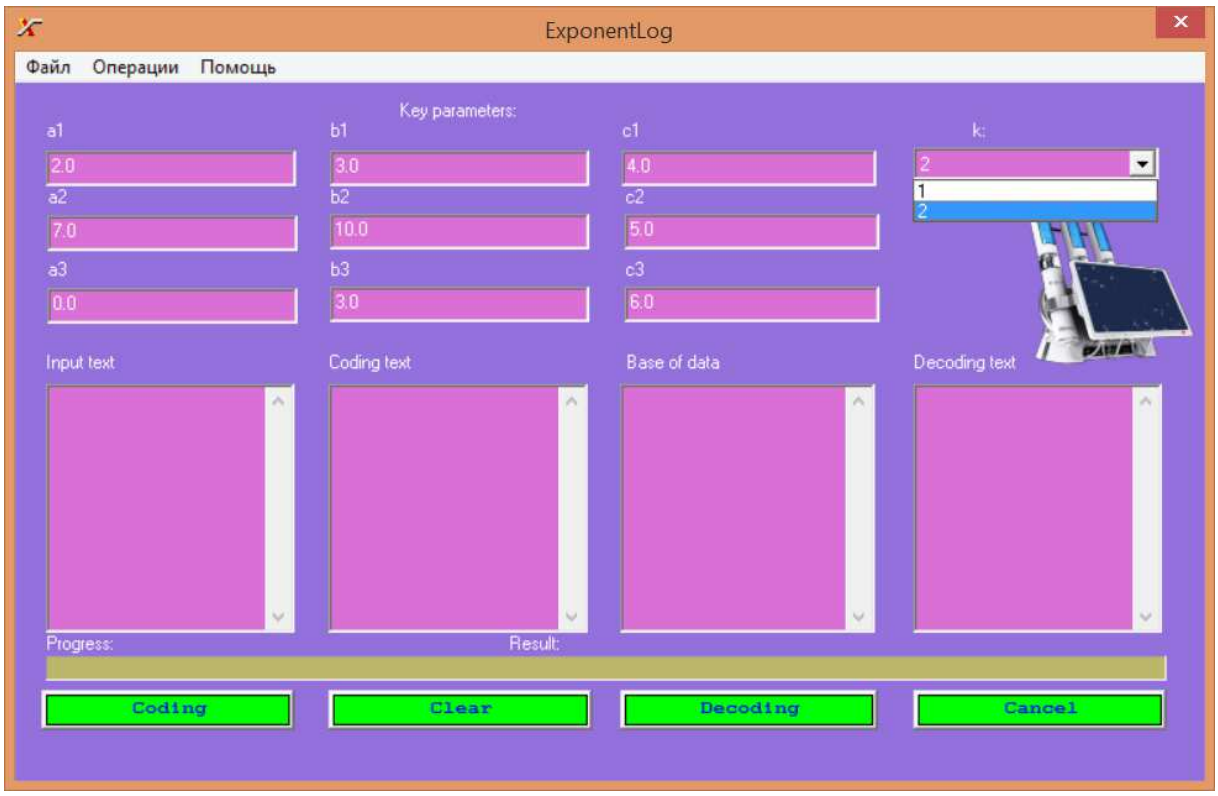

Figure 1. – Program interface

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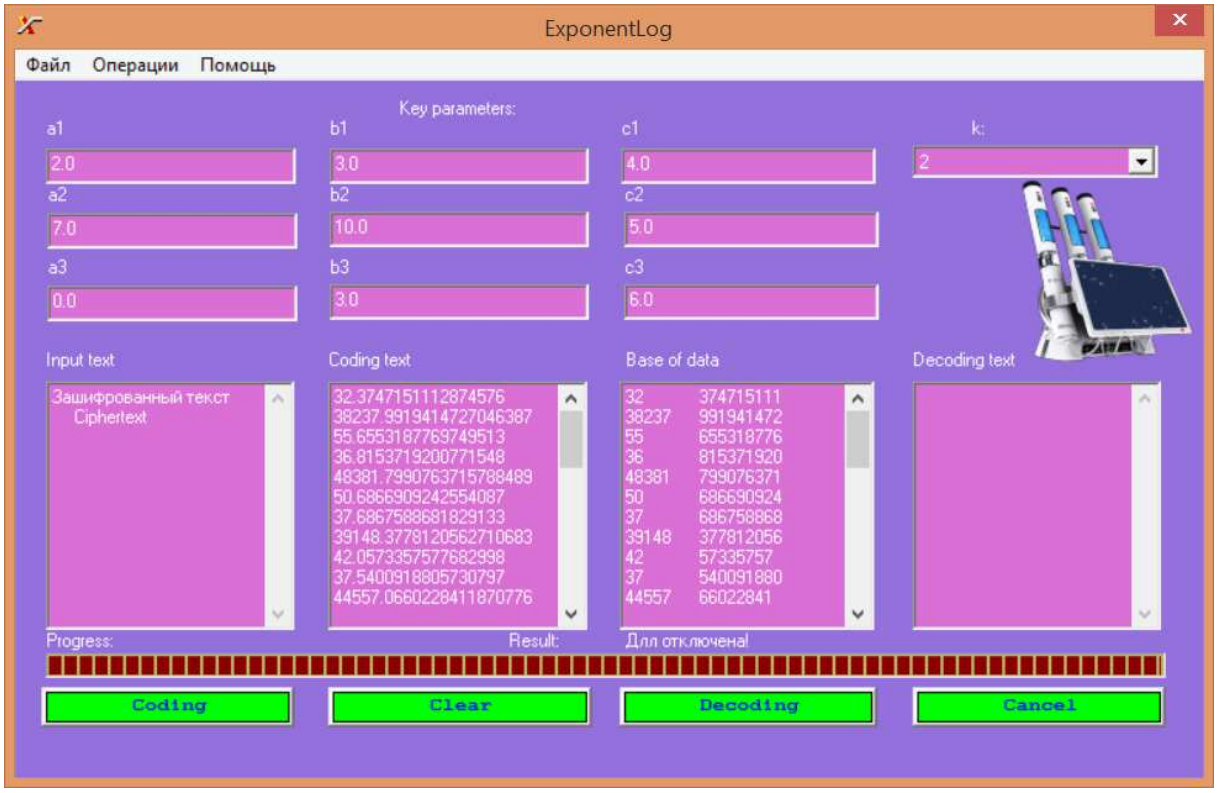

Figure 2. – Encryption Interface

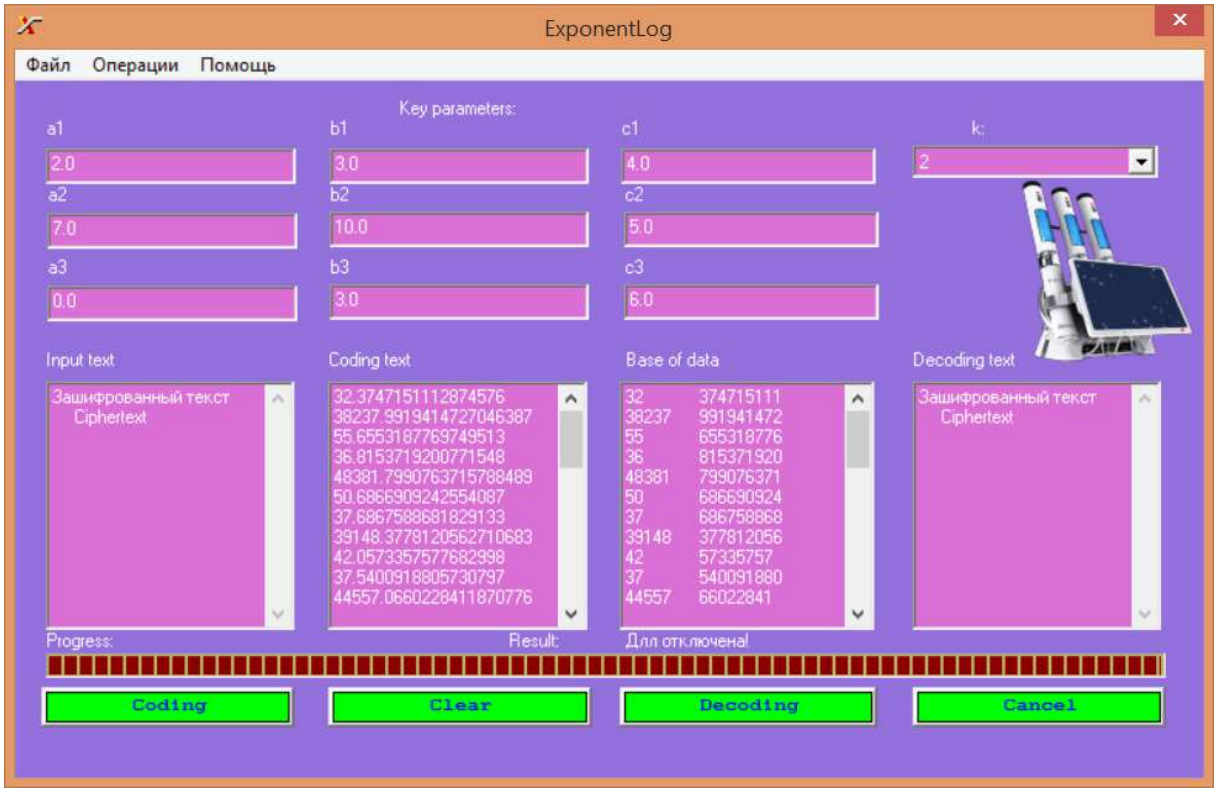

Figure 3. – Decryption Interface

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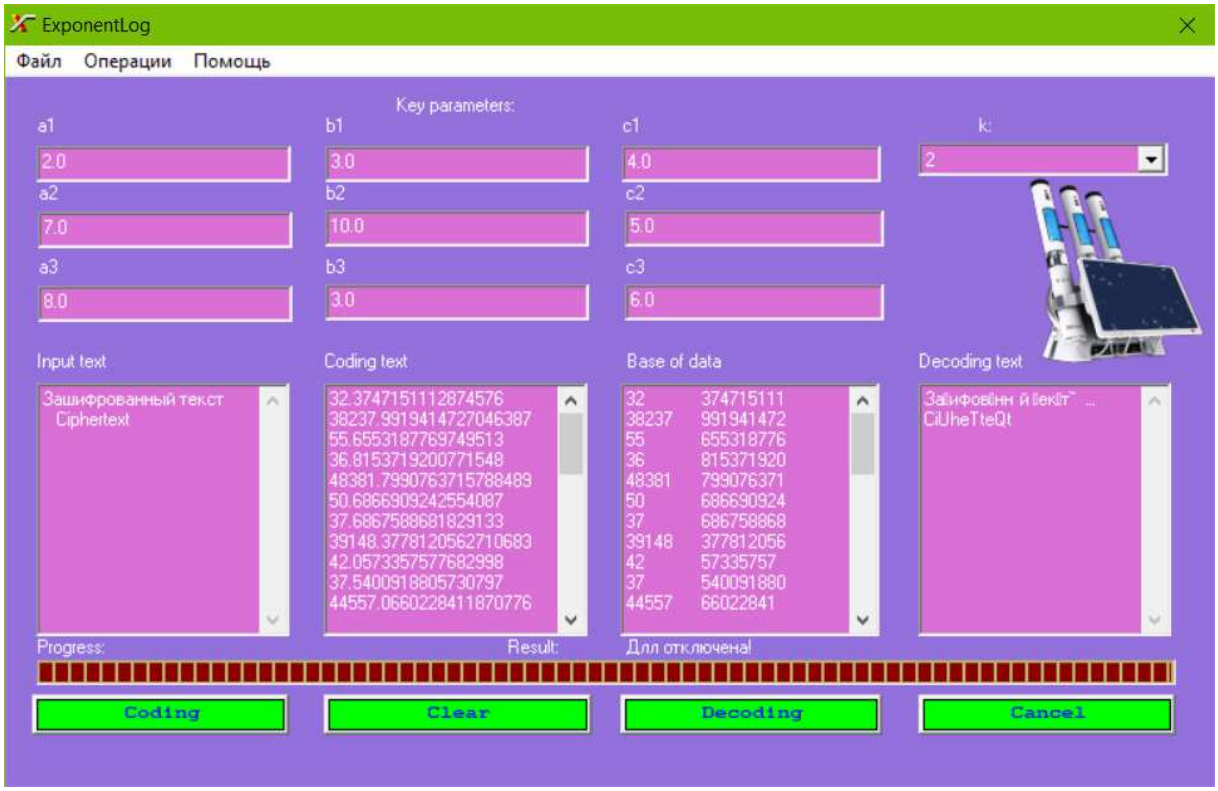

Figure 4. – Error in decrypted text if you change key parameters

Incrediblygreatciphersensitivityrelativelysmall$10^{-10}-10^{-12}$keychanges $(Left, raight, a), (left, raight, n)$, provides greater dimensionality of space distribution of the keys. If the supercomputer cryptanalyst picked up the keys to the fixed code nonlinear functions with speed$10^9 \frac{1}{sec}$, would require hacking time, exceeds the lifetime of the Earth (more than 5 billion years old). Such a large dimension is guaranteed by the use of double-precision (double) for the arguments and nonlinear functions. Indeed, a single range of one key parameter can be placed10^{16}different ciphers. Strong encryption of nonlinear functions is ensured by two reasons: big dimension key space, a large set of nonlinear functions with "floating" scoped-line, which allows on the one hand increase key space, and on the other hand increase the strong encryption.

Thereare 2 classesofnon-linear functions. They were used in this application: the hyperbolic sine and hyperbolic cosine. Applied algorithms in the program can be used to store passwords in the database with a length of up to several hundred-thousand characters. Adding randomization algorithms to encrypt nonlinear functions makes applied algorithms invulnerable to cryptanalyst.

In this article, you learned how to build a graphical interface of the system on the basis of information hiding nonlinear functions, proved on analysis of the reliability of non-linear encryption functions.

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UDC 004.4'22

EFFECTIVE METHODS OF SEO PROMOTION OF WEB SITES BUILT ON THE BASIS OF CMS WORDPRESS

MIKALAI LAPKOUSKI, DMITRIY PYATKIN
Polotsk State University, Belarus

The article presents practical ways of work with web sites built on the basis of CMS Wordpress. They will help to achieve maximum results in their SEO promotion. It is considered as a built-in CMS Wordpress functionality, presented by third-party plug-ins.

What is SEO? It is an acronym that stands for Search Engine Optimization. It's a strategy used by website owners to get more traffic by ranking higher in search engines. Search engine optimization isn't about tricking Google or gaming the system. It's simply about creating a website that has optimized code and formatting which makes it easy for search engines to find your website[1].

Why SEO is important. Search engines are often the biggest source of traffic for most websites. Google and other search engines use advanced algorithms to understand and rank pages appropriately in search results. But those algorithms aren't perfect — they still need human help to understand what your content is about. If your content isn't optimized, then search engines won't know how to rank it. When people search for the topics you write about, your website won't appear in the search results, and you'll miss out on all that traffic. It is really important for all business owners to make their website search engine friendly, so that they can maximize their search traffic.

Site's Visibility Settings. WordPress comes with a built-in option to hide your website from search engines. The purpose of this option is to give you time to work on your website before it's ready to go public.

However, sometimes this option can get checked accidentally and it makes your website unavailable to search engines.

If your website is not appearing in search results, then the first thing you need to do is to make sure that this option is unchecked.

Simply log in to the admin area of your WordPress site and visit Settings » Reading page. You need to scroll down to the 'Search Engine Visibility' section and make sure that the box next to 'Discourage search engines from indexing this site' is unchecked [2].

SEO friendly URL structures in WordPress. SEO friendly URLs contain words that clearly explain the content of the page, and they're easy to read by both humans and search engines.

Some examples of SEO friendly URLs are [3]:

— https://www.wpstart.com/how-to-install-wordpress/

— https://www.wpwiki.com/common-wordpress-errors-and-how-to-fix-them/

Notice that these URLs are readable and a user can guess what they will see on the page just by looking at the URL text.

So what does a non-SEO friendly URL look like?

— https://www.example.com/?p=10467

— http://example.com/archives/123

Using SEO friendly permalink structure improves your chances of getting better positions in search results.

Here is how to check and update your WordPress site's permalink structure. You need to visit the Settings » Permalinks page. Select the post name option and then click on the 'Save Changes' button to store your settings.

WWW or non-WWW. If you are just starting out with your website, then you need to choose whether you want to use www (http://www.example.com) or non-www (http://example.com) in your site's URL.

Search engines consider these to be two different websites, so this means you need to choose one and stick to it.

You can set your preference by visiting the Settings » General page. Add your preferred URL in both the 'WordPress Address' and 'Site Address' fields. From a SEO standpoint there's no advantage to using one or another.

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XML sitemaps in WordPress. An XML Sitemap is a specially formatted file that lists every single page on your website. This makes it easy for search engines to find all of your content.

While adding an XML sitemap does not boost your site's search rankings, it does help search engines find the pages quickly and start ranking them.

If you're using the Yoast SEO plugin, then it will automatically create an XML sitemap for you. To find your sitemap, just go to this URL (don't forget to replace example.com with your own domain name) [4]:

—http://example.com/sitemap_index.xml

Optimizing blog posts for SEO. Often beginners make the mistake of thinking that installing and activating a WordPress SEO plugin is all what's needed. SEO is an ongoing process that you must keep up with if you want to see maximum results.

Yoast SEO allows you to add a title, description, and focus keyword to every blog post and page. It also shows you a preview of what users will see when they Google your website.

When writing a blog post, simply scroll down to the Yoast SEO section and take full advantage of it [5].

Properly using categories and tags in WordPress. WordPress allows you to sort your blog posts into categories and tags. This makes it easy to manage your content by topics, and for your users to find the content they're looking for.

Categories and tags also help search engines understand your website structure and content. Categories are meant for broad grouping of your posts. If your blog was a book, then categories will be the table of content.

For example, on a personal blog you can have categories like music, food, travel, etc. Categories are hierarchical, so you can add child categories to them.

On the other hand, tags are more specific keywords that describe the contents of an individual post. For example, a blog post filed under food category can have tags like salad, breakfast, pancakes, etc. Think of these as indexes section in a text book.

By using categories and tags properly, you make it easy for your users to browse your website. Since it's easy for users, it also makes it easier for search engines to browse your website.

Internal linking in Wordpress. Search engines assign each page on your website a score (page authority). The recipe of this score is kept secret so that people cannot game the results. However, the most common signals of authority are links.

This is why it's important that you link to your own content from your other blog posts and pages.

You should make it a habit to interlink your own posts whenever possible. If you have multiple authors, then create a pre-publish blog post checklist that requires them to interlink at least 3 other blog posts.

This will help you boost your pageviews, increases the time users spend on your site, and ultimately will improve the SEO score of your individual blog posts and pages.

NoFollow external links in WordPress. As mentioned above, links help search engines decide which pages are important. When you link to a website, you are passing some of your site's SEO score to that link. This SEO score is called "link juice."

For good search rankings you need to make sure that you are getting more link juice from other websites than you are giving away.

Adding the "nofollow" attribute to external links (links to websites that you don't own) instructs search engines not to follow those links. This helps you save link juice.

A normal external link looks like this in HTML:

—Example Website

An external link with the nofollow attribute looks like this:

—Example Website

You can also add rel="nofollow" checkbox to the insert link popup. This will allow you to easily add nofollow to external links [6].

Full posts vs summaries or excerpts. WordPress displays and links to your posts from a number of pages like home page, category archive, tags archive, date archive, author pages, etc.

By default, it shows the full article content on all these pages. This affects your site's SEO, as search engines may find it to be duplicate content. Full articles also make your archive pages load slower.

Showing full articles everywhere also affects your page views. For example, users who subscribe to your RSS feed will be able to read the full article in their feed reader without ever visiting your website.

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The easiest way to solve this is by showing summaries or excerpts instead of full articles.

You can do this by going to Settings » Reading and select summary.

Optimizing Images in WordPress for SEO. Images are more engaging than text but they also take more time to load. If you are not careful with image sizes and quality, then they can slow down your website.

You need to make sure that you use images that are optimized to load faster.

A trick you can use to optimize your images for search engines is to use descriptive title and alt tags. These tags help search engines understand what your image is about. They also help users with visual impairment as their screen readers can read the alt and title tags to them.

WordPress allows you to add title and alt tags when you upload an image.

If you are a photographer or add a lot of images to your WordPress site, then you need to use a gallery plugin [7].

Conclusion. In the course of this study, the most effective ways of SEO promotion of a site created on the basis of CMS Wordpress were considered. The question of optimizing the speed of website loading, which also affects SEO, was indirectly raised. The methods given in the article can be used on other sites, as well as in other CMS-systems with similar functionality.

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UDC 621.371.39

GSM ANTENNA DESIGN

ANTON STANOVOY, VICTOR YANUSHKEVICH
Polotsk State University, Belarus

The article presents the results of designing a GSM antenna. In connection with the development of radio-electronic devices and communication systems, there is a need for GSM antennas. The use of antennas in radio systems allows to increase the capabilities of radio communication systems, radar, as the amount of information transmitted per unit of time is directly proportional to the frequency band of the signal; also allows for high noise immunity of communication channels; improve accuracy when assessing the relative orientation of moving objects.

Introduction. An antenna is a device for radiation and reception of radio waves [1].

The shape, size and design of antennas can vary depending on the length of the emitted or received waves and the destination of the antenna. Antennas are used in the form of a piece of wire, combinations of such segments, reflective metal mirrors of various configurations, cavities with metal walls in which slots are cut (slot antenna), spirals of metal wires and others [2].

GSM antenna is the most common antenna with a fairly narrow radiation pattern in the horizontal and vertical planes. An antenna consists of a set of elements: one vibrator, to which a signal is brought in and taken off (active vibrator) and several passive vibrators, one of which is the reflector and the others work in the mode of directors. The task of the reflector is to weaken the radiation in the rear, not the working direction, the director's task is to amplify the signal in the right direction. All vibrators are parallel and lie in the same plane, this plane determines the polarization of the antenna. Often, such an antenna is called an "wave channel" antenna or "Uda-Yagi" antenna [3].

Main part. The shape, size and design of antennas can vary depending on the length of the emitted or received waves and the destination of the antenna. Antennas are used in the form of a piece of wire, combinations of such segments, reflective metal mirrors of various configurations, cavities with metal walls in which slots are cut (slot antenna), spirals of metal wires and others.

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The calculation for the antenna allows to obtain only approximate results, since it is necessary to take into account many interrelated factors (the length and thickness of vibrators, the distance between them), and if it is associated with cumbersome calculations. Therefore, most often design the antenna, selecting all their sizes experimentally, adhering to the following rules:

1) for a given operating wave λ, calculate and set the length of the active vibrator 2l taking into account the shortening Δl

2) set the length of the reflector 2 lp by 5 - 10% longer than the length of the active vibrator, and the distance between the vibrators is about 0.2 λ;

3) using the field indicator, measure the field strength E_O (towards the active vibrator) and E_180 (towards the reflector), and adjusting the distance dp between the vibrators and the length of the reflector achieve the minimum ratio E_180⁄E_O. for a system of two vibrators;

4) add a director, the length of which 2l_q is set shorter by 10 - 15% of the active length, and the distance a_d to the last is about 0.2 λ, and the minimum ratio E_180⁄E_O is achieved by adjusting the specified dimensions. For a system of three vibrators (this may require a slight adjustment of the reflector);

5) add successively second, third, etc. directors and make similar adjustments.

The shape of the radiation pattern (DN), the standing wave ratio (CWS) and the reflection coefficient (S11) are calculated for the frequency from 1.92 GHz to 2.17 GHz, the material is copper. The antenna has a directional radiation in the direction of 0 °, in the direction of -180 ° there is observed a reverse low radiation of the radiation pattern as shown in Figure 1. The antenna has good matching properties in the frequency range from 1.99 GHz to 2.17 GHz (Figure 2). The reflection coefficient from the input decreases from 0 dB at 1.92 GHz to -10.4 dB at 2.17 GHz, at 2.045 GHz, the reflection coefficient is -6 dB.

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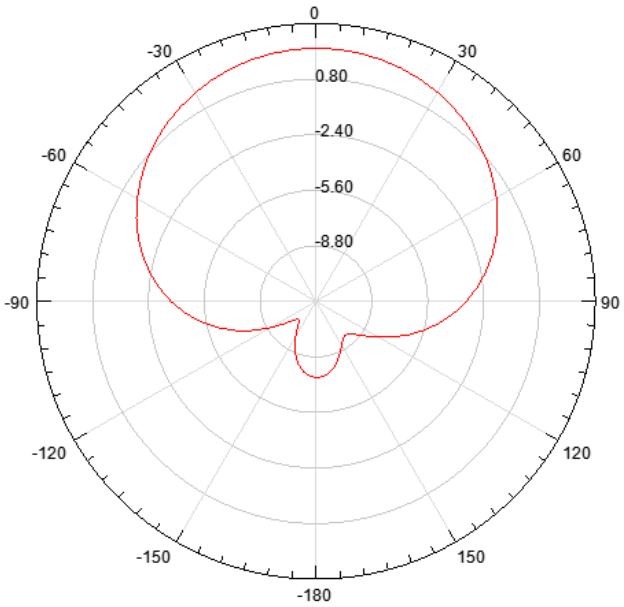

Figure 1. – Antenna pattern

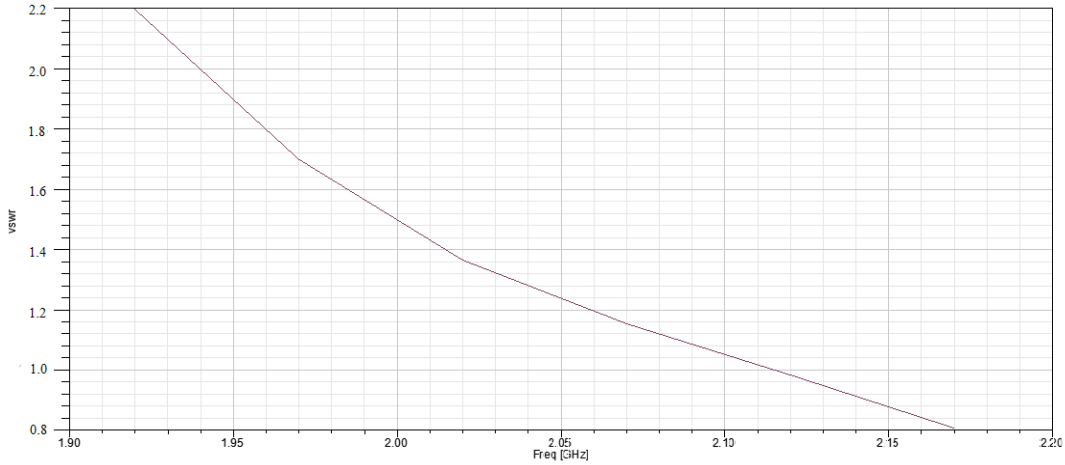

Figure 2. – Antenna standing wave ratio

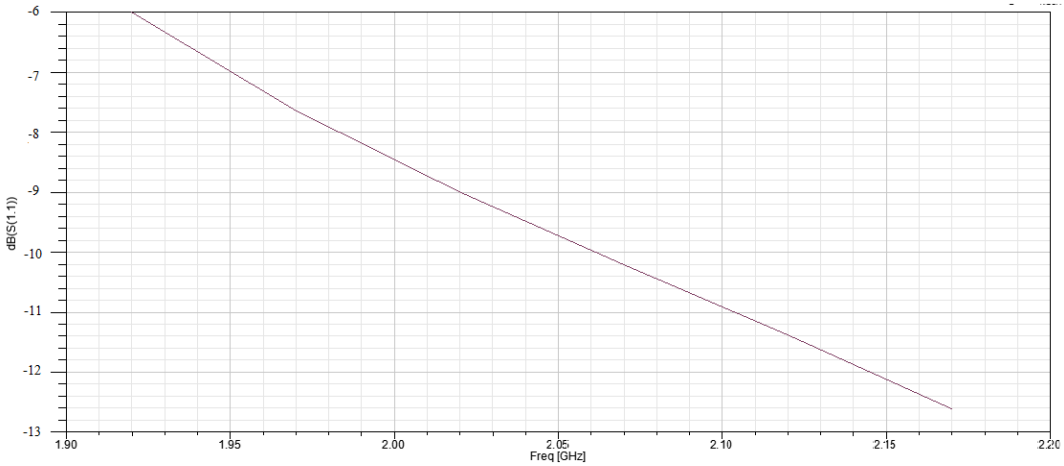

Figure 3. – S_{11} antenna parameter

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Conclusion. In connection with the development of radio-electronic devices and communication systems, there is a need for GSM antennas. The use of antennas in radio systems allows you to increase the capabilities of radio communication systems, radar, as the amount of information transmitted per unit of time is directly proportional to the frequency band of the signal; also allows for high noise immunity of communication channels; improve accuracy when assessing the relative orientation of moving objects.

Universal Mobile Telecommunications System (hereinafter UMTS) - Universal Mobile Telecommunications System - cellular technology, developed by the European Telecommunications Standards Institute (ETSI) for the introduction of 3G in Europe. In order to differentiate from competing solutions, UMTS is also often referred to as 3GSM in order to emphasize that the technology belongs to 3G networks and its continuity in development with GSM networks.

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UDC 004.42

APPROACHES TO THE DEVELOPMENT OF THE FRONT-END PART OF A WEB APPLICATION ON THE EXAMPLE OF "WEBSITE FOR THE SALE OF GAMES"

ULADZIMIR TRAPEZNIKAU, RYKHARD BOHUSH
Polotsk State University, Belarus

The article presents the analysis of the technologies used in the implementation of web application interfaces. The example of the implementation of the web interface of one of the pages of the web application is given.

Introduction. Various software products accessed through a web interface are called today web applications or sometimes also web-based systems. A web application is a client-server application in which the client acts as a browser, and the server is a web server. The logic of the web application is distributed between the server and the client, the data is stored mainly on the server, information is exchanged over the network. One of the advantages of this approach is the fact that clients do not depend on the specific operating system of the user, so web applications are cross-platform services.

A significant advantage of building web applications to support standard browser functions is that the functions must be executed independently of the client's operating system. Instead of writing different versions for Microsoft Windows, Mac OS X, GNU / Linux and other operating systems, the application is created once for an arbitrary chosen platform and is deployed on it.

The relevance of creating a web application is justified by the fact that with the development of portable computers and mobile devices, the client part of the web application can be used not only on desktop computers and laptops, but also on the mentioned mobile devices.

Means of solving the problem. Let's consider the main approaches and means for implementing the interface of the developed web application covering the amateur handball of the Republic of Belarus.

As an authentication system, the ASP.NET Identity system will be used, which allows to authorize through external services, manage roles to differentiate access to data, validate email and phone by SMS, and validate passwords [1].

To optimize the appearance of the site for various types of devices and to simplify the task of graphic design of the site, Twitter Bootstrap, jQuery, AJAX are used.

jQuery is a javascript library, the use of which makes development of javascript code much faster and easier. In the recent past, this library allowed to quickly develop scripts. The jQuery library helps easily access any DOM element, access and manipulate the attributes and contents of DOM elements. Also, the jQuery library provides a convenient API for working with AJAX [2].

AJAX, or, longer, Asynchronous Javascript And Xml is a technology for interacting with the server without reloading the pages. Due to this, the response time is reduced and the web application interactivity more resembles the desktop. For example, it is possible to leave comments on the page summarizing the results of the competition and immediately see the result of adding a comment without reloading the page. To exchange data with the server, a special XmlHttpRequest object is used, which can send a request and receive a response from the server. When updating data, the web page does not completely restart, and web applications become faster and more convenient [3].

Bootstrap is a framework that Twitter has developed. It is designed to facilitate the construction of a graphical interface. The library itself includes a huge number of elements such as buttons, web forms, navigation blocks and much more. Of course, if nothing is initially changed, the resulting form will be similar to that of many other developers using the same framework, but it should be borne in mind that in the early stages of development a fairly accurate interface can be obtained, and eventually it can still be customized. The source codes are also distributed by the MIT license, which allows free use and change of technology [4].

ASP.NET Core MVC is a cross-platform, open source development framework for building web applications and services using the Model View Controller (MVC) pattern. It is a successor to several legacy Microsoft web development frameworks and merges the functionality previously found in ASP.NET MVC, ASP.NET Web Pages, and ASP.NET Web API in a single modular framework. ASP.NET Core MVC offers orders of magnitude better performance than legacy ASP.NET and can be deployed almost anywhere including Windows Server, Mi-

crosoft Azure, Linux, and macOS. It also has built-in tooling that simplifies packaging ASP.NET Core MVC applications for use with container architectures such as Docker and Pivotal Cloud Foundry.

ASP.NET Core MVC shares many of the same programming constructs as ASP.NET MVC classic but has been rewritten from the ground up on top of Core CLR. It is more lightweight and significantly faster than ASP.NET MVC classic. Benchmarks conducted by the ASP.NET team have shown that ASP.NET Core can process more than 1.15 million requests per second with 12.6Gbps throughput. This is a 2,300 percent improvement over ASP.NET 4.6.

Knockout is a JavaScript library that helps to create rich, responsive display and editor user interfaces with a clean underlying data model. Any time you have sections of UI that update dynamically (e.g., changing depending on the user's actions or when an external data source changes), KO can help to implement it more simply and maintainably.

Headline features:

– Elegant dependency tracking - automatically updates the right parts of your UI whenever a data model changes.

– Declarative bindings are a simple and obvious way to connect parts of UI to the data model. It is possible to construct a complex dynamic UIs easily using arbitrarily nested binding contexts.

– Trivially extensible - implement custom behaviors as new declarative bindings for easy reuse in just a few lines of code.

– Additional benefits:

– Pure JavaScript library - works with any server or client-side technology

– Can be added on top of an existing web application without requiring major architectural changes

– Compact - around 13kb after gzipping

– Works on any mainstream browser (IE 6+, Firefox 2+, Chrome, Safari, Edge, others)

– Comprehensive suite of specifications (developed BDD-style) means its correct functioning can easily be verified on new browsers and platforms [5].

Interface design. On the main page of the site one can see games, filtered by genres and supported OS. At the top of each page of the site, using the master page, one will see the navigation bar and registration, login, exit buttons from the personal cabinet, bucket (fig.).

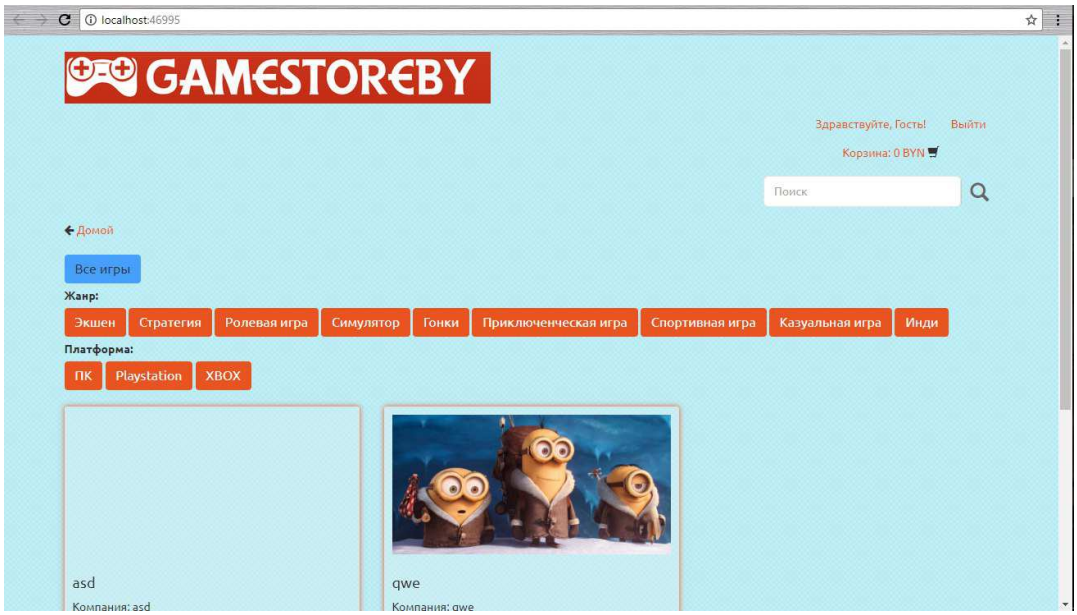

Figure. – Home page

When clicking on the "Registration" link, the user will be redirected to the registration page. On this page, you must enter a name, unique email, password and password confirmation. If the user fill out the forms correctly, they will be redirected to the login page.

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Also, on the right side of the screen on the personal cabinet page, the user can change the avatar by downloading an image up to 4 MB in size.

Conclusion. In conclusion, we would like to say that when developing web interfaces it is necessary to take into account not only the beautiful external component, but also important factors such as "usability", ease of use, understandability for the end user, browser independence, cross-platform, adaptability for various sizes screens, dynamism. And all these requirements can be achieved using a small set of frameworks and libraries, as in this case it's Twitter Bootstrap, AJAX, jQuery, Knockout.

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DESIGNING OF THE GAMING APPLICATION "FLAMY – UNUSUAL PUZZLE" FOR MOBILE DEVICES USING ANDROID OPERATING SYSTEM

ANASTASIYA LABUZAVA, OXANA GOLUBEVA
Polotsk State University, Belarus

This paper discusses the designing of the gaming application "Flamy – Unusual Puzzle" for mobile devices using android operating system.

The application has a series of levels in which user must solve different tasks and puzzles using not only their own logic and intelligence but also the hardware and physical capabilities of the device.

The application's main functionality identification. Main menu displays on screen when you start the application. This menu provides following features:

– start the game;
– rate the game;
– exit the game.

If the user starts the game then current player's level opens on the screen. Level provides number of lives and points information. In addition, the user can get access to the menu of tips and bonuses or return to the main menu. When the user completes level, he gets access to the next one. There also should be implementation of the level successful completion congratulations and a brief description of the correct solution. In case of an incorrect solution – one "life" is taken. If zero "lives" remains then a dialog box opens providing the following choices:

– go back by five levels;
– view advertisements to restore "lives".

When choosing the first option the current level is reduced by five, the second – all lives are restored and the current level remains the same. In case of successful completion of the entire game, congratulations screen should be implemented.

The choice of the menu item "Rate the game" gives to the user opportunity to rate the game. Then on the next screen user can set a rating from one to five; if the score is from one to three then the user can write feedback to the developer about the game, otherwise, write a review on Google Play. User receives additional points in gratitude regardless of his decision after rating the application.

If the user chooses to exit the game, the application should be closed.

Use cases. The use case diagram is the initial model with which the modeling process begins in UML. It describes the functional purpose of the system in the most general way from the point of view of all users and stakeholders.

When creating use-case diagrams, two types of entities need to be distinguished – actors and precedents. An actor is a set of logically related roles that interacts with precedents. A precedent is a description of a set of consecutive events including system-performed variants which leads to the observed by an actor result [2].

For a puzzle game, you can create only one actor – a player. The main requirements for the developed application are displayed using the diagram of use (fig. 1).

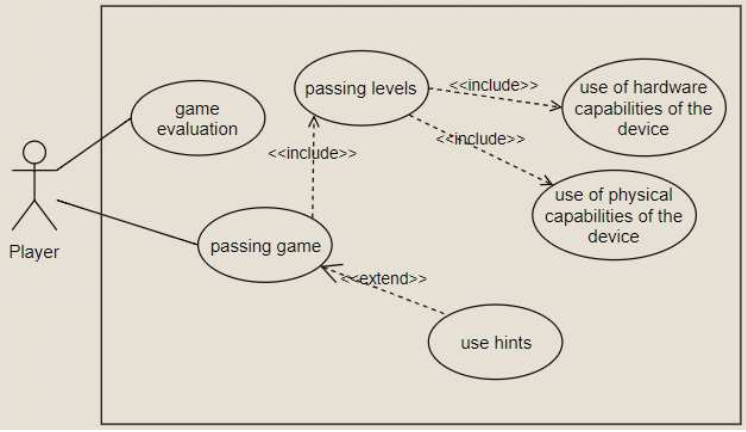

Figure 1. – Use case diagram

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The player can interact with the program in various ways: to pass and rate the game. He can use the tips, hardware and physical capabilities of his mobile device to pass the game.

UI development. An important part in application designing takes the development of the user interface. The user interface is a kind of communication channel through which the user and his mobile device interact. Therefore, the efficiency of working with the application depends on the quality of user interface design.

An important task is to develop a graphical user interface. The game application is developed for mobile devices running the Android OS, so it will be built according to the Material Design specification.

A graphical user interface (GUI) is a type of on-screen representation, in which the user has access to all visible on-screen objects (interface elements) and directly can manipulates them. Most often, GUI elements are implemented on the basis of metaphors and display their purpose and properties, which facilitates the understanding and mastering of programs by unprepared users.

The graphical user interface is a form of user interface that allows users to interact with electronic devices through graphical icons and visual indicators such as secondary notation, instead of text-based user interfaces, typed command labels or text navigation. [1].

Any Android application is a collection of Activities and their interaction with each other. Activities are screens that are created using XML markup.

We will develop a friendly graphical interface that will help the player navigate through the application for convenient user experience of the game. The main activities are the main menu, a screen with a level and a menu of tips (fig. 2).

Figure 2. – Main menu prototype

As can be seen from Figure 2, the main screen should have the following:

– large logo with the name of the game in the center;

– three large buttons arranged vertically one behind the other under the logo with the name of the game.

The logo is static and non-clickable.

When you press the conditional button to go to the game application should open the screen with the level (fig. 3).

Now, based on the layout provided in Figure 3, we will develop the concept of a graphical user interface. As can be seen from the figure above, there is information about the current number of "lives", number of player points and button that do return to the main menu. Main area of the level consists of the current task, its condition and button to go to the prompts and bonuses menu. Below main area is the advertising space. An advertising banner will be displayed there if there is connection to the Internet. Otherwise there is a monochromatic empty area.

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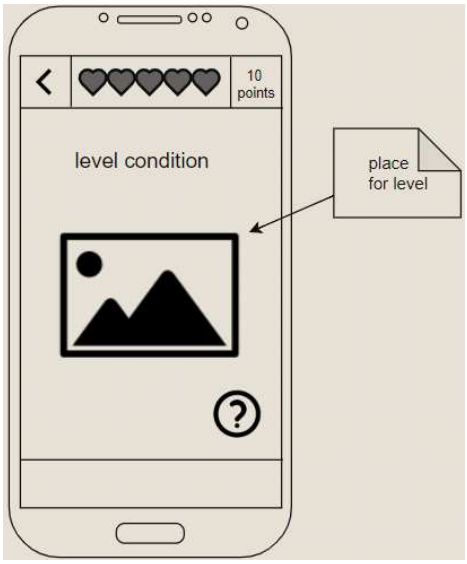

Figure 3. – Screen prototype for game levels

When you click on the conditional button for going to the menu of tips and bonuses, a menu of dialog box opens (fig. 4).

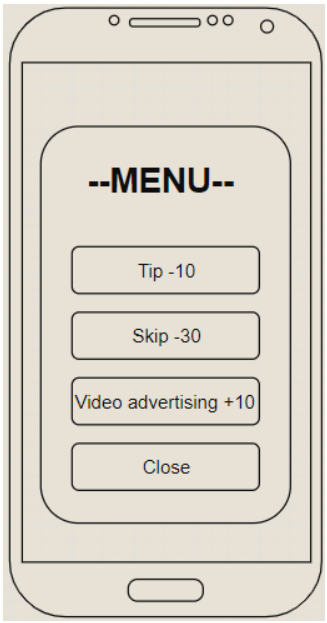

Figure 4. – Prototype menu hints and bonuses

Based on the layout shown in Figure 4, we will develop the concept of a graphical user interface. The menu of tips and bonuses is a dialog box consisting of the "Menu" label and four buttons located one under another:

- "Hint -10";
- "Skip -30";
- "Video advertising +10";
- "Close".

Clicking on the "Hint -10" button displays a small dialog box with the text of the hint and the "X" button for closing and also subtracts ten points from the player's current account. "Skip-30" button allows the player to skip the current level and move on to the next, with thirty points deducted from the player's current account. If

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a player clicks on the "Video advertising 30" button, the video with advertisement is played on the screen. After viewing this video, the player gets plus thirty points to his current account points. Clicking on the "Close" button close the dialog box and return player to current level.

Conclusion. In this article the basic functionality was identified, diagram of use cases was created and user interface was developed for the "Flamy - Unusual Puzzle" game application.

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UDC 512.643+517.977

ABOUT ONE PROPERTY OF THE PRINCIPAL LEADING MINORS OF THE LOWER TRIANGULAR MATRIX

KSENIA KALITA, ALEXANDER KOZLOV
Polotsk State University, Belarus

In this paper, we considered a set of square matrices with positive angular minors. We implemented the similarity transformation triangular matrices with positive diagonal elements over the matrices. In Theorem 1, a sufficient condition was established to preserve the positivity of the angular minors of a square matrix with positive angular minors under the similarity transformation using the above-mentioned triangular matrices. In Theorem 2, a more rigorous sufficient condition was established for the preservation of a similar property with an additional restriction on the norm of the matrices under consideration.

Introduction. Analysis of numerical matrix characteristics in its various matrix transformations (e.g., in the similarity transformation, congruence, etc.) is one of the main problems in matrix theory. The aim of this paper is to study preservation of the principal leading corner minors' of a square n-dimensional matrix positivity and, moreover, of their separation from zero using the similarity transformation on the set of lower triangular matrices with positive diagonal elements.

Material and methods. We obtained the main results using the methods of linear algebra and matrix theory.

Findings and their discussion. Let $\mathbb{R}^n$ be a n-dimensional Euclidean vector space supplied with the norm $\| x \| = \sqrt{x^T x}$ (here the symbol T means the transpose of a matrix or a vector); $e_1, e_2, \ldots, e_n$ be vectors (columns) of the canonical orthonormal basis for the space $\mathbb{R}^n$; $\mathbf{M}_{mn}$ be the space of real $m \times n$-dimensional matrices supplied with the spectral (operator) norm $\| H \| = \max\limits_{\|x\|=1} \| Hx \|$, i.e. the norm induced by the Euclidean norm in the spaces $\mathbb{R}^n$ and $\mathbb{R}^m$ [1, p. 357]; $\mathbf{M}_n := \mathbf{M}_{nn}$. Denote by $E = [e_1, \ldots, e_n] \in \mathbf{M}_n$ the identity matrix. For any number $l \in \mathbb{N}$ denote the set of lower triangular $l \times l$-matrices with positive diagonal elements by $\mathcal{R}_l \subset \mathbf{M}_l$.

Definition 1. For any fixed number $k \in \{1, \ldots, n\}$ and any matrix $H = \{h_{ij}\}_{i,j=1}^n \in \mathbf{M}_n$ by $(H)_k \in \mathbf{M}_k$ denote it's *principal leading k-dimensional submatrix* [1, p. 30], i.e.

$$(H)_1 = (h_{11}), \quad (H)_2 = \begin{pmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{pmatrix}, \quad \ldots, \quad (H)_n = H.$$

Determinants of leading principal submatrices of a matrix $H \in \mathbf{M}_n$ are called the *principal leading corner minors* [1, p. 30].

For any number $l \in \mathbb{N}$ by $\mathcal{H}_l \subset \mathbf{M}_l$ denote the set of l-dimensional matrices with positive principal leading minors, i.e.

$$\mathcal{H}_l := \{H \in \mathbf{M}_l : \det(H)_k > 0, \ k = \overline{1, l}\}.$$

Definition 2. For any number $j = \overline{1, n}$ by $S_j \in \mathbf{M}_n$ denote the matrix received from a matrix R by changing its first j strings by the appropriate strings of a matrix H, i.e.

$$S_j := R + \sum_{i=1}^{j} e_i e_i^T (H - R), \quad j = \{1, \ldots, n\}.$$

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In the sequel, with the use of monograph's terminology [2, p. 283], consider matrices $S_j \in \mathrm{M}_n$, $j = \overline{1,n}$, to be the *intermediate steps on the way from* R *to* H.

Definition 3. An ordered pair (R,H) of matrices on the set M_n is called *law-abiding* [2, p. 283], if the ratio $\det R > 0$ is correct and for each number $j \in \{1,\ldots,n\}$ of matrices S_j, which are the intermediate steps on the way from R to H, such ratios as $\det S_j > 0$ are correct.

Definition 4. *Square* n*-dimensional matrices* M and N are called *similar* [1, p. 61], if such matrix as $S\,(\det S \neq 0)$ exists so the following equality is correct

$$M = SNS^{-1}$$

and the transformation of matrix N itself with the use of the matrix S is called the similarity transformation.

Theorem 1. *Let* $R \in \mathcal{R}_n$, $H \in \mathcal{H}_n$. *The inclusion* $RHR^{-1} \in \mathcal{H}_n$ *is performed if and only if a pair* (R,H) *is law-abiding.*

The invariance of the positivity property of the principal leading corner minors of the matrix $H \in \mathcal{H}_n$ in the similarity transformation using the matrix $R \in \mathcal{R}_n$ is established by theorem 1, if these matrices are law-abiding. However, a stronger statement is also true. It is about the preservation of the principal corner minors' of the matrix H separation from zero in the similarity transformation using with not only the law-abiding condition but also the ρ-law-abiding of the same pair (R,H).

For any real numbers $r \geqslant 1$ and $\rho \in (0,1)$ let $\mathcal{R}_n(\rho,r) \subset \mathcal{R}_n$ be a set of lower triangular $n \times n$-matrices R with positive diagonal elements for which $\| R - E \| \leqslant r$ and $\det R \geqslant \rho$ are correct, i.e.

$$\mathcal{R}_n(\rho,r) := \{R \in \mathcal{R}_n : \| R - E \| \leqslant r, \det R \geqslant \rho\},$$

and a set of $n \times n$-matrices $\mathcal{H}_n(\rho,r) \subset \mathrm{M}_n$, for which $\| H - E \| \leqslant r$ and all the principal leading minors are not less than ρ, i.e.

$$\mathcal{H}_n(\rho,r) := \{H \in \mathrm{M}_n : \| H - E \| \leqslant r,\ \det(H)_k \geqslant \rho,\ k = \overline{1,n}\}.$$

Definition 5. Let $\rho \in (0,1)$ be a random fixed number. According to the definition from [2, p. 283] an *ordered pair* (R,H) on a set M_n^2 is *called* ρ*-law-abiding*, if $\det R \geqslant \rho$ and for any $j \in \{1,\ldots,n\}$ belonged to S_j, which are intermediate steps on the way from R to H, such inequalities as $\det S_j \geqslant \rho$ are correct.

Theorem 2. *Suppose* $r \geqslant 1$ *and* $\rho \in (0,1)$. *If a pair* (R,H) *for which* $R \in \mathcal{R}_n(\rho,r)$ *and* $H \in \mathcal{H}_n(\rho,r)$ *is* ρ*-law-abiding, then there exist such numbers as* $\rho_1 = \rho_1(\rho,r) \in (0,1)$ *and* $r_1 = r_1(\rho,r) \geqslant 1$, *for which* $RHR^{-1} \in \mathcal{H}_n(\rho_1, r_1)$.

Conclusion. The obtained results can be further used in the theory of controllability of asymptotic invariants of linear systems of ordinary differential equations in the study of global Lyapunov reducibility [2, p. 258 - 259] and even the global attainability [2, p. 253] of such systems.

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UDC 004.42

OPENSTREETMAP DATA RENDERING

ANTON SHUBKO, RYKHARD BOHUSH
Polotsk State University, Belarus

A map as a symbolic depiction emphasizing relationships between elements of some space was invented many centuries ago. And it is not surprising that online maps have become a common and popular thing in our age of high technologies. In the modern world people extensively use online maps for different purposes such as the search of a route for a walk, search of the necessary address or assistance during an excursion in an unfamiliar city.

There is a huge number of existing online map products, free or paid, with different accuracy and detailing levels, however I would like to focus on the particular one, the OpenStreetMap. OpenStreetMap (OSM) is a collaborative project to create a free editable map of the world. Rather than the map itself, the data generated by the project is considered its primary output. The creation and growth of OSM has been motivated by restrictions on use or availability of map information across most of the world, and the advent of inexpensive portable satellite navigation devices.

Conceptual difference of the OpenStreetMap is in the fact that OSM is not just a map, but a set of geographical information. Together with the fact that the project is not commercial, this opens broad horizons for further development based on this platform.

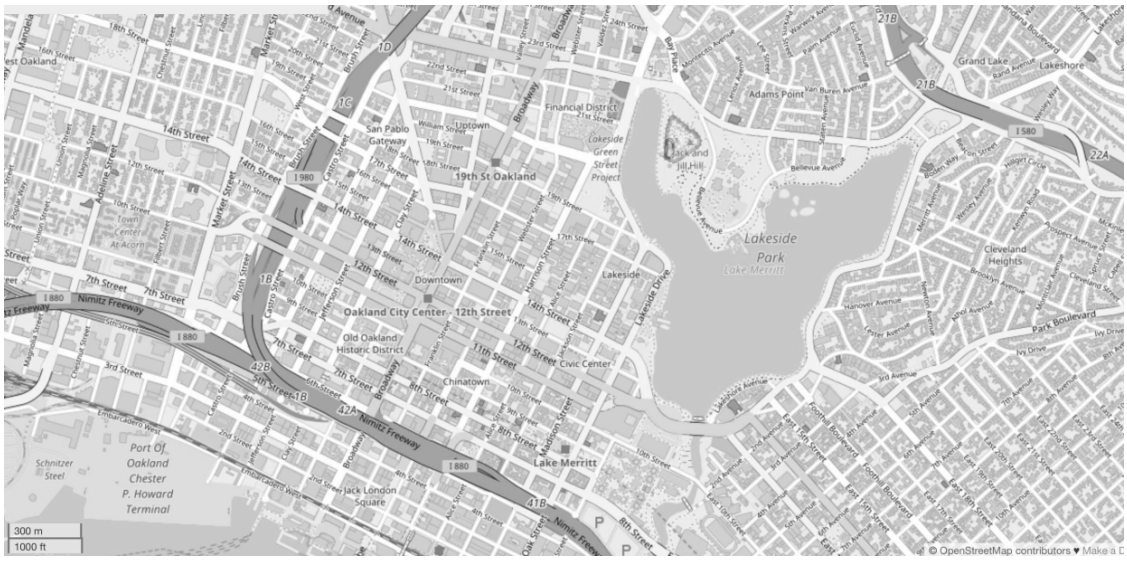

Figure 1. – Example of OSM map

The main objective of the paper is to define the process of development of a product based on the OSM for rendering geographical maps.

Analysis of the subject domain made it possible to delineate the following technical requirements for a typical product based on the OpenStreetMap data:

– Transformation of XML data to object-oriented data and their rendering as cartographic images;

– Development of a user-friendly web-resources for displaying the maps (using such features as cached data for fast access, ability to re-render the new data on-the-fly).

– Implementation of ability to customize appearance of the map (e.g. to change designations, the displayed objects layers, etc.).

These requirements would let the product if not beat then at least correspond to functionality of the product competitors which are available in the market. However, even the mentioned range of requirements lead to a number of problems that need to be resolved during the development process.

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Firstly, work with large volumes of data is the real issue for such software products. At the moment, size of the archived OSM of data is nearly 80 GB, and the unpacked data size is more than 200GB. Also it is important to point out that the data constantly and dynamically change (about 3GB of the archived data per week).

The problem defined above can be solved using several specific technologies and frameworks. For example, usage of the Java-based StAX API allows to avoid issues with memory overflow while parsing of XML data. Furthermore, for the reduction of memory consumption in such a case it is possible to apply such well-known software development pattern as Flyweight. Despite the fact that the Java programming language has been chosen for the development, and the existence of a quite popular opinion that JVM-based languages are oriented to high memory consumption in runtime, there is a great variety of options for its optimization on different levels, from the highly specialized libraries for implementation of a particular part of logic, to alternative implementations of the Java Virtual Machine itself that would provide developers with precise control of memory usage and a set of options of how it could be reduced.

One more problem that might be come across during the implementation of such product is high server load while rendering images and also load on a communication channel during transmission of images to a user.

As options for solution of the problem, popular concepts of microservice and serverless architecture can be considered. In general, the described architecture approaches could allow to reduce time expenses related to rendering, because they imply easy ways to organize horizontal scaling of a system, multithreading design, and help to organize stable load balancing to support a great number of the web-resource users. Currently a lot of successful commercial products tend to be created based on the microservice architecture, because it is flexible, easily modified and easily expandable. Moreover, splitting responsibilities for particular parts of logic between different services allows to increase resilience of the product, because particular small web-services can be easily restarted/replaced, and there are a lot of existing frameworks and products that allow to organize several hosts with the same application as a single cluster under the reverse proxy and manage their availability dynamically to correspond to current client needs and load.

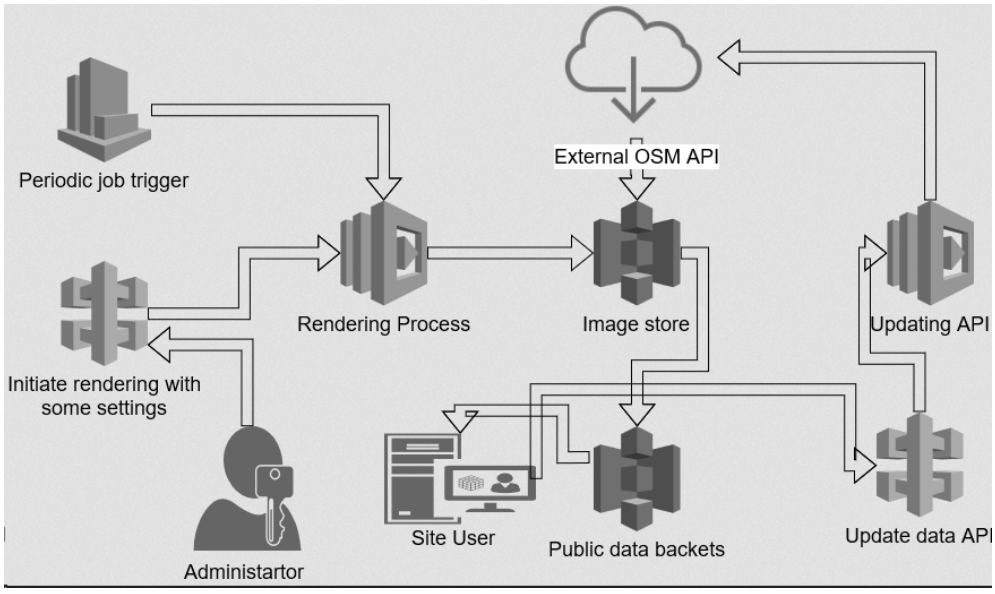

Figure 2. – A chart of high-level product architecture

With respect to scaling opportunities of microservices and economy of resources (i.e. an ability to use additional capacities only when they are really necessary, like peaks with high load of users or while rendering process is started), it is possible to consider cloud solutions such as:

- Microsoft Azure;
- Google Cloud Platform;
- Amazon Web Services.

All the enumerated options provide solutions from-the-scratch which allows to avoid expenses for labor-consuming hardware maintenance and to save a lot of money and resources during idle times. Besides the sim-

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ple provisioning of computing capacities or simply remote servers for web-service deployment, now they allow to organize stable, highly scalable web services, either serverless or server-based, with databases and message queuing services deployed in the same cloud, maintaining guaranteed resilience and advanced options for cost management.

Finally, it is worth mentioning that there is a need to constantly update image database. Such dynamic data as maps should be easily updated in real time with the minimum or even without downtime to provide users with the correct and topical displayed information in time. Users of today's web expect that the pages they visit will be interactive and smooth and that is where the developer needs to increasingly focus the time and effort. Pages should not only load quickly, but also run well; scrolling should be stick-to-finger fast, and animations and interactions should be silky smooth.

This problem can be solved by applying several advanced mechanisms for data processing. More precisely, it means that, for example, there would be a global task to redraw the whole map, and a set of small background subtasks, for updating only a certain zone of the map. In combination with the versioning of displayed images, it becomes possible to update the map (both entirely and making small amendments) in a comfortable way for the users who have already started to use the map.

The developed product could have a great range of application areas, such as tourism and recreation, scientific researches, etc.

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UDC 004.432.2

OVERRIDING DEFAULT CALLING CONTEXT IN JAVASCRIPT

KIRYL LAPKOWSKI, DMITRIY PYATKIN
Polotsk state University, Belarus

The article is devoted to overriding the context of function calls in JavaScript. Let's consider all possible cases of setting the context of functions. We will analyze how effective the existing mechanisms are. As a result, an alternative way to set the context of functions will be formulated.

Introduction. JavaScript is a multi-paradigm programming language. This universality of language entails some problems. For example, if we consider JavaScript as an object-oriented programming language, we can see that such mechanisms as an abstract class are not implemented at the language level (although the programmer himself can easily program a class that cannot be instantiated), and prototype inheritance complicates writing a program in a functional style.

Setting the call context incorrectly is more likely to result in errors during program execution than in the inability to implement any principles of different programming paradigms. However, if the program has not been properly tested, errors may be rare, difficult to reproduce, and have a significant impact on the program.

Primary partition. The call context is the value in the context of which the function was called. Any function in JavaScript can refer to the this keyword within itself [1]. The this keyword refers to the context of a function call. The function is associated with the object at the time of the call, and this within the function receives the corresponding value. Consider four possible cases of determining the context in the order of their priority:

– Binding using the new operator. If the function was called with the new operator, this will get a reference to the newly created, empty object. Listing 1 providesan example.

Listing 1 - defining the context for the foo function using the new operator

```
varbar = newfoo()
```

– Explicit binding. If the function is called using the call or apply methods, or a context is bound to the function using the bind function, then the context of the call is the first argument passed to these functions. Listing 2 showsan example.

Listing 2 - defining the context of a function using the call method

```
var bar = foo.call(obj2)
```

– Implicit linking. If the function is called in the context of some object, also known as a container object. Then this will get a reference to this object. Listing 3 shows an example.

Listing 3-specifying an implicit context for a function

```
var bar = obj1.foo()
```

– Default binding. If none of the above cases are applicable to the function call, this will get the default value. In strict mode it is undefined, in non - strict mode it is a global object [2]. Listing 4 showsan example.

Listing 4-setting the default function context

```
var bar = foo()
```

The problem of tight coupling and binding default

The function context is lost if the function is used as a variable [3]. Typically, you use a hard binding to bind a context, or an arrow function that retrieves the context from a closure.

Hard binding of the calling context to the function (using the bind method), decreases the flexibility of the function, allowing you to override the context using the implicit or even explicit calling context.

Binding a function to the default context is rarely intentional, because in the case of binding to undefined, any attempt to read a property from this, or a method call, will result a runtime error. If you do not use strict mode, the global object will get into the context of the call, and changing any property or method of the object will change the global object. A scenario with a global object as the context of a call often results in hard-to-catch errors.

The implementation overrides the default context

As a solution to the problem of tight coupling and linking by default, you can override the calling context. The function implementation is presented in listing 5.

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Listing 5-implementing the default context override

```
if (!Function.prototype.softBind) {
  Function.prototype.softBind = function(obj) {
        varfn = this,
        curried = [].slice.call( arguments, 1 ),
        bound = function bound() {
            return fn.apply(
                (!this ||
                    (typeofwindow !== "undefined" &&
                        this === window) ||
                    (typeofglobal !== "undefined" &&
                        this === global)
                ) ?obj : this,
                curried.concat.apply( curried, arguments )
            );
        };
        bound.prototype = Object.create( fn.prototype );
        return bound;
  };
}
```

Conclusion. The article deals with various ways of context binding and the problems of their use. A function that sets the default context, which allows to solve the problem of loss of context, saving the ability to override it further in the program.

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UDC 004.42

DEVELOPING A USER INTERFACE FOR AUTOMATED WORKPLACE TO ACCOUNT MOTOR TRANSPORT

DENIS PATSANKOV, YURY KRAVCHENKO
Polotsk State University, Belarus

This article discusses the principles of building a graphical user interface of an application.

An important task is to develop a graphical user interface. According to the technical task, the software is developed for the operating system of the Windows family, therefore, it is necessary to follow the specifications developed by Microsoft for software development.

A graphical user interface (GUI) is a type of on-screen presentation in which the user can select commands, run tasks and view file lists, pointing to icons or items in menu lists shown on the screen.

The user interface is a collection of the information model of the problem area, the means and methods of user interaction with the information model, as well as components ensuring the formation of the information model during the operation of the software system

The main advantage of a good user interface is that the user always feels that he is managing the software, and not the software that controls it.

To create such a feeling of "inner freedom" for the user, the interface should have a number of properties.

- The naturalness of the interface;
- Interface consistency;
- User friendly interface ("user forgiveness" principle);
- The principle of "feedback";
- Ease of interface;
- Interface flexibility;
- Aesthetic appeal [1].

Any application for Windows operating system is a window created by the Form component. Form is the most important visual component. Forms are visible Windows windows and are the main part of almost any application.

An application can have several forms, one of which is considered the main one and is displayed first when the program starts. When you close the main form of the application, the entire application stops working, and all open application windows are also closed.

Taking into account the recommendations described above, it is advisable to present the graphical interface on the main form with the shortcut buttons, which will be responsible for certain program functions:

- storing information about the work of the enterprise;
- storing information about drivers;
- systematization of data on waybills;
- systematization of data on vehicles;
- systematization of data on drivers;
- data formation in .xml format.

As for the main features of the interface being developed, the following can be noted. By selecting the File / Open menu and loading the database, you can work with a fully functioning program. After opening the database file, all menu items become active.

The "References" menu item allows you to view, add, edit or delete data. To view the necessary data, you need to select one of the menu items.

When you click the "Convert" button, the data is saved in the directory selected by the user and converted to XML format.

When you click the "Add" button, you are transferred to a new form on which data will be added. When adding a new record, check for correct input is taken into account, in case of incorrect data entry, a message is displayed on the screen.

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When you select one of the "Waybills" menu items, a child form appears on which in the upper right corner there are data search buttons for a given criterion, and in the upper left corner of the button for possible operations on data, add, edit, delete and convert.

Findings.

This article describes how to build a graphical interface of applications for the Windows operating system and present examples of the application. The main advantage of a good user interface is that the user always feels that he is managing the software, and not the software that controls it.

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UDC 699.844:004.94

PROTECTION INCREASE OF SPEECH INFORMATION BY USING GLASS PIPES ON WINDOW FENCES

ANATOLI KAZIUTSIN, VLADIMIR ZHELEZNYAK, KANSTANTSIN RAKHANAU
Polotsk State University, Belarus

The paper proposes and justifies a way to increase the security of speech information by attaching glass tubes (stiffeners) to a window fence. A method for estimating changes in the resonances of a window enclosure with fixed stiffeners is given. With the help of the developed laboratory installation, a study of the window fence was performed. Calculated indicators of changes in the maximum resonance of window fencing with stiffening ribs installed.

Introduction. Isolation of the airborne noise of a room is its most important characteristic in terms of protection against leakage of voice information. Of all the elements of enclosing structures, window barriers are most vulnerable to attenuation of sound frequencies. In [1], an assessment of the sound insulation of airborne noise by window barriers by changing the calculation of the thickness of the glasses and increasing the air gap between them is given, the use of glasses with different thickness and the intervals between them is justified for the greatest security of speech information. However, in practice, changing the thickness of the glass and the distances between them is not always possible.

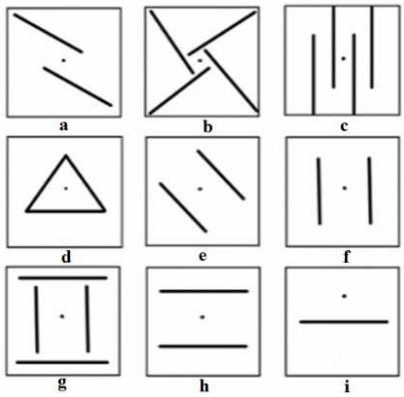
To reduce the sound level, the use of sound insulation is more effective than the use of sound absorption indoors [2]. So in the study of metal structures, for example, in [3], in order to increase the rigidity of window barriers, it is recommended to change the geometric parameters of the window barriers - the shape of the section. When designing metal structures, the main practical means of increasing rigidity is to maneuver the geometrical parameters of the system, and not the characteristic of metals, which is determined only by the completely atomic-crystalline lattice of the main component.

The easiest way to reduce the strain of metal structures is to reduce the level of stress (increase the structure). However, this path is not always rational, since it is associated with a significant increase in the mass of the structure. In the case of bending, a rational way to reduce deformations is to choose the most optimal form of sections, loading conditions, type and arrangement of supports.

By analogy with metal structures, this paper proposes the installation of stiffeners on a window fence, which changes the cross-sectional shape of a window fence and is a more rational alternative to changing the thickness of the glasses and the distances between them.

Stiffening ribs window fencing. Stiffeners can be used without replacing window fencing. Stiffeners are transparent glass tubes made of quartz sand and some other materials that do not disturb the interior and exterior. Fastening of the ribs is ensured by a snug fit to the glass of the window enclosure and the application of adhesive along the position of the rib to the window enclosure.

Placing the glass tubes on the window fence can be done in various ways (schemes of ribs). The stiffener scheme is a method of arranging glass tubes on the glass of a window enclosure. Some possible stiffener patterns that were studied on are shown in Figure 1.



a - parallel shifted; *b* - mill; *c* - four shifted; *d* - triangle; *e* - two parallel oblique; *f* - parallel vertical; *g* - two vertical and two horizontal; *h* - parallel horizontal; *i* - single
Figure 1. – Schemes of ribs

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Window fencing is schematically depicted by a square, inside of which one of the schemes of stiffening ribs is shown by straight lines, the vibrator is depicted by a dot in the center of the square.

Depending on the stiffener scheme used, the maximum resonance of the window fence varies. Estimation of the change in the maximum resonance is proposed to be performed in a laboratory setting using the technique presented below.

Technique for the study of resonances. The level of protection of speech information in [1,4,5] is usually described using the information indicator - speech intelligibility. To assess intelligibility, the frequency speech range (100–10000 Hz) is divided into equal-articulation bands, which make the same contribution to speech intelligibility [4].

The maximum resonance of a window fence is the most powerful resonance in a band of equal speech intelligibility, the smaller the value of the maximum resonance, the more protected is the speech information in the band. The main indicator in the method is the total change in the maximum resonance of a window fence with installed stiffeners to the window fence without installed stiffeners, expressed in decibels.

The application of the resonance research technique and experiment is impossible without creating a laboratory setup. A laboratory setup was created, on the basis of which a study of resonances was conducted.

Results. The experiment was carried out in a laboratory at an ambient temperature of + 18 °C. The measurements were carried out in the frequency range from 100 to 10,000 Hz. The calculated value of the total resonance change for a window enclosure without fixed stiffeners was 0.1117 V.

Table 1 presents the obtained indicators of changes in the level of maximum resonances of a window fence with fixed stiffeners to the window fence without installed stiffeners.

Table. – Indicators of changes in the maximum resonances of the window fencing with fixed stiffeners to the window fencing without installed stiffeners

Indicatorschangesresonances	Stiffener Schemes								
	a	b	c	d	e	f	g	h	i
Sum max. resonance amplitudes $\sum_{Ri}$, V	0.1215	0.1016	0.099	0.1005	0.0993	0.1135	0.0979	0.1003	0.1038
Levelchanges max.amplitudesresonances with installedribsstiffness δ_n, dB	0,7304	-0,8231	-1,0483	-0,9177	-1,0220	0,1388	-1,1454	-0,9350	-0,6371

From Table it can be seen that the scheme g has the maximum level of variation of the maximum amplitudes of resonances, and the schemes a and f, on the contrary, increase the intensity of the sound wave due to the resulting resonances. Scheme g showed an increase in the security of speech information by 12.3%, compared to window barriers without stiffeners.

For example, figure 2 shows the frequency response of the circuits with the highest rate of change in the level of the maximum amplitudes of resonances using 4 and 2 stiffeners e, g and window fencing without stiffeners installed on it.

The graph shows that for circuits g and e, the resonance is shifted in frequency. So when using the g scheme, the resonance from the frequency of 3240 Hz of window fencing without installed stiffeners shifted to the frequency of 3048 Hz, the level of voice information security increased. A scheme e in this frequency band shows a decrease in the level of security of speech information and the shift of the resonance from 3240 Hz to 3146 Hz. In general, in all bands, g and e circuits showed an increase in the level of voice information security.

To increase the visibility of the frequency offset of the resonances, Figure 3 shows the dependence of the change in the maximum resonance level on the frequency when stiffening ribs are installed, with respect to the resonances of the window fencing without stiffening ribs, calculated by fomule:

$$i = 20\lg\frac{U_{Ri}}{U_{R0}}, \partial Б .$$

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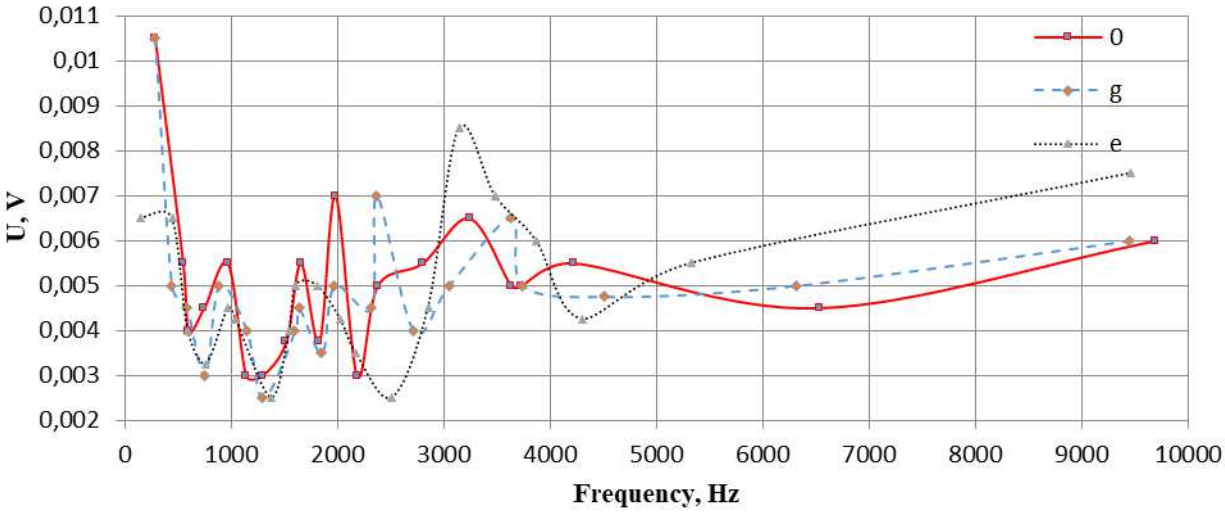
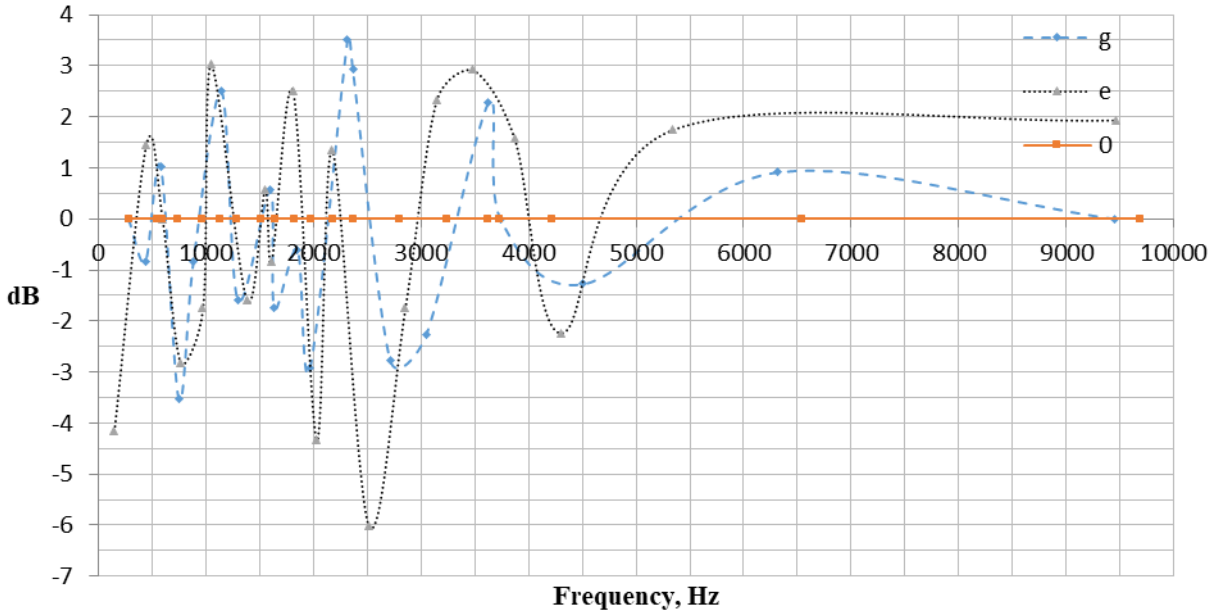


0 – window fencing without stiffeners; *g* – two vertical and two horizontal; *e* – two parallel oblique
Figure 2. – Schemes e, g and window fencing without stiffeners installed on it



0 - window fencing without stiffeners; *g* - two vertical and two horizontal; *e* - two parallel oblique
Figure 3. – The dependence of the change in the maximum level of resonance on the frequency when stiffening ribs are installed

In Figure 3, the graph shows how much the maximum resonance level with the stiffening ribs has changed. The positive values of the graphs on the ordinate axis reflect an increase in the maximum resonance - a decrease in security. Negative values - decrease in the maximum resonance or increase the security of speech information. Ideally, the stiffening ribs should be plotted in negative values of the y-axis for all frequencies. The absence of a change in the maximum resonances plots the graph along the ordinate axis. For the presented values, the graphs clearly show the change in the frequencies of maximum resonances with stiffening ribs installed. The change of resonances for most bands in the range from -6 to 3.5 dB is also traced.

Conclusion. The paper proposes and justifies a way to increase the security of speech information by attaching glass tubes (stiffeners) to a window fence. Fastening stiffeners allowed in various schemes. Some of the possible schemes investigated in the work showed a decrease in the overall maximum resonance of window barriers, which increases the security of speech information.

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With the help of the developed laboratory installation, a study of the window fence was performed. Calculated changes in total maximum resonance when stiffening ribs are installed.

As a result, it was revealed that:

1. The scheme of stiffeners **g** (two vertical and two horizontal glass tubes) has the highest level of attenuation of the total maximum resonance, and shows an increase in the level of protection of speech information by 12.3% or -1.145 dB compared to window fencing without stiffeners.

2. When using stiffeners, in addition to changing the level of the maximum resonance, there is the effect of shifting sound resonances. The offset of the sound frequencies of the resonances depends on the stiffening ribs scheme used. Thus, by selecting the most optimal stiffener schemes for window fencing, it is possible to eliminate or reduce the resonances of the window fencing.

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