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PILE FOUNDATION IN THE INTEGUMENTARY DEPOSITS OF IRAQI MESOPOTAMIA

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The paper presents the results of field tests of piles in Mesopotamia. In spite of the marked drawback of the American methods (ASTM) practiced in Iraq, it was concluded that it's feasible to implement a building practice of Iraq actions of the Belarusian standard. Pressed load should start such in which the settlement pile of tens of millimeters and there is a complete failure of the shear forces along the barrel. Reliable estimate of the ultimate bearing capacity of piles should be performed after additional field studies.

The natural basis structures in these regions of Iraq, in most cases are clay soils. Based on data from engineering and geological surveys in the design of raft and strip foundations of low-rise buildings should be limited to the contact pressure approximately 80 – 110 kPa, where settlement reaches the normative values. [1].

If necessary, transfer the base of large concentrated loads and avoid high deformability in such circumstances expedient to apply the foundations of deep deposits. Characteristic for the Mesopotamian area of Mesopotamia geotechnical incisions to a depth of 20 to 30 m and drilling are presented in the work of column. [2]

Planned in some areas of Mesopotamia construction of unique objects for Iraq (support span bridges, slab-bottoms tank capacitive, high-rise buildings) led to the relevance of the use of high load-bearing capacity of foundations. In areas of Mesopotamia the author tested piles pressed by statistical load (Fig. 1). In all cases, the pile cut through the clay layer with the lower end of the pile rests on a layer of sandy soil. In Al-Nasiriyah 2-meter layer of clay on the 4-meter layer of sand underlain by clay formation. In Al-Diwaniyah 14-meter layer of clay soil is underlain by sand sediments. In Khder 7-meter layer of clay soil is underlain by fine sand. Test piles are made in Iraq practiced by American method (ASTM) [4]. Figure 2 shows a plot of the settlement S from load P, and marked by the length of piles. Shutter speed under load was 1 hour and then proceeds to the next step. In this stabilization could remain unfinished, which should be attributed to the shortcomings of this technique.

The presented in Figure 2 graphs show that the actual settlement piles define the value 2,77 – 7,61 mm. In this case, for small values of settlement piles that do not even reach maximal shift is not possible to judge the actual full load-bearing capacity. Soil shears resistance along the side surface of the barrel and compress them at the low end, were not realized to the full magnitude we can conclude that the piles are able to take the load more than their value in the experience. Therefore, the final decision should be taken after further study of piles with higher loads at full pressed settlement measured in tens of millimeters after the collapse of the shear forces along the trunks and inclusion in the process of compression of the soil under their lower ends.

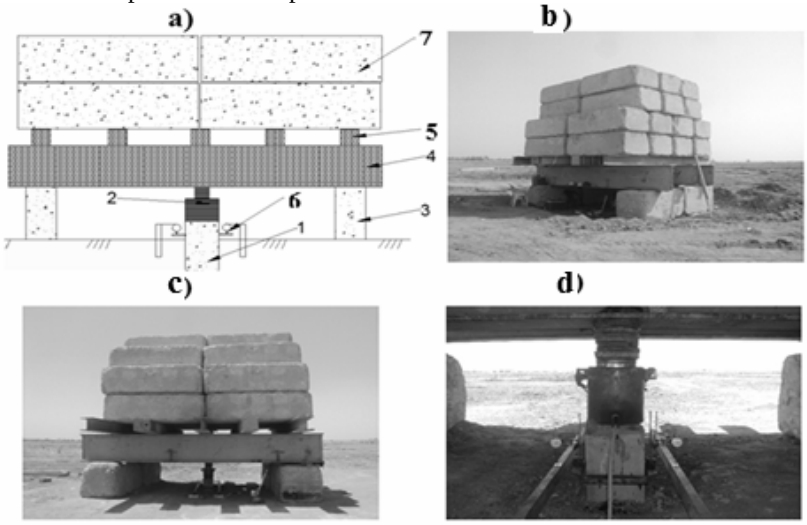

Fig. 1. Diagram and experienced test stand piles indentation:
a) – the platform; **b)** – end view; **c)** – side view; **d)** – jack with the reference Istemi;
1 – testing pile; 2 – hydraulic jack with a pump; 3 – the base support; 4 – longitudinal beam;
5 – crossbar; 6 – the reference system with deflect meter; 7 – load

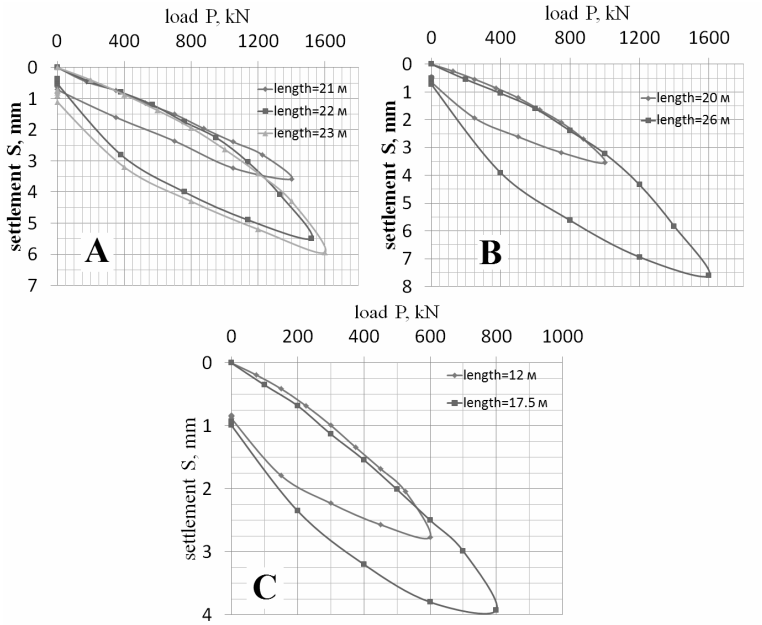

Fig. 2. The graph depending S = *f*(P) (A) Al-Nasiriyah, (B) Al-Diwaniyah, (C) Khder

Practiced Iraq method ASTM piles comprise studies lack of exposure time on loading levels within 1 hour - for this stabilization time cannot end.

In this regard, it is appropriate to use in Iraq techniques Belarusian standard TKP [3], which contains requirements excerpts load steps to stabilize settlements.

Field test piles pressed load in different areas of Mesopotamia have confirmed the possibility of transferring heavy loads on piles, cutting through clay strata and to wipe them with the lower end on the sandy ground they spread. However, due to the limited ability to create value of the pinch load and low precipitation (a few millimeters) of the complete failure of the shear forces along the barrel did not happen.

For accurate final assessment of bearing capacity of piles bases in Mesopotamia they should be tested on the pinch load with bringing settlement trunks to values not less than ten millimeters in which the resistance of the soil under the lower end and the side surface can be realized in full.

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THE STRENGTH CALCULATION FOR BULK MATERIALS STORAGE

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Silage bunker, lateral pressure, Kuhlmann's graphical method, bulk materials, bending moment, symmetry of the load, calculation of strength. The aim of this work is to study issues of identifying the lateral pressure of loose bodies on the walls of bunkers and calculation of internal forces arising from this load. As a result, studies have shown that the presence of a hard core of loose body significantly reduces the amount of sliding wedge, thus reducing the design load. In this work the calculation of the horizontal belt hopper with the use of force in the calculation of statically indeterminate systems is carried out. The result of the studies shows that the presence of the hard core in granular material significantly reduces the amount of sliding wedge, thus reducing the design load.

Storage tanks for bulk materials have acquired wide usage in various industries. The most technologically advanced in the process of construction and operation are tanks of rectangular shape. In the design of silo, bunkers, bridges and retaining walls are used Kulmann's graphical methods [1, 2] to determine the lateral pressure of bulk materials, Kennen-Jansen's and Erie's formula [3]. The derivation of Erie's formulae to determine the horizontal pressure on high walls of infinite height, limiting the granular medium is based on the classical solution of the equilibrium conditions of sliding wedge ACDE, (Fig. 1).

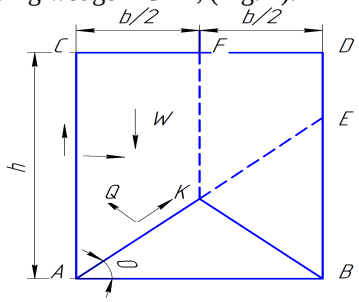

Fig. 1. Design scheme

In calculation of the lateral pressure by Erie's formulas there is a significant discrepancy with the experimental results, which suggests the formation of a hard core of a rechargeable battery (AKB), were the sag of the sliding wedge ACFK and KFDB can occur. To establish this claim we introduce the following assumptions: the backfilling material is taken incoherent by the plane of break of the AU and AK frictional forces. From exercise, the equilibrium conditions of the prism ACFK we obtain:

$$Q = W\frac{tg\theta - \mu}{1-\mu\mu' + (\mu+\mu')\,\mathrm{tg}\,\theta},$$

$$W = \frac{\gamma b}{2}\left(h - \frac{btg\theta}{4}\right),$$

Here θ – the plane angle with the horizon collapse, μ – the coefficient of the backfill internal friction and μ´– the coefficient of friction of the backfill against the containers, γ – the density of the backfilling material. Lateral pressure is the biggest when substituted into the formula of the determined value:

$$tg\theta = \sqrt{\frac{4h}{b}\frac{1+\mu^2}{\mu+\mu'} + \frac{\mu}{\mu+\mu'} + \frac{(\mu-\mu\mu')^2}{(\mu+\mu')^2}} - \frac{1-\mu\mu}{\mu+\mu'}$$

$$\mathrm{tg}\,\theta = \sqrt{Z} - \frac{1-\mu\mu}{\mu+\mu'}$$

The intensity of the lateral wall pressure can be obtained from the condition $q = \frac{dQ}{dn}$,

$$\frac{\gamma b}{2(\mu+\mu)}\left\{1-1{,}5\frac{1+\mu^2}{(\mu+\mu)\sqrt{z}} + \frac{(1+\mu^2)\left[\frac{2h}{b}+\frac{1-\mu\mu}{2(\mu+\mu)}\right]}{(\mu+\mu)\sqrt{z}\left[\frac{4h}{b}+\frac{-\mu}{1+\mu^2}+\frac{(1-\mu\mu)^2}{(\mu+\mu)(1+\mu^2)}\right]}\right.$$

The equation (4) can be simplified if we take:

$$\left[\frac{2h}{b}+\frac{1-\mu\mu'}{2(\mu+\mu')}\right] \div \left[\frac{4h}{b}+\frac{\mu}{1+\mu^2}+\frac{(1-\mu\mu')^2}{(\mu+\mu')(1+\mu^2)}\right] = 0.5$$

$$q = \frac{\gamma b}{2(\mu+\mu')}\left[1-\frac{1+\mu^2}{(\mu+\mu')\sqrt{z}}\right]$$

$$z \to \infty \; q = q_{max} = \left[1-\frac{1+\mu^2}{(\mu+\mu')\sqrt{z}}\right]$$

The largest determining lateral pressure appeared twice as low as that calculated by Erie's formula. On the ground of the analysis of the results obtained in [1] and [2] we propose the replacement of the lateral pressure uniformly distributed around the perimeter by the loading zone of the silo according to the scheme: the short side

of the triangle and the long side of the trapezoid. Such horizontal pressure distribution allows to consider understatement of the value which confirms the results presented in [3].

The rectangular belt hopper is a closed out line, id est, three times not identified by the system. The calculation of the frame is made by force method [4] and [5], the basic system of the force method is shown on the Figure 2.

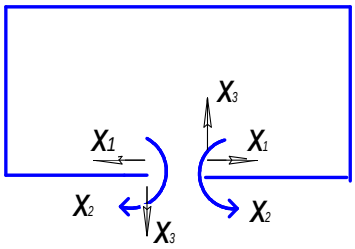

Fig. 2

The System of canonical equations of the force method has the following form:

$$\begin{aligned} \sigma_{11}x_1+\sigma_{12}x_2+\sigma_{13}x_3+\Delta_{1p}=0 \\ \sigma_{21}x_1+\sigma_{22}x_2+\sigma_{23}x_3+\Delta_{2p}=0 \\ \sigma_{31}x_1+\sigma_{32}x_2+\sigma_{33}x_3+\Delta_{3p}=0 \end{aligned} \quad (1)$$

The primary system is formed by using the symmetry properties that allows you to divide the system of equations (1) into the subsystem.

$$\sigma_{11}x_1+\begin{cases}\sigma_{12}x_2+\Delta_{1p}=0 \\ \sigma_{33}x_3+\Delta_{3p}=0\end{cases} \quad (2)$$

$$\sigma_{21}x_1+\{\sigma_{22}x_2+\Delta_{2p}=0 \quad (3)$$

The last of the equations (2,3) becomes an identity due to the symmetry of load. Thus, the problem reduces to solving a system of two equations (2).For calculation the dimensions of the rectangle frame are as follows a = 3m b= 4m.The determination of the coefficients of the unknowns and free members of the canonical equations are satisfied by the graphic-analytical method. Mp diagram is presented in Figure 3.

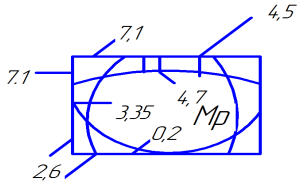

Fig. 3

Solving the system of equations (2)X_1 = -1,52, X_2 = -1,22.
The final diagram is constructed by the formula:

$$M = Mp + м_1x_1 + м_2 x_2.$$

The moment diagram is shown in Figure 4.

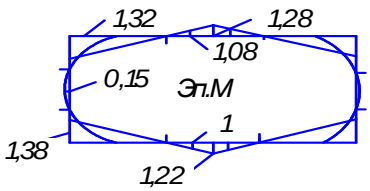

Fig. 4

Comparison of the results of the above calculation with those obtained in [6], [7] are presented in Table.

Point	1	2	3	4	5
Uniform Load	1,31	1,55	0,16	1,55	1,31
The specified load	1,22	1,38	0,15	1,32	1,28

The comparative analysis of the results obtained together with the solutions presented in the [6], [7], where the load is regarded as uniformly distributed along the perimeter of the frame and shows the following. Bending moments in the long side of the middle section are less than 7 %, the average cross-section is less than the short side by 9 %.The greatest reduction of bending moments coincides with the constructional unit and makes about 12 %.

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TO ROOF FRAME OPTIMIZATION

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This paper shows the design criteria truss, identified optimization problem for such structures. Shows an example of calculation for optimization lattice girder supporting roof trusses with a triangular lattice in order to find the most efficient configuration of the body structure.

In the modern industrial, civil, agricultural, construction, and are often used in bridge girders [1, p. 77]. Material for their manufacture may serve as concrete, metal, wood. The geometrical dimensions of the farms are more dependent on the operating conditions. In general, the choices of geometrical parameters are taken into account the requirements of minimum weight farms, as well as the smallest area of the outer contour of the farm. Weight structures made up of weight belts and grids [2, p. 118]. With increasing height the belts farm weight decreases and increases the weight of the lattice due to increase in length and bracing struts. Determining the most effective configuration of the body farm is a major task of optimization.

Lattice trusses should be used small element, a simple form. The choice depends on the type of lattice design features of the farm; method nodal lattice compounds belts bearing on the kind of the column, the desired dimensions of the space between the array elements. The most commonly used with additional triangular lattice struts, since it has the least number of rods and assemblies.

Design criteria such as farm structures are the economic indicators – the cost, weight, complexity, and duration of erection or unique design and aesthetic aspects [3, p. 37]. However, in the latter case, the criteria for examining hard and their use do not fit into the framework of mathematical programming problems. There are currently quite a lot of approximate methods for solving optimization problems of building structures [4, p. 8]. One of the important problems in this area is the development and improvement of methods for solving engineering problems of structural mechanics, which have a maximum simplicity, reasonable accuracy. These methods include the isoperimetric, solving complex optimization for prestressed trusses [4; 5, p. 143]. When using the isoperimetric method in the classical sense solutions are obtained in the form of unilateral or bilateral isoperimetric inequalities characterizing a set of geometric shapes. These inequalities have some practical value and give satisfactory evaluation of physical-mechanical and geometrical characteristics (area, perimeter, aspect ratio, etc.).

As is known, various types of lattice trusses perceive lateral forces [6, p. 121]. As a rule, the system determines the overall complexity of grids manufacturing farm, its metal consumption [7, p. 78]. For example, for farms with parallel belts effective are the use of a triangular lattice, which allows you to obtain the minimum number of identical units and the minimum length of array elements [8, p. 301; 9, p. 113].

Exemplas of optimization farm with a triangular lattice

Consider the example of optimization roof frame triangular lattice (Fig. 1).

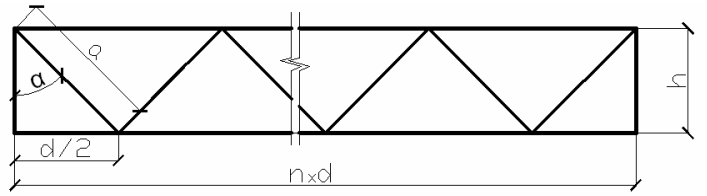

Fig. 1. Roof frame with a triangular lattice

Figure 1 shows the number of farm belts *n*, belt length *d*, length struts *h*, length struts and a variable angle to the vertical brace α. We define the perimeter and the sum of the lengths of internal bracing given the fact that:

$$d = 2a \cdot \sin\alpha; \quad (1)$$

$$h = a \cdot \cos\alpha. \quad (2)$$

The total length of all elements of the farm will be equal to:

$$U = 2a(2n\sin\alpha + \cos\alpha + n). \quad (3)$$

The area bounded by the outer perimeter is equal to:

$$A = a^2 \cdot n \cdot \sin 2\alpha. \quad (4)$$

We define the ratio of the area of the farm limited to the length of the outer perimeter truss elements:

$$K = \frac{A}{U} = \frac{a^2 n \sin 2\alpha}{2a(2n\sin\alpha + \cos\alpha + n)}. \quad (5)$$

To differentiate the function *K* for an unknown corner α:

$$\frac{dK}{d\alpha} = 0. \quad (6)$$

$$2an\cos 2\alpha \cdot [2n\sin\alpha + \cos\alpha + n] = a^2 n \sin 2\alpha [2n\cos\alpha - \sin\alpha] \cdot \quad (7)$$

Will reduce the resulting equation for *an*:

$$d = 2a \cdot \sin\alpha 2\cos 2\alpha [2n\sin\alpha + \cos\alpha + n] = a\sin 2\alpha [2n\cos\alpha - \sin\alpha] \cdot \quad (8)$$

A further solution of (8) is possible by iteration with the substitution of arbitrary values of *n* and α. The angle of inclination to the vertical brace varies $30\text{-}60^0$, usually a multiple of the value of *n* is 1.5 (3) *m*, and depends on the span of the building.

This optimization technique farm when changing the angle braces can be used for other types of lattices (diagonal, sub diagonal, rhombic). It should be noted that the proposed method of optimization of truss elements refers only to find the most effective configuration of the body structure. It does not take into account the properties of the raw materials, the possible deformation structures, as well as the types of external influences.

Thus, further research in this area must take into account external factors, their values and the material used.

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CONVERSION OF DESIGN PRINCIPLES TO «GREEN» STANDARDS IN REPUBLIC OF BELARUS. SOLAR BATTERIES

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The term «green building» is examined in the article. The definitions of solar batteries and solar panels are given. Advantages and restrictions on the use of solar energy are specified. Some examples of solar panels usage in constructions on the territory of Belarus are presented. The analysis of potential efficiency of solar batteries usage on the territory of the Republic of Belarus at the expense of favorable conditions of insolation is carried out.

In the recent years the relation to housing construction in the highly developed countries has been changing under the influence of such global factors as exhaustion of natural resources, climate changes, overexploitation of lands and growth of population.

It is known that buildings around the world use 40 % of all consumed primary energy, 67 % of electricity, 40 % of raw materials and 14 % of reserves of drinking water, and also make about 35 % of emissions of carbon dioxide and nearly a half of all solid city waste [1]. In this regard, it is necessary to consider the main characteristics of housing in complex: environmental friendliness, profitability, energy efficiency, providing healthy lifestyle and comfort. These principles are fundamental in «green construction».

«Green construction» («Sustainable building») is a practice of construction and exploitation of buildings at simultaneous preservation or improvement of buildings quality, the purpose of which is to decrease the level of energy consumption and material resources throughout all life cycle of the building: beginning with a site choice for design, construction, operation, and finishing with repair and demolition.

The energy which is spent on production of materials is one of the main indicators: the energy consumption is lower, the used material is better. In this regard, steel, plastic, cement belong to the most energy-intensive construction materials, wood – to the least. That is why the statement that wood is the basis of the «green» house and is an environmentally friendly material is right.

The construction of buildings from wood on «green» technologies at this stage of development is actively conducted in the USA, Canada, Europe (Germany, Austria, France, Sweden, Norway, Finland), Japan, South Korea and some other countries. Belarus and Russia are lagging behind the developed countries and for the present use «green» technologies and materials only a little [2].

Most of people don't think over what amount of energy they consume and how these indicators can be lowered due to energy saving. Energy certification gives stimulus to people and to the organizations to invest in energy saving actions in their own buildings. In the Republic of Belarus within the pilot project energy certification of five buildings is carried already out and the results are very impressive [3]. The Renewable Power association has been created, the law «About Renewables» is adopted. Belarus entered the International agency on renewables.

The potential of solar energy in Belarus is rather big. Already now on roofs of private houses a large number of solar batteries appear [4].

«*Solar panels*» (solar batteries) are sets of the «solar cells» connected with each other and enclosed in a frame. «*The solar cell*» (a solar element) represents the small semiconductor device transforming light energy to electric energy.

This phenomenon was opened in 1839 by the French physicist Edmond Bekkerel and called in a consequence «photoeffect». The use of solar energy for receiving electricity has a number of advantages: it doesn't demand fuel, works constantly, silently. It has a long term of accident-free service, reliability, general availability, possibility of any change of power of operating system. Solar panels are an optimum choice for autonomous systems of power supply, but also they

have restrictions: in winter time the productivity of solar batteries decreases by one and a half or two times, they have low efficiency for use in heating systems, the need of high energy efficiency and sufficient intensity of light [5].

In general, in Minsk it is possible to use the same amount of energy, as in Warsaw, Berlin, Amsterdam, London. And in Riga, Tallinn and Scandinavian cities of solar energy it is much less, than in Minsk. Thus Germany provides 20 % of all the needs for energy at the expense of alternative sources, and by the amount of the sun energy it is on the first place in the world. By quantity of the solar energy arriving on a surface, Belarus is at the same level as Germany, Japan, Canada, where the solar power engineering develops very actively. Potential efficiency of solar batteries usage on the territory of the Republic of Belarus only at the expense of favorable conditions of insolation is more than 10 % higher, than in Poland, the Netherlands; it is more than 17 % higher, than in Germany.

In our country there are conditions for the development of the science intensive photo-power. There are large research centers in the field of micro and optoelectronics, the corresponding analytical and production equipment, a number of essential scientific results in the areas of materials science, chemistry, technology of silicon, connections of A3B5, A2B6, formation clarifying luminescent, sheetings, etc. which can be used when developing solar elements. Rather big material base isn't loaded and it is suitable for providing a large-lot production of solar elements and heliostations. In areas there are highly qualified personnel and there is experience of the international scientific cooperation in definite areas. Industrial production of solar batteries in the republic hasn't been developed yet, and there are no consumers as well. But there is a possibility of joint (complementary) use of photo-power with other types of renewables (solar collectors, bio-energetics, etc.). Some niches in Belarus where the photo-power with success can be used can be also found. The special system of preparation and retraining of personnel capable to make solar batteries hasn't been organized so far, but it can be created easily.

Anyway the work on installation of solar panels in the republic has begun. They can serve as an example: the building of Kraysk agricultural cooperative (Fig. 1), the house in Voronyansky St. in Minsk (Fig. 2), one of the buildings of Milavitsa factory (Fig. 3), BSUIR university (Fig. 4) and private houses in Minsk and Minsk area (Fig. 5.) and many others.

Fig. 1. Agricultural cooperative

Fig. 2. Minsk, Voronyansky St.

Fig. 3. Milavitsa factory

Fig. 4. BSUIR

Fig. 5. Private house in Minsk

Installed capacity of station in Kraysk agricultural cooperative makes 70 kW. There are 280 solar batteries and 3 inverters which transform the direct current developed by the battery to the variable. The farm is planned approximately on 400 animals. The electric power requirement of one cowshed with a milking office is about 40 kW • h. The installed batteries will allow supplying in the summer the requirement of this cowshed and one more which construction has only begun. «Excess» energy can be provided to a network. The station cost 1 billion rubles, and has to be repaid approximately in 8 years. In spite of the fact that the buildings belongs to the state, energy will go to a network at the usual price without the raising factor. The state is ready to buy such energy from the private companies three times more expensively than a usual tariff in order to stimulate the development of «green power».

On the rooftop of the building in Voronyansky St. as experiment solar batteries are installed from which the illumination of entrances works. The battery will transform solar energy into electric. The electric power is accumulated and

transferred in the special place where LED lamps are installed. For some years of their usage the economic feasibility in installation of similar solar batteries weren't seen therefore in practice they aren't used widely in Minsk.

The solar thermal collector installed on a roof of one of buildings of Milavitsa factory allows to heat up to 500 l of water.

On the roof of the building of BGUIR and ecological university named after A.D. Sakharov solar batteries are installed, but their application is more for demonstration and education, than practical.

Requirements to modern housing are constantly growing: they can't be satisfied without the use of the most perfect technologies and materials. The ecological assessment of construction materials becomes equivalent to indicators of their bearing ability.

It is necessary to consider the main characteristics of housing in complex: environmental friendliness, profitability, energy efficiency, providing healthy lifestyle and comfort.

The energy which is spent for materials production is one of the main indicators: the lower is energy consumption, the better is material for usage.

The advantages of solar energy usage: lack of fuel need, permanent and silent job during the long term of accident-free service, reliability, general availabilвity, possibility of any change of power of system.

The restrictions of solar batteries usage: decline in production in winter time by one and a half or two times, low efficiency for use in heating systems, need of high energy efficiency and sufficient intensity of light.

Potential efficiency of use of solar batteries on the territory of the Republic of Belarus only at the expense of favorable conditions of insolation is more than 10 % higher, than in Poland, the Netherlands; is more than 17 % higher, than in Germany.

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UDC 624.04: 620.17 (043.3)

EXPERIMENTAL STUDY OF WELDED BEAMS, SUPPORTED BY SLOPING REINFORCEMENT RIBON A FLAT BEND

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The article investigates the impact of the geometry and type of sloping reinforcement rib on the bending stiffness of reinforced thin-walled bars. Experimental study is designed to determine the coefficient changesin deformability of beams in the formulation along their length of sloping reinforcement rib. A quantitative assessment of the impact of sloping reinforcement rib on the stiffness of thin rods with bending moment is given.

The theory calculation of thin-walled spatial rods (they include I-composite beams) is continuously improving on the basis of the achievements in the field of theoretical and experimental studies. However, the foresaid does not apply to simple bending of thin-walled open section with sloping reinforcement rib.

In the special literature, predominantly national, only a few papers of theoretical [1, 2, 3, 5] and experimental [4, 6, 7] character are published, in which the authors discuss the issue of the steel continuous beams to flat bend with walls reinforced of sloping rib. The main disadvantage of these experimental studies was that they were conducted on models with small geometric dimensions (L = 1500mm). The lack of complete experimental data on the effect in an arbitrary section of the beam, as well as its bending stiffness required further research implementation, which are described below.

Moving in the middle of the span is found according to the formula Mor-Vereshchagin.

$$\Delta_i = \sum \int_0^l \frac{m_i \cdot M_P}{EI} dx \,. \tag{1}$$

Moments of cargo and unit status:

$$M_P^x = (\frac{ql}{2} \cdot x - \frac{qxl}{2}), \quad m_1^x = \frac{1}{2} x \,. \tag{2}$$

Installation of sloping reinforcement rib stiffness along the length of the element will change and therefore, to find a displacement mid-span it is needed to consider cross-sections with different rigidities.

That is why this equation moving section of the beam at mid-span:

$$\Delta_i = \sum \int_0^l \frac{m_1^x \cdot M_P^x}{EI} dx = 2 \int_0^{\frac{1}{2}l} \frac{(\frac{1}{2} l)(\frac{ql}{2} \cdot x - \frac{qx^2}{2})}{EI} dx, \quad (3)$$

where I ≠ const.

As the moment of inertia in this case is variable, we will set its value piecewise intervals in which will be determined in accordance with Figure 1.

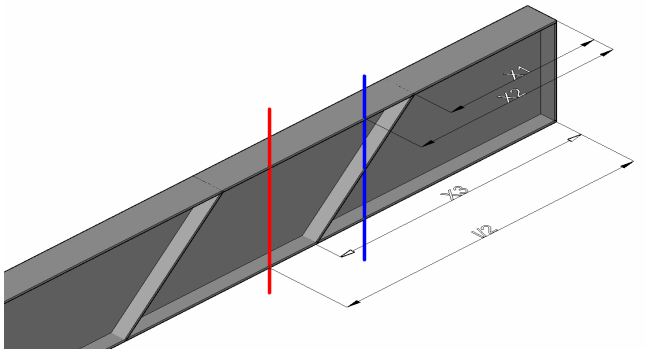

Fig. 1. Determination of intervals piecewise

Since the neutral axis passes through the center of gravity of the cross section, its position on a plot X3 ≥ x ≥ X1is determined from the condition:

$$t_f \cdot b_f \cdot (\frac{t_f}{2} + h_w - s(x)) + (h_w - s(x)) \cdot t_w \cdot (\frac{h_w - s(x)}{2}) - (t_f \cdot b_f \cdot (\frac{t_f}{2} + s(x)) + s(x) \cdot t_w \cdot \frac{s(x)}{2}) - \frac{t_r}{\cos\alpha} \cdot (b_f - t_w) \cdot (\frac{t_r}{2\cos\alpha} + s(x) - x \cdot \tan\alpha) = 0, \quad (4)$$

where s(x) – distance from the upper face of the bottom chord to the center of gravity of the cross section.

Hence:

$$s(x) = \frac{\frac{h_w^2 \cdot t_w}{2} - \frac{t_f^2 \cdot b_f}{2} + b_f \cdot t_f \cdot (\frac{t_f}{2} + h_w) + \frac{t_r \cdot (b_f - t_w) \cdot (x \cdot \tan\alpha - \frac{t_r}{2\cos\alpha})}{\cos\alpha}}{2 \cdot b_f \cdot t_f + h_w \cdot t_w + \frac{t_r \cdot (b_f - t_w)}{\cos\alpha}}. \quad (5)$$

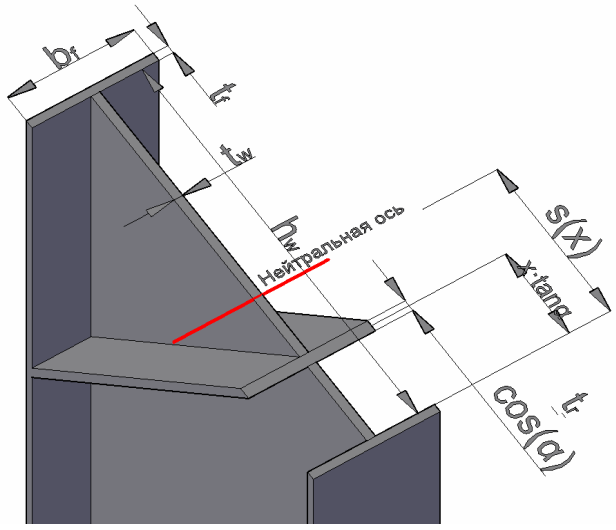

Fig. 2. Determination of the moment of inertia with tilt edges

Thus, the moment of inertia of I-section, supported by sloping ribs can be represented in the form:

$$I(x)=\begin{cases} 0\le x<x1\rightarrow 2\cdot\left(\frac{b_f\cdot t_f^3}{12}+b_f\cdot t_f\cdot\left(\frac{h_w}{2}+\frac{t_f}{2}\right)^2\right)+\frac{t_w\cdot h_w^3}{12} \\ x1\le x\le x2\rightarrow \left(2\cdot\frac{b_f\cdot t_f^3}{12}+b_f\cdot t_f\cdot\left(\left(\frac{t_f}{2}+h_w-s(|x1-x|)\right)^2+\left(\frac{t_f}{2}+s(|x1-x|)\right)^2\right)\right)+ \\ +\left(\frac{t_w\cdot h_w^3}{12}+t_w\cdot h_w\cdot\left(\frac{h_w}{2}-s(|x1-x|)\right)^2\right)+\left(\frac{b_r\cdot\left(\frac{t_r}{\cos(\alpha)}\right)^3}{12}+\frac{t_r}{\cos(\alpha)}\cdot b_r\cdot\left(s(|x1-x|)-|x1-x|\cdot\tan(\alpha)\right)^2\right) \\ x2\le x\le x3\rightarrow \left(2\cdot\frac{b_f\cdot t_f^3}{12}+b_f\cdot t_f\cdot\left(\left(\frac{t_f}{2}+h_w-s(|x3-x|)\right)^2+\left(\frac{t_f}{2}+s(|x3-x|)\right)^2\right)\right)+ \\ +\left(\frac{t_w\cdot h_w^3}{12}+t_w\cdot h_w\cdot\left(\frac{h_w}{2}-s(|x3-x|)\right)^2\right)+\left(\frac{b_r\cdot\left(\frac{t_r}{\cos(\alpha)}\right)^3}{12}+\frac{t_r}{\cos(\alpha)}\cdot b_r\cdot\left(s(|x3-x|)-|x3-x|\cdot\tan(\alpha)\right)^2\right) \\ x3<x\le x4\rightarrow 2\cdot\left(\frac{b_f\cdot t_f^3}{12}+b_f\cdot t_f\cdot\left(\frac{h_w}{2}+\frac{t_f}{2}\right)^2\right)+\frac{t_w\cdot h_w^3}{12} \end{cases}. \quad (6)$$

Experimental studies of beams with sloping ribs on a flat bending was conducted on seven models of welded single-span simply supported beam pivotally-I-symmetric airfoil span L = 3 m cross-sectional dimension: the wall – 500×10 mm, horizontal sheets – 150×10 mm. Alignment along the length of the test beams and dimensions of inclined stiffening ribs are shown in Figure 3.

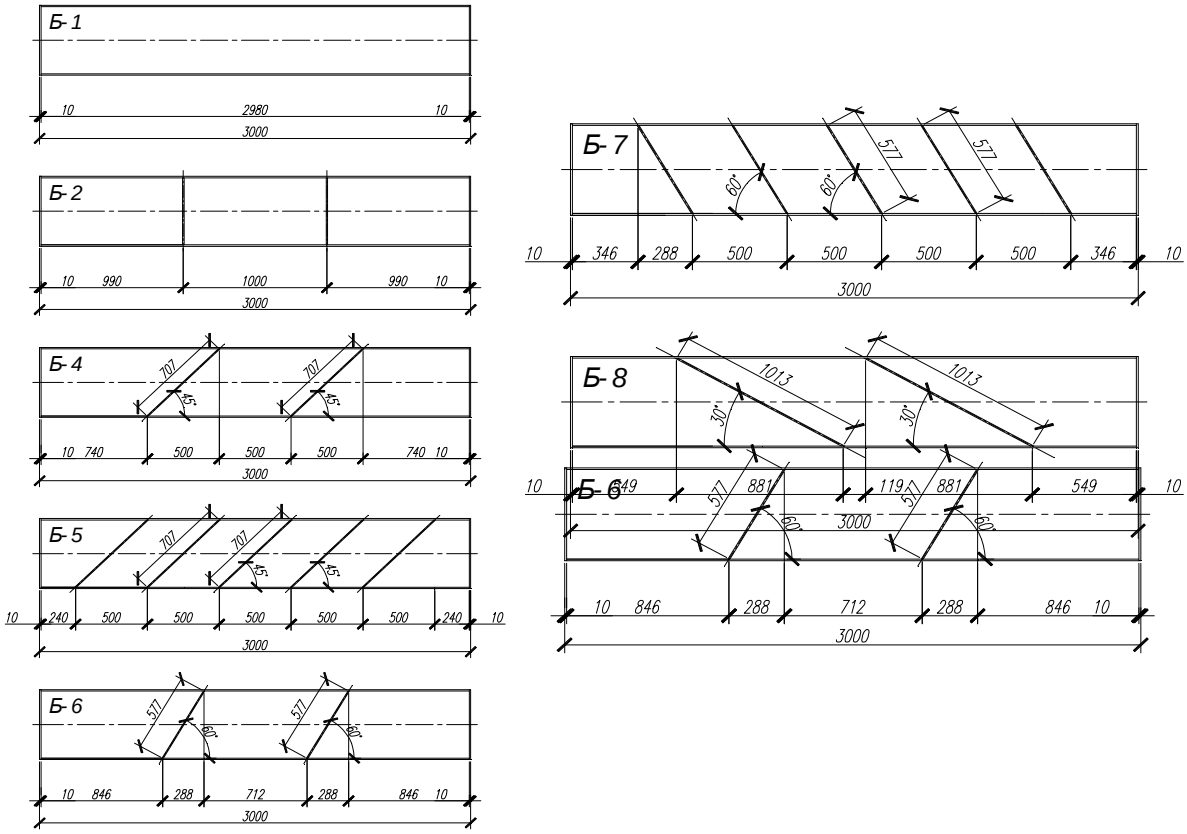

Fig. 3

Beams were made of steel BM-ST 3ps GOST 380-60 *, welding zones, walls and inclined ribs were conducted electrodes E-42A with a thickness of 8 mm seam. Each beam was tested in the horizontal position on the 200-ton hydraulic press.

The load as a concentrated force P was passed at mid span through the square stamp size 60×60 mm to the compressed zone in the plane of maximum stiffness.

Monitor stresses in these sections was performed using strain sensors mounted on the wall and belts in compressed and stretched zones.

The load was transmitted steps from zero to 32 tons with a constant step 4 tons. Moreover, the research was fulfilled for the load, increasing by stages, it was held for 20 – 25 minutes at each subsequent stage reaches.

Table 1 summarizes the data theoretically, numerical and experimental research.

Table 1 – Summary table of results

Name	Test data		Data of numerical solutions		Theoretical data	
	Deflection, mm	σx, max, MPa	Deflection, mm	σx, max, MPa	Deflection, mm	σx, max, MPa
B-1 (without ribs)	3,09	220,27	3,02	167,81	2,76	191,68
B-2 (2 ribs 90°)	3	220,27	3	167,37	2,76	191,68
B-4 (2 ribs 45°)	2,89	198,14	2,96	169,43	2,63	191,68
B-5 (5 ribs 45°)	3,01	166,73	2,91	168,78	2.62	191,67
B-6 (2 ribs 60°)	2,87	198,45	2,98	168,44	2,67	191,68
B-7 (5 ribs 60°)	3,08	177,75	2,96	167,72	2.69	191,67
B-8 (2 ribs 30°)	3,11	203,96	2,87	173,73	2,58	191,68

Thanks to setting sloping reinforcement rib the stiffness of reinforcement rods is increased. The deflection can be reduced by 1,3 – 14,5%. Normal stress σ_x in dangerous section can be reduced by 4,4 – 24,3 % while increasing the total weight of the structure by 1,8 – 13,3 %.

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UDC 624.014.2

ON THE USE OF TRUSSES WITH LOWER AND UPPER TYPE OF BELT BEARING

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The article deals with trusses of lower and upper type of belt bearing, types of the upper belt and mesh, the calculation of the most effective type. The cross section type of the chosen truss is analyzed as well.

Trusses make the bases of numerous framed structures and vary in their usage. They are applied in ceilings, floors, as profiled walls of covers, shifts, etc. Trusses are applied in various fields of engineering: bridges, frames of industrial buildings, sports objects, halls, stage constructions, tents and runways.

Trusses have various shapes depending on architectural and functional specifications of the design. Geometry of a truss is specified by the belt shape and the mesh type.

According to the belt shape trusses are divided into trapezoid, triangular, parabolic or segment, polygonal, flat-chord trusses (Fig. 1).

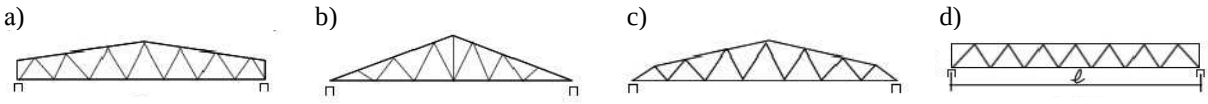

Fig. 1. Trusses according to the belt shape: a) trapezoid; b) triangular; c) polygonal; d) flat-cross

According to the mesh type trusses are divided into braced diagonal, triangular, triangular with additional poles, triangular with truss poles, rhombic, cross (Fig. 2).

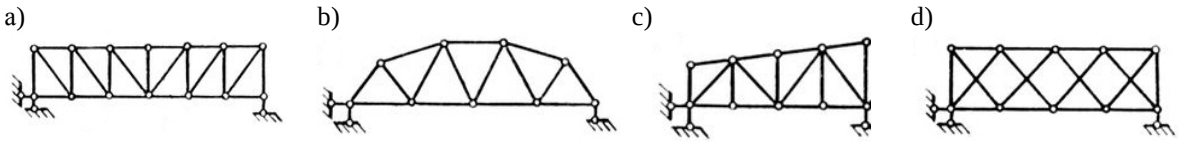

Fig. 2. Trusses according to the mesh type:
a) diagonal; b) triangular; c) triangular with additional poles; d) cross

Flat-chord and trapezoid belt trusses are used more often. Lenticular and former trapezoid trusses, applied in the construction of the entry zones of buildings, have recently become rather widespread as well. There are only two types of bearings among all the types of the truss constructions: the lower and the upper belt. The lower belt bearing type was typical of the XX-century buildings. The upper belt bearing type construction has recently found its industrial application in Vitebsk region, Belarus. Nowadays closed profiles are used for cross-section manufacturing: double angles, channels. The choice of the bearing type and the most effective cross-section shape of the belt are the issues to be clarified.

To find the most effective type of bearing the building of the rehabilitation water centre was chosen as a diploma project as well.

The building designed consists of a two-storeyed part – administrative and economic room, and a one-storeyed part – a swimming pool. General characteristics are 27,38 × 39,4 × 12,2m.

The space of the swimming pool was examined for the possible usage of trusses (Fig. 2).

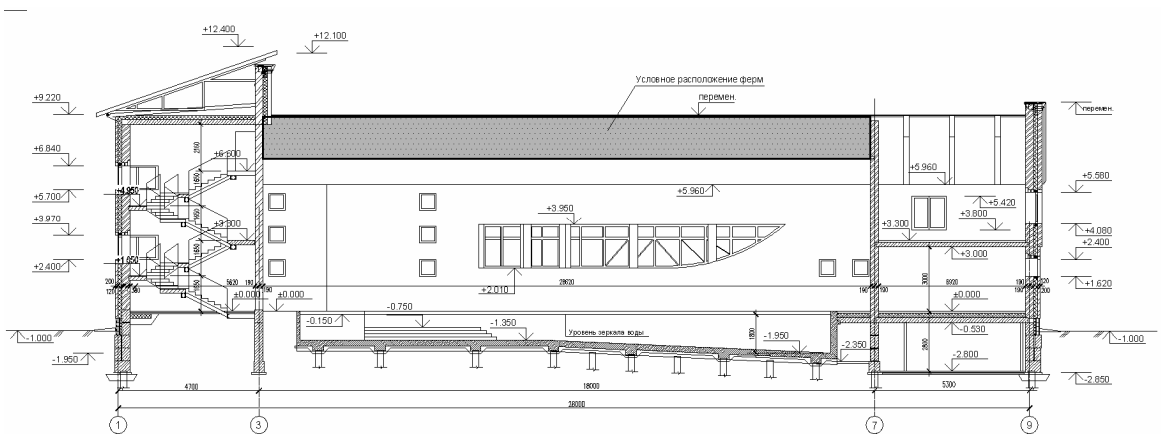

Fig.1. Section of the building

Two trusses of trapezoid belt and diagonal mesh type have been chosen for the experiment, as the most widely used types in the Republic of Belarus. The trusses are of 18 meters span each (Fig. 3).

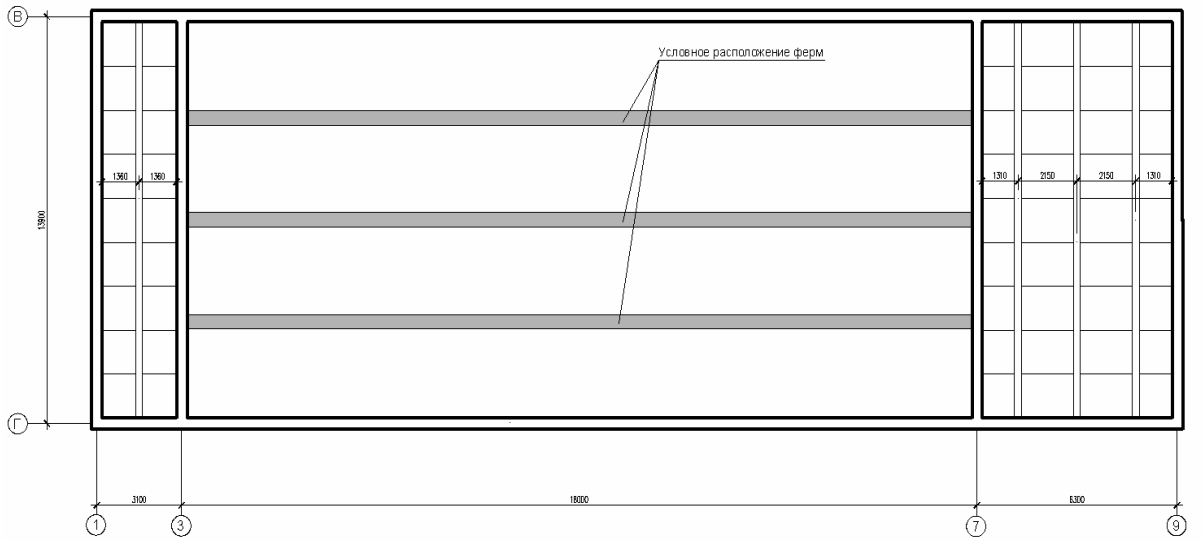

Fig. 2. Allocation of the trusses

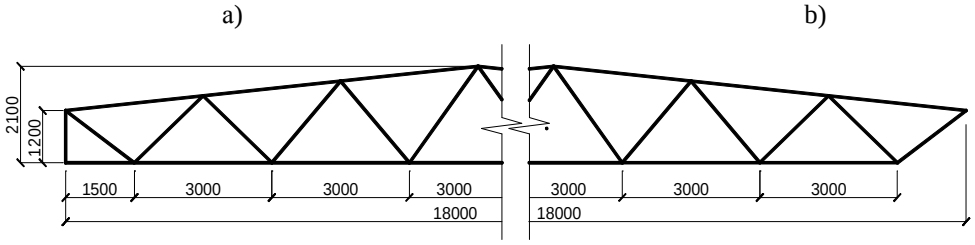

Fig. 3. The studied trusses: a) the lower bearing type; b) the upper bearing type

Sizes, belt shapes and diagonals are assumed as equal. Equal unit load is applied to find the internal forces. Forces of the poles are shown in Figure 4.

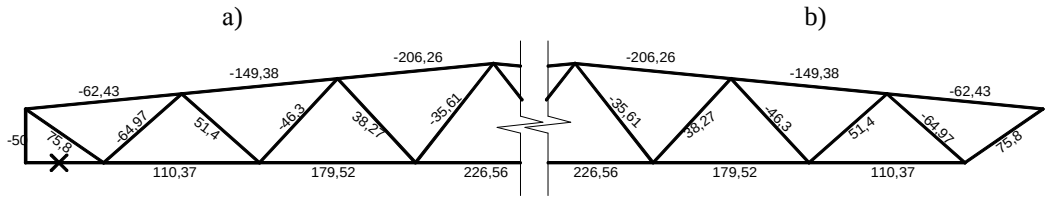

Fig. 4. Forces of the poles of the trusses: a) forces of the lower bearing type trusses;
b) forces of the upper bearing type trusses

According to the calculations the forces of the poles are identical. The upper bearing belt truss is more economically sound as the material consumption for a truss is 10 per cent less, when the span is 18 meters. So the upper bearing type truss is relevant for further research.

Three types of belt sections are compared and the most effective type of the section is found for the chosen type of the truss. The results are arranged in the table (Table 1).

Table 1 – Belts characteristics

Section	Size, mm	Area *A*, cm^2	Radius of inertia *i*, cm	Mass 1m, kg
	75x75x5	14,78	3,35	11,6
	102x4,5	13,8	3,5	10,82
	100x100x3,5	13,19	3,91	10,36

The results prove that a bent-weld-and-closed profile is the most effective one according to its characteristics.

In conclusion it is important to say that the upper bearing type truss is the most economically sound type due to 10 per cent lower material consumption for each truss, when the span is 18 meters. Bend-weld-and-closed profile is the most effective, among the studied, due to its lower mass and section area.

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UDC 691-405

MIXTURES AND THEIR CHARACTERISTICS

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Here the mixture, which used for filling up the pores of macadam basis and promoting receiving the monolithic basis with the minimum of shrink deformations and with the help of a vibrodelivery method and penetration viscometer are considered.

The aim of our research is cement dough, the methods of its best arrangement between macadam base, as the aim of our research – to create a monolith, which will be strong, rigid, and non-shrink. It is an important characteristic of the highway.

We can determine viscosity of a raw mix by the penetration viscometer. The principle of operation of the PM-3 penetration viscometer (Fig. 1) is the following:

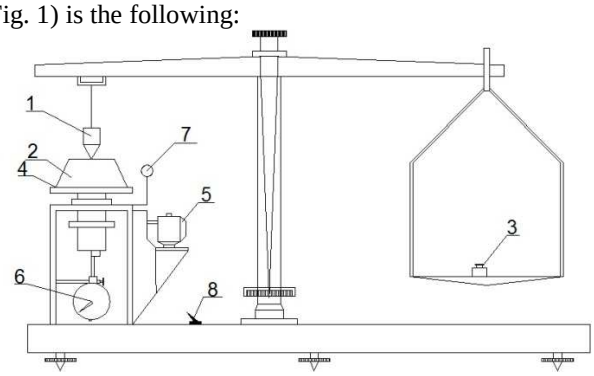

Fig. 1. Penetration viscometer PM-3 (1 – cone; 2 – model; 3 – scale with weightes; 4 – little table; 5 – electric motor; 6 – indicator; 7 – lamp; 8 – switch)

The principle of operation of the penetration viscometer shows that by results of measurements on the penetration viscometer the limit tension of shift τ_0, and the operating tension of shift τ which part, except τ_0, is the dynamic component depending on viscosity and a gradient of speed in a shifted layer is defined not. Thus, for definition of rheological characteristics by results of measurements on the penetration PM-3 viscometer it is necessary to know the character and the sizes of the shift area of the studied environment at movement in it the conic indicator, and also the size of a gradient of speed of shift [1, p. 9].

Let's consider the deformation scheme which is of great importance as it is the characteristic for the majority of the raw mixes applied in production of construction materials. Figure 2 shows that the particles of the environment adjacent to a surface of a cone, move together with the last, and at a certain distance from a cone surface where a trajectory of movement of particles pass to horizontals, they aren't mobile. Therefore, in all deformable volume there is a shift. Thus the sliding surface I-I, dividing deformable and not deformable volumes

of the environment, is the cone surface which top coincides with top of a conic indenter. Tags on horizontal layers of the material, formed by immersion of a thin steel plate in strictly vertical direction in a sample before introduction of a cone (Fig. 2). Therefore, particles of the environment move vertically. [1, p 12]

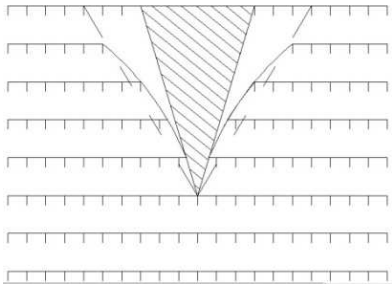

Fig. 2. Trajectory and diagram speeds of movement of particles
at cone immersion in clay and cement dough; cement and sand solution, silicate mix

At separate concreting of designs by vibrodelivery way it is necessary to use mixtures with grains of the different diameter, answering to the requirements shown to them, as to materials for concrete. However the major additional technologies property which grains with the maximum diameter have to have at separate concreting, their ability to pass cement dough in intergrain space is. In steam channels of filling up from grains as a peculiar incompressible viscous liquid with determination mobility can identify movement with the maximum diameter of cement dough from filtration viscous liquid in the porous environment. One of parameters of the porous environment, characterized its ability to pass through itself viscous liquids, is hollowness.

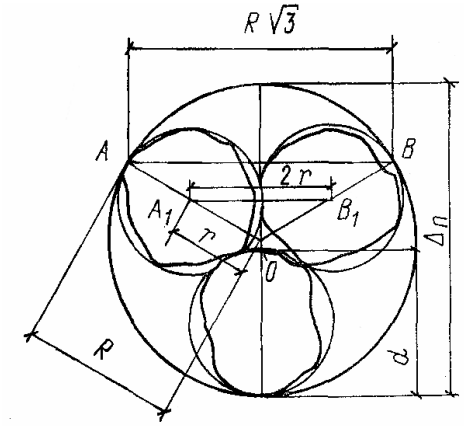

Fig. 3. Arrangement of grains of sand in a round time at formation of a steady wedge

The meaning of optimization of granulometric structure mixed knitting is defining when construction materials are receiving. As the powders mixed from particles of different types and the sizes, which form spatial structural units clusters that conducts to streamlining of disperse system. The maximum instability is observed on the boards of the section of structural units. Therefore, it is necessary to consider their qualitative and quantitative structure, depending on the purpose of the mixed powders.

The models of the new class «Mixture-mixture-feature», offered in works is perspective are used for the solution of tasks of the analysis and optimization of the mixed knitting.

Granulometry of powders – interdependent factors form «mixture».

Average values of results of explosive durability in points of the plan are shown in tables (for powders without lime table 1.1, from 10 % of lime table 1.2, from 30 % of lime table 1.3). Values of explosive durability are expressed in PA.

Table 1.1 – for powders without lime

1	2	3	4	5	6	7	8
2,69	3,12	2,19	2,35	2,34	2,71	2,65	2,28

9	10	11	12	13	14	15
2,56	2,17	2,24	2,78	2,35	2,74	2,70

Table 1.2 – for powders from 10 % of lime

1	2	3	4	5	6	7	8
3,63	3,99	3,25	2,86	2,69	3,38	3,61	3,48

9	10	11	12	13	14	15
2,83	2,73	2,95	2,86	3,04	3,39	2,93

Table 1.3 – for powders from 30 % of lime

1	2	3	4	5	6	7	8
4,52	4,80	4,42	4,10	3,61	3,67	3,51	3,60

9	10	11	12	13	14	15
3,65	4,08	3,95	4,06	4,19	3,56	3,43

From the tables it is obvious that it is possible to regulate structure of a mix and to select the most favorable structure by means of composition change of powders [2].

The packings of spherical particles modeling monodisperse silica gels of varying density are constructed by the Monte Carlo method. Each model contains 8000 particles in a cube with periodic boundary conditions. Models with densities (extents of space filling) $\eta = 0,59$ and $\eta = 0,37$ were studied in detail. For quantitative analysis of the structure of empty interparticle space, Voronoi-Delaunay geometrical constructions are used. By analogy with the mercury porosimetry method, the «intrusion» curves, indicating the fraction of the pore volume accessible for a probe of the given size are built. The results of a standard analysis of these curves and the real arrangement of interparticle space in these models are discussed. The approach using the numerical simulation and the geometrical method suggested for model analysis is a promising trend in structural studies of porous materials.

Atomic arrangement is a traditional goal of structural studies. In recent years, however, increasing attention has been paid to another aspect of structure, namely, empty interatomic space. Problems of this kind show promise of interesting applications such as diffusion studies in glasses or chemical potential calculations in liquids. Mass transfer in corpuscular porous materials is a broader application of this aspect of structural research. Disordered packings of spherical particles are rational structural models for such materials; therefore, methods for model construction and analysis elaborated in the physics of fluids and glasses for atomic systems prove to be useful for this problem as well.

For mass transfer in porous materials, it is essential for the micro- and macrostructural problems to be interpenetrated. It is necessary to have a clear understanding of the structure of individual cavities, on the one hand, and to handle the whole system of pores, which is a macroscopic object, on the other. Traditionally, theoretical investigations deal with only one of these problems; the other is treated in a rough approximation. This is partly due to the fact that the pore microstructure may not be quantitatively defined in cases other than elementary. For example, in systems of spherical particles, the simplest pores are configurations of several spheres. In previous works, typical configurations were chosen to be the unit cells of particular crystal lattices. For the unit cell, one can easily use the unit cell approach to the whole system, which is rather problematic, because the majority of the compounds under study are noncrystalline. In another approach admitting the existence of a single pore system, the starting construction is a net of pore nodes (cavities) and bonds (narrow throats). Here problems of different kinds arise. First, the microstructure of the net nodes and bonds, performing the role of the local pores and windows between them, is unknown. Second, the structure and connectivity of the net itself are not clear. No physically justified answers to these questions can be given [3].

At research of the received mixtures, the results of structural durability allow to choose optimum pickings and to pick up mixtures with adjustable steam channels. Features of granulometric mixes structure and existence of steam channels in their structure allow to use a vibrodelivery way of concreting. For similar structure of mixes the penetration method of mixes with different granulometric structure is used and optimization on $D > 40$ d is carried out.

In further researches it is planned to use and cement and sand solutions for concreting of the bases, but additional researches to avoid jamming of structures are necessary.

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ON DEFLECTED MODE OF PRE-CAST AND IN-SITU CONSTRUCTIONS IN THE CONTACT JOINT ZONE

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Pre-cast and in-situ constructions are widely used in building industry of the Republic of Belarus [1, 2]. Such constructions are rather various nowadays. The technology of pre-cast and in-situ slabs production came to Belarus from Europe, where mass erection of detached houses has been applied for more than 50 years already. The most known European and national construction methods, based on gilled pre-cast and in-situ slabs in Belarus and the CIS, are «Dakh», worked out in Polotsk State University and adapted for use in Belarus; pre-cast and in-situ slabs «Marko», Russia, and others [3]. All pre-cast and in-situ constructions include four units: beams of different spatial frame types, block-liners, a mesh and in-situ concrete. The principles of the usage of light-weight reinforced beams are rather similar. The differences are in their configurations and the material of block-liners: porous ceramics, haydite concrete, cellular polystyrene, etc.

Research of pre-cast and in-situ constructions proves the emergence of extra deflected mode as a result of inconsistency of shrinkage and time yield of concrete when traditional concrete, based on Portland cement, is used as an in-situ part of a built-up section.

The matter of research is the influence of shrinkage on deflected mode of the whole construction under working load and its taking into account in design [1]. The information found in literature is rather contradictory.

A great amount of national and foreign research works are devoted to the problem of concrete adherence. In-situ operations, use of permanent forms and study of pre-cast and in-situ constructions stimulate scientists' research activity. Contact joint durability has been widely studied by numerous scientific, design and educational institutes of Belarus: BNTU, BSTU, BelNIIS, PSU; and the CIS: NIIZHB, NIISP.

The concrete adherence matter comes into consideration at the process of reconstruction and newly built pre-cast and in-situ constructions, as there should not be any shift of jointing surfaces. The rate of contact joints between old and new concretes should be minimized [2]. Joints in constructions are widely stressed by bending moments, contractive, stretching and shearing forces.

Estimation of joints resistance to shearing forces, if there are reinforced rods crossing the joint, is one of the most important and complicated issue. Correct estimation of shear strength of a joint influences the combinability of units in the construction and a load-carrying capacity in general [4].

To find the influence of shrinkage strain of concrete in an in-situ unit on shearing forces it is important to find out the strength of the joint by in-situ concrete curing [4].

Figure 1 illustrates the relation of free shrinkage strain to curing.

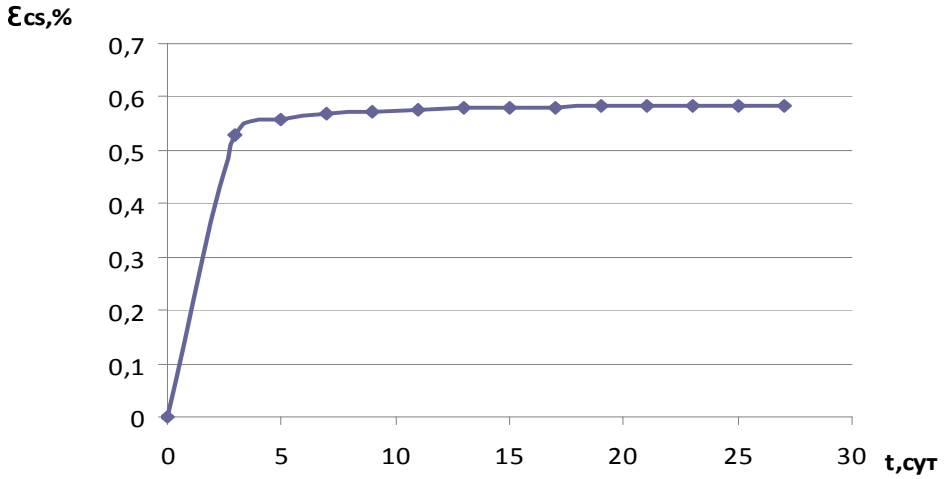

Fig. 1. Relation of free shrinkage strain to curing

Calculations of contact joints durability are carried out on the bases of a pre-cast and in-situ slab «TERIVA» (Poland). Shearing forces in the joint of a pre-cast and in-situ constructions in their performance have been found. Forces of the kind happen due to the difference in shrinkage strain of in-situ and pre-cast concretes and proper weight of a construction (Fig. 2).

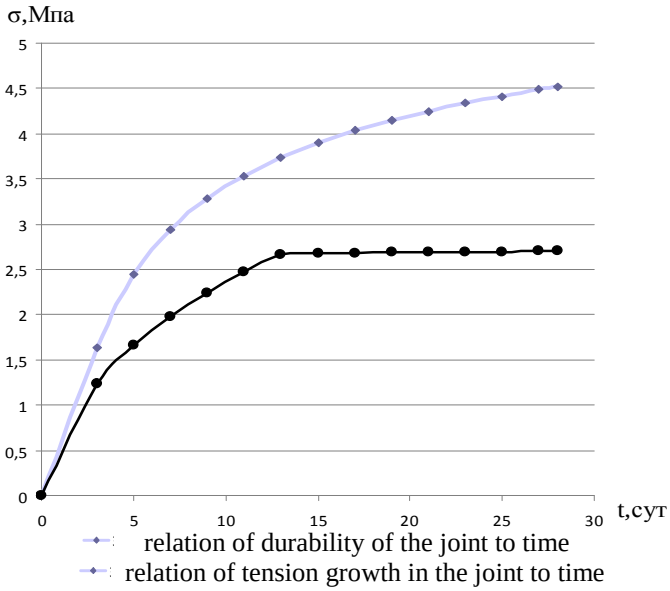

Fig. 2. Data comparison

The data received guarantee the durability of the contact joint because of the stress by in-situ concrete curing. The durability of the joint is almost 27 per cent higher than working shearing stress. So we are sure that shrinkage strain of in-situ concrete influences a pre-cast beam as well as the whole construction. The rate of influence of shrinkage strain on the deflected mode of a construction during its operation requires additional studies.

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TECHNOLOGICAL AND METHODOLOGICAL WORKING-OUTS IN THE SCOPE OF GRADUAL REDUCTION IN POWER CONSUMPTION BY HEATING AND VENTILATION SYSTEMS OF BUILDINGS DURING THEIR MODERNIZATION

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The working-out refers to the technique of heating and ventilation and is proposed for use in the town-planning industry for energy- and resource- saving in heating and air supply to buildings with modern warm attics and ventilated transparent facade systems.

According to current regulations, the ventilation of residential buildings is carried out by means of infiltration through unorganized arrival of outside fresh air into the living space through leaks in the exterior walling, vent or any other ventilation devices. In this case, all the power inputs to heat outdoor air are compensated by the heating systems, which exceed the heat loss through the exterior envelope of buildings. The removal of the ventilation air flow from areas of maximum allocation hazards (kitchens, bathrooms and toilets) is organized through exhaust openings in the volume of warm attics, with the subsequent release of warm air into the atmosphere through the sectional exhaust shafts. This technological scheme of heat and air supply to buildings is too power-consuming, as it does not use the secondary and natural energy sources.

The reduction in power consumption from external sources of heating and ventilation of buildings requires a gradual modernization of technological schemes and design, the creation of new technological solutions, the development of theoretical fundamentals of heat and mass transfer processes and analytical methods of calculation and design of systems of heat and air supply airtight buildings in terms of energy efficiency.

According to the results of research the technological scheme of using warm attics not as three-dimensional sectional exhaust chambers, but as the supply volume chambers with preheating outdoor air due to transmission of heat lost by the building through the floor of the upper floor and the natural heat of solar radiation through the warm floor of the attic with subsequent heat removed exhaust air through the plate heat exchanger installed in the volume of warm attic, for preheating outdoor air supply ventilation air has been developed. (Patent № 9618 «Technological attic of the building» 22.07.2013.)

Hinged transparent facade systems turn out to be very efficient by virtue of architectural and aesthetic parameters, the protection of facades of buildings from atmospheric influences, durability, economy, simplicity of design and a number of other positive qualities of slot ventilated air layer, in which under the influence of the greenhouse effect natural heat of solar radiation is accumulated on the outer side and on the inner side the transmission heat lost through the outer fence is closed by a hinged facade, reinforcing the effect of preheating of outdoor ventilation air supply. (Patent № 8381 «Regenerative device ventilation building» 04.03.2012 г.).

According to Figure 1, it is seen that with a gradual modernization of the building by introducing the technological scheme of warm attics, suspended translucent facades and data sharing activities, the load on the heating system is significantly reduced, and therefore, these activities are energy efficient.

Based on the analysis and generalization of the known technical solutions a complex of measures on further improvement of heating and ventilation systems on the criterion of minimizing energy consumption from external sources due to a more extensive use of internal reserve of potential secondary energy resources and natural heat of solar radiation has been developed. The methodological basis for the analytical calculation and design of systems of heat and air supply to energy efficiency buildings has been formed, confirming the significant reduction of their energy consumption from external sources.

The results of the research are used for educational purposes during lectures and practical sessions, carrying out research on the state budget subject and can be widely used in the practice of urban planning.

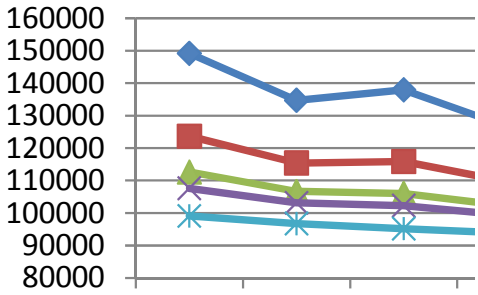

Fig. 1. Diagram showing changes in the thermal load on the heating system with a phased modernization of the building with the introduction of the technological scheme of warm attics and wall facades

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COMBINED AIR AND HEATING SUPPLY SYSTEMS OF AIRPROOF BUILDINGS

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Nowadays the exterior envelope of buildings demands the constant increase in its heat-shielding characteristics. The buildings are designed according to the normative base of the Republic of Belarus. But on the stage of calculating the temperature balance there often occurs the following situation: the heat loss is much less than the heat gains. In this case the entire heating load is directed to the heating of infiltrating air. This air has to be taken inside disorderly but that is not possible because of the high airtight packing of the building envelope. This report represents the technological schemes and practical solutions to the effective energy and heat air supply to the leak tight buildings.

The embedded panel systems are widely used in the buildings with the high standard comfort. The heating elements of the embedded panel systems are normally the coil pipes made of stainless steel.

Water is basically used as a heat carrier in the house construction. Steam is rally used at industrial enterprises and domestic household. This report considers the possibility of overheated air use. The latter can be used as a heat carrier which can be low n through the evacuated canals of concrete panels. This will solve two problems at the same time: heating and air supply.

Heat supply and ventilation systems are the most power- and resource-consuming. Modern engineering equipment must provide the reliability and comfort of handling together with its low value, steel intensity, labor intensity during its installation and the high-tech industrial development of the building construction.

Heat energy, gas and electric power are the most widespread types of power consumption in urban planning branch of economics.

Gas is still most widely used for cooking and water heating but in the near future it will be replaced by electric power because of the hygienic, economic and strategic reasons.

City and industrial heat power plants, big district boiler houses are the source of heating in residential and public places. Individual local boiler houses will be used more seldom because of the air contamination.

The production efficiency of the heat energy is 2,5 times higher than that of the electric power at the ordinary heat power plant. Still the use of the electric power can be economically practical because of the considerable transit waste of heat energy of the branchy centralized systems in big cities or far-away districts.

According to sanitary and ecological standards the biggest heat supply sources are located outside cities. That increases the cost of the construction and operation of heat supply systems.

Heat supply troughs are constructed for heating, ventilating and hot water supply systems. Their structure of the feed through is complex and demands considerable space (from 15 to 100 square meters) depending on the equipment, type and parameters of the carrier. The presence of boosting recycling pump demands the increase of space up to 25 square meters.

Heating systems are related to ventilating systems concerning their final goal-the creation of human comfort in the buildings. That is why the foreign experience of the use of air conditioning systems shows its high operational characteristics.

To compare the achieved level and perspectives of heating-ventilating systems development one must take into consideration the climatic conditions. The climate of the Republic of Belarus is colder than that of many foreign countries. The open air average temperature of the coldest month in Minsk is -6,9 °C, in Vitebsk -7,9 °C, in Berlin -0,3 °C, New York +0,8 °C, in Paris +2,3 °C, in London +4 °C. Because of these differences man) heating-ventilating devices can't be applied in our country.

The research in the sphere of updating the heating-ventilating systems has been constantly carried out for over 25 years by the Chair of Heat/Gas Supply and Ventilation at Polotsk State University. It has been either state financed or self-supported. The huge amount of work has been fulfilled within the sphere of its implemen-

tation into the national economy of the Republic of Belarus, the former USSR with the considerable technical and economical effect.

Figure 1 presents one of the process flow sheets of the building air heat supply. It is suggested to use. The natural and waste energy (solar radiation and exhaust air) are actively used along with the primary source - natural gas and air supply in it.

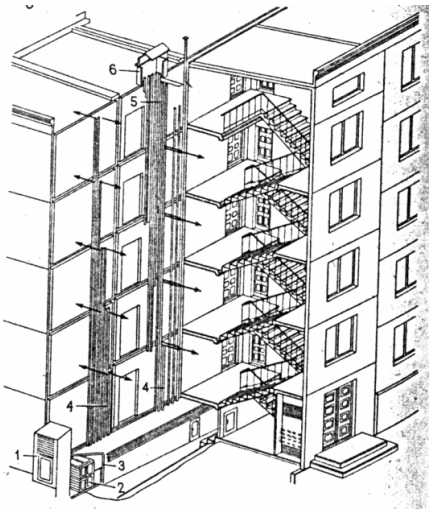

Fig. 1. Air heating of the buildings

The peculiarity of the architectural-planning operation of the multistoried building is the accommodation ladder cage and sectional air flue 5. It gets through all the building. Air flue is constructed as a vertical shell-and-tube heat exchanger. There are gas-burning, devices for air heating (13) in the bottom part of the air flue and also a pan for condensate gathering and drainage. The top part contains clack valve and ventilator (15) for the spent air emission into the atmosphere.

Inside the heat-exchanging hole (dr. 6) there are heat-exchange pipes (6) which are vented to the atmosphere air through the horizontal air flues (7) in the top part and air-intake pipes (3). The air-intake pipes (3) are made up of high-angle panes (2) and the face the outer wall load carrying structure (4). In the bottom part the heat-exchange pipes (are vented to the atmosphere air through the horizontal air flue (8), located in the basement and the air diffusion pipes (9), constructed as attachable ones to the inner surface of the outer wall (4), through supply registers are connected with the rooms, which are vented to atmosphere through the exhaust air terminal (10), vertical pipes (11), horizontal air flues (8), tube space of the heat exchanging hole (5), clack valve or ventilator (15) are vented to the atmosphere.

This process flow diagram shows the natural or positive circulation of the open air through the positive-pressure network of the heating ventilation system. First the open air enters the vertical air-intake pipes. Passing the pipes bottom-up the air is simultaneously and preparatory heated because of the solar radiation heat and transmission heat. Then the air is directed to the heat-exchange hole through the top horizontal air-flues and moves the heat-exchange pipe downwards. The air is simultaneously heated up to 70 % because of the heat utilization of exhaust air which moves as an approach flow bottom-up through the tube space. The final heating to the reference temperature of the incoming air is done with the help of gas-burning devices, equipped with the safety automatics and air temperature control.

Figure 2 shows the temperature calculation results of the incoming and evacuated air during its motion through the heat-exchange hole with the variable conditions depending on the setting temperatures of the open air.

The recommended combined system of heat and air supply has three vertical riser flows in the flow circuit. These riser flows have the height of all the building. There is also a descending current with the changing height. This provides steady natural circulation of the air heat carrier during the heating season. When the open air temperature is increased ($t_п$ > C) and the gravitational pressure is decreased the hole ventilator usage is needed.

The new progressive heat and air supply technologies of residential and public buildings are to be created nowadays. They can provide human comfort according to the criteria of energy, resource-saving and ecology.

Together with the rise of heat-shielding properties of the walling and its tight packing (that twice decreases heat consumption of the buildings) the other efficient way in the urban planning is the further development of the heat supply technology of the buildings with the water replacement on steam and air. That will make possible to get rid of expensive and energy-consuming pumping facilities, which are used to pump huge amounts of water in multitube long-distance and distributing systems and lift on the multistoried building height.

Water pipe lines branchy network, numerous multipurpose hardware, various heating devices are characterized not only by high capital outlays but are also hard to operate because of the high persistence of the water heat carrier.

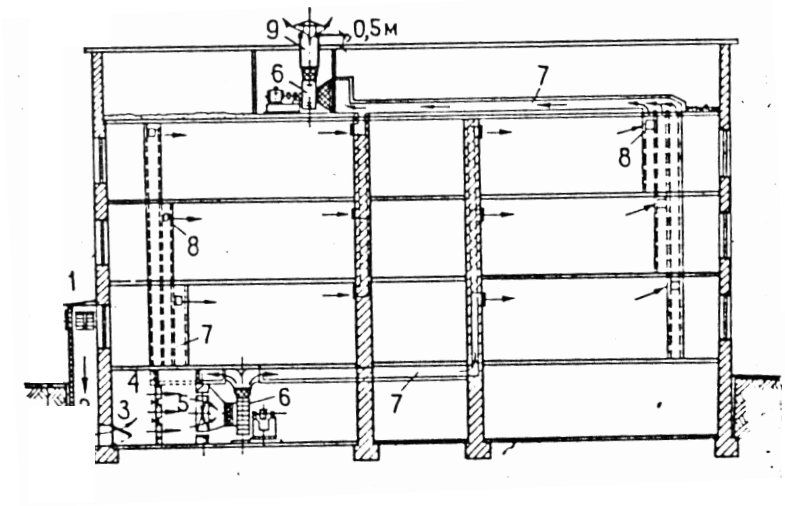

Fig. 2. Ventilating system

The air heating process flow sheet of the multistoried and public houses has many advantages in comparison with the certain analogues. The air heating terminal is practically combined with the ventilation in which the quick-acting types of heat carriers (superheated steam and air) are used.

Figure 1 shows the heating system of the multistoried building of cellar structure (residential buildings, hostels, hotels, sanatoriums etc.), in which the air intake goes through the intake hole 1, heating centre 2, air diffusing hole 3, and vertical channels 4 of the blowing ventilation. The spent air vent is provided through holes 5 of the exhaust ventilation and exhaust hole 6. Only one ventilator can be installed in the enclosures for the rated air change in summer and also during the transition period if there is a little natural draft or there is a lack of it.

The host-based system of mechanical ventilation is preferable for public buildings, demanding high-level of air exchange (shops, banks, hospitals etc). Such systems work according to the heating schedule in which the air motion is forcibly performed by the ventilator, installed in the air handling or exhaust chamber (Fig. 2).

The high pressure air-conditioning systems are installed in multistoried public buildings of cellular structure abroad. The speed of air in their air flues is 20 – 30 m per sec. This allows to decrease the profile of the air flue and the volume it takes in the building. These systems must be equipped with a high-pressure ventilator, an airproof air flue and special acoustic absorbers that set to work during the air outlet into the rooms to prevent aerodynamic noise. These systems can perform heating functions, but they may have high capital and operational costs and are not widely used in the civil engineering construction in our country [2, 3].

It is important and economically practical to construct more effective heating-ventilating systems of residential and public buildings in the Republic of Belarus which imports energy raw resources in the conditions of the world energy crisis. That is a heavy burden for the economy of the whole nation.

Thanks to the implementation of the pipeless heating technology combined with the air supply systems the huge amount of the expensive pumping equipment will be disengaged. Shut-off-and-regulating armature from steel, iron and non-ferrous metal, steel pipes and metal-roll can be used in industry or in agriculture for irrigation systems construction and water supply.

On condition that the energy consumption is decreased (using the air heating technology) more than a third of energy output can be directed on export increase and currency receipts.

The economical effect of the suggested technology implementation in the housing complex of the Republic of Belarus (calculation due to 01.01.2000) is 8, 04 billion US dollars. As for the actual pay off period it is T = 7,18 year. If the competitive product is marketed in Russia the economical effect will be much higher.

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UDC 624.078.4

IMPROVED CONSTRUCTION OF PLATFORM JOINT OF HOLLOW CORE SLABS OF FORMLESS MOLDING

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The improved joint design, in which the vertical pressing force is not transmitted over the entire area of supporting zone by the top of the wall, but «in points» – at the locations of the top working reinforcement, greatly increases the vertical compression of anchoring zone of the upper prestressed reinforcement.

The production of precast prestressed hollow-core slabs of formless molding on long benches has been launched recently in the Republic of Belarus. [1] The feature of the manufacturing processes of such panels is their reinforcement in the form of exceptionally longitudinal prestressed rods (or wire ropes) and the inability to install the shear reinforcement grids in shelves and embedded parts. In addition, the length of the stress transmission area on a concrete reinforcement typically exceeds the length of the site of their bearing on the wall. As a result, a negative bending moment is practically perceived only by a concrete cross-section [2]. It should be noted that during their design and experimental processes hollow core panels are presented as simple beared beam structures. It is not fair for application of the most common platform joints for multi-storey buildings with brick, block and paneled walls. In the bearing zone of slabs due to the entrapment a negative bending moment occurs. The above features of the design of panels in platform joints may result in the formation of shear and cracks with large opening in the bearing zone.

Modern regulations on the design of hollow core panels, in addition to avoiding possible negative bending moments with the help of some structural measures, take account of them in the design calculations [3, 4]. Known methods of structural mechanics calculations for linearly deformable materials without real work of reinforced concrete with cracks and knots compliance do not give reliable results. Therefore, obtaining the dependence «support bending moment – the angle of rotation» in the place of the platform joint is relevant for the account in the calculation of deformation features of hollow-core slabs of formless molding.

In order to increase strength and reduce compliance of anchoring of the top fixtures in the area of the platform joint there was developed the advanced design interface in which the vertical pressing is not transmitted over the entire area of the top supporting the wall, but «in points» – at the locations of the top of fixtures. For this purpose additional steel plates have been used, which were located on the upper ends of the locations of fixtures within its anchorage. In such a construction of platform joint the value of compression reinforcement anchorage zone is multiplied.

The purpose of the experimental study is to validate the proposed design of the platform joint, set the cracking pattern and eventual destruction scheme and establish the dependence «support bending moment – the angle of rotation» in the place of the platform joint.

Experimental research was performed on samples of special-fragments of platform joints, which are two pieces of hollow-core slabs beared as consoled at one end to the lower portion of the vertical wall and pressed in the place of their bearing portion of the top of the vertical wall.

On the upper bound of the plate over the locations of top fixtures on a cement sand mortar steel plates with dimensions of 50 × 100 × 5 mm are installed. The vertical pressing from the overlying floors is transmitted and distributed between the plates by means of distribution traverses with a width of 200 mm enhanced with transverse stiffeners , imitating the upper portion of the vertical wall. The design and dimensions of samples of platform joints, as well as the geometric dimensions and reinforcement of hollow-core slabs are presented in Figure 1.

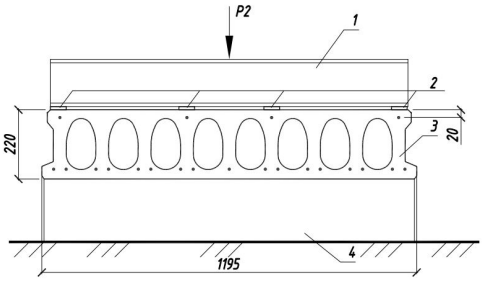

Fig. 1. The geometric dimensions and reinforcement of hollow-core slabs:
1 – distribution traverse; 2 – steel plate; 3 – hollow-core slabs; 4 – wall panel

The sample was tested on a joint platform cantilevered scheme. The plates at one end were supported by a fragment of a wall panel 200 mm thick and at the other – by the end of the lever from the rolling I-beam, which balanced the

weight of the hollow-core slab. The distance from the axis of the platform joint of panels to the point of application of the vertical load was about 2 m. The scheme of a fragment of the experimental setup is shown in Figure 2.

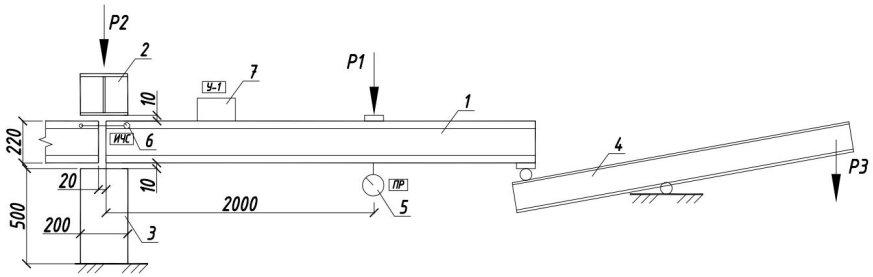

Fig. 2. Schematic of the test set: 1 – hollow-core slabs; 2 – distribution traverse; 3 – wall panel; 4 – Arm; 5 – deflectometer; 6 – the dial gauge; 7 – electronic inclinometer

Experimental research showed the performance of the proposed design of the platform joint. The maximum value of the negative bending moment was 30,7 kNm, which exceeds the value of the bending moment of formation of cracks which equals 22 kNm.

There was a feature noticed in the joint destruction in the local pressing of the anchoring zone of the working reinforcement, which consists in the broken outline of the crack on the upper bound of the plates in the joint area (see Fig. 3, a), as compared with the uniform pressing of the whole area of the upper bearing wall fragment (Fig. 3, b).

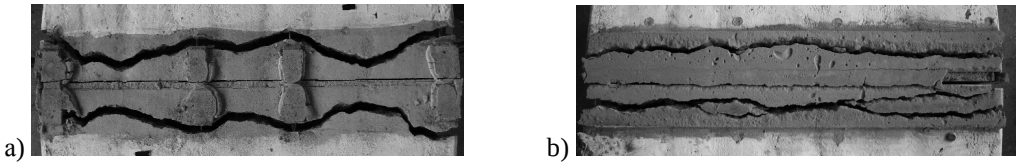

Fig. 3. Appearance of samples after the tests: a) improved joint platform; b) joint platform with uniform pressing

The experimentally obtained dependence «support bending moment – the angle of rotation» in the place of the platform joint allows the calculation of hollow floor slabs of formless molding with platform joints of the proposed design based on the actual scheme of their deformation. The experimental dependence «support bending moment – angle of rotation of the cross section» is shown in Figure 4.

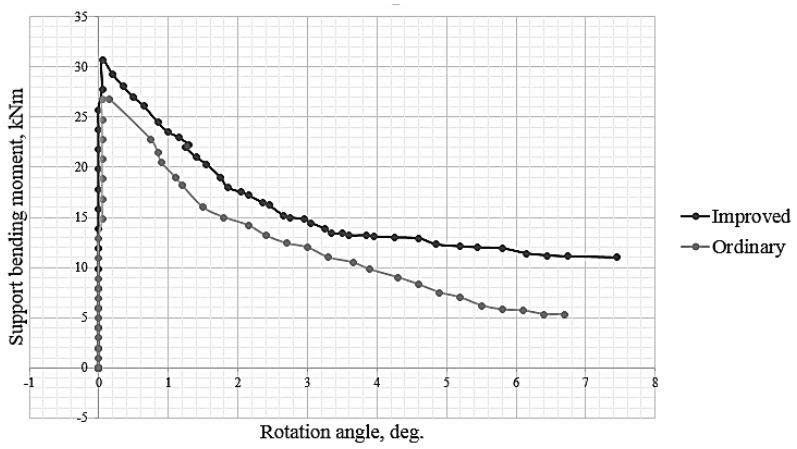

Fig. 4. Experimental dependence «support bending moment – angle of rotation of the cross section»

The improved joint design, in which the vertical pressing of slabs is not transmitted over the entire area of supporting the top of the wall, but «in points» – at the locations of the top working reinforcement, greatly increases the vertical compression zone of anchoring of the top working reinforcement plates.

The experimentally obtained dependence «support bending moment – the angle of rotation» in the place of the platform joint, allows the calculation of hollow-core floor slabs of formless molding based on the actual scheme of their deformation.

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UDC 697:721.011.25

TECHNICAL SOLUTIONS OF VENTILATION SCHEMES IN INHABITED AND PUBLIC BUILDINGS WITH EXTERNAL FENCES OF THE RAISED TIGHTNESS

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In the work are presented possible variants of technological schemes for an effective utilization in systems of ventilation of high-rise buildings with external protecting designs of the raised tightness to which the preference is given systems combined heat and air delivery, combined with ventilation.

Currently, any building or structure shall be operated in compliance with all applicable technical regulations, and conformity with the principles of energy conservation. For energy efficiency use of modern technical solutions, technologies and materials [1]. In modern construction, increasingly are building with outer fences high tightness. For the design, construction and operation of such facilities should provide for measures to meet the required parameters of microclimate of buildings. To ensure the required parameters of internal air heating and ventilation systems are used.

For the buildings of the inhabited and public appointment having external fencings of raised tightness, three basic technological schemes of ventilation are possible [2, 3]:

- systems of exhaust ventilation with natural gravitational prompting and the organized inflow of external air for the account of infiltration through equivalent apertures, cracks, channels or ventblocks of the various design, arranged in external protecting designs;
- systems of forced-air and exhaust, general and local ventilation with natural and mechanical prompting;
- systems of ventilation combined with air heating of buildings.

In all considered variants wide use of regeneration means of warmth deleted from ventilated premises is possible. By the first variant of ventilation the delivery of external air in ventilated premises is carried out through artificial apertures in external protections under the influence of the natural gravitational prompting resulting in difference of pressure on either side of an external protection because of a difference of temperatures of external and internal air. The normalized temperature of internal air is supported in the set limits by the system of heating of buildings with which help the cores heat loss through external protections and additional losses of the warmth are compensated. A major loss of the building occurred through external enclosures: walls, windows, floors, above the basement or attic, roof. Additional losses are linked to the heating of the intake air through the ventilation openings in the outer fencings. Devices for air flow may vary in design, such as holes, valves, channels or ventblocks. All air shafts, ducts, and openings, whether for inlet or outlet of air, must be constructed so as to be easily cleaned out. The inlets must in addition be fitted with regulating valves for opening and closing them in varying degrees [4]. The general technological scheme of such ventilation of buildings with external protections of the raised tightness is represented by Figure 1.

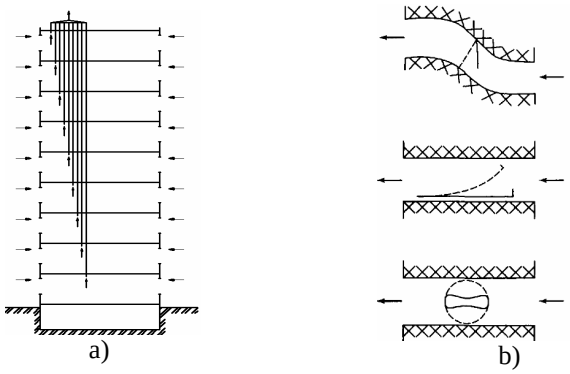

Fig. 1. The building with a natural extract and the organized inflow through apertures in external walls: a) the scheme of movement of air streams; b) constructions of devices for air flow

The second technological scheme of ventilation of buildings with external protections of the raised tightness assumes the device of forced-air and exhaust general and local systems of ventilation with the natural and mechanical prompting the circuit diagrams of which are presented in figure 2. The technological scheme of the forced-air and exhaust ventilation with the natural prompting, represented in figure 2, a) assumes the air exchange organization in ventilated premises of many-storied buildings removal of internal air through exhaust channels and giving of fresh external air through inflow channels. Air intake for the flow in the lower part of the building through natural difference of pressures. Of the total duct, located in the basement or the technical premises, outside air enters the premises operated by vertical channels. As the air warms up it gets into the accepted premises in the amount of not less than regulatory. Air elimination also occurs on vertical channels emerging on the roof or a warm attic.

The diagram shown in Figure 2, b) includes combined ventilation system of the building. This scheme provides the system of channels, fans and other equipment for air treatment. Supply and removal of air in ventilated premises can be done in two ways. If the housing is to maintain the natural draught ventilation, enough with the significant difference between the outside and inside temperatures, the fan does not operate. In the warm season of the year the outside air temperature is approaching the internal temperature, pressure difference decreases. When the exchange of air reaches the minimum value, supply and exhaust fans are automatically enabled to increase the airflow to the required values. Mechanical aeration mode space is especially necessary in the case of the alignment of internal and external air temperatures. In such cases, to create comfortable conditions for the environment there should be intensive airing of that system of mechanical ventilation well.

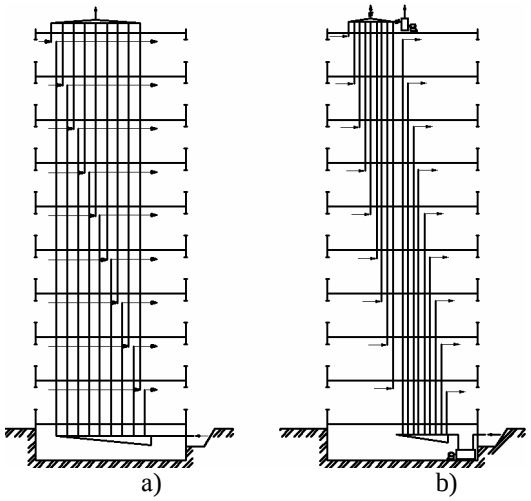

Fig. 2. The scheme of a forced-air and exhaust ventilation of buildings:
a) with natural prompting; b) with mechanical prompting of movement

In buildings with increased requirements to comfort of conditions in summer with intense exposure to sunlight may be used an inflow fans for the admission of warm external air through chambers of an intensive irrigation with delivery cooled air in the adiabatic regime in ventilated rooms according to requirements.

By the third variant ventilation of buildings with external protections of the raised tightness can be carried out under the technological scheme of combination with the air heating which circuit diagram is presented on Figure 3.

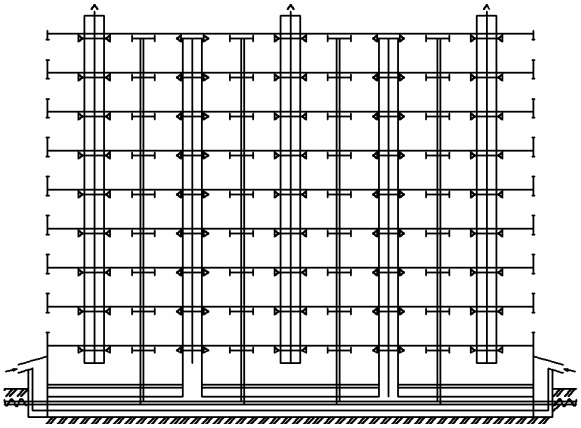

Fig. 3. The circuit diagram of air heating of the buildings, combined with ventilation

Unlike the first variant in which having heated up external inflow air it is made at the expense of a thermal overload of system of water heating, in the third variant ventilating supply air overheats to settlement values and moves in a heated premise, compensating it heat loss and maintaining temperature of internal air in normalized limits. At such combined technological scheme of the combined heating and ventilations the scheme of automatic maintenance of the set temperature mode of a building by installation of gages of temperature in control premises and the automatic regulators of the expense established before heaters of air. As a result, installations of heating supply centers are greatly simplified. .It will allow changing almost instantly parameters of air with changing of weather conditions (intensive solar radiation, wind, overcast, etc.) with considerable economy of thermal energy.

Along with economy of thermal energy the simple scheme of regulation will allow to exclude dependence of internal parameters of a microclimate from weather conditions, to create stable conditions of the air environment in ventilated premises and thus it raises the social importance of such technical decision [2, 3].

An extensive introduction in scales of town-planning of technology of ventilation of buildings of inhabited and public appointment under the schemes combined with heating assumes to all national economy of the country considerable economic benefit.

For this purpose it is enough to imagine that in new construction building there will be no necessity to lay a too much of pipes of miscellaneous diameter, expensive multipurpose armatures, numerous heating devices, various on a design. In buildings will not be installed circulation pumps that move huge masses of water heating systems and consume significant energy in the operation of hot-water heating systems of buildings. Reducing costs through the implementation of short-term introduction of new technologies of heating and ventilation in accordance with the proposed scheme, there is undeniable economic benefits and their weights for the country, the national economy. If all these expenses sharply to reduce at the expense of realization of short-term introduction of new technology of heating and ventilation under the offered scheme of the combined operating mode there are indisputable economic gains and their scales for a national economy.

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UDC 624-2/-9

THE ANCHORAGE OF UNTENSIONED REINFORCEMENT

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The article concerns the main factors that influence the anchorage of untensioned reinforcement and it also presents the analysis of the effect of web and confinement reinforcement in welded reinforcements made by resistance spot welding, on the anchorage of longitudinal reinforcement EN 1992-1-1-2009.

Anchorage is the process of fixing reinforcement in concrete, which is achieved by putting the reinforcement behind design section to the length necessary for putting a bar into work (straight embedment of anchorage) or by taking special building measures. The nature of detensioning in reinforced-concrete structures depends on many different parameters. For examples, for the mechanism of straight anchorage they are:

1) the properties of concrete – mix proportions, consistency, shrinkage, a direction of concreting, concrete strength and so on [1, 2];

2) the properties of reinforcement – mechanical characteristics, profile, diameter, depth of concrete cover, arrangement of H-bars and so on [3, 4, 5, 6];

3) stress strain behavior of enveloping concrete. It is known that the increase of concrete compression intensity within 0,1 – 0,4 f_{ck} leads to the gain of adhesional strength during the pulling out. And conversely, the existence of force leading to web reinforcement decreases the effectiveness of anchorage greatly.

Structural anchorage (used to plain reinforcing bars) is done by fixing hooks, offsets, anchoring loops of wire at the ends of bars. When grip anchorage or anchorage with the help of hooks or loops of wire is not enough special anchorage devices are used, such as anchor washers , buttenheads, short bars and bars welded to base tables and so on [7] (Fig. 1).

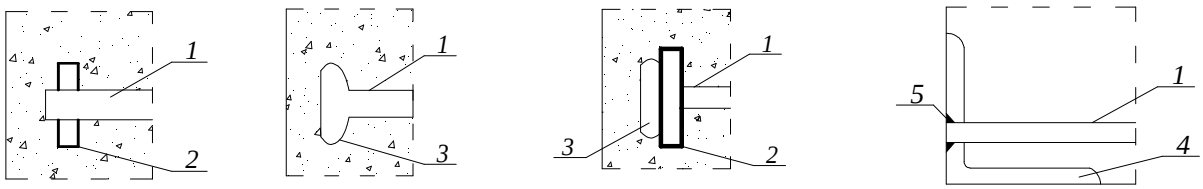
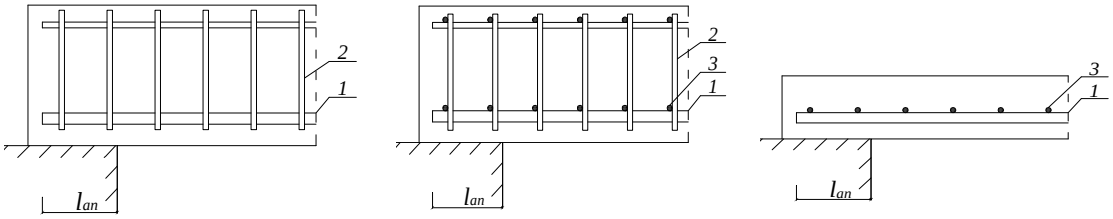


Fig. 1. The examples of the anchorage of a longitudinal bar by the means of special devices:
1 – bar; *2* – anchor washer; *3* – buttenhead; *4* – angle seat; *5* – welding

By using in reinforced-concrete structures welded reinforcement units (welded wire fabric, bar-mat reinforcement, space frame) that are made by the means of resistance spot welding, a bearing rod obtains additional factor that increases the properties of the anchorage of longitudinal reinforcement – welded cross and distribution bars, some of which will be in the transfer zone of prestress (Fig. 2).



a) *b)* *c)*

Fig. 2. The anchorage of welded longitudinal reinforcement bars on free end supports of flexural members:
a) – in beams with welded reinforcement, *b)* – in beams with space welded frame, *c)* – in fabric-reinforced slabs
(*1* – longitudinal reinforcement, *2* – cross reinforcement, *3* – distribution reinforcement)

In such elements one of the main factors that changes the nature of the anchorage of longitudinal reinforcement in a cross joint is the weld shrinkage of bars - quantitative characteristic of bars pressing into in the place heated during resistance welding to the plastic condition (Fig. 3).

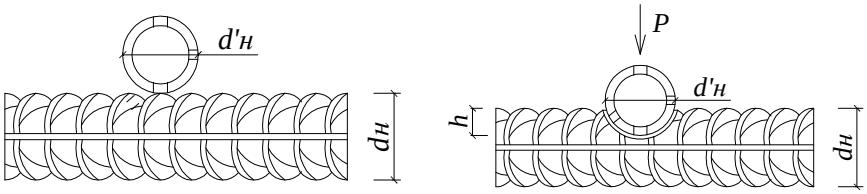


Fig. 3. Weld shrinkage of bars

In technical conditions the minimum quantity of the weld pressing of bars in cross joints with standard and non standard strength is fixed on welded reinforcement units for reinforced-concrete structures (table 1).

Table 1 – Relative value of the weld pressing of bars

Type of welding	Class of reinforcement	$d_н$	Value of $h/d_н'$ for joints with diametre ratio $d_н'/d_н$				Minimum value of $h/d_н'$, providing nonstandard strength
			1	0,5	0,33	0,25	
К1-Кт	S500	4-5,5	0,35-0,5	0,28-0,45	0,24-0,4	0,22-0,35	0,17
	S240	6-40	0,33-0,6	0,28-0,52	0,24-0,46	0,22-0,42	0,17
	S400	6-40	0,4-0,6	0,35-0,7	0,3-0,62	0,28-0,55	0,17
	S500	6-32	0,4-0,6	0,35-0,46	0,3-0,46	0,28-0,42	0,20

But, the calculation procedure in [9] provides for the possibility to increase the load-carrying ability of anchorage by taking into account available welded cross bars, only for reinforcement with similar nominal diameters – only cross bars with $Ø_t \geq 0{,}6Ø$ should be taken into account (Fig. 4). So, in the standard [8] there are formulas for the calculation of anchoring capacity of cross bars with the diameters 14 – 32 mm or ≤12 mm with the bar diameter ≤ 12 mm.

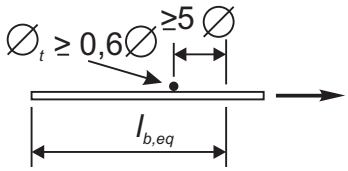


Fig. 4. Equivalent length of anchorage for welded cross bar according to EN 1992-1-1-2009

From practical design experience it is known that in the manufacture of welded reinforcements and welded fabrics (especially in cases when cross reinforcement is placed for reasons of design) the ratio of diameters of welded cross and longitudinal bars is usually ≥ 0,25. So, in the standard the decrease of anchorage effective length for such welded reinforcement units isn't taken into consideration. That's why, it's necessary to find out the generalized coefficient of a welded cross bar influence on the anchorage of a longitudinal bar so that it should include the maximum possible amount of factors: the ratio of reinforcement diameters, shearing strength class, amount of shrinkage, the amount of cross and distribution bars in the zone of anchorage and so on.

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UDC 666.972

STUDY OF THE EFFECT OF PLASTICIZER ON THE PHYSICAL AND MECHANICAL PROPERTIES OF CONCRETE MIXTURE AND CONCRETE IN ACCORDANCE TO THE INTERNATIONAL TEST METHODS

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This article is devoted to the methods in preparation of concrete, corporation between the American and the European methods, climates in the Middle East countries, the effect of weather on the concrete: heat, moisture and curing of concrete,

Concrete is the most widely used construction material through the world and has gained a unique place in the construction industry, it is used more than any other man-made material in the world. As of 2006 around 7.5 cubic kilometers of concrete are made each year, more than one cubic meter for every person on Earth [1].

Concrete is a hardened building material created by combining a chemically inert mineral aggregate (usually sand, gravel, or crushed stone), a binder (natural or synthetic cement), chemical additives, and water.

During hot weather conditions, a number of on-site factors can work against deriving optimal performance from concrete. When combined with low relative humidity and strong winds placing and finishing requires special care. Recently this problem have been more effect on the construction business in the Gulf Arab States such as Qatar and Saudi Arabia according with the hot weather, the water scarcity and the cost of extracting. The coastal cities environment in Saudi Arabia and the Gulf states are classified globally as one of the high-risk on the concrete structures because they contain the highest percentage in the world of ultraviolet and infrared rays

with the lack of rain every year [2]. We suppose that the appropriate methods for solving this problem in preparing of concrete is by adding some chemical admixtures, depending some precautions and curing concrete.

Firstly, we will review the following points:

1. The international methods in preparation of concrete

• GOST - State Standard Gost

GOST standards are regional standards administered by the Euro-Asian Council for Standardization, Metrology and Certification (EASC).

The collection of GOST standards includes over 20,000 titles used extensively in conformity assessment activities in 12 countries. Serving as the regulatory basis for government and private-sector certification programs throughout the Commonwealth of Independent States (CIS), the GOST standards cover energy, oil and gas, environmental protection, construction, transportation, telecommunications, mining, food processing, and other industries. The following countries have adopted GOST standards in addition to their own, nationally developed standards: Russia, Belarus, Ukraine, Moldova, Kazakhstan, Azerbaijan, Armenia, Kyrgyzstan, Uzbekistan, Tajikistan, Georgia, and Turkmenistan [3].

• BSI – British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. Royal Charter incorporates it [4].

• New European standards for concrete

European Standards are being introduced gradually to replace the current British Standards used in the construction industry. The standards are being implemented across Europe to create harmonization between all member states and remove trade barriers between members. This harmonization will create and promote opportunities to increase free trade throughout the European Community.

From 1 December 2003, the British standard for concrete, BS 5328, was withdrawn and replaced by the new European standard for concrete, EN206-1. This Europe wide standard is complemented by the British version of the concrete standard, BS 8500. In the UK, EN 206-1 shall be called BS EN 206-1 and together with BS 8500-1 and BS 8500-2, will offer direction and guidance on the specification, production and control for ready mixed concrete [5].

• American Concrete Institute

The American Concrete Institute (ACI) Founded in 1904 and headquartered in Farmington Hills, Michigan, USA, the American Concrete Institute is a leading authority and resource worldwide for the development and distribution of consensus-based standards, technical resources, educational programs, and proven expertise for individuals and organizations involved in concrete design, construction, and materials, who share a commitment to pursuing the best use of concrete [6]. It should be noted that the Middle East countries and the Gulf States usually were used the European method. Recentlythey use the American method.

2. The difference between the American and European methods

Table 1 represents the basic regulations on the manufacturing methods, storage and testing of concrete samples.

Table 1 – The basic regulations on the manufacturing methods, storage and testing of concrete samples

Method	American Concrete Institute	European standards for concrete
Form, size and number for compressive test	Cylinder, 300 × 50d mm and 2 cylinders or more for testing	Cubes, 100 × 100 × 100 mm and 3 cubes for testing
Storage and Curing	Room with temperature = 23±2° C / Tank fill ofwater in temperature = = 23±2°C	Room with temperature = 20° C / chamber at normal temperature = 20 ± 2° C with a relative humidity of not less than 95 %.
Compressive strength for samples	By using special compressive machine for cylinders	By using special compressive machine for cubes

The differences are manifested in the form of methods, the minimum number of samples and storage conditions. For example, in ACI – American Concrete Institute usually uses cylinder with 150 mm diameter and 300 mm of height, but EN - European standards for concrete usually uses cubes, that are length, width and height equals 100 mm. Also there is a difference between ACI and EN in storage and curing samples, for example, storage in ACI shall be in a room with a temperature approximately 23 ± 2° C. After 24 ± 8 h we must remove the specimens from the molds and cure them by using water storage tanks from the time of molding until the moment of test. For EN, storage specimens shall be in a room with temperature 20° C and curing must be in a chamber at normal temperature 20 ± 2° C with a relative humidity of not less than 95 %.

3. The effect of hot weather on the concrete and the ways of precautions

Generally, the climate in the Middle East is very hot and dry in the summer. In Lebanon (Beirut) for example hot with temperature average is approximately +32° C and humidity 55 %, but the climate in the Gulf States is not only very hot, but also very dry. The temperature average in Saudi Arabia (Makah) in the summer is approximately +44° C, with humidity 25 % and +42° C, 29 % in Qatar (Doha).

Using and placing concrete during the hot summer months present far different challenges than use and placement during cold weather. The summer month effects of temperature, wind, and air humidity can all have a negative impact on the performance of concrete. For purposes of concrete use and placement, «hot weather» can be defined as any period of high temperature during which special precautions need to be taken to ensure proper handling, placing, finishing and curing of concrete. Hot weather problems are most frequently encountered in the summer, but critical drying factors such as high winds and dry air can occur at any time, especially in arid or tropical climates [7].

Higher temperatures cause water to evaporate from the surface of the concrete at a much faster rate and cement hydration occurs more quickly, causing the concrete to stiffen earlier and improving the chances of plastic cracking occurring. Concrete cracking may result from rapid drops in the temperature of the concrete. This occurs when a concrete slab or wall is placed on a very hot day and which is immediately followed by a cool night. High temperature also accelerates cement hydration and contributes to the potential for cracking in massive concrete structures. Higher relative humidity tends to reduce the effects of high temperature. Other hot weather problems include increased water demand, which raises the water – cement ratio and yield lower potential strength, accelerated slump loss that can cause loss of entrained air, fast setting times requiring more rapid finishing or just lost productivity [7]. It should be noted that the international specifications and codes recommend procedures for placing concrete in a hot and cold climate, they do not adequately address the influence of the total environment. ACI 305R, «Guide to hot weather Concreting» for example, defines hot weather as any combination of high ambient temperature, high concrete temperature, low relative humidity, wind velocity and solar radiation that tends to impair the quality of freshly mixed or hardened concrete by accelerating the rate of moisture loss and rate of cement hydration [8].

We supposed that the following list of precautions will reduce or avoid the potential problems of hot-weather concreting:

• Use materials and mix proportions that have a good record in hot-weather conditions.
• Cool the concrete, one, or more of its ingredients (aggregates and mixing water).
• Add ice if it is needed to lower the temperature of concrete.
• Use a concrete consistency that allows rapid placement and consolidation.
• Reduce the time of transport, placing and finishing as much as possible.
• Schedule concrete placements to limit exposure to atmospheric conditions, such as at night or during favorable weather conditions.
• Consider methods to limit moisture loss during placing and finishing, such as sunshades, windscreens, fogging, or spraying.
• Apply temporary moisture-retaining films after screening.
• Organize a preconstruction conference to discuss the precautions required for the project.
• Consider modifying the concrete mixture to include set retarders and water reducers, and the lowest practical cement factor[9].

4. The need to use chemical admixtures

Water reducers, retarders, and superplasticizers are admixtures for concrete, which are added in order to reduce the water content in a mixture or to slow the setting rate of the concrete while retaining the flowing properties of a concrete mixture. Admixtures are used to modify the properties of concrete or mortar to make them more suitable to work by hand or for other purposes such as saving mechanical energy.

ASTM C494 Type F and Type G, High Range Water Reducer (HRWR) and retarding admixtures are used to reduce the amount of water by 12 % to 30 % while maintaining a certain level of consistency and workability (typically from 75 mm to 200 mm) and to increase workability for reduction in w/cm ratio. The use of superplasticizers may produce high strength concrete [10].

For unusual cases in hot weather and where careful inspection is maintained, a retardingadmixture may be beneficial in delaying the setting time, despite the somewhat increased rate of slump loss resulting from their use. Ahydration control admixture can be used to stop cement hydration and setting. Hydration is resumed, when desired, with the addition of a special accelerator (reactivate). Retarding admixtures should conform to the requirementsof ASTM C 494 (AASHTO M 194)[9].

We should be noted that like these admixtures usually used in the Gulf States such as Qatar and Saudi Arabia.

5. Curing of concrete in the hot areas

Curing has a strong influence on the properties of hardened concrete; proper curing will increase durability, strength, water tightness, abrasion resistance, volume stability, and resistance to freezing andthawing and deicers.

Curing and protection are more critical in hot weather than in temperate periods. Retaining forms in place cannot be considered a satisfactory substitute for curing in hot weather; they should be loosened as soon as practical without damage to the concrete. Water should then be applied at the top exposed concrete surfaces. On hardened concrete and on flat concrete surfaces in particular, curing water should not be more than about 11° C (20° F) cooler than the concrete. This will minimize cracking caused by thermal stresses due to temperature differentials between the concrete and curing water. The need for moist curing is greatest during the first few hours after finishing. To prevent the drying of exposed concrete surfaces, moist curing should commence as soon as the surfaces are finished and continue for at least 24 hours. The concrete should be protected from drying with curing paper, spraying fogging and sprinkling, heat-reflecting plastic sheets, pond of water or membrane-forming curing compounds [11].

In the first stage of experimental work conducted studies of the samples modified concrete by the method described in GOST.The studies used Portland cement CEM I 42,5N with an activity of 47,5 MPa at a rate of 350 kg per 1m³. The results are shown in Table 2.

Table 2 – The physico-mechanical characteristics of the concrete mixture and concrete

Number of sample	Type of admixtures	Consumption admixtures, % of the weight of cement	W/C	Mobility, cm	Density, kg/m³	Compressive strength, Mpa, at the age	
						7 days	28 days
1	Without admix.	–	0.55	4-5	2444	24.4	30.5
2	Superplasti-cizer C-3	0.6	0.55	20-21	2447	24.4	30.3
3			0.45	4-5	2474	34	43.5
4	Superplasti-cizer Type F	0.5	0.52	21-22	2449	24.3	30.2
5			0.42	4-5	2475	44.5	47.7
6	Superplasti-cizer Type G	0.5	0.52	21-22	2446	26.7	33.4
7			0.42	4-5	2483	42.8	46.3

Superplasticizer C-3 was added in an portion of 0,6 % of the weight of the cement, which increased the mobility of concrete mixture to 20 – 21 cm. When using superplasticizers of type F and G, similar performance was achieved on mobility of concrete by adding additives with the amount of 0,5 % of the weight of cement. The density of control composition and experimental concrete specimens ranges between 2444 – 2449 kg/m³. It should be noted that using less additives of type F and type G (compositions 4, 6) slightly reduced water consumption, compared with the composition 2. Using superplasticizers allows to increase the mobility of the concrete mixture 4 – 5 times compared to the control composition and at the same time get a full-strength concrete at the age of 7 and 28 days.

Adding superplasticizers provides an opportunity not only to increase the mobility of the concrete mixture, but also increase the strength of concrete while reducing water consumption. While maintaining the mobility of 4 – 5 cm in the experimental compositions 3, 5 and 7, water – cement ratio decreased to 0,42 – 0,45. Reducing water flow allowed to condense concrete structure, which is confirmed by an increase in the average of density of 40 kg/m³, as well as substantially increase the strength of concrete. At the initial stage of curing at 7 days, strength of concrete with the addition of C-3 increased by 40 % compared to the control composition 1. The greatest effect of reducing the flow of water is observed in compounds with the additions of type F and G, where strength increased 76 – 83 % more than of the control composition 1 and 26 – 31 % than composition 3.

It should be noted that in the 28 days strength value of compositions 5, 7 exceeds the value of 7 days only with 2 – 3,5 MPa. In this case, the strength of concrete with the addition of the C-3 (composition 3) is increased by 28 % and the figure will be closer to 5, 7.

Thus, reducing the flow of water allows to obtain concretes strength exceeding controlling composition after 28 days by 43 – 56 %. Effectiveness in strength occurs in the first days after adding type F and G to the compositions. Concrete that contain the additives gains about 90 % of the strength in the first 7 days according to the indicators at the age of 28 days.

According to the results in the first stage of the study, we can conclude that, for the manufactured, stored and tested specimens, and according to the procedure set GOST, significant effect of superplasticizers allows to increase the mobility of the concrete mixture by 4 – 5 times, while maintaining the required concrete strength or mobility of a given concrete mixture by reducing the water flow, and increasing the concrete strength by 1,4 – 1,55 times.

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MORTARS WITH CARBON CONTAINING FILLER

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This work presents the results of the investigations of the basic properties of mortars and solutions with the carbon containing filler. The optimum amount of the filler for cement and lime plaster has been defined. The indicators of viability of mortars, their frost resistance and the degree of adhesion of solutions to the surface have been identified.

In the laboratories of the department of construction production complex studies of the fundamental properties of mortar mixtures and solutions with the carbon containing filler have been carried out. Feedstock for a large-tonnage filler is water treatment sludge, which is a secondary product of the Polotsk and Novopolotsk central electrical heat plants. 192 kg of cement-lime plaster type M 75 and lime- sand mortar where a ratio of lime to sand was 1: 6, the latter used for interior decorating, were taken for control. The mobility of mortars was 8 cm.

The optimum amount of filler was determined, on the grounds of indicators of strength of solutions, their peel ability and water-holding capacity. The results of the studies are shown in tables 1 and 2.

Table 1 – Key indicators of quality of cement plastering mortars and solutions

№ composition	Cement consumption 1 m^3, kg	Consumption filler 1 m^3, kg	W/S	Strength, MPa		Laminating, %	Water-retaining ability , %
				7 days	28 days		
1	168,6	33,2 (40*/20")	1,45	4,1	5,8	10,6	95,2
2	167,5	49,4 (60/30)	1,28	4,6	6,6	9,4	95,5
3	166	65,5 (80/40)	1,12	5,5	7,8	8,2	96,5
4	165	81,2 (100/50)	1,19	5,0	7,2	8,0	97,2
5	163,8	96,7 (120/60)	1,24	4,7	6,7	9,1	97,8
* – percentage of filler input from the calculated mass of lime; " – percentage of filler input from the calculated weight of cement.							

Table 2 – Key indicators of the quality of lime plastering mortars and solutions

№ composition	Consumption, kg			Strength, MPa		Laminating, %	Water-retaining ability, %
	lime	filler	water	7 days	28 days		
1	230	-	343	0,8	1,5	7,8	96,2
2	190	38 (20 %)*	328	0,6	1,5	7,8	96,5
3	169	58 (30 %)	314	0,8	1,6	7,9	96,3
4	147	78 (40 %)	305	1,3	1,8	8,1	96,6
5	124	99 (50 %)	301	0,9	1,5	8,0	96,4
6	99	118 (60 %)	301	0,7	1,2	8,3	96,0
* – percentage reduction of lime consumption by weight							

The optimal addition of the filler with a maximum particle size of 80 microns to plaster cement mortars is 60 – 100 % of the estimated mass of lime. The strength of the control solutions, which are 7 days old, exceeds that of cement lime mortars by16-20 %. Experimental data based on the results of the research have revealed that for lime plaster mixtures the optimum lime consumption reduction is 40 – 50 % if the amount of the filler constitutes 80 % of the mass of the replaced lime. Peel ability and water retention are kept at the reference values , whereas the strength of the filled seven- day- old solution exceeds that of lime mortar by 60 % and the strength of twenty-eight-old day filled solution exceeds that of lime mortar by 15 %.

Additionally, it was found out that shrinkage deformation for cement - calcareous solutions was 1,5-1,8 mm/m, and for those with the cement filler 0,7-1,1 mm/m. In lime mortars shrinkage deformation control composition is 2,1 mm/m , while in lime mortars with the filler it is 1,2-1,4 mm/m.

Reduced shrinkage strain at 40 – 60 % promotes the formation of a more homogeneous structure, reduces the probability of occurrence of micro cracks and thus increases the strength of plaster containing the filler.

Viability is an important indicator in the production of plastering mortars. In order to find out the term of the possible use of mortars with the filler change in mobility over time was estimated.

Within half an hour a decrease in the mobility of cement and cement-lime mortars was recorded. After the first hour of the test only the mobility value of the filled cement mortar, where the amount of the filler constituted 100 % of the calculated weight of lime, remained unaltered. The greatest fall in the mobility by 1,6 cm was observed in cement mortar. 3 hours after the start of the test the mobility of the cement mixture reached 5 cm,

and lime - cement – 5,5 cm. During the same time the mobility of the filled mortars decreased by 11 – 22 %. One hour later the mobility of cement -lime mortar was 4,9 cm and that of the filled ones amounted to 5,9 – 6,5 cm.

It was found that decrease in mobility of plaster mortars is much slower than that of cement or cement-lime and amounted to only 5cm after 6 – 8 hours after the start of the test. For plaster mixtures viability increases by 1 – 2 hours.

Intense change in mobility in plaster mixtures is due not only to low initial mobility, but also to a large amount of cement in plastering compositions.

In experimental plaster filler mixtures the increase of the dosage of the filler up to 100 % by weight of lime slows down the processes leading to hydration of cement and prolongs the term of its hardening, which can be explained by the increase in the amount of organic impurities containing in the filler – up to 10 % - and also by the presence of plaster – up to 9 %. At the initial stage of hydration there appears ettringit, which in a finely divided state slows hydration $3CaO \cdot Al_2O_3$ and prolongs the time of cement hardening.

An important indicator of durability of solutions is their frost resistance. When holding research there was determined the frost resistance of plaster mortars of M50 and M75 brands. The tests for frost resistance showed that changes in the strength of masonry solutions of M50 and M75 brands and their mass losses were not observed after 50 and 75 cycles, respectively.

In plastering compositions M50 brand strength reduction was observed after 55 cycles of freezing and thawing. During the examination of samples of plaster formulations after 60 cycles there was detected a slight peeling on the surface of the control and experimental compositions. After 60 cycles the cement-lime solution dropped in strength by 11 and the cement mortar with filler by 8 %.

It was recorded that the cement-lime mortar strength decreased by 25 % after 70 cycles. The strength of the filled mortar decreased by 17 %, and only after 80 cycles of the alternate freezing and thawing it decreased by 26 %.

In the samples of the plaster cement-lime mortar of type M 75 superficial peeling appeared after 75 cycles, with a slight decrease in strength by 8 %. Cement plaster filled mortar had no damage to the surface and only after 80 cycles slight peeling was noticed.

Strength test at 85 cycles of alternate freezing and thawing displayed the deterioration of the characteristics of the cement-lime mortar by 13 %, and those of the cement mortar with the filler by 7 %. After 90 cycles of testing the strength of the cement-lime solution decreased by 26 %. It must be noted that the magnitude of the fall in the strength of the experimental sample is half as much and is equaled to 12 %. The strength of the experimental sample reached the maximum permissible level only after 100 cycles and amounted to 23 %.

The decrease in frost resistance of mortars M50 and M75 within 5 – 10 cycles as compared to that of the masonry structures is determined by the difference in the composition as well as the granulometry of the filler, which is quartz sand. It causes the increase in the absorption of water. The dependence in question is confirmed by the data of water absorption by the mortars, which is 7,6 – 8,1 % and thus 15 % higher than that of masonry compositions.

For plaster M50 and M75 indicators of frost resistance differ by one brand. So cement- lime mortar M50 has a frost resistance brand F50, and a cement mortar with filler – brand F75. Lime-plaster cement composition M75 corresponds to frost resistance mark F75, and cement mortar with filler – mark F100.

Thermal performance of plastering mortars was determined on the mixtures of brand M 75. Cement-lime mortars served as control mortars. The control lime mortars had a ratio of components 1:6. The results are shown in tables 3 and 4. The indicators of density and a coefficient of thermal conductivity are for solutions in a dry state.

Table 3 – Heating technical parameters of cement mortars

№ composition	Appointment solution	Consumption, kg		Density, kg/m^3	Coefficients. thermal conductivity (W/m·°C)	Thermal resistance, m^2·K /W	Factor vapor permeability, mg/(m·h ·Pa)
		lime	filler				
1	plaster	90	-	1820	0,51	0,048	0,1
2		-	72 (80 %)	1920	0,45	0,064	0,095
* – percentage filler input from the calculated mass of lime							

In experimental compositions with the filler density increases relatively to the control composition by 90 – 110 kg/m^3.The increase in the density of the solutions is due to the formation of a maximum dense structure of the cement filler, which lowers the initial emptiness of the system. It is also explained by a lower aquasolid interaction of the mortars with the filler.

Table 4 – Heating technical indicators of lime mortars

№ composition	Appointment solution	Consumption, kg		Density, kg/m^3	Coefficients of thermal conductivity (W/m·°C)	Thermal resistance, m^2·K /W	Factor of vapor permeability, mg/(m·h ·Pa)
		lime	filler				
1	plaster	230	-	1690	0,39	0,081	0,12
2		147	78 (40 %)*	1780	0,35	0,095	0,11
* – percentage reduction of lime consumption by weight							

The coefficient of water vapor permeability of plaster lime mortars is 14 – 16 % higher than that of cement compositions. For cement mortars the coefficient of water vapor permeability virtually remains unchanged and is within 0,095 – 0,1 mg/(m·h·Pa) and for lime mortars it is 0,11 – 0,12 mg/(m·h·Pa)).

The formation of denser structure solutions with the filling results in lower open porosity as compared to control compositions. Therefore, despite the higher density of experimental compositions with a filler the indicators of factor conductivity are 11 – 15 % lower than those of the control compositions. Wherein the thermal resistance is increases by 15 – 25 %.

Thus, the heat engineering characteristics of cement and lime mortars containing the filler provide the necessary parameters for dressing both the exterior and the interior of buildings.

While determining the degree of adhesion of mortars containing the filler it was found that by using them as a base for ceramic bricks and concrete blocks, heavy fracture occurred within the solution, i.e. it bore a cohesive character. Despite the high surface roughness of gas silicate blocks destruction generally has an adhesive nature, with the partial destruction of the samples observed on the rough surface structure of silicate units. Adhesion strength to the surface of test solutions is 33 – 42 % higher than that of the control formulations and amounts to 0,3 – 0,59 MPa.

The results of the studies of adhesion of the filler-containing plastering mortar showed that in the control samples the degradation, regardless of the material of the base, occurred on the boundary between the mortar and the base whereas the contact surface of the solution remained virtually intact. The samples of lime mortars with the filler were destroyed within the structure of the solutions The adhesion strength of the test compositions reached 0,23 – 0,29 MPa which is 21 – 38 % higher than that of the solution with lime.

Research efforts reveal that the optimum filler for plastering cement mortars is that with the maximum size of particles amounting to 80 microns and the best share of it is 60 – 100% of the estimated mass of lime The durability strength of solutions with the filler within 7 days exceeds that of cement-lime mixtures by 14 – 17 %.

Optimum lime consumption reduction for plastering lime mixtures is 40 – 50 % with the introduction of the filler to an amount of 80 % of the replaced mass of lime. Water-retaining and peel ability remain at the level of the control data, whereas the strength of the filled mortars exceeds the strength of the lime composition by 60 % within 7 days and by 15 % within 28 days

The presence of the filler in cement plaster formulations can increase the viability of the mortars by 1,5 – 2 times which makes it possible to reduce the supply of the amount of the mortar to the construction sites thus decreasing labour intense and transport expenses. Cement plasters with the filler have a lower water absorption and lower strength drop in water-saturated state by 20 – 25 % compared to the cement-lime mortar which contributes to frost resistance increase by 15 % and ensures compliance with STB 1307 requirements.

Adhesion plaster cement and lime mortars filled more than 30 – 35 % of the performance of control formulations, which presumably would reduce the possibility of peeling plaster layer from the bottom in the operation of buildings in the event of exposure.

UDC 711.04

DESIGN FOR SPECIAL POPULATIONS

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There is a small number of people that deviate from the healthy norm in society due to stages in human development, injury, traumas, congenital disease or genetic abnormalities. The design for special groups is created for these groups of people.

For many years, the needs of people with disabilities have been constantly ignored. Creation of necessary conditions for such people just was not considered important or essential.

But now, the design of interiors and buildings for the disabled has become of a different character. Design for people with special needs has become a standard component in the construction.

Nowadays people with disabilities can get into almost any office buildings, dwelling houses, shopping centres or cafes. Such opportunity has appeared through the creation of a special barrier-free environment.

Barrier-free environment or universal design allows all people, including older people and people with disabilities to move in the public space without anyone's help. It is an opportunity for people with disabilities to engage in social, professional and cultural spheres and sport life of the country, obtain decent education and qualified job and have a rich and full life [3].

Basic principles of the universal design are equality, respect towards each other's peculiarities and functionality.

A barrier-free environment is a space that allows free and safe movement, function and access for all, regardless of age, sex or condition. A space of services that can be accessed by all, without obstacles, with dignity

and with as much independence as possible. The environment means buildings, roads, parks, gardens and other places, services, modes of transportation, products of daily use, etc. There is a popular belief that a ramp and an elevator lift are all that is needed to make a built space barrier-free [4].

It must be clearly understood that barrier–free goes far beyond just a ramp and has many other necessary aspects. These range from passage widths of doors to flooring surfaces, from counter heights to door handles and railings, from signage and auditory signals to tactile guides.

On the face of it, it is only persons with disabilities for whom barriers become major obstacles. However, it is necessary to realize that every person, at some stage of life, faces barriers. A small child, an elderly or infirm person, a pregnant lady, the temporarily disabled, all are vulnerable to barriers. Therefore, the list of people affected by barriers is as follows:

- Wheelchair users
- People with limited walking/ movement abilities
- People with visual impairment or low vision
- People with hearing impairment
- Elderly and infirm persons
- Pregnant ladies
- Children
- People with temporary disabilities [1].

A barrier-free environment is a basic right of all. It is not a matter of choice or option. Ensuring access is a basic social necessity benefiting everybody. Not allowing a person equal opportunities and participation is an infringement on his or her rights as a citizen of this country.

In January 1992, the American Disabilities Act of 1990 (the ADA) became law. This landmark civil rights legislation represents one of the most significant steps in eliminating widespread discrimination caused by the imposition of barriers restricting persons with disabilities.

People with distinctive but similar design needs constitute special population. This group include persons with limited motion, hearing, or vision, as well as the elderly who may have some form of impairment in one or more of these areas. For such people, it is necessary to create a special interior [2].

The minimum clear passage width for a single wheelchair is 900 mm continuously. An accessible route should be 1200 mm wide to allow both a wheelchair and a walking person except where extra space is required at the doorways (Fig. 1).

The minimum passage width for two wheelchairs to pass side by side is 1500 mm. In the case of continuous stretch of corridor, the preferable width is 1800 mm.

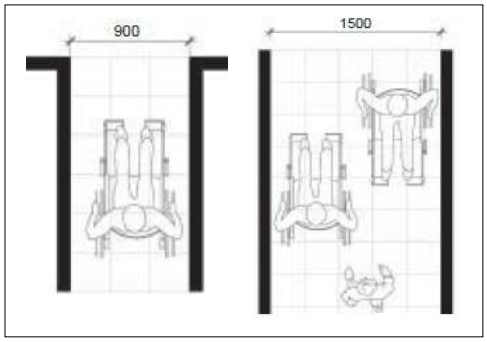

Fig. 1. Wheelchair Passage Width

Ground and floor surfaces along accessible route and in accessible spaces, including floors, ramps, stairs and curb ramps, should be level, stable, firm and slip-resistant. The surface should not be excessively textured and undulating.

Any part of an accessible route with a slope greater than 1:20 shall be considered a ramp (Fig. 2) [5].

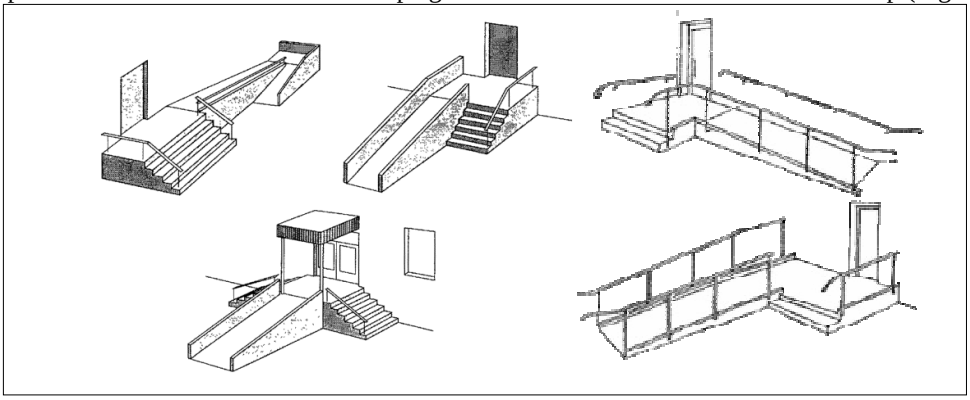

Fig. 2. Ramps

Handrail texture:

- Railings must meet all necessary dimension requirements (Fig. 3).
- Handrail should be slip-resistant.
- Railings should be painted a contrasting colour to the surroundings for the visually impaired.
- For emergency stairs or ramps a tactile strip at least 900 mm long should be applied to the top and bottom ends of the handrail to alert the visually impaired [5].

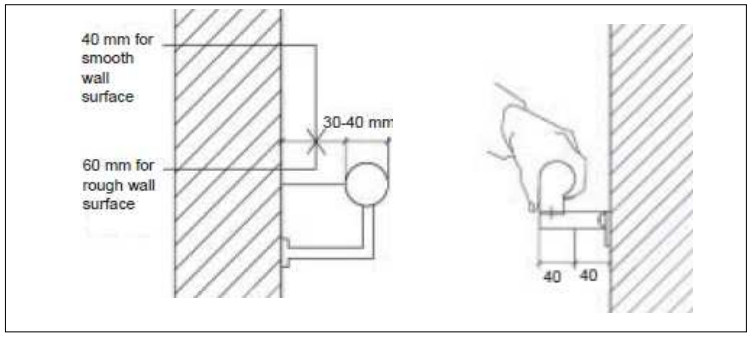

Fig. 3. Handrail

Any type of door, hinged, folded or sliding should have a minimum clear opening of 900 mm when fully open (Fig. 4).

Revolving doors and turnstiles should be supplemented with auxiliary side hung door not less than 900 mm clear. In the case of double-leaf doors, at least one door should have a minimum opening clearance of 900 mm.

Thresholds, if unavoidable, should not exceed 12mm and should have a bevelled sloped edge at 1:12 gradient.

Door hardware should be selected such as not to require fine finger control, grasping. Handle should be of a lever type rather than circular knob. Door hardware such as handles, latches, etc should be mounted between 900 mm and 1200 mm from the finished floor level and must enable the user to operate it by a single hand [1, 6].

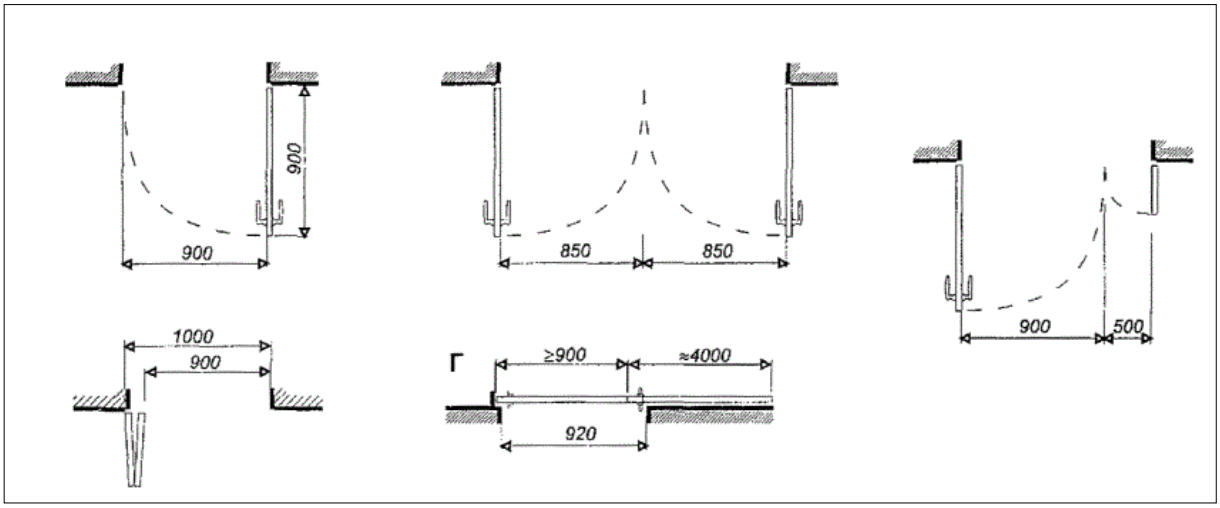

Fig. 4. Doors

The washroom should have a minimum internal dimension of 1750 mm × 1500 mm. Controls must be mounted between 900 mm and 1200 mm from the finished floor level.

Bathing space should have minimum dimensions of 1500 mm × 750 mm for usage by all types of the disabled, it should provide a 900mm horizontal grab bar and a 750mm vertical grab support at 900 mm from the finished floor level.

A shower head for the cubicle should be of the hand-held type with allocation for fixed use. The hose must be not less than 1500 mm long. Enclosures made for the shower area and bathtubs should not interfere with the controls and must allow easy transfer space for the person on the wheelchair. Soap dishes must be recessed and placed on the same wall as the shower head at a height between 900 mm and 1200 mm from the finished floor level.

A toilet cubicle designed for a wheelchair user should be of internal dimensions not less than 1500 mm × 1500 mm [1].

A minimum clear space of 1500 mm dia. must be provided between the counter and the opposite wall to facilitate wheelchair turning.

Shelves should be such that they are not more than 500 mm deep and not more than 1200 mm high from finished floor level. There should be a minimum gap of 400 mm between the edge of the work-top and the lower edge of the upper shelves.

Thus, the barrier-free environment is designed to ensure that buildings and facilities accessible to people with disabilities such as the inability to walk, difficulty while walking, resting on crutches, blindness, speech defects, hearing or vision.

Providing the building with all the necessary requirements for persons with disabilities will provide an opportunity for everyone to participate in all spheres of society (social, sporting, economic, educational, entertainment, etc.).

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PERSPECTIVES OF USING ASH FROM THE COMBUSTION OF PEAT IN CIVIL ENGINEERING

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The article provides an overview of the composition and properties of ash waste from the burning of peat at power stations in Belarus. It also summarizes suggestions for the areas of peat ash use in the production of building materials. It is shown that peat ash can be used in the manufacture of ceramic products, products of autoclaved hardening and also for water-repellency of dry mixes.

According to the State program on the creation of energy sources based on local fuels the flow of ash waste is to increase up to 300 000 tons annually, amounting to nearly 10 % of the total quantity of municipal and industrial waste [1]. The most widely spread local fuel is peat, the share of which in the total quantity of fuel will have amounted to 4,3 % by 2020 [2]. The largest reserves of low ash and medium ash peat are concentrated in Vitebsk region – 46 % of all stocks of the Republic [3]. Due to its physical and chemical composition peat ash, as a raw material, can be used in different productions and, above all, in civil engineering.

The dependence of the chemical composition of ash or slag ash, as the products of the burning of peat, on the substances which they include is displayed in Table 1 [3].

Table 1 – Averaged chemical composition of the ash and slag ash

SiO_2	AI_2O3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	P_2O_5	SO_3	ППП
41-65	6-10	8-17	12-28	0,5-0,8	1,1-1,7	0,5-0,7	0,3-0,5	0,4-2,0	0,06-1,4	0,01-6,0

It was found out [4] that peat ashes consist mainly of amorphized by firing clay material and quartz grains, hardly altered by firing. The crystalline phase is represented mainly by quartz; besides, there is calcium oxide, dicalcium silicate, hematite, feldspar, minerals of the melklit group and presumably pyaticalcium trihaluminat.

A phasal chemical analysis of peat ashes, by means of the technique developed by S.M. Royakom, E.I. Nagerovoy and G.G. Kornienko [5], showed that the major part of calcium oxide in the ash is present in the form of silicates and calcium aluminates, these compounds are easily hydrated.

The correlation of the components of ash determines its activity and astringent properties. The main criterion for determining the binding propertie s of ash is the presence of free calcium and magnesium oxides. The major characteristics of the chemical composition of ashes are the module of the basis M0, which is the correlation between mass fractions of the major oxides and the total content of acidic oxides, and the silicate module MC, which displays the ratio of reactive

dioxide of silica to the total content of aluminum and iron oxides. For basic slags and ashes M0 > 1, for weak acidic – M0 = 0,9 – 1,0, for acidic – M0 = 0,6 – 0,9, and for strong acidic – M0 < 0,6. However, according to the works P.I. Bozhenov it is more appropriate to apply [6] the Core Touch, which has the following formula:

$$K_{осн} = \frac{(CaO + 0{,}93MgO + P_2O) - (0{,}55Al_2O_3 + 0{,}35Fe_2O_3 + 0{,}7SO_3 + 1{,}27CO_2)}{0{,}93SiO_2}. \quad (1)$$

The concepts of free open $CaO_{откр св}$ free closed $SaO_{закр св}$ free and total lime $CaO_{сумсв}$ .have been introduced in this work where.

$$CaO_{сумсв} = SaO_{открсв} + SaO_{закрсв}. \quad (2)$$

It has been found out [8] that the basic ash consists essentially of reactive calcium oxide CaO, silicon oxide SiO_2 and aluminum oxide AL_2O_3. Mass fraction of calcium oxide CaO is not less than 10%. The basic ash contains hydraulically active ingredients and is independently astringent.

Acidic ashes consist mainly of SiO_2 reactive silicon with a mass content of not less than 25 % aluminum and AL_2O_3, wherein the calcium oxide content does not exceed 10 % and the mass fraction of free calcium oxide $CaO_{св}$ is not more than 1 %. [8] Acidic ash has properties of typical pozzolans and can be applicable as an active mineral supplement.

Such products of firing clays as: amorphous clay substance of metakaolinit type – amorphous SiO_2 and $A1_2O_3$, and aluminosilicate glass reveal pozzolanic activity in the composition of the ash and slag. Reactivity to calcium hydroxide is different with them and depends on the temperature changes of kaolinite clays during fuel combustion. Having a large specific surface area metakaolinit Al_2O_3 x $2SiO_2$ reacts with Ca $(OH)_2$ at ordinary temperatures to form calcium gidrosilikates and gidrogelenit [3].

Activity of amorphous SiO_2 and $A1_2O_3$ formed at higher temperatures is much less, which is explained by a sharp decrease in the specific surface area due to sintering and crystallization of new formations – mullite and cristoballite. High temperature sintering and melting of clay minerals reduce sharply their surface area and their activity accordingly. Consequently, the glass phase of the ash and waste is of little activity at ordinary temperatures. Increase in the combustion temperature over the allowable limit leads to a drop in activity of most types of fuel ash [3].

The results of the calculations of activity criteria of ash waste solid fuel done in this work [3] are given in table 2.

Table 2 – Quality criteria of ash waste solid fuels at some power enterprises of Belarus

Enterprise	Type of fuel	*Mo*	*Mc*	*K*
Brest Republican unitary enterprise of electricity «Brestenergo»	A mixture of wood chips (60 %) and peat (40 %).	0,39	2,98	0,51
	Peat fuels. PRUTP "Gatcha-Osovsky)	0,36	2,83	0,47
	Peat fuels. TPU "Berezovsky"	0,27	6,27	0,38
	A mixture of 60 % wood chips and peat 40 %.	0,32	4,82	0,45
	Slag	0,55	2,17	0,70
RUE Minsk Electricity «Minsk-energy» Zhodinskaya CHP	Shredded peat briquette	0,59	1,08	0,75
	Milled peat	0,56	2,53	0,73
Berezino District management industrial gas enterprise «Berezinoraygaz»	Milled peat	0,52	3,23	0,76
	Peat briquettes	0,78	1,46	1,08
JSC «TBZ Usyazh»	Peat briquettes	0,52	2,22	0,7
JSC «Starobinsky TBZ» Branch «Nesvizh»	Peat briquettes	0,47	2,78	0,64

The authors of this work [3] draw a conclusion that the investigated ash waste of Belarusian enterprises is mostly of hidden active type, requiring intensification of hardening. It is supposed that they can be used in the manufacture of industrial products hardening by heat treatment alongside with activation.

As a result of previous studies [9] binding properties exhibited by slag from burning peat at autoclaved hardening have been identified. It has been discovered that it is particularly important to have 25 % or more of calcium oxide in ashes, which determines their hydraulic activity during water thermal processing. It has also been found that ash with a lower contents of calcium oxide exhibit binding properties only when lime and gypsum dehydrate are added to it.

A series of bricks with peat ash from the city's CHP was manufactured at theVilnius sand lime brick factory. It was noted [4] that the sand-lime brick with peat ash (ash: lime 1: 1) was sufficiently strong, and after autoclaving it satisfied the requirements of GOST for the products of brand 150.

In the same factory gas silicate partition plates with peat ash binder were manufactured. The molding mixture consisted of 90 % peat ash, 10 % lime (about 90 kg / m^3) and 5 % gypsum dihydrate. Gas silicate strength with the density of 950 kg / m^3, amounted to 4,5 – 5,0 MPa. The binder of the same composition was used to produce ash sand wall blocks. At a consumption of 550 kg of the binder per 1 m^3 of concrete its strength was 22 – 25 MPa [4].

With the peat ash from the Kirov TPP autoclave reinforced slabs were made. 3 % of gypsum was added to the ash. The strength of concrete with 450 kg of binder per 1 m^3 of the product reached 25 MPa. Ash and sand walls of «Krestianin» type were also manufactured on a peat ash basis at Petrashunayskaya TPP. After the maturation under normal conditions, they showed the strength of 20 MPa and were able to stand 15 cycles of freezing and thawing. [4] Organic compounds emitted from peat raw material may be used for hydrophobization of dry mortars, preventing caking, clumping, and consequently, the loss of activity during storage and transportation. [3] Our work prooves that the concrete and cement solutions prepared on the basis of hydrophobized mixtures have reduced water permeability, water absorption, high frost resistance and so on.

Bitumens are considered to be initially composed of hydrophobic peat raw materials. It was proposed to carry out the activation of the hydrophobic organic mineral mixture in order [10] to give the disperse material a maximum water proofing effect. It was found that the hydrophobic effect of the modified cements increases with the rise in the degree of decomposition of the peat raw materials used to prepare the additives. The comparison of a group chemical composition of peat organic matter, used for production of additives, showed that the cements (dry mix), which were filled with the modifiers with predominant contents of bitumen as well as humic and fulvic acids, have the highest hydrophobicity. The system acquires high water repellency properties with the optimum ratio of the initial components in a dry mortar.

According to their strength characteristics concrete and cement mortars based on hydrophobized peat binding additives are not inferior to the samples of unmodified materials, with the concentration of the mineral binder [10] up to 3 – 5 % of the weight. [11] It is pointed out in this work that the ash of solid fuels can be used in the manufacture of ceramic products, providing a reduction in density of a ceramic crock and improving the thermal protective performance of brick. It was discovered that, depending on the chemical and technological properties of the clay and the desired characteristics of the finished product the amount of peat ash injected into the charge can vary from 5 to 20 %. Adding ash clay to charge, besides reducing the coefficient of sensitivity to drying, can improve the rheological properties of the clay by increasing plastic strength, thereby reducing the number of defects, arisen during the process of extrusion, in macrostructure of the ceramic skull, thus enhancing mechanical strength and frost resistance of brick [3].

Thus, the results of the research and experiment suggest that the ash waste from the burning of peat at Belarusian enterprises are hidden active. It is possible to use peat ash as part of binders in the manufacture of products of autoclaved hardening. First of all peat ashes with a share of calcium oxide of 25 % or more are to be used.

Organic compounds released from peat raw materials, can be used for water-repellency of dry mixes.

The addition of 5 to 20 % of ceramic ash peat to the composition of clay in the manufacture of batch products can provide a reduction in the density of ceramic crock and improve a thermal protective performance of brick.

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UDC 79.11

CALCULATION OF EXTREME BROADENING OF LOADED FOUNDATIONS ON NATURAL BASIS

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Bases loaded immediately after the construction, compared with those in which the area of the supporting parts increases as load grows, have different stress-strain state of the redistribution of the ground contact pressure at the base of the foundation.

The calculation is performed for an increasing area of foundation supporting parts in the process of construction. It is necessary to take into account different types of deformability of the foundation soil under the central and lateral areas at different stages of loading. The calculation is performed in two stages.

At the first stage we study the stress state of the system under load F_S, at the second - n.d.s. broadens the plate to size L under load F_i taking into account the different deformability of the soil under the central and side areas.

A stress field is formed when the initial load is applied to an array of ground. After the application of an additional load there appears an increase in the ground voltage. Reactive earth pressure under accrued (side) areas is ($\triangle L_1$; $\triangle L_2$) Function additional load is $P_б(x;y) = f_1(\triangle F)$ And under the center – functioning of the initial and additional load at the same time $P(x;y) = f_2(F_S) + f_3(\triangle F)$. For the final decision we summarize the intermediate results.

Let us consider «strip» conventionally isolated from the foundation tape transverse as a strip of unit width. As indicated above, the calculation is performed in two stages. The first step in the study of the mechanism of formation n.d.s. where deformation characteristics of a base (using the Winkler hypothesis – the coefficient bed) are assumed to be constant over the entire length l. To determine these characteristics we use a graph of «load-precipitate». At the first stage of loading the load is considered tobe zero, then the numerical value of the coefficient of bed K_1 isdetermined in the first section of the chart, and the ratio of pressure on the ground p_1 to the value of rainfall Stamp S_1 experienced caused by this force action:

$$K_1 = \frac{p_1}{S_1}.$$

At the second stage, the calculation of band width loaded load is done $\triangle F = F_i - F_S$. Characteristics of subgrade at this stage of calculation should be made at different length L. For the central portion having already upset S_1 Coefficient bed K_2 characterized by cutting 1-2. Value K_2 equal:

$$K_2 = \frac{\triangle p}{S_2 - S_1}.$$

Under the side of the plate contact pressure distribution is uneven: the busiest section is $\triangle L_2$. Thus, we have two side portions that have come into operation at the same time after the application of the additional load $\triangle F$ having, in principle, different stress state. Coefficients of bed (K_1 ; K_3) are characterized by a secant slope portion 0-1 for marking the change in pressure in the first case from 0 to $\triangle p_1$ And in the second - from 0 to $\triangle p_2$. Coefficients K_1 and K_3 may be equal or different because of the peculiarities of formation of the state of stress. In the case of separation of the sole foundation from a subgrade bed one of the coefficients is zero.

The state of equilibrium or movable of deformable systems is known, besides differential equations it can be described by using variation principles. Thus, the equilibrium position of a conservative system is a position in which the force function of all the forces of the system has a minimum value. To determine this minimum,the so-called direct variation methods, including the Ritz method are applied. Most problems in the theory of elasticity and structural mechanics can not be solved exactly. The usage of the variation principles allows obtaining an approximate solution and at the same time with all desired accuracy.

This method is used to determine the effective forces, as well as linear and angular displacements broadened under load, applied with a certain force, the support member lying on the Vinklerovom basis. An elastic line study of the foundation strip ($b = 1m$) is described by a coordinate function adopted in the form of a polynomial of the 6th degree:

$$V(x) = a_{11} + a_{21}(15l^4x^2 - 5l^2x^4 + x^6),$$

where Initial bandwidth (after broadening L), a_{11}, a_{21} – Unknown coefficients.

At the ends of the strip imposed power conditions:

$$EIV^{II}(0) = 0,\ EIV^{II}(L) = 0,$$
$$EIV^{III}(0) = 0,\ EIV^{III}(L) = 0.$$

The left edge of the strip is accepted as original. Based on the upper band, the potential energy of the band broadening is the sum of the potential energy of bending plate and the potential energy of the elastic foundation:

$$П_S = 1/2\int_0^l E_1 I_1 (V^{III}(x))^2 dx + 1/2\int_0^l K_1 V_S^2 =$$

$$= 1/2\int_0^l E_1 I_1 \left[a_{21}(30l^4 - 60l^2x^2 + 30x^4) \right]^2 dx +$$

$$+1/2\int_0^l K_1 \left[a_{11} + a_{21}(15l^4x^2 - 5l^2x^4 + x^6) \right]^2 dx =$$

$$= 1/2\left[E_1 I_1 a_{21}^2 186l^9 + (a_{11}^2 l + 7.72 a_{11}a_{21}l^7 + 28.76 a_{21}^2 l^{13})K_1 \right] =$$

$$= 93E_1 I_1 a_{21}^2 l^9 + K_1(0.5a_{11}^2 l + 3.86 a_{11}a_{21}l^7 + 14.38 a_{21}^2 l^{13}).$$

Power function of the external force has only term taking into account the initial work load:
$V_S = F_S V_S (l/2 + e) = F_S \left\{ a_{11} + a_{21}(3.43l^6 - 12.37l^5 e + 8.4l^4 e^2 - 7.5l^3 e^3 - 1.25l^2 e^4 + 3le^5 + e^6) \right\}$ The total energy of the system to build:

$$Э_S = П_S - U_S = 93E_1 I_1 a_{21}^2 l^9 + K_1(0.5a_{11}^2 l + 3.86 a_{11}a_{21}l^7 + 14.38 a_{21}^2 l^{13}) - F_S V(l/2 + e) .$$

Using the basic equation of the Ritz method:

$$\frac{\partial Э_S}{\partial a_i} = \frac{\partial (П_S - U_S)}{\partial a_i} = 0 .$$

Weobtain:

$$\frac{\partial Э_S}{\partial a_{11}} = K_1 a_{11} l + 3.86 K_1 a_{21} l^7 - F_S = 0$$

$$\frac{\partial Э_S}{\partial a_{21}} = 186 E_1 I_1 a_{21} l^9 + 3.86 K_1 a_{11} l^7 + 22.08 K_1 a_{21} l^{13} -$$

$$-F_S(3.43l^6 - 12.31l^5 e + 8.4l^4 e^2 - 7.5l^3 e^3 - 1.25l^2 e^4 + 3le^5 + e^6) = 0.$$

We denote by A the expression at factor F_S in the formula . After transformations we obtain the system of equations:

$$\left\{ \begin{array}{l} a_{11}K_1 l + 3.86 K_1 a_{21} l^7 - F_S = 0 \\ 3.86 K_1 a_{11} l^7 + a_{21}(186 E_1 I_1 l^9 + 22.08 K_1 l^{13}) - F_S A = 0 \end{array} \right\} .$$

Determine the parameters $a_{11}, a_{12}, a_{21}, a_{22}$,We obtain expressions for the forces acting in the broadened under load and upload foundation strip.

$$V(x) = V_1(x) + V_2(x) = a_{11} + a_{21}\left[15(l/2)^4 x^2 - 5(l/2)^2 x^4 + x^6 \right] +$$

$$+a_{12} + a_{22}\left[15(L/2)^4 x^2 - 5(L/2)^2 x^4 + x^6 \right];$$

$$\varphi(x) = V^I(x) = a_{21}\left[30(l/2)^4 x - 20(l/2)^2 x^3 + 6x^5 \right] +$$

$$+a_{22}\left[30(L/2)^4 x - 20(L/2)^2 x^3 + 6x^5 \right];$$

$$M(x) = -E_1 I_1 a_{21}\left[30(l/2)^4 - 60(l/2)^2 x^2 + 30x^4 \right] -$$

$$-E_2 I_2 a_{22}\left[30(L/2)^4 - 60(L/2)^2 x^2 + 30x^4 \right];$$

$$P(x) = -E_1 I_1 a_{21}\left[-120(l/2)x + 360x^2 \right] - E_2 I_2 a_{22}\left[-120(L/2)x + 360x^2 \right].$$

The endurance capacity of foundation depends on two factors: the strength of the structure itself and the stress state and the strength of the base. The diagram of the jet pressure on the broad foundation is different from that of the ordinary and it can be concluded that the stress field in the soil base will also be formed in different ways, ie, limit equilibrium zone soils at different stages of loading and under various sections of scalable foundation slab will have a different character.

As it is known, the zone of plastic deformation in the ground increases under the slab while it is located below the broadening of the plate edges. The broadening and dogruzheniya of these zones reduce, until the complete cover. But then

increasing load zones begin to develop under the edges of the broadened plate. These areas are expanding and deepening. It is noticed firstly that the zones differ in configuration; secondly, that in the case of the construction of a consistent depth of zones of limit equilibrium is smaller; Thirdly, despite the greater depth of the development of the zones under the most critical section the foundation slab they are reduced in comparison with the areas emerging in the case of a single loading.

To investigate the stress-strain state (n.d.s.) of soil mass under Accreted stove should use one of the most popular numerical methods - the boundary element method (BEM). This method allows tosolve a variety of boundary value problems of mechanics of deformable bodies, using various fundamental solutions of boundary integral equations. In general terms, they can be taken down in the following way:

$$c_{ij}(\xi)u_j(\xi)+\int_r P_{ij}^*(\xi,x)u_j(x)d\Gamma(x)=\int_r u_{ij}^*(\xi,x)\,p_j(x)d\Gamma(x)\,.$$

In this work we present a study of a stress-strain state of round and rectangular plates supported by ribs, which appear during the operation of plastic deformation.The technique of determining the stress-strain state is enhanced by increasing the cross sectional area of the beams. We also formulate recommendations on the design to broadens the foundations on natural ground, loaded centrally and eccentrically with applied load. The obtained data in the conclusions and the methodology developed at an engineering level can be used to solve specific problems and remove defects in the development of standards of construction elements.

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COLOUR IN ARCHITECTURE

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The article is about different ways of using colour in architecture. It is devoted to the way a colour influences another one and human perception as well. It also explains how we can change the whole view of architectural objects using colour.

Colour in architecture is one of the means of art expressiveness. Composition tasks in the range of colour of constructions and architectural complexes are solved using the colour of buildings or finishing materials, the colouring of surfaces in building process, or emphasizing of separate constructive elements industrially. Colour promotes the manifestation of volumes, the planes, details.

With the help of colour, we can distinguish a separate building among other buildings of an architectural complex. For example, intensive colour of the building of the Moscow Council of deputies of workers distinguishes it from other buildings forming the street and the square adjoining the building. Thus, the building gets the predominating role in the composition of the street and area in spite of the fact that its size is less than the size of the neighboring buildings.

In mass construction according to standard projects, the role of the colour is rising. With the help of colour, we can completely diversify the same houses and parts of buildings; we can give elegance and attraction to the buildings with a simple form. For this purpose in new regions of cities large wall panels of various colour are grouped in buildings using different schemes of a relative positioning; the emphasis on colour of balconies, loggias, staircases, entrances and etc. is also widely applied.

The colour of buildings has an impact on the level of average illumination of streets: the fewer the number of floors is and the bigger the width of streets is, the greater the effect on emotional and figurative characteristics of buildings is. The streets formed with gray facades of buildings at an insufficient level of illumination look gloomy, dim, and those formed with yellow and white facades look "solar" even on cloudy days. Except emotional, symbolical value, the colour also has functional importance. Colour gives us the information about constructions, and also about the main functions of that object. Besides, we can distinguish functionally important elements such as doors and windows and details of the building with the help of colour.

Symbolic and psychological meaning of colour scale of architectural instructions

Many monuments of different eras prove that the colour scale has a symbolic meaning and a huge psychological impact on a person. In particular, the Babylon temple of Nebuchadnezzar had the colour scale symbolizing seven planets, which were known during that period to mankind. Gradual transition from black to orange, red, yellow, green, blue, and white created the composition of traditional symbolics, and showed the grandness of the construction as well.

In Ancient Egypt temples, the palette of exquisite wall paintings consisted of yellow, green, blue, purple, white and black colours. They all symbolized separate concepts: the golden-yellow colour – the Sun, the red colour – the person, the green colour – the eternity of nature, the purple colour – the earth, the blue colour – justice. In exteriors of Ancient Greece temples, which became famous for rich ornaments and decor, terracotta shades were used, and in interiors cult statues painted and inlaid with gold, ivory, and expensive wood were given an important role. Thanks to the refinement of colours these decorative elements made an impression of solemnity and luxury.

Colour in XX century's constructions

The achievements in science and technology, and a new way of stylistical thinking in the XX century increased associative and psychological meaning of colour in architecture. Artists of the European countries, first of all, of France, Holland, Russia and Germany, considered colour as the main tool for the organization of the artificial environment thus having form-building and psychological qualities. However, it did not lose the main properties – the symbolical ones. The red colour, for example, became a symbol of revolution.

In 1920 a well-known Swiss architect Le Corbusier carried out polychrome experiments which had an urban character. In the settlement of Pessak built on his project near Bordeaux facades of all houses were coloured. It means that the polychrome played a role of an active town-planning element here.

Colour compositions of modern buildings

Today experts of different countries are studying the influence of colour on the architectural environment and images of the building. It is difficult to solve this problem in housing, where precise geometrical rhythm of typical houses combines with the environment. That is why nowadays more often you can find bright facades of multistory houses and

complexes in new regions of Moscow, Kiev, Kishinev and other cities. Such facades differ in a saturation of supergraphics drawing on a light background of the sky. There is a very wide palette of colours used in modern architecture.

They say that it is not a problem that new houses with bright colours began to appear in cities. But it is very important to have a unified colour concept in cities, which lets us make an urban environment harmonious, and not to turn into a crazy quilt, which is formed on a whim of private customers. It is very difficult to keep the city from chaotic colour schemes without a uniform concept, and it is desirable to use half-tone colours for city architecture to avoid open and rectilinear shades for facades of residential sites of the city. They are used locally, for allocation of separate parts of the facades. It gives people a more positive mental spirit. The half-tone better matches the natural landscape of the earth and the sky.

Scientists claim that the accompanying conditions influence the perception of colour. First, colour in the environment is considered in the aspect of four scales: a city or an area, a street or a square, a certain house, details. Secondly, specific aspects of perception should also be noted, for example side, front, top, and bottom views. Thirdly, the existence of natural and artificial illumination, also the falling shadow from surrounding objects cause various versions of colour vision. The accompanying conditions must be taken in account of design, because they can change the impression of the chosen colour in the environment making it different from what it should to be. There are two most widespread spaces for an urban architecture; they are streets and squares. The colour scale can influence their look. Light tones can emphasize the integrity of the flatness of a street. When the colour of the sidewalk repeats in the design of facades, or it is included into the horizontal partitioning of the buildings along the street as means of the allocated colour strips, the effect of lengthening is created. One more method of composite manipulations by means of the colour is the expressiveness of the vertical position of facades. It is carried out through vertical partitioning of buildings by contrast colours.

Now we can notice the problem of very contrast combinations of the colour palette characteristic of historical buildings together with the newest elements of a city environment. We can expect that the use of new materials and technologies will change colour concepts, new qualities of the environment will be created and the characteristic image of the city will be developed too.

Colours make various physiological impact on the person. They cause good or bad feelings, raise or reduce person's activity. The colouring of industrial, administrative and educational objects has significant influence on the increase or decrease in productivity; in medical institutions effective room colouring may have a beneficial impact on patients' health. The influence of colour on a human body can be indirect, thanks to the property of colour increasing or reducing the sizes of rooms visually; thereby it makes an impression of their isolation or freedom.

The strongest irritant is the orange colour; the following ones are yellow, red, green, purple. Cold and neutral colours (blue, green-blue and different shades of violet) have the lowest irritating influence. Irritating colours are suitable for colouring only of small surfaces indoors, quiet – for surfaces of a bigger scale.

Warm colours work actively and cause a feeling of cheerfulness, and under certain conditions, they even cause excitement. A cold colour works in a calming way disposing to rest and thoughtfulness and serenity. Green colour removes a nervous tension.

Physiological action of this or that colour also depends on its brightness and on a place of usage. Warm bright colouring of the top parts of a room favorably influences the person; the same colouring of walls makes them closer to the viewer and causes the feeling of warmth; floors which are painted in these colours visually increase room height, give it lightness. Warm dark colouring of a ceiling gives the room spatial clearness and solemnity; the colouring of walls emphasizes their protecting function; floors of dark colours make impression of durability and reliability. Cold bright colouring of ceilings gives the feeling of light and ease, a room with such colouring of walls seems spacious, and the floors look more smooth and cause a desire to speed up the move. Cold dark colouring of ceilings makes a gloomy impression: the same colouring of walls causes a feeling of cold; the floors of dark and cold colours lower the room height visually. White colour is the colour of absolute purity and order. In colour designing of interiors, it plays the leading role. It gives different shades to the rest of the colours, changing their saturation, giving different lightness.

The perception of colour changes over time, not only physically, but also psychologically. Like classical four types of the temperament of person, colour has a specific meaning. Bright, saturated colours possess short impulses capable of mobilizing and influencing for a short time. Low-saturated colours, on the contrary, over time find new nuances possessing more long-term influence on the human mind. Warm colours (red, orange, orange-yellow) originally make a stimulating impact in an interior, but they must be balanced by opposite or neutral colours, for example, gray-green. Violet colour gives balance to any interior. Soft, dark tones can also muffle some gushing forth temperament of the sanguine person. And the choleric person, for example, perfectly gets on with red colour, even in its most intensive forms. The red functions dynamically, actively, temperamentally, brightly. The bluish-red mutes a very sociable temperament, at the same time without bringing the choleric person to passivity. The counterbalancing additional colour is green.

In our dynamic, chaotic time contrast scheme of a combination of colours in an interior appears to be most popular. But any experiment, even the most courageous colouristic one, shouldn't ignore fundamental laws of a combination of colours. Psychologists noted that the best of all humans' eyes perceive a combination of blue colour on white background, and worst of all - red on yellow. All colours strongly differ on extent of drawing attention. Blue-violet will absolutely attract your look, dark blue – 90 %, turquoise – 85 %, intensive lemon colour – 60 %, black – 47 %, dark-violet – 42 %, yellow – 22 %, blue – 17,5 %, light-blue – 14,5 %, brown – 9,5 %, ruby – 7,5 percent of views.

So, in conclusion we must admit that colour is a means of art expression, it promotes the manifestation of volumes, the planes, details. With the help of colour, we can emphasize the main purpose of the building in an architectural complex. Besides, colour has influence on human psychological state. That is why we should pay more attention to colour in architecture.

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UDC 77.03

DYNAMICS OF MULTI-SPAN BEAMS ON NONLINEAR ELASTIC TIES UNDER ARBITRARY LOAD

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In this paper we propose a method that simplifies the creation of mathematical models of the dynamics of beam systems with an infinite number of degrees of freedom, a large number of boundary conditions and the composition of active forces. The method is based on the iterative solution of the equations of the dynamics of the free beam under the action of many forces, which included support reactions.

Consider the solution of the problem of vibration of an elastic beam on an elastic mass on an elastic sealing, as shown in Figure 1.

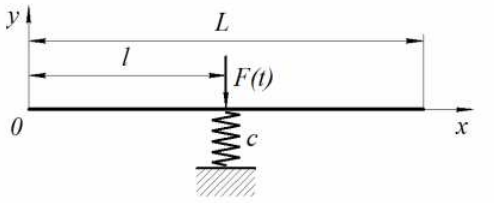

Fig. 1

In order to explain the advantages of the proposed method of solution, compare it with the traditional method of solution of the problem decomposition to their own forms.

In accordance with this method, the displacement y(x, t) of any point of the beam at any point in time is represented as a sum of products of functions of the form $W_k(x)$ on a temporary function $G_k(t)$:

$$y(x, t) = \sum_{k=1}^{\infty} W_k(x) G_k(t), \quad (1)$$

where *k* – number of waveforms.

Time function depends on the type of exposure (impulse, step, or a harmonic or more). For this example, assume that the exposure step, i.e. at time t = 0 at the center beam by the force applied F(t) = Fo, which continues to operate for an indefinitely long period of time.

The shape function depends only on the coordinates x and in a general way for beams of constant cross section is determined by the function Krylov.

S(*αkx*), *T*(*αkx*), *U*(*αkx*), *V*(*αkx*)*:*

Wk (*x*) = *C1* · *S*(*αkx*) + *C2* · *T*(*αkx*) + *C3* · *U*(*αkx*) + *C4* · *V*(*αkx*),

C – constants determined by the boundary conditions;

S (*αkx*) = *0.5* (*ch* (*αkx*) + cos (*αkx*)),

T (*αkx*) = *0.5* (*sh* (*αkx*) + sin (*αkx*)),

U (*αkx*) = *0.5* (*ch* (*αkx*) - cos (*αkx*)),

V (*αkx*) = *0.5* (*sh* (*αkx*) - sin (*αkx*)) – Krylov function.

In this example, the left end of the beam *(at x = 0)* and no reaction in the sealing of time, therefore, the second and third derivatives of the shape function are equal to zero, this in turn means that the constants *C3* and *C4* are also zero. From the shape function of the first two terms are:

$$Wk\,(x) = C1 \cdot S\,(\alpha kx) + C2 \cdot T\,(\alpha kx). \quad (2)$$

When moving from the left to the right end of the beam after passing through the intermediate support to form additional term function *W (x) = DV (αk (xl))*, where l – coordinate support, so when 1 x shape function has the form:

$$Wk\,(x) = C1 \cdot S\,(\alpha kx) + C2 \cdot T\,(\alpha kx) + DV\,(\alpha k\,(x\text{-}l)). \quad (3)$$

Dn – constant determined by the magnitude of the amplitude R from the elastic sealing: $D = R / \alpha 3EJ$. To determine the constant D we obtain the expression:

$$D_k = -\frac{cW_k(l)}{\alpha^3_k EJ} = -\frac{c}{\alpha^3_k EJ}(C_1\mathrm{S}(\alpha l) + C_2\mathrm{T}(\alpha l)) \ . \quad (4)$$

The right end of the beam (as well as the left) is free, so the second and third derivatives at $x = L$ are equal to zero.

As a result of reforms and expressing *C1* through *C2* obtain the frequency equation:

$$f(\alpha) = T(\alpha L) + S(\alpha l)S(\alpha(L-l))\frac{c}{\alpha^3 EJ} -$$

$$\frac{U(\alpha L) + S(\alpha l)T(\alpha(L-l))\dfrac{c}{\alpha^3 EJ}}{V(\alpha L) + T(\alpha l)T(\alpha(L-l))\dfrac{c}{\alpha^3 EJ}}\left[U(\alpha L) + T(\alpha l)S(\alpha(L-l))\frac{c}{\alpha^3 EJ}\right] . \quad (5)$$

As mentioned earlier, in this example, the case of the step of loading the design. With zero initial conditions for each form of motion is described by the well known relation to fluctuations in the system with one degree of freedom with damping. Only instead of mass, stiffness, damping coefficient and natural frequency should be replaced by their equivalent values:

$$G_k(t) = \frac{P_k}{c_k}\left[1 - e^{-h_k t}(\cos(\sigma_k t) + \frac{h_k}{\sigma_k}\sin(\sigma_k t)\right]. \quad (6)$$

Expression (6) is the time function, as discussed in the beginning. As a result of transformation, substituting the expression (6) in (1) we obtain the equation to obtain the coordinates of any point of the elastic system at any time.

Now consider the method proposed in this paper to solve the same problem. Represent beam lying on an elastic support (and generally any number of resilient supports), as a free beam. In this case, we do not need to be bulky frequency equation and the shape function. Frequency equation and the function of the free form of the beam are easy to deduce or take from the directory:

$$f(\alpha) = V(\alpha L)T(\alpha L) + U(\alpha L)^2,$$

$$W_k(x) = \frac{V(\alpha_k L)}{U(\alpha_k L)} \cdot S(\alpha_k x) + T(\alpha_k x).$$

Taking into account the dynamics of the beam equation notation is as follows:

$$M_k \ddot{G}_k + 2h_k m_k \dot{G}_k + c_k G_k = P_k(t), \quad (7)$$

where *Pk(t)* – the sum of the forces acting on an equivalent weight:

$$P_k(t) = (-F(t) - cy(l,t))W_k(l) = -(F(t) - c\sum_{k=1}^{\infty} W_k(l)G_k(l),$$

where *F(t)* – dependence of the driving force from time to time;

y (l, t) – the movement of the point of attachment to the elastic sealing of the beam.

Knowing the initial conditions for the function of time, we find its new value at time $t_{i+1} = t_{i+\tau}$. To do this, we consider the solution of the differential equation of motion (7).

Equation (7) is a non-homogeneous differential equation of the second order. Its decision is made up of the general solution of the homogeneous equation and a particular solution of the inhomogeneous equation:

$$G(t) = Go(t) + Gch(t).$$

Particular solution of the inhomogeneous equation describes the natural oscillations and contains two arbitrary constants, which are determined by the initial conditions:

$$G_o(t) = e^{-ht}(C_1\cos(\sigma t) + C_2\sin(\sigma t)).$$

A particular solution of the inhomogeneous equation describes the forced motion of the system after a complete decay of natural oscillations and constant right-hand side can be written as [3]:

$$G_u(t) = \frac{P}{c}\left[1 - e^{-ht}(\cos(\sigma t) + \frac{h}{\sigma}\sin(\sigma t)\right].$$

Thus, the general solution of the inhomogeneous equation has the form:

$$G(t) = e^{-ht}(C_1\cos(\sigma t) + C_2\sin(\sigma t)) + \frac{F}{c}\left[1 - e^{-ht}(\cos(\sigma t) + \frac{h}{\sigma}(\sigma t))\right]. \quad (8)$$

After transformations we obtain the final expression with which the initial conditions and the values of all the forces acting can calculate the new value of *G* and its first derivative.

Due to the linearity of the equation (7) to improve the accuracy, stability and speed of the algorithm of its solution instead of the usual numerical methods, such as methods of Euler or Runge-Kutta, conveniently at each integration step used an analytical approach. Consider a one-step integration. We neglect, changes in power *Pk*(t) for this step. In this case, the formula (8) is exposed stepwise in a solution, however, dividing the time interval into sufficiently small steps,any impact can be represented as the sum of a large number of slightly different from each other steps.

To illustrate the usefulness of this approach to the calculation of the dynamics of systems under the influence of forces that vary not stepped law, consider the dynamics of a system with one degree of freedom under the force varies harmonically. The solution of equation (7) for the harmonic effects is as follows:

$$G(t) = e^{-ht}\left\{\left[G(0) - \frac{F_0}{m}\frac{(\sigma^2-\omega^2)}{(\sigma^2-\omega^2)^2+4h^2f^2}\right]\cos(\sigma t) + \left[\frac{\dot{G}(0)+hG(0)}{\sigma} - \frac{F_o}{m\sigma}\frac{h(\sigma^2-\omega^2)}{(\sigma^2-\omega^2)+4h^2\omega^2}\right]\sin(\sigma t)\right\} + \frac{F_o}{m\left[(\sigma^2-\omega^2)^2+4h^2\omega^2\right]}\left[(\sigma^2-\omega^2)\cos(\omega t) + 2h\omega\sin(\omega t)\right] \quad (9)$$

Figure 2 shows graphs of oscillations built with step τ = 0,2 *s*. In Figure 3, the same process is built step τ = 0,01 *s*. As initial conditions, the following values were taken: *G* (0) = 5 m, $\dot{G}$ (0) = 50 m / s.

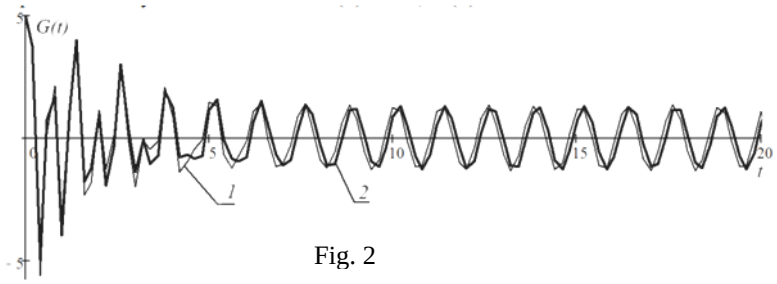

Fig. 2

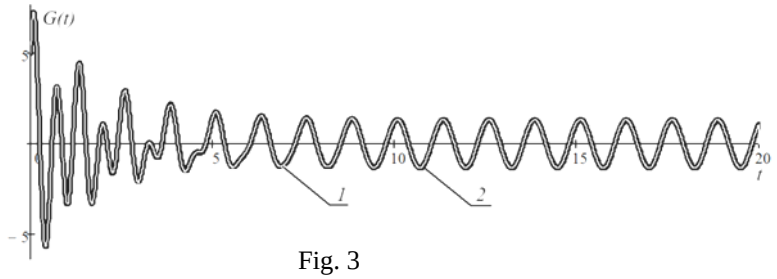

Fig. 3

According to Figure 2 and 6 show that the time step τ = 0.01s results are the same.

To summarize, we can conclude that for a large number of supports solution for the problem of the vibration of elastic systems with an infinite number of degrees of freedom can be made, representing the beam free. This approach is in contrast to the classical one and allows without making cumbersome expressions to determine the frequency equation and the shape functions to get a reasonably accurate solution, thus to consider the nonlinear elastic ties, to calculate the dynamics of the system under the influence of arbitrary power, determined at each iteration depending on the behavior of the elastic system.

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THE CHURCH OF THE INTERCESSION OF THE BLESSED VIRGIN MARY

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Polotsk as one of the oldest towns of Belaya Rus, is known for its numerous monuments of Orthodox architecture. Sophia Cathedral of the XI century (extant in reconstructed form), complex of the Saviour-Euphrossinia Convent with buildings of different time periods. But there were buildings on the Polotsk land of temples, information about which you will not find in any books on architecture, not in publications in archeology. These were religious buildings of later, not of the medieval period. During the Soviet period, because of their large number, they were not give the status of architectural monuments and were totally to the extent possible destroyed. The result of this policy was complete destruction of the architectural heritage of spiritual one.

In Polotsk victims of the post-revolutionary period were not only people, but also churches: Cathedral of St. Nicholas, St. John the Theologian convent in Pardaugava, the church of the Archangel Michael in Zapolote, the Church of St. George in Ekimani and Church of the Intercession.

Polotsk Church of the Intercession of the Blessed Virgin Mary was built in 1781, or to be more exact, rebuilt from an old Polotsk Church of the Epiphany monastery. To some extent this was a continuation of the tradition… in the ancient city of necropolis, were in this place since the time of the Polotsk Principality. Traces of this necropolis were discovered by archaeologists during the construction of fiberglass.

In 1804, by order of Emperor Alexander 1st, who visited Polotsk in July 1802, the Church of the Intercession Cathedral, that is the city's main church, actually started to performs the role of the cathedral church.

After the restoration of Polotsk diocese and the Jesuit church of St. Pereosvyascheniya, Jesuit Church of St. Stephen's Cathedral Church of St. Nicholas of Myra, in 1833 the Church of the intercession was converted into a parish. 57 years later after moving to a new location the Church building fell into complete decay, and was closed. Instead, in 1838, a new Church was built in a former Franciscan monastery. The Church received the name of Novo-Pokrovskaya Church and was located in the Nizhnepokrovskaya street [1]. However, next year the brick building of the former Church got covered with cracks due to settling of the foundation, and the Church was closed. In 1867, was drafted to the extension of the bell tower and the alteration of the wooden Church of the intercession, which was closed with 38 years. Perhaps around this time (in late 60 – early 70's) it was renovated and reopened.

1900 illuminates the site of a wooden building that housed the Church. The fire destroyed the temple and 100 yards. However, icons and jewelry were been saved, and the congregation moved them to St. Sophia's Cathedral.

In 1903, the decree of Polotsk Orthodox Consistory about the construction of the new Church [2].

In the 30-ies, like many other churches, the Church was closed, the priests were subjected to repression and persecution. After the liberation of the town from the Germans, the building was desolated for the while, and then it was the candy factory (Fig.1). In 1960 the factory was burnt in a fire.

Fig. 1. The Church of the Intercession at the time of Polotsk occupation by Nazi invaders.
Winter 1941 – 1943

The issue was only raised in 1991. The restoration however was delayed for many reasons: the building was desolated for a while. Then it was made into a confectionary.

Active restoration work began in 2003 with the blessing of Metropolitan Philaret, who was then in power. The author of the new project was the architect Domogarov Mikhail Illarionovich.

In July 7 the first dome of the temple was installed.

In October 14, 2004 during the celebration of the Intercession of the blessed virgin Mary the Restored sanctuary was sanctified and put into operation [3].

Fig. 2. The Church of the Intercession of the Blessed Virgin Mary. Modern look

The Church of the Intercession of the Blessed Virgin Mary has a tragic history: it suffered from a large number of fires and rebuilding's. But in spite of everything in the 21st century, Pokrovsky temple performs its educational mission, helping many people find Pease and joy.

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RIGID REINFORCEMENT EFFICIENCY IN STRENGTHENING OF STRIP FOUNDATIONS

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The article focuses on the main advantages of rigid reinforcement in the strengthening of strip foundations. The analysis of constructive solutions providing the collaboration of existing foundation elements and those of the reinforcement is done. The main results of research work on the bearing capacity of foundation piling of reinforcement foundation by rigid reinforcement are presented.

When designing the strengthening it's necessary to use to the maximum the existing foundation, providing its collaborative work with the reinforcement's elements [1, p. 131].

Collaborative work of reinforcement's elements of strip foundations with existing construction is provided by several methods:

1) by the installation of concrete keys, projections in cavities of the existing foundation or bearing structures of a building;

2) by the installation of anchors embedded in the body of existing foundations;

3) by the installation of through armature;
4) by the welding of armature of elements of spread with exposed armature of reinforcing foundation;
5) by means of special support elements: braces, unloading metal or reinforced concrete beams.

When using rigid reinforcement, metal-rolling profile will create rigid connection between existing foundation and construction of reinforcement that gives the possibility to reinforcement's elements to put into the operation immediately, without initial deformations that can negatively affect existing foundation. The use of rigid profile when reconstruction works and strengthening of foundation has significant advantages in comparison with the above mentioned methods of ensuring of collaboration:

1. Rigid profile let elimination of attenuation of construction that on the contrary needs to be reinforced. Using this method of strengthening it's possible to avoid attenuation of foundation in those places where the implementation of element of reinforcement under the sole of existing foundation is planned. It's also possible to refuse making keys and cavities, using this method of reinforcement collaboration of new and old concrete will be provided thanks to rigid rod and surface of reinforcing construction with made notch that will let both reduce the cost of reinforcement, and avoid excessive attenuation of existing foundation as well.

2. The use of rigid profile, in comparison with anchors made of steel reinforcing rod let avoid even small displacements and deformations of reinforcement's element with respect to existing structure, that can't be fully performed by anchor made of steel reinforcing rod embedded in the body of reinforcing foundation.

3. When using rigid profile, the hole in the foundation body is arranged with help of diamond crown that does not provoke vibration load to the foundation body and does not result in accidental deformations, and the hole is completely filled by concrete mixture and it's not the area of attenuation, after completion of reinforcement works. When doing through-hole bores for reinforcement bars, installed with the use of perforator, there is vibrational load spread the whole body of the foundation that can lead to undesired attenuation. Besides performed aperture cannot be completely filled during concreting, that's why it's a place of low coherence after completion of reinforcement works.

4. The proposed method using rigid reinforcement is more cost-effective than using installation of different constructions with braces and metal distributing beams along the entire length of the reinforcing foundation. Saving is done due to the fact that there is no need to use installation of metal-rolling distributing elements. Rigid rods are installed in increments when the compression zones disjoint and therefore destructions of compressed concrete are eliminated that allows exclusion of distribution beams.

5. Method of strengthening of strip foundations using rigid reinforcement is more mechanized and less dangerous, as there is no need to attenuate the foundation to install reinforcement construction under the sole of foundation, there is also no need to install keys and cavities in existing foundation that allows not to attenuate reinforcing structure and avoid injury while performing of work. The proposed method does not allow the collapse of construction and it can be performed without full development of a ground up to the base of foundation that eliminates pile heave and violation of hydrogeological conditions under existing foundation.

6. This method makes it possible to transplant strip foundation to jack piles, bored piles or inclined piles situated on one or both sides of the strip foundation. When strengthening using transplantation of strip foundation on piles it's possible to eliminate almost completely development of deformations and foundation settlement, because bearing capacity of shaft bearing pile is of 200 – 400 kH, bearing pile – 800 – 1000 kH.

To ensure a durable adhesion between new and old concrete the surface of existing foundation should be purified from soil, old waterproofing layer, chemicals, as well as from incoherent solution, concrete, they should wash and dry, perform notch of contact surface [2, p. 228].

In order to study strength and deformation properties of interface node with rigid armoring a number of experimental tests using almost natural samples were carried out.

For the initial test sample was taken foundation block series FSB 9-6-3. With the help of diamond crown, in the middle of the block in transverse direction there was done hole to insert there rigid rod. Diameter of made hole is of 160 mm.

For reinforcement there were chosen two rigid rods - channel № 6,5 for sample № 1 and flanged beam (welded of two channels № 6,5) for sample № 2, and, for comparison, when reinforcement of the sample № 3 it was used reinforcement cage of four rods with a diameter of 16 mm and reinforcement class S240. All rods of carcass are identical and equal; distance between lower and upper pairs of rods was of 96 mm and distance between right and left rods of 35 mm. For transverse reinforcement of carcass there were taken 3 clamps of armature of class S240 with diameter of 6 mm. The cross section of carcass has been chosen so that the geometric characteristics of carcass coincide with the geometrical characteristics of the cross section of two channels welded by walls.

Load transfer from foundation block (existing foundation) when reinforcement using rigid armoring is performed using rigid rod and concrete additional part of foundation (banquets). Size of banquet for the test was adopted of 300 × × 300 × 600. Moreover, foundation block, as of concrete elements of reinforcement (banquets), is leveled up to 100 mm.

There were taken 3 blocks for the test that will let to compare efficiency of use of rigid reinforcement with appliance of different sections of reinforcing elements.

For concrete pouring there was used concrete of class C30 / 37, which was further proved by results of test of selected control samples of concrete. Spud vibrator was used to condense and compress concrete mix.

Demolding of reinforcement elements was performed after 3 days; tests were performed after 28 days after execution of concrete works. Preventive maintenance of concrete was executed by saving humid environment of surface of construction that was in contact with open air.

For testing there were installed 12 strain gauges (ICH – 10) in places of the greatest by size displacements of one point in regard to another.

For the first sample there was taken foundation block FBS 9-6-3 reinforced by use of rigid rod – channel № 6, 5. Ready sample was placed under press and it was installed on a layer of cement-sand mortar. Alignment of sample was performed on support site of press. Geometrical center of foundation block was determined, to provide central loading and exclusion of irregular compression of sample. Load was applied in steps of 5 tons.

Breaking load, for sample №1, attained 68 tons. The first micro-cracks appeared at load of 20 tons at base of foundation block near sensor №3. With further loading the same cracks began to appear near sensor №9. Finally destruction of concrete element of reinforcement took place that delicately deteriorated due to punching by rigid rod - channel. Appearance of test sample №1 after test is shown in figure 1.

Fig. 1. General view of sample №1 after test

For the second sample there was taken foundation block FBS 9-6-3 reinforced by using rigid rod - flanged beam (welded of channels № 6,5). Ready sample was placed under press with its installation on layer of cement-sand mortar. There was executed alignment of sample on support site of press. Geometric center of foundation block was determined to provide central loading and exclusion of irregular compression of sample. Load was applied in steps of 5 tons.

Breaking load, for sample №2, amounted to 103 tones. The first micro-cracks appeared at load of 40 tons at the base of foundation block near sensors №9 and №12. Cracks in the length of the test were not significantly increased. Finally destruction of concrete of foundation block took place due to cutting force of rigid rod that demonstrates effectiveness of such reinforcement. With significant crack growth and destruction of foundation block there were also cracks on one of the elements of reinforcement. Appearance of sample №2 after test is shown in figure 2.

Fig. 2. General view of sample №2 after test

For the third sample there was taken foundation block FBS 9-6-3 reinforced using prefabricated reinforcement cage. Ready sample was placed under press with its installation on layer of cement-sand mortar. There was performed alignment of sample on support site of press. Geometric center of fundamental block was determined, to provide central loading and exclusion of irregular compression of sample. Load was applied in steps of 5 tons.

Breaking load, for sample №3, amounted to 82 tones. The first micro-cracks appeared at load of 40 tons on the top of foundation block. Cracks during all time of test were in progress and increased. Finally destruction of concrete of foundation block took place due to cutting force of reinforcing element. Although nature of destruction of samples №2 and №3 matches, but rigid rod as a result could support load of 20 tons more than reinforcement cage, which also witnesses of effectiveness of rigid reinforcement.

Appearance of sample №3 after test is shown in figure 3.

Fig. 3. General view of sample №3 after test

After undertaken test of foundation elements reinforced with use of channel, flanged beam and frame of rod armature we can conclude that use of rigid profile is more effective than carcasses, it can be seen from diagrams of deformation of experimental samples, which are displayed in figures 4 and 5.

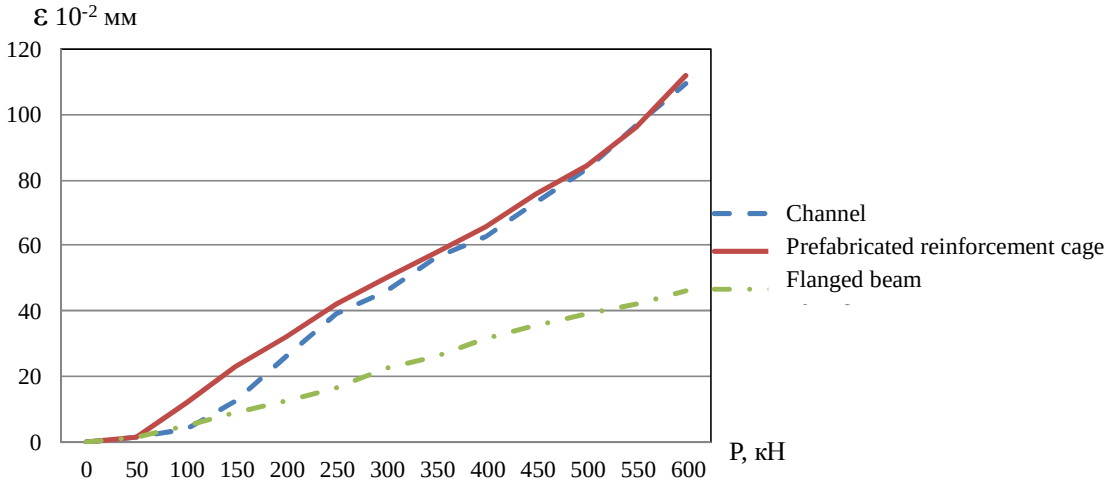

Fig. 4. Diagrams of deformation (vertically) of experimental samples when central compression

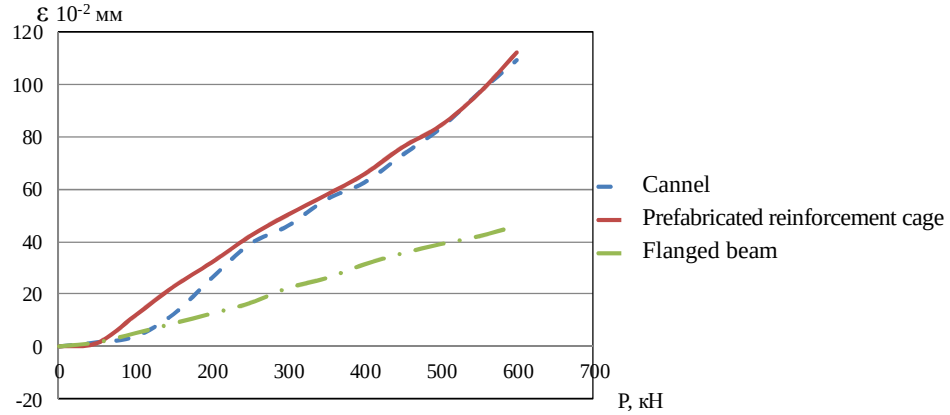

Fig. 5. Diagrams of deformation (horizontally at base of concrete footing) of experimental samples when central compression

From the graphs, it can be seen that displacements both in horizontal and vertical positions with the use of I-beam are significantly less than in other variants of the reinforcement. Consequently, the use of rigid rod in the reinforcement significantly increases the rigidity of junction of the reinforcement element and the existing foundation. It can also be noted that the use of rigid rod not only reduces deformability, but also increases bearing capacity of the whole construction what is also a significant factor when choosing a method of reinforcement.

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UDC 624.04:620.17(043.3)

PLANT FOR INTEGRATED STUDY OF SIMPLE BENDING, RESTRAINED TORSION, TORSION BENDING

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The article deals with an experimental plant designed for the integrated study of simple bending, restrained torsion and bending torsion of different elements and constructions. The authors introduce a schematic diagram of the plant with a description of its constituent elements, as well as some testing points of the constructions.

The plant is designed for the integrated study of simple bending, restrained torsion and bending torsion of different elements (Point. 7) and constructions, made of these elements: prismatic bars (Fig. 2а), closed cross-section (Fig. 3а, б), open profile (Fig. 3 в, г, д), pre-stressed strut frames (Fig. 2 б), bents, trusses, roof and floor slabs. The materials of the studied elements and constructions are reinforced concrete, steel, duraluminium, plastic.

The plant consists of two rigid rectangular frames (Point. 1; channel No. 40), rest upon four bases (Point. 2). The bases are fixed to the bed with six anchor bolts 24 mm in diameter each. The angles are fixed to the upper part with bolts (Point. 5) and expand spatial rigidity of the installation and serve as fastening elements of the vertically placed constructions. I-beams (Point 4) are placed on the lower cross-channels No. 40 (Point. 3); there are hydraulic jacks on the beams (Point. 8) which generate the vertical bottom-up load up to 500 kN on each jack.

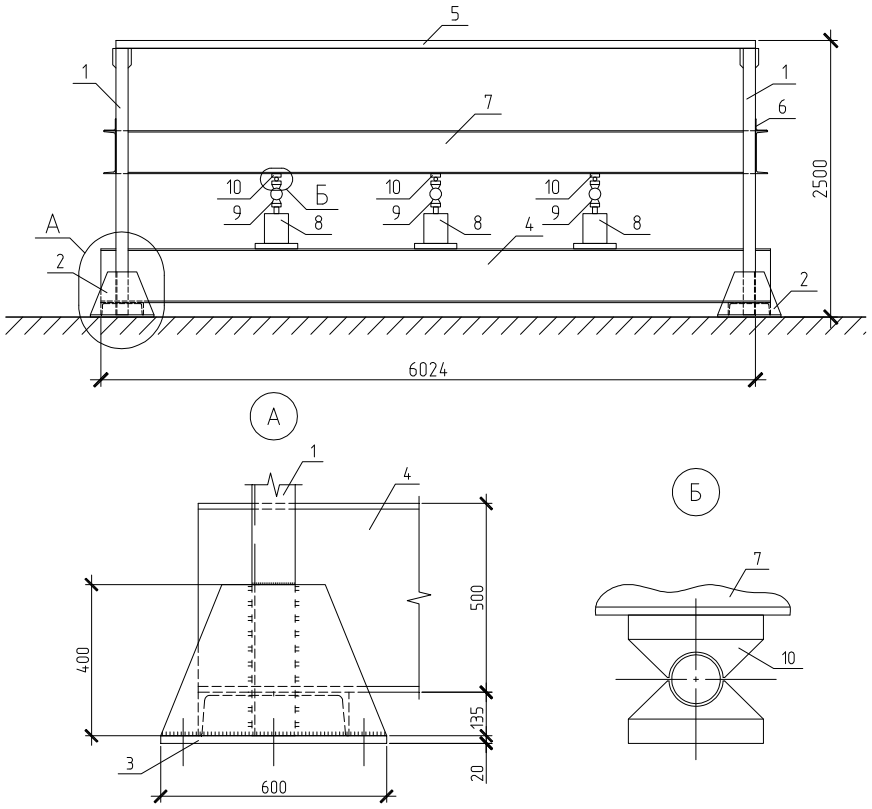

Fig. 1

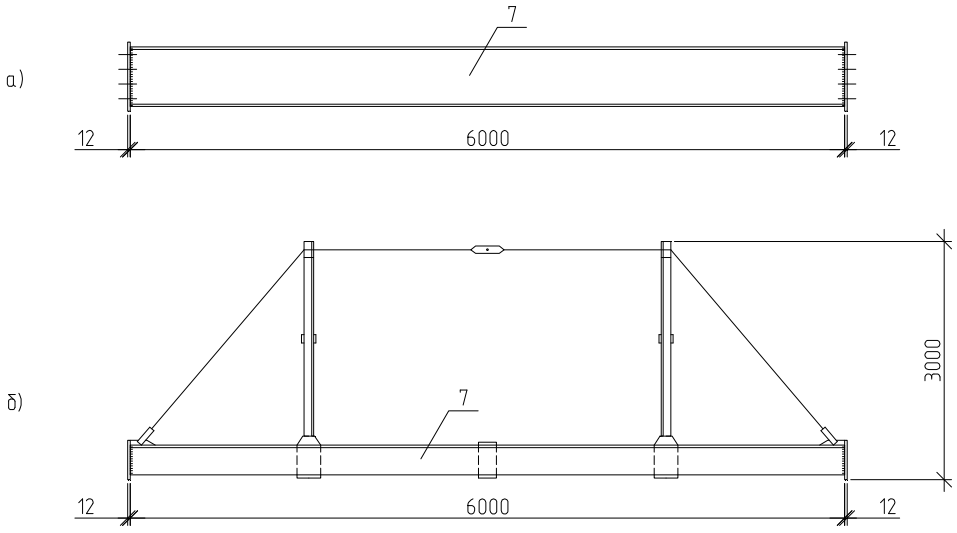

Fig. 2

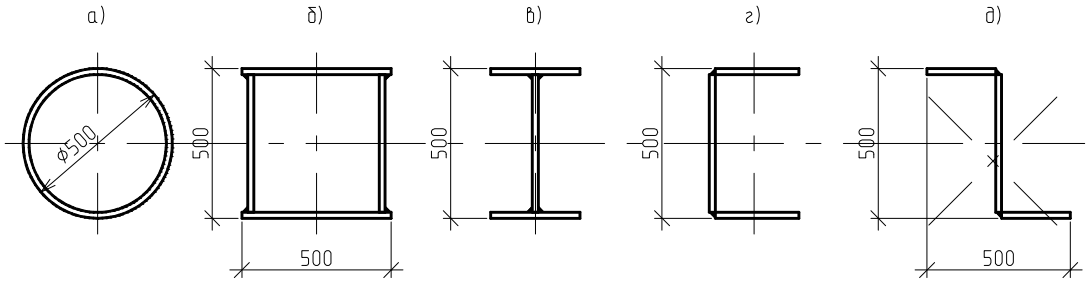

Fig. 3

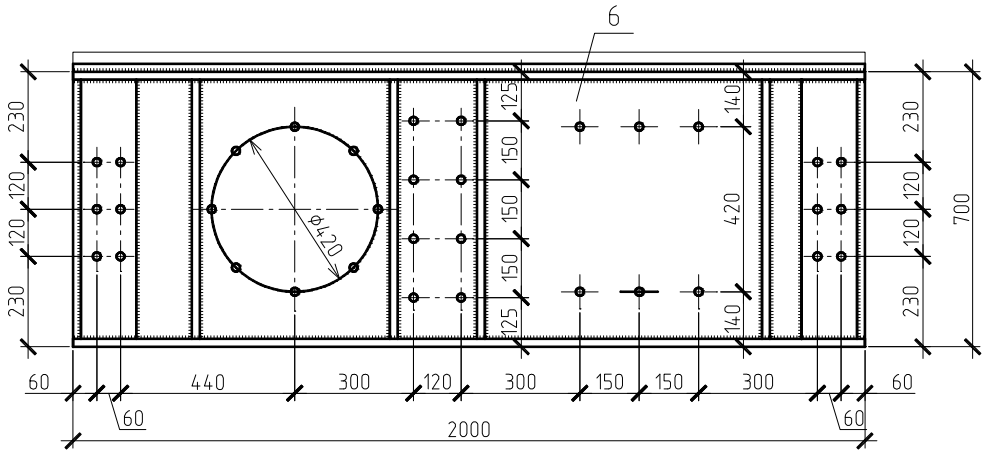

Fig. 4

The load, measured with dynamometer (Point 9), is transported to the construction (Point. 7; simple bending, pure bending) by means of post supports (Point. 10). The load is transported from the jacks to a special construction by torsion bending and then to the studied element. The construction, transporting torsion load, may vary due to different profiles of the cross-section. The construction consists of two beckets (Point. 11, 12) and welded cantilevers (Point. 14), when reinforced concrete tubes are tested (Fig. 5). To increase friction between them and the tube the beckets are tightened with four high-strength bolts with the help of elastic liners (Point. 14). A torque spanner is used for tightening.

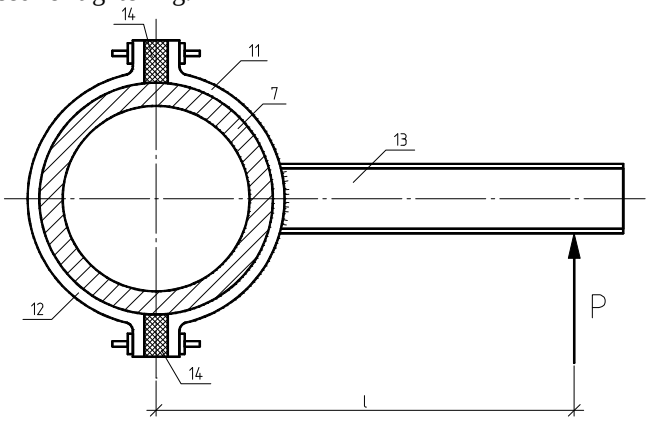

Fig. 5

Strain tension may vary from 10 kN to 100-150 kN. It depends on geometric parameters of the tubes. Shifting the load point P along the cantilever (Point. 13), the bending stress rate less than 5 per cents of restrained torsion stress can be observed, thus only torsional deformation can be taken into account in the future. A set of removal cross bars makes the plant unique. The bars are fixed to the frames (Point. 1), the studied constructions are fixed to the latter. The bars are made of welded channel and L-angle 16/10 to enlarge bending rigidity of the bar. The installation is loaded before the test itself to press the bolts down. Bending deformation properties of the cross bars and cantilevers should be taken into account by data analyses.

Tension and deformation of separate sections of the construction are changed by means of resistance strain gauges, strain gauge factor equals to $\delta = 2.5\text{-}3.0$; indicating gauges, grating period is 0.01 mm; and Maksimov's deflectometer.

Industrial, civil, mechanical engineering and farm building are the most favourable fields of application of the plant.

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UDC 624.012

RELIABILITY OF REINFORCED CONCRETE STRUCTURES DESIGNED ACCORDING TO THE DESIGN CODES OF BELARUS AND THE UKRAINE

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The article presents the results of reliability analysis of reinforced concrete structures designed and built in accordance with design codes that are valid in Belarus and Ukraine. It is noted that such structures have different reliability levels as well as failure probabilities. Approaches to assessment loads and actions on structures which are stated in European, Belarusian, former USSR, and Ukrainian standards were analyzed. It is shown that in most cases former USSR and Ukrainian standards do not meet the modern requirements for safety of structures. Additionally the results of reliability-based calibration of partial factors are presented. The calibration resulted in the reduced value of partial factors for permanent loads on precast elements.

The process of reforming the Belarusian system of standards is not completed yet. It is confirmed by the fact that three generations of normative documents have legal validity. These documents have followers as well as opponents, at the same time they lead to the results that are sometimes differ significantly.

In this connection numerical criteria for unbiased comparing different design codes are needed as well as the tool and methods to estimate the criteria.

According to the concept of reliability of structures stated in the international standard ISO 2394 [1] structures and structural elements should be designed basing on the standardized target reliability parameters that are expressed in terms of permissible probability of failure P_f or in terms of reliability indices β. Therefore the comparison of all the standards based on the numerical values of β seems to be the most objective.

The rules for setting the characteristic values of all the variables together with the system of partial factors (also called safety factors) and load combination factors create the safety margin for structures. Ideally, it should correspond to the target reliability levels stated in structural codes. And of course, the expected reliability level of structures should be checked before making any corrections in design standards. But in reality it doesn't always happen.

There are lot of works devoted to reliability level assessment for different countries (Holický, Sýkora, Retief, Sørensen, Faber and many others [2 – 6]). The mentioned works were aimed to assess existing reliability level and to calibrate some partial factors within the bound of Eurocodes, considering its unified rules and approaches to assess loads and combine them.

Performing the same study, namely to assess the reliability level of structures designed in accordance with Eurocodes is needed for Belarusian and Ukrainian conditions. It will show the level of reliability of new and existing structures.

It should be noted that the standardized approaches for assessing loads and actions on structures **have an essential influence on reliability level**. The comparative in-depth analysis of all the mentioned standards regulating the rules for assessing loads from the position of the reliability theory has not been carried out till this moment.

Moreover there is a lack of data on reliability levels of structures designed and erected by former USSR standards, as well by modern Belarusian and Ukrainian standards. The main challenge of such study consists in creating the base for comparing different standards. As it will be shown later the considered standards comprise completely different rules for deriving design combinations of loads on structures. Actual statistical data on actions (e.g. snow or wind loads) should be taken into account at that.

The aim of the present paper is to estimate the level of design reliability of structures (provided by using a system of safety factors and combination factors for loads and resistance of structures) in persistent design situations, according to the design codes that have been valid in the Republic of Belarus and Ukraine for the last decade. The following problems should be solved for this purpose:

– to formulate the state functions for structural elements that allow considering different ratios of permanent, live, and snow loads;

– to develop the probabilistic models of basic variables contained in the state functions;

– to estimate the reliability level of structures, designed in accordance with different standards. At that, different systems of safety factors and combination factors as well as the difference in combination rules for loads should be taken into account;

– to perform reliability-based calibration of the partial factor for self weight of precast structural elements.

Known methods of reliability theory will be used; among them are the methods based on the 1-st order approximation of the probabilistic state functions as well as approaches of extreme values theory (for assessment of stochastic processes of loading). The detailed explanation of the methods and models used will be given below.

The comparative analysis of the standards regulating the rules for assessing loads while designing the reinforced concrete structures is carried out in this article.

Three groups of standards are valid in the Republic of Belarus at present. These are:

- Eurocodes EN 1990 – EN 1991 [7, 8] (*hereinafter referred to as Eurocodes*);
- Belarusian design code SNB 5.03.01-2000 «Concrete and reinforced concrete structures design» [9];
- the USSR design standard SNiP 2.01.07-85 «Loads and actions» [10].

Comparing the code SNB 5.03.01 [9] with the system of Eurocodes and ISO 2394 [1], it should be noted that these standards are 100 % harmonized in respect of loads assessment in design. However, the majority of provisions stated in SNiP 2.01.07-85 [10] contradict the ISO 2394 and EN 1990 [7] that are also valid in Belarus. For example, there are inconsistencies in the classification of loads and actions, in values of partial factors for loads, in combination rules for loads for *Ultimate* as well as *Serviceability Limit State* design of structures.

The Ukrainian standard DBN B.1.2-2-2006 «Loads and actions» [11] is also considered in the article. This document mainly repeats the concept of SNiP, but also contains some approaches similar to those used in EN 1991.

The Eurocodes and SNiP 2.01.07-85 [10] are of different generations of standards, and the requirements to safety level for SNiP are already out of date. They are both based on limit state design principles. A system of partial factors and combination factors makes it possible to present limit state functions in a semi-probabilistic form. However, there are certain differences both in the rules for deriving design combinations of loads on structures, and in numerical values of partial safety factors γ and combination factors ψ.

The Ukrainian standard DBN B.1.2-2-2006 «Loads and actions» [11] mainly repeats the concept of SNiP, but for determining characteristic values of snow and wind loads an approach similar to the one used in Eurocodes [7, 8] is applied. This approach is based on 50-years return periods for the extreme values of loads.

The rules for deriving design combinations of loads on structures in persistent design situations are presented in Table 1. The case when permanent, live, and snow loads are imposed, is considered.

Besides the differences shown in Table 1 it should be stipulated that coefficients γ and ψ have disparate treatment and mathematical concept within the bounds of corresponding standards. As well, there are distinctions in loads classification and in method of setting characteristic values of loads and actions. These aspects are indicated in Table 2.

Table 1 – The rules for deriving design combinations of loads on structures in persistent design situations

Standard	**Design value of load effect on a structure or a structural element**
EN 1990:2002 [7] SNB 5.03.01-2002 [9]	$\max\begin{cases}\gamma_G\cdot G_k+\gamma_Q\cdot\psi_{0,Q}\cdot Q_k+\gamma_S\cdot\psi_{0,S}\cdot S_k\\ \xi\cdot\gamma_G\cdot G_k+\gamma_Q\cdot Q_k+\gamma_S\cdot\psi_{0,S}\cdot S_k\\ \xi\cdot\gamma_G\cdot G_k+\psi_{0,Q}\cdot\gamma_Q\cdot Q_k+\gamma_S\cdot S_k\end{cases}$
SNiP 2.01.07-85 [10]	$\max\begin{cases}\left(\gamma_G\cdot G_k+\gamma_Q\cdot\psi_{Q,\text{reduced}}\cdot Q_k^{(\text{reduced})}+\gamma_S\cdot\psi_S\cdot S_k\right)\cdot\gamma_n\\ \left(\gamma_G\cdot G_k+\gamma_Q\cdot\psi_{Q,\text{full}}\cdot Q_k^{(\text{full})}+\gamma_S\cdot\psi_S\cdot S_k\right)\cdot\gamma_n\end{cases}$
DBN B.1.2-2-2006 [11]	$\max\begin{cases}\left(\gamma_G\cdot G_k+\gamma_Q\cdot\psi_{Q,\text{reduced}}\cdot Q_k^{(\text{reduced})}+\gamma_S\cdot\psi_S\cdot S_k\right)\cdot\gamma_n\\ \left(\gamma_G\cdot G_k+\gamma_Q\cdot\psi_{Q,\text{full}}\cdot Q_k^{(\text{full})}+\gamma_S\cdot\psi_S\cdot S_k\right)\cdot\gamma_n\end{cases}$

Note: detailed symbol definitions may be found in Table 2

One can see from Table 2 that there is a significant difference between the approaches to setting characteristic values of loads. The safety factor *for permanent loads* γ_G in Eurocodes has a greater value, but it should be used together with combination coefficient ξ that is not specified in the other two groups of standards. Another important difference comes from the fact that within the bounds of SNiP the factor γ_G has a physical meaning of overload factor, and its value is assigned using this consideration.

A striking difference in approaches to setting characteristic values *for snow loads* should be noted: in EN 1991-1-3 [8] the characteristic value is the value which on average is exceeded once in 50 year. An analogous approach is accepted in Ukrainian standard DBN [11]. Meanwhile, within the bounds of SNiP [10], the characteristic value of a snow load is the mean value of 1-year maximums.

Wind loads are not considered in this paper because the approaches to setting characteristic values of wind load are similar to the ones just described.

Table 2 – The comparison of approaches to setting characteristic values of loads in the structural codes

	Eurocodes, SNB 5.03.01	SNiP 2.01.07-1985	DBN B.1.2-2-2006
	Permanent load		
Characteristic value	$G_k = E[G]$	$G_k = E[G]$	$G_k = E[G]$
Partial safety factor	$\gamma_G = 1.35$	$\gamma_G = 1.1$	$\gamma_G = 1.1$
Combination factor	$\xi = 0.85$	–	–
	Snow load		
Characteristic value	$S_k = E[S_{max}]$ for T=50 years	$S_k = E[S_{max}]$ for T=1 year	$S_k = E[S_{max}]$ for T=50 years
Partial safety factor	$\gamma_S = 1.5$	$\gamma_S = 1.4$ when $(G_k + Q_k) / S_k \geq 0.8$ $\gamma_S = 1.6$ when $(G_k + Q_k) / S_k < 0.8$	$\gamma_S = 1.0$
Combination factor	$\psi_{0,S} = 0.6$	$\psi_S = 0.9$	$\psi_S = 0.9$
	Variable (live) load		
Characteristic value	Q_k	$Q_k^{(full)}=Q_k$ $Q_k^{(reduced)}=0.2Q_k$	$Q_k^{(full)}=Q_k$ $Q_k^{(reduced)}=0.23Q_k$
Partial safety factor	$\gamma_Q = 1.5$	$\gamma_Q = 1.3$	$\gamma_Q = 1.3$
Combination factor	$\psi_{0,Q} = 0.7$	$\psi_{Q,full} = 0.9$ $\psi_{Q,reduced} = 0.95$	$\psi_{Q,\,full} = 0.9$ $\psi_{Q,reduced} = 0.95$
Reliability coefficient depending on importance of a structure	–	$\gamma_n = 0.95$	$\gamma_n = 0.95$

Notes:
1) operator E[…] means the mathematical expectation of a parameter;
2) subscript k (e.g. in Q_k) means the characteristic value;
3) return period T is a statistical measurement based on historic data denoting the average recurrence interval over an extended period of time for an event

According to SNiP [10] and DBN [11], in contrast to Eurocodes, *variable live loads* are divided into full and reduced values. The ratio of full and reduced values in Table 2 is estimated using the characteristic values of live loads on floor slabs in residential buildings (given in SNiP and DBN).

In the fundamental case the state function (or the failure function) of a structure comprises two groups of *basic variables*, namely R (related to resistance of the structure), and L (related to the loads on the structure). A state function can be formulated as:

$$g(R, L) = R - L. \tag{1}$$

The probability of failure of the structure may be assessed through

$$P_f = Probability[g(R, L) \leq 0] = Probability[R - L \leq 0]. \tag{2}$$

The reliability index β is a conventional measure of reliability. It is related with probability of failure through the following equation

$$P_f = \Phi[-\beta], \tag{3}$$

where $\Phi[\ldots]$ is the cumulative distribution function of the standardized Normal distribution. The relation between β and P_f is given in Table 3.

Table 3 – Relation between β and P_f

P_f	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}
β	1.28	2.32	3.09	3.72	4.27	4.75	5.20

Originally the reliability index β was introduced as the complete solution of the problem with two normally distributed basic variables, which is having as well the simple geometrical interpretation. Nowadays it is still widely used in different reliability problems as the numerical values of β are more convenient to operate with than very small numbers of failure probabilities.

For estimating reliability level of structural elements, which is provided by the system of partial factors and combination factors, the following procedure is applied. It is based on the 1-st order reliability method (FORM) as well as the method of quickest descent (which are both used for analysis of probabilistic state functions of structures and for estimation of the values of reliability indices). The Ferry Borges – Castanheta model [12] and Turkstra's rule [13] are used for probabilistic modeling of actions and combinations of actions. This approach provide for transformation random processes of loading into appropriate random variables, for which probabilistic models should be determined.

The value of target reliability index for structures is accepted as $\beta = 4.7$ for the reference period $T = 1$ year in accordance with EN 1990 [7]. Normal distribution is adopted for modeling permanent loads, Gumbel distribution – for modeling variable loads, Normal distribution – for load effect uncertainties, LogNormal distribution – for modeling resistance of structural elements.

In general form the probabilistic state function $g(\boldsymbol{X})$ which characterizes safety margin of a structural element (*Ultimate Limit State*) includes basic variables describing loads as well as resistance:

$$g(\boldsymbol{X}) = z \cdot R - \Theta \cdot [(1-\eta)\, G + \eta((1-k_s)Q + k_s S)], \tag{4}$$

where $\boldsymbol{X} = \{R, \Theta, G, Q, S\}$ – is a vector of basic variables; z = is a cumulative design parameter, e.g. cross-sectional area, reinforcement area; k_s = factor between 0 and 1, giving the relative importance of snow load among two variable loads (*live load – snow load*); $\eta = (Q_k + S_k)/(G_k + Q_k + S_k)$ = factor between 0 and 1, giving the relative importance of permanent load among other loads (*permanent load – variable loads*).

In the general case the process of making probabilistic model comprises two steps: the selection of the appropriate distribution law for the considered random variable or random process, and the setting of the parameters of this distribution.

The probabilistic models of basic variables $\boldsymbol{X}$ included in state function (4) are described in Table 4. They characterize resistance of structural elements R, permanent loads G, variable live Q and snow S loads, as well as basic variable Θ which makes it possible to take into account uncertainty in load effect model.

While developing the probabilistic models the contradictions of standards Eurocodes, SNiP, and DBN in loads classification as well as in mathematical treatment of a characteristic value are taken into consideration.

Table 4 – Proposed probabilistic models of basic variables

Basic variable	*Characteristic value*	*Distrib.*	μ	σ	*V*
Permanent load (*G*)	G_k	Normal	G_k	$0.1G_k$	0.1
Live load (*Q*) (for residential building)					
Eurocodes ($Q_k = 1.5\text{kN/m}^2$)	Q_k	Gumbel	$0.2Q_k$	$0.19Q_k$	0.95
SNiP 2.01.07-1985 ($Q_k^{(\text{full})} = 1.5\text{kN/m}^2$) ($Q_k^{(\text{reduced})} = 0.3\text{kN/m}^2$)	$Q_k^{(\text{full})} = Q_k$ $Q_k^{(\text{reduced})} = 0.2Q_k$		$0.2Q_k$	$0.19Q_k$	0.95
DBN B.1.2-2-2006 ($Q_k^{(\text{full})} = 1.5\text{kN/m}^2$) ($Q_k^{(\text{reduced})} = 0.35\text{kN/m}^2$)	$Q_k^{(\text{full})} = Q_k$ $Q_k^{(\text{reduced})} = 0.23Q_k$		$0.2Q_k$	$0.19Q_k$	0.95
Snow load (*S*)					
Eurocodes	S_k	Gumbel	$0.38S_k$	$0.21S_k$	0.55
SNiP 2.01.07-85			$0.58S_k$	$0.32S_k$	0.55
DBN B.1.2-2-2006			$0.38S_k$	$0.21S_k$	0.55
Resistance (*R*)	R_d (design value)	LogNormal	$1.4R_d$	$0.15R_d$	0.11
Model uncertainty (Θ) for load effect	Θ_k	Normal	Θ_k	$0.05\Theta_k$	0.05

The proposed probabilistic models for variable loads correspond to the return period T = 1 year.

The probabilistic models of *live load* (see Table 4) are developed basing on the investigation of statistical parameters of loads on structures in residential buildings presented in JCSS Probabilistic Model Code [14]. It should be noted that JCSS guidelines correspond to the results of investigation published in USSR by Raizer, Bulychew et al. in 1980s [15–17].

The probabilistic models of *snow load* are based on the own results of the current statistical investigation of long-term data collected from 18 weather stations which are spread proportionally on the territory of Belarus [18]. Moreover the zoning of the territory by characteristic values of snow load according to the Belarusian National Annex to EN 1991-1-3 [8] and SNiP 2.01.07-85 [10] is also taken into account. While considering the Ukrainian standard DBN B.1.2-2-2006 [11] we accepted that the same approach as in Eurocodes is applied for defining a characteristic value of snow load. Therefore the probabilistic models are described here identical to those corresponding to Eurocodes.

The probabilistic model of the *resistance of structural elements R* is developed for flexural reinforced concrete members basing on the experimental and theoretical investigation [18].

Generally speaking we consider a reinforced concrete structural element designed with the following assumptions:

– resistance of the element is calculated according to Eurocode 2. This means that all the coefficients related to the resistance as well as partial factors for concrete and steel strength are taken from EN 1992 [19];

– loads and actions on the element are set in accordance with the concerned standard (Eurocodes, SNiP, or DBN) with appropriate partial factors and combination rules;

– the element is supposed to be part of a structure or a building located in Belarus. This condition is relevant for assessment of snow loading only; it is caused by the fact that we have comprehensive statistical data on snow loads available only for the territory of Belarus.

Figure 1 shows the reliability index β as a function of load parameters η and k_s which define the ratio of permanent, variable live and snow loads.

The reliability index β_t = 4.7 is stated as a target value in EN 1990 [7] for RC2 reliability class of structures and for the reference period T = 1 year.

The compiled reliability diagrams make it possible to conclude that provided the proposed probabilistic models of basic variables (Table 4) are valid the system of partial safety factors and combination factors stated in Eurocodes gives the required level of reliability of designed structures in most of the design situations. However in some cases reliability of structures in persistent design situations does not meet the requirements of RC2 reliability class; and the actual average reliability level corresponds to the minimum recommended level. At the same time the rules for assessing loads on structures in accordance with SNiP 2.01.07 [10] *do not meet* modern reliability and safety of structures requirements.

One can see on diagrams from Figure 1 that using Eurocode results in structures with the value of reliability index at average greater by 1 than for structures designed in accordance with SNiP 2.01.07 [10]. It means that the probability of failure for the latter can 10-100 times exceed the maximum permissible values.

In respect of the Ukrainian standard DBN [11] it is evident that there will be no significant increase in reliability of structures if the characteristic values for snow and wind loads are defined basing on 50-years return periods but using an old approach (those stated in SNiP [10]) to deriving design combinations of loads.

In this section we describe the results of calibration of partial factor for self weight loading. Within this case study we consider a precast reinforced concrete structural element. Such elements can be characterized as heavy elements for which the load of self weight could be of considerable proportion among other loads.

According to EN 1990 [7] the design combinations of actions on a structural element *in persistent or transient design situations* may be expressed in general format as:

$$L_d = \max \begin{cases} \sum_j \left(\gamma_{G,j} \cdot G_{k,j}\right) + \gamma_{Q,1} \cdot \psi_{0,1} \cdot Q_{k,1} + \sum_{i>1} \left(\gamma_{Q,i} \cdot \psi_{0,i} \cdot Q_{k,i}\right) \\ \sum_j \left(\xi \cdot \gamma_{G,j} \cdot G_{k,j}\right) + \gamma_{Q,1} \cdot Q_{k,1} + \sum_{i>1} \left(\gamma_{Q,i} \cdot \psi_{0,i} \cdot Q_{k,i}\right) \end{cases}, \quad (5)$$

where the less favorable of the two expressions is to be chosen.

In case of only one permanent and one variable load acting, e.g. self weight plus live load, the design combinations should be:

$$L_d = \max \begin{cases} \gamma_G \cdot G_k + \gamma_Q \cdot \psi_{0,Q} \cdot Q_k & (6.1) \\ \xi \cdot \gamma_G \cdot G_k + \gamma_Q \cdot Q_k & (6.2) \end{cases}$$

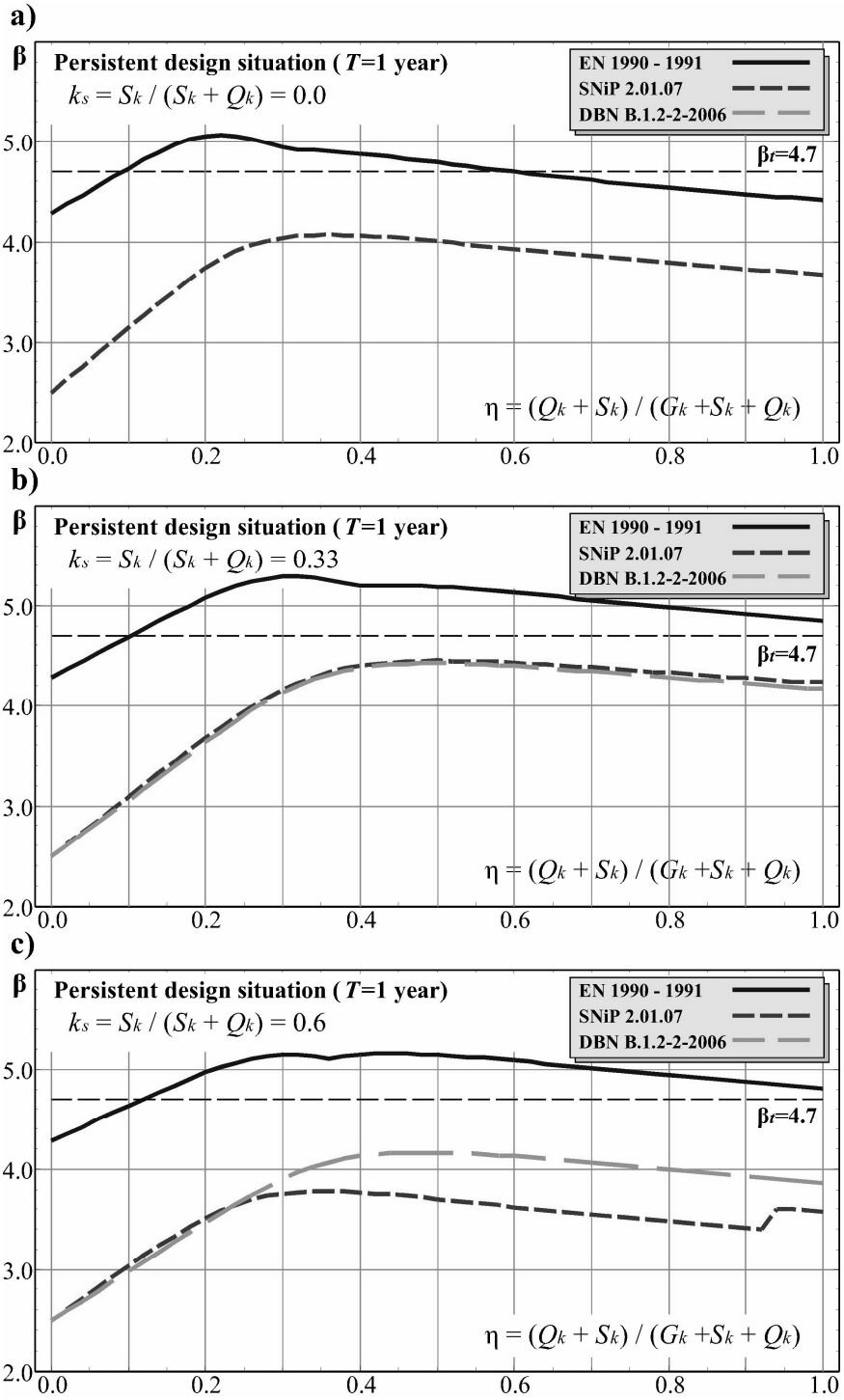

Fig. 1. Reliability index β for structural elements as a function of load parameter η with:
a) k_s = 0.0; **b)** k_s = 0.33; **c)** k_s = 0.6

In general case the following values of partial factors and combination factors are recommended in EN 1990, as given in Table 5.

Table 5 – The values for γ , ψ_0 , and ξ according to EN 1990

Load type	*Partial factor*	*Combination factor*
Permanent – self weight *G*	γ_G = 1.35	ξ = 0.85
Variable – live load *Q*	γ_Q = 1.5	$\psi_{0,Q}$ = 0.7

The probabilistic state function $g(\boldsymbol{X})$ of the structural element (*Ultimate Limit State*) can be presented as:

$$g(\boldsymbol{X}) = z \cdot R - \Theta_E \, [\chi \, G + (1-\chi) Q], \tag{7}$$

where z = is a cumulative design parameter, e.g. cross-sectional area, reinforcement area; $\chi = G_k / (G_k + Q_k)$ = factor between 0 and 1, giving the relative importance of permanent load among other loads (*permanent load – variable loads*).

The probabilistic models of basic variables are given in Table 6. The models for the resistance R and live load Q are the same as described in the previous sections.

Table 6 – Proposed probabilistic models of basic variables for precast elements

Basic variable	*Characteristic value*	*Distrib.*	μ	σ	*V*
Permanent load (*G*)					
- for any element	G_k	Normal	G_k	$0.10G_k$	0.05
- for precast element		Normal	G_k	$0.05G_k$	0.05
Live load (*Q*) (for residential building, reference period T = 50 yrs)	Q_k	Gumbel	$0.6Q_k$	$0.20Q_k$	0.33
Resistance (*R*)	R_d (design value)	LogNormal	$1.4R_d$	$0.15R_d$	0.11
Model uncertainty (Θ) for load effect	Θ_k	Normal	Θ_k	$0.05\Theta_k$	0.05

It is known that precast concrete plants should have conformity assessment for product geometry and strength of materials organized. It means that products with geometrical parameters being out of tolerances should be rejected. That is why self weight of precast elements cannot exceed considerably its nominal values. Thus the difference between cast-in-situ and precast elements in terms of reliability theory may be expressed in changing probabilistic model for self weight loading. In our case we assume that the coefficient of variation of self weight for precast elements should not exceed 0.05. The model for permanent load G in Table 6 takes into account this assumption.

It is possible to estimate reliability level of precast structural elements by applying the approaches and methods as stated in the previous sections.

Figure 2 shows the reliability index β as a function of load parameter χ.

The reliability index $\beta_t = 3.8$ is stated as a target value in EN 1990 [7] for the RC2 reliability class of structures and for the reference period T = 50 years.

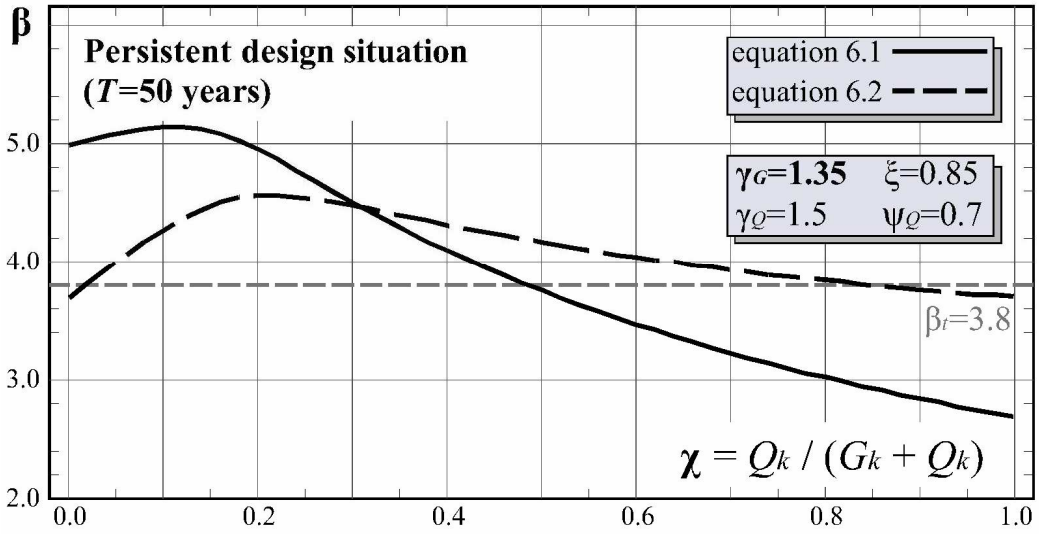

Fig. 2. Reliability index β for structural elements as a function of load parameter χ for the reference period T = 50 years and γ_G = 1.35

One can see from the Figure 2 that there is certain excessive reliability in the area where contribution of permanent loads is significant ($\chi \leq 0.6$). It means that we may reduce the value of γ_G in such an extent that the reliability level for the considered area will not be lower than the required target level β_t.

The new reduced value of $\gamma_G = 1.15$ was determined for those elements corresponding to the area on the plot with significant self-weight loads ($\chi \leq 0.6$). The new reliability diagram is shown on Figure 3.

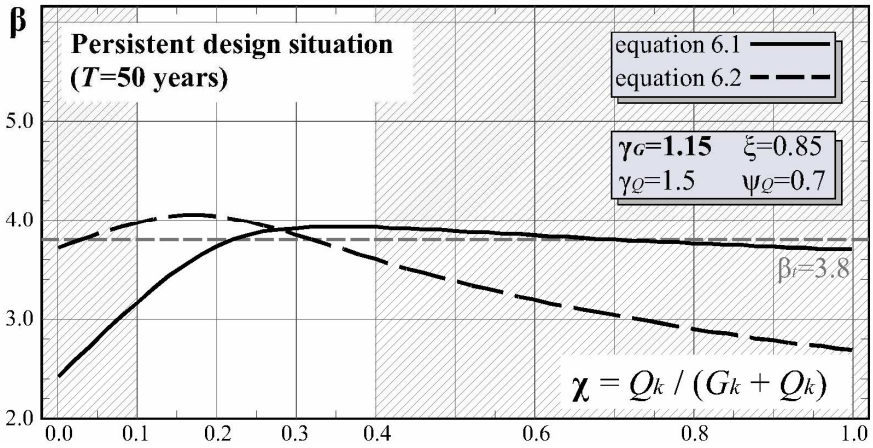

Fig. 3. Reliability index β for structural elements as a function of load parameter χ for the reference period T = 50 years and $\gamma_G = 1.15$

The Belarusian National Annex to EN 1990 [7] allows using the reduced value of partial factor $\gamma_G = 1.15$ if the following conditions are provided:

- the system of quality control is organized at the plant;
- the coefficient of variation of self weight of the structural element is not higher than 0.05;
- the ratio of the variable loads to the full load on the element including self weight should be in the range:

$$0.1 \leq \frac{\sum_{i\geq 1} Q_{k,i}}{\sum_{j\geq 1} G_{k,j} + \sum_{i\geq 1} Q_{k,i}} \leq 0.4 \,. \qquad (8)$$

It can be seen that assuming the mentioned conditions the value of the partial factor γ_G for self weight loads can be reduced significantly. These results are expected to provide a great economical effect for precast concrete industry.

The existing combination rules for loads for *Ultimate Limit State* design of structures have been described according to the three design codes that have been valid in the Republic of Belarus as well as in Ukraine for the last decade.

Probabilistic methods of reliability analysis of structural elements were used to compare these standards by a criterion of reliability index that is provided by the appropriate design rules for loads assessment. Probabilistic models of loads have been developed subject to the nature of these loads and to their expected duration.

It has been shown that the levels of reliability of structures designed according to former USSR and Ukrainian standards are significantly lower than the required level, and that the probability of failure for such structures can exceed maximum permissible values up to 100 times.

Additionally the results of reliability-based calibration of partial are presented. The calibration resulted in the reducing the value of the partial factor for self-weight loads on precast elements from $\gamma_G = 1.35$ to $\gamma_G = 1.15$.

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UDC 662.61

SELF-COMPACTING CONCRETE – A MATERIAL OF A NEW GENERATION

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We consider the technological, technical and economic advantages of self-compacting concrete (SCC) compared with traditional concrete of vibrational compacting. We analyze the state of normative base for the application of self-compacting concrete in construction practice, as well as composition of SCC. We investigate the possibility for reducing the cost of self-compacting concrete.

One of the dominant trends in concrete technology during the last ten years has been growing interest in the self-compacting concrete.

In the literature we can find many definitions of the self-compacting concrete, but they characterize it in the same way. It is concrete, that is able without impact on it additional external energy to flow under its own weight, retaining its homogeneity, and also ensuring a complete compaction, filling formwork and encapsulation of rebar and embedded parts.

The advantages of self-compacting concrete in comparison with other traditional types of concrete are as follows:

– creation of building structures, having high strength and no defects caused by errors when compacting the concrete mix;

– the ability to create any geometry of concrete structure;

– the use of a simpler and less massive construction formwork (due to the lack of the concrete vibration process, on the formwork is not affected by additional static and dynamic load);

– the possibility of placing per shift larger volume of concrete;

– no necessity of concrete compacting and hence eliminating errors, which might arise during its compacting;

– work of the personnel in a safe conditions during concreting;

– the absence of noise and vibration, which have a negative impact on both the staff and the residents living near the construction site;

– shortening the duration of construction.

History of the self-compacting concrete began in Japan in 1990. Professor Haim Okamura [1] created and put into practice a new generation of concrete admixtures, that is high additives for improving the mobility of the concrete mix on the basis of polyacrylate and polycarboxylate. He managed to get the concrete mix, having a high plasticity and a low water content, allowing to provide high-quality performance and increased durability of the concrete. Due to the unique properties and advantages of the concrete, it quickly spread through Western Europe.

In November 2003, in Berlin, «German Committee for reinforced concrete" published normative document «DAfStb-RichtlinieSelbsverdichtenderBeton (SVB-Richtlinie)» [2], which set out the terms and definitions, methods for diagnosis of the self-compacting concrete, and linkages document with other European regulations.

Summing up the experience gained when using self-compacting concrete in 2005 European organizations BIBM, CEMBUREAU, ERMCO, EFCA, EFNARC in 2005 developed a document «European standards for liquefied self-compacting mixture», which regulates the technical characteristics and consumer qualities constructions, made from self-compacting concrete ; requirements to source materials and composition of concrete recommendations for its use At present the study of the self-compacting concrete and methods of its diagnostics is actively continuing. Recently the studies have been carried out in at the construction department of the Technical University of Berlin, under the supervision of Professor Bernd Hillemayera [3].

So far the regulations of the Russian Federation have no indication of the possibility for the construction of the self-compacting concrete. In the republic of Belarus research in the field of the self-compacting concrete has been conducted for eleven years and its the results have become the basis for the development of Technical Code of practice «Products and designs from self-compacting concrete. Rules for the manufacture» [4]. Technical Code provides requirements for the self-compacting concrete, guidelines for the appointment of technological modes of concrete works, technique of designing of concrete with the characteristics of the spreadability of the concrete mix, strength and deformability of concrete, kinetics of increase in strength for a given temperature and humidity conditions.

In the selection of composition of the self-compacting concrete most researchers consider that in solving this problem the most important thing is the rational selection of recipes for self-compacting concrete. The concept of this formulation is based on increasing the amount of small dust particles, the type and amount of additives. Traditional concrete mix, in which predominates possible high content of particulate filler and a low content of fine particles, is not used in the preparation of self-compacting concrete, instead suspended fine particles (cement + particulate filler with a grain size $\leq$ 0,125 mm + additives for concrete), mixing water and thinner SCC form a glue, in which a large granular filler just «floats».

At present in the production of self-compacting concrete they use thinners of new generation based on polycarboxylate, highly efficient complex chemical modifier, which appeared in the 1990s and referred to a PC or PCE. The action of plasticizers of a new type based on a set of electrostatic and spatial effect, which is achieved by means of lateral polyether chains of hydrophobic molecules of the polycarboxylate ether. On one side should be known, the interaction of cement polycarboxylate based diluent, on the other side when it is necessary to take into account the mobility characteristics based on temperature. Besides some thinners when mixed int he mixer can cause excessive thinning action, which is denoted as «sediment effect» and can lead to subsequent delamination concrete.

To maintain a high fluidity strength and prevent separation and prevent the concrete mixture must have a certain viscosity. This problem is solved by introducing in the concrete mixture of additives, thickeners or using highly mineral additives. Introduction of mineral additives such as silica fume, ground limestone together with a smaller loss of mobility gives concrete mixture the mineral additive for two hours than without.

Spherical particles of the additives function as «bearings» by reducing the friction between the particles. Mineral supplements function not only as thickening agents (increasing the viscosity of the concrete mix, and water retention capacity), but also increase hydration process of the binder, contribute to an increase in the degree of crystallinity and the resulting hydrate, among which the proportion increases of more stable and sustainable weakly basic Hydrosilicates calcium.

The composition and types of self-compacting concrete are constantly evolvtd by many researchers.

Thus Kotov D.S. [5] in his study of the properties of cement stone used cement PC 500-DO, superplasticizer CM-1, hyperplasticizers HP-1 and «Stachement-2000-MG30», mineral additive – fine dolomite.

The paper presents experimental and scientifically sound mathematical models of the compressive strength and tensile modulus, the longitudinal and transverse strains, strains of shrinkage of self-compacting concrete. It has been established that to obtain a more accurate mathematical models of physical and mechanical properties of the SCC it is advisable to use structural methods, and structural characteristics by proposed N.P.Bleschikom and employees of BelNIIS.

Ta Van Fan [6] revealed a pattern of influence of rice husk ash in combination with silica fume and superplasticizer on the pore structure and the strength of crystalline concretion own deformation of cement stone SCC.

In the opinion of N.M.Morozova, V.I.Avksenteva, I.V.Borovskih, V.G.Hozina [7] its economically effective to use as fillers crushing screenings generated during the production of aggregates. Screenings of crushed rubbles by their chemical nature zre close to the main components of concrete and they are non-corrosive, which

suggests that they are sufficiently effective in the composition of self-compacting concrete. In this study, consisting of crushed waste in SCC were used together with silica fume, allowing to obtain high processing properties of the mix and strength properties of the hardened concrete.

However Ivanauskas EV [8] revealed, that crushed granite screenings and ground quartz sand is not suitable as components of the SMS because of the low water-holding capacity, angular shape of the particles, large emptiness and pollution and he found that it is effective to use as a substitute for the cement. Dolomite cement wastes (up to 15 % by weight of cement).

Chan Le Hong [9] proved the possibility of obtaining special heavy self-compacting concrete mixtures of highly mobile benign on three fractions aggregate and finely divided filler of barite ores in combination with hyperplasticizer additive.

It has been established that the high content of more dense than conventional concrete cement stone does not impair the deformation properties of SCC – autogenous shrinkage values and the values of the initial modulus of tension.

S.L. Gorbunov, Y.B. Fedorov, B.J. Trofimov, E.A. Gamaliy [10] investigated the effectiveness of plasticizers in self-compacting mortar mixes. Used as a plasticizer – superplasticizer C-3, a new generation superplasticizer ADDIMENTFM 40 on polycarboxylate ethereal on the basis of firm ADDIMENTSika (Germany). Then obtained adequate mathematical specifications depending on the dosage of cement systems plasticizers and additives ash – for variable values water-cement ratio.

A.K. Dyatlov [11] justified a possibility of obtaining modified fine self-compacting concrete on the basis on Portland cement with integrated nano-containing additive using microfiller type «Mikrodur RX», containing up to 20 % of nanoscale grains < 1 mm, using microfiller type «Mikrodur RX», containing up to 20 % of nanoscale grains < 1 mm, and fine flour carbonate (2,1 – 6 mkm), would increase the degree of hydration of the binder due to accumulation of water, increase the volume of cement gel and reduce the capillary porosity.

The patent of Shan Sandrine (Fr.), TiboTeri (Fr.) [12] proposed to use for self-compacting concrete the mix of different types of calcined bauxite sand of different particle size distribution: fine sand with an average grain size of less than 1 mm and coarse sand with average granulometry of less than 10 mm, and if necessary, white carbon, where 90 % of the particles have a size less than 1 micron, with an average diameter of about 0,5 microns, contains fumed silica in an amount of not more than 15 parts by weight 100 parts cement, antifoaming agent, superplasticizer (predominantly used type of modified polycarboxylate superplasticizer ether additionally ultrafine calcium carbonate particles having a specific surface equal to or more than 10 m^2 / g).

J.A. Alexandrov from engineering marketing company «MC Bauchemi» [13] notes, that, in accordance with the experience of the application of plasticizers in the preparation of SCC outstanding results have only been achieved with hyperplasticizers based on ether polycarboxylates (PCE). Other types of additives (based on LST, SNF, etc.) cannot compete with ether polycarboxylates technical and economic parameters. Additives, including air-entraining, accelerating and decelerating hardening concrete, can be used in the same manner as in ordinary concrete, based on the additives manufacturer's recommendations for their use in a methods of introduction.

Analyzing the state of the regulatory framework for self-compacting concrete in general and primarily in the Republic of Belarus, it can be concluded that the current Technical Code of practice 45-5.03-266 contains guidelines and recommendations for the design, construction and use of heavy SCC, intended for the construction of concrete and reinforced concrete structures using formwork. These technical standards and regulations for self-compacting concrete for road surfaces are absent.

From the perspective of the priorities in road construction in the Republic of Belarus with cement concrete coaling, the development of technical regulations is important.

After analyzing the cost-effectiveness of SCC on the basis of the experience of using this type of concrete, it should be noted:

– self-compacting concrete because of its modified composition and cost of individual components of the concrete mix is more expensive than ordinary concrete the same species. The difference in price amounts 13 to 18 Euro per 1 cubic meter;

– the most effective mineral additives are metakaolin and silica fume. Metakaolin (kaolin thermally activated) was obtained by calcining kaolinite at a temperature of 650-8000 C. The process of obtaining this material is associated with high energy and fence material;

– significantly higher sealing effect in the structure of self-compacting concrete is achieved by the use of ultrafine microsilica (silica dust). Microsilica is the most expensive mineral supplement, the cost of which ranges from 0.25 to 0,50 EUR / kg;

– economy of means is possible by using the SMS due to the fact that there is no need of compacting the concrete mix at the construction site, the device breaks during concreting and its cost ranges from 3 to 6 euros

per 1 cubic meter of concrete. Besides, the production of high quality concrete structures of enhanced durability ensures long life of their operation without maintenance and major repairs.

Summarizing the above, it should be noted:

1. The use of self-compacting concrete in the manufacture of precast and construction of monolithic reinforced concrete structures is a perspective direction in improving technology and precast reinforced concrete and further development of the building complex Republic of Belarus.

2. Due to the high cost of SCC, we must carry out research so as to get economical components for self-compacting concrete.

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STRENGTH AND DEFORMABILITY OF CONNECTIONS OF REINFORCING BARS

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The aim of presented in this work experiment is to obtain experimental data on the strength and deformability of connections of reinforcing bars.

Selection of the binder in the composition in the form of the joint of the polymeric composition based on epoxy resins due to the possibility to obtain high strength during rapid-day material. Connection length in this combination is taken to be the initial 250 mm (diameter of the abutting rods multiplied by 10) based on the results of the tensile test samples of compounds with different length sleeves. With a length of pipe – 10 ∅25 tests showed stable values gap in median plane connection with efforts of relevant ultimate steel pipe (Fig. 1).

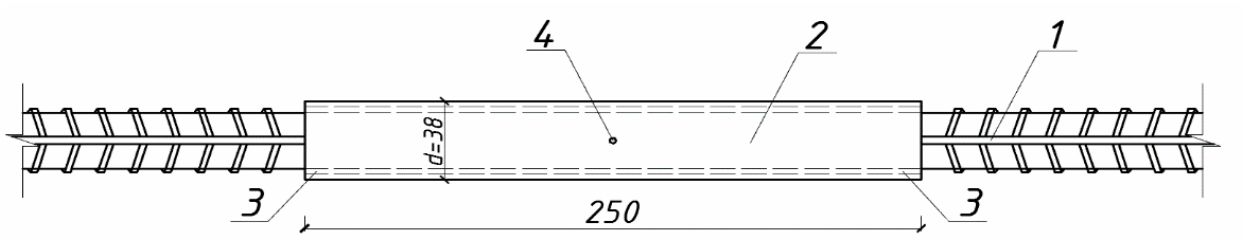
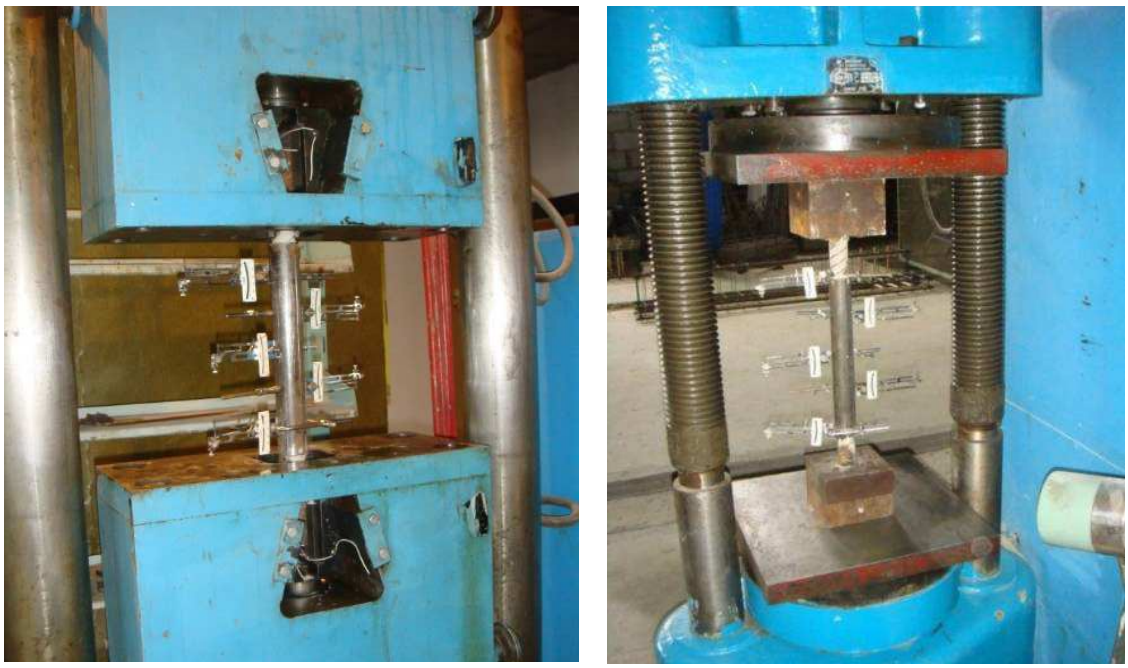


Fig. 1. Construction coupler connection reinforcement bars
1 – docked rebars ∅ 25 S500; *2* – coupling of d = 38 mm pipe with wall thickness of 4 mm;
3 – epoxy compound; *4* – 3 mm diameter hole.

Given the experience [1] proposed design with the steel grade C235, used in the manufacture of pipe compound offers a long anchoring 4d (100 mm). During the preliminary tensile test three samples were tested. The tests were carried out on a tensile testing machine R-50 at a constant rate of loading (Fig. 2 (A)).

The destruction was caused by pulling one of the reinforcing bars with loads of 153kN, 141kN, 194kN. As a result, it was decided to increase the length of anchoring to 5d (125 mm).

Compression testing was performed on the P-125 press at a constant rate of loading. To conduct the experiments special steel base of the prism, the size 200 × 200 × 50 mm, were made, two on each end of the armature. One of each pair of prisms were drilled a hole in later prism bolted. Prism was inserted in a hole in upright position and secured by rebar epoxy resin, then a similar operation was done with the other end fittings. General view of the structural assembly can be seen on Figure 2, B.



A) B)

Fig. 2. The test sample in the tensile testing machine (A),
general view of a mechanical press as compound (B)

Taking into consideration the importance of the characteristics of deformability connection rebar to study the characteristics of strain distribution along the length and displacement relative to the coupling rods abutting ie compliance of the joint, the deformations were monitored at certain points of the samples by means of strain gauges type PKB with base 20 mm.

Observation of the linear movement of the abutting rods relative to the clutch lever was carried out by mechanical strain gauges of Gugenberger with an accuracy of 0,001 mm.

5 samples were tested bytension and compression. Rods tested were numbered 1P, 2P, 3P, 4P, 5P. Rods controlled compression 1K, 2K, 3K, 4K, and bars with couplings 1C, 2C, 3C, 4C, 5C. The loading was carried out step by step with an interval of 25 kN and 10 kN compression tension.

The results of these tests are shown in Table 1. The results of processing the data obtained are graphs deformation connection sample and the value of its elements and relative movement of the coupling abutting rods.

Table 1 – Summary table of tests of mechanical connections fittings

Compression		Type of destruction	Tension		Type of destruction
№ of sample	Crushing load		№ of sample	Crushing load	
1C	256 kN	Loss of stability	1P	212 kN	pulling rod
2C	256 kN	Loss of stability	2P	210 kN	pulling rod
3C	276 kN	Loss of stability	3P	230 kN	pulling rod
4C	269 kN	Loss of stability	4P	240 kN	pulling rod
5C	270 kN	Loss of stability	5P	240 kN	pulling rod

Under compression deformation in the coupling sections was considerably less strain abutting rods at all stages of loading. The explanation for this is less stress intensity at a higher cross-sectional area. In the transition zone, at the beginning and at the end of the coupling, the gradient is formed of deformation associated with the process of redistribution of stresses between the docked bars and clutch. Right in these areas bending of the specimens observed at the time when the buckling limit in compression effort.

When stretched, the initial stages of loading up 0,5 N_{max} character strain distribution along the length of the joint is similar to the distribution pattern when tested in compression. At higher stages of loading, approaching the critical zone is clearly seen anchoring, manifested through the work of adhesion forces in areas of intense transmission of forces between the rods and the coupling. Also at high stages of loading a zone of advanced nonlinear deformation middle joint, where in the future due to the achievement of ultimate strength of steel and the cleavage of the coupling.

Deformation of elements in the compound and the abutting rods relative movement of the coupling amount and nature of compressive deformations are different from deformations in tensile movement. Dependence N_{max} / N_i – compressive prototypes joints equal to the level of loading 0,7 N_{max}, is linear, with further loading schedule becomes non-linear shape, showing decreasing character of displacement values equal to 0.04 ... 0,08 mm. Tensile dependence N_{max} / N_i – is linear up to 0,7 N_{max}, then there is a growing non-linear dependence to the values 0,06 – 0,1 mm. It follows that by moving the rod with respect to the coupling connection compliance with the tensile force is 1,3 – 1,5 times greater than that when compressing.

After spending this research, the following conclusions can be made:

• Tensile test of the proposed design of the mechanical connection in the adopted configuration showed stable values gap efforts by the average cross-section corresponding to ultimate steel pipe couplings.

• Limiting compressive load at buckling interface prototypes had values close to the results of the tensile test.

• The nature of the strain distribution along the length of prototypes was found as well as its compliance in the form of linear displacement with respect to the coupling abutting rods. The areas creating strain concentration along the length of the joint were determined.

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TECHNOLOGY, MACHINE-BUILDING, GEODESY

UDC 504.75

PRODUCTION ENVIRONMENT AND EMPLOYEES` LABOUR ACTIVITY FACTORS OF AUXILIARY DEPARTMENTS OF JSC «NAFTAN»

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At present oil refining and petrochemical industries are the most stable operating sectors of the economy ensuring population and national economy demands for fuel and energy resources. However the vast majority of substances used in the refining and petrochemical industry have harmful (toxic) and carcinogenic properties. The main directions in ensuring a safe production environment for people are the hygienic regulation of harmful factors, socio-hygienic monitoring of working conditions and workers` health with the appropriate science-based development and implementation of environment quality control system and the prevention of harmful factors impact on the basis of effective public health supervision and implementation of preventive activities.

In recent years, human health maintenance in the workplace can be referred to one of the major problems of humanity. It depends not only on social and economic factors, but also largely on the state of the production environment. In connection with the increase of air pollution in the working area, the problems of human health protection have been and remain rather acute, since half of the Belarusian population live and work in the industrialized cities.

It is known that the working environment of refineries is formed under the influence of a number of concurrent factors, which have different material nature, and peculiar features of effects on the human organism. Human labour activity is connected with the exposure of a variety of production environment factors, severity and intensity of the process. Hygiene labour conditions are determined by the production process organization, the equipment used the degree of automation and mechanization, which specify the spectrum and intensity of production factors exposure. It is repeatedly proved that the adverse production factors have a negative impact on the health of workers.

In the development of norms and standards of working conditions factors each factor is considered separately (without taking into account the simultaneous exposure of other factors on the worker). Therefore the usage of single assessments of individual working conditions factors can significantly distort the real impact of the labour conditions on the employee. For example the combined action of noise and temperature increase, vibration and temperature reduction and many others. The combined effects of factors of working conditions on the worker, as we know, can be manifested in the form of potentiating (disproportionate exposure intensification), the summation of independent action effects, as well as in the weakening of the final effect. Thus, workers` health damage is attributed to the complex influence of production environment factors.

To assess the working conditions at the workplaces of auxiliary departments we used and analyzed workplaces certification maps on working conditions for major blue-collar occupations of department №5 «Repair and assembly shop»,department №9 «Energy supply shop» and department №46 «Transport department» of JSC «Naftan», Novopolotsk. The ground for the selection of research subjects is the fact that at refineries it is also necessary to pay attention to auxiliary departments since the cumulative impact of harmful production factors adversely affects the health of workers.

Certification of workplaces and complex hygienic evaluation of working conditions at the auxiliary departments of the refinery plant enabled to identify groups of factors, each of which individually or in combination could adversely affect the health of workers:

– physical: noise, infrasound, vibration, microclimate, lighting, EMF, UV radiation, thermal radiation, dust and aerosols;

– chemical: harmful substances - manganese in welding aerosol, iron oxide, ozone, carbon monoxide, saturated hydrocarbons C1-C10, benzene, toluene, acids, hydrogen sulfide, methyl ethyl ketone, nitrogen dioxide, hydrogen fluoride.

– psycho physiological: emotional stress (degree of responsibility for the personal activity outcome, the significance of errors, your own life risk degree, the degree of responsibility for the safety of others); working stance (squatting position, kneeling, work in an awkward constrained or sloped posture); physiological discomfort (PPE), sensory load (duration of focused observation).

The analysis of the results of workplaces certification showed that the working conditions of workers under study in accordance with SanPin RB 13/02/2007 «Hygienic classification of working conditions» range from allowable 2nd class to harmful 3rd Class of 1- 4 degrees.

Optimal working conditions (class 1) are such conditions that preserve workers' health and create the background for maintaining a high level of working efficiency.

Acceptable working conditions (class 2) are characterized by such levels of production environment and working process that do not exceed the hygienic standards for workplaces, and possible changes in the functional state of an organism arising under their influence recover during the regulated rest or by the beginning of the next shift and do not adversely affect the near and the long-term health status of workers and their offspring. Optimal and acceptable conditions of work are referred to safe ones.

Harmful working conditions (class 3) are characterized by the presence of harmful industrial factors going beyond the hygienic standards and having adverse effects on the organism of the worker and / or his offspring.

1st Degree of Class 3 (3.1). Working conditions are characterized by such deviations of harmful factors levels from hygienic standards that cause functional changes, restoring usually during a longer (than the beginning of the next shift) interruption of contact with hazards and increase the risk of health damage.

2nd Degree of Class 3 (3.2). The levels of harmful factors causing persistent functional changes and leading, in most cases, to an increase of production conditioned morbidity (which is manifested by increased morbidity with temporary disability and, above all, by such diseases that reflect the state of the most vulnerable organs and systems for the given harmful factors), the appearance of initial symptoms or mild (without loss of labour capacity) forms of occupational diseases arising after prolonged exposure (often after 15 years or more).

3rd Degree of Class 3 (3.3). Working conditions are characterized by such levels of harmful factors, the effects of which, as a rule, lead to the development of occupational diseases of mild and moderate severity (with the loss of labour capacity) in the period of the labour activity, the growth of chronic (work-related) pathology, including elevated levels of morbidity with temporary disability.

4th Degree of Class 3 (3.4). Working conditions are characterized by such levels of harmful factors, under which severe forms of professional diseases and high level of general morbidity with temporary disability may arise.

The conducted analysis of certification materials of working conditions shows that workers are exposed to a number of harmful and hazardous working factors, the main of which is undoubtedly the chemical one.

Workers` working conditions of the most common specialties of department number 5 «Repair and assembly shop» of JSC «Naftan» (electric and gas welder, turner, heat-treater at HFC units, grinder, sharpener) refer to harmful conditions of the 3rd class 2-3 degrees. Arc manual welder works under the conditions of the highest degree of danger 3.4 according to chemical factors.

Working conditions of the electrician of repair and installation of electro equipment at department number 9 «Energy supply shop» of JSC «Naftan» are referred to harmful 3rd Class 1 degree; workers' of department number 46 «Transport department» of «Naftan» (bulldozer operator, excavator operator, front loader driver) work under 3rd Class 2nd degree harmful conditions.

There are harmful chemical substances of 2nd, 3rd, 4th hazard classes (class of substances is determined by the MPC) in the working area air of the considered departments. Conducted researches have shown that under steady flow of the technological process, the concentration of harmful substances at the departments №5, №9 and №46 does not exceed the MPC. Deviation from the hygienic standard MPC is department №5 for arc manual welder. The MPC data are reflected in Table 1.

Table 1 – Chemical factors of production area at department №5 JSC «Naftan» Novopolotsk

Factors and indexes of production environment	Arc manual welder				
	nitrogen dioxide	carbon monoxide	hydrogen fluoride	manganese in welding aerosol	iron oxide
Hygienic standards (MPC, MPL)	2	20	0,5	0,1	6
Actual values	2,81	35,87	1,36	6,19	19,5

Despite the fact that the concentration of harmful substances in the working area air does not exceed permissible concentration, combined with adverse physical factors of production area they can adversely affect the health of the workers of the investigated enterprise. Their influence is diverse and lies in the violation of the nervous, hematopoietic, cardiovascular, digestive, immune and other systems` functioning.

It should also be taken into account that prolonged exposure to noise with levels above 80 dB, which is typical of each specialty, can lead to impairment of hearing – professional bradyacuasia.

Auxiliary departments workers` contact with hazardous and harmful occupational factors at the refinery enterprise affects the health and has an impact on the state of the main physiological functions of the body.

Taking into consideration that chemical substances having negative impact on the organism of the refinery workers are the part of raw materials and finished products, it is not possible to exclude them from the technological cycle. It is necessary to develop recommendations and actions to improve working conditions, to prevent occupational diseases and reduce occupational traumatism at the refinery.

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OCCUPATIONAL RISK ASSESSMENT AT HAZARDOUS INDUSTRIAL FACILITIES

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The present study proposes a semi-quantitative approach to occupational risk assessment at hazardous industrial facilities. The basic idea of the proposed approach is to merge spatial information and job profile features in order to improve occupational risk assessment.

Nowadays high attention is paid to integrated risk assessment which is mainly forced by the tendency to a more efficient safety management system. Occupational Safety (OS) and Accident Hazard (AH) are two major concerns at process industry. These two risks have been traditionally analyzed in a separate way in industrial practice as well as in the legislation. In industrial practice, AH scenarios are very roughly evaluated during OS assessment and vice versa. At present the increasing attention towards integrated safety management systems is forcing plants to manage all risk sources. This integration becomes critical for larger establishments – such as refineries and petrochemical plants – due to the high number of exposed workers and the intrinsic plant complexity [1 – 5].

The goal is to have a unified metric for all potential hazards: occupational injuries and diseases (e.g. due to chemical and physical exposures), and major accidents (e.g. due to losses of hazardous or toxic materials, etc.). Thus, an integrated risk level (*Rj*) characterizing the *j*-th work profile (i.e. for each worker belonging to this job profile) has been proposed in equation 1:

$$R_j = \sum_{k=1}^{K} \left[\left(\left[(R) \right]_{OS} \right)_k + \left(\left[(R) \right]_{AH} \right)_k \right] \cdot t_{j,k} \,, \tag{1}$$

where the $t_{j,k}$ – parameter represents the time spent by the *j*-th worker in the *k*-th unit (expressed as percentage); the R_{OS} and R_{AS} indexes estimate occupational and accidental risk levels respectively in the *k*-th unit.

Then the two risk indexes are described in detail.

For the R_{OS} estimation, an individual OS risk level index, is defined by equation 2 for the *k*-th unit:

$$R_{_{OS},k} = \sum_{i=1}^{N_k} P_{t,k} \cdot S_{t,k} \cdot M_{t,k} \,, \tag{2}$$

where N_k is the total number of hazards estimated in the *k*-th unit; the $S_{t,k}$ parameter estimates the severity of consequences characterizing the *i*-th hazard in the *k*-th unit; the $P_{t,k}$ parameter represents the event probability and the $M_{t,k}$ parameter represents the mitigation capability estimated for the *i*-th hazard in the *k*-th unit.

For the R_{AH} estimation, a global risk level characterizing the k-unit is defined in equation 3:

$$R_{AH,k} = \sum_{i=1}^{N_h} P_{t,h} \cdot S_{t,h} \cdot A_{t,h} \,, \tag{3}$$

where N_h is the total number of accidental scenarios estimated in safety reports; the $S_{t,h}$ and the $P_{t,h}$ parameters represent respectively the consequence severity and the probability (expressed in event/year) evaluated for the *h*-th accidental scenario. The $A_{t,h}$ parameter is defined as the part (expressed as percentage) of the plant area affected by damage areas, estimated for the *h*-th scenario.

The following hypotheses have been suggested for the model development:

- Estimated risks in each area are independent.
- Hazard sources have a fixed position within the plant layout.
- The worker presence at different plant units is assumed constant during the work shift.

The proposed method has been tested at a plant of propane deasphalting sludge of «Naftan» JSC, where about 50 people work every day. It represents an effective test case as different hazard types are simultaneously present. Information about estimated probability and consequence severity for each *i*-th hazard category outlined for each k-th workplace ($W_1 – W_6$) are reported in Table 1.

Results showed that W_5 and W_4 are the most critical workplaces for the Occupational Safety analysis.

Information about estimated consequence severity and the probability (expressed in year) evaluated for the *h*-th accidental scenario are reported in Table 2.

After calculating separately the two indexes (R_{OS} and R_{AH}), the integrated risk level for each job profile may be derived as defined by equation 1. Thus, these «local» indexes characterizing the specific risk type will be converted in so called «individual» indexes by combining with data about the time spent by each individual job profile at each workplace (detailed calculation is proposed in Table 3).

Thus, high risk level at the unit of propane deasphalting sludge of «Naftan» JSC is due to such occupations, as compressor unit machinist and machinist of processing pump machinist.

Table 1 – Data required for R_{OS} estimation

i-th hazard category	Parameters R_{OS}	k-th workplace					
		Outdoor equipment area	compressor	hot pumping	propane pumping	in furnaces	control room
		W_1	W_2	W_3	W_4	W_5	W_6
Injuries by fall	$P_{t,k}$	0,0522	0,0522	0,0522	0,0522	0,0522	0,0522
	$S_{t,k}$	10	10	10	10	10	10
	$M_{t,k}$	0,1	0,1	0,1	0,1	0,1	0,1
	R_{OS}	0,0522	0,0522	0,0522	0,0522	0,0522	0,0522
Injuries by contact with moving, rotating parts	$P_{t,k}$	0,0169	0,0169	0,0169	0,0169	0,0169	-
	$S_{t,k}$	10	10	10	10	10	-
	$M_{t,k}$	0,1	0,1	0,1	0,1	0,1	-
	R_{OT}	0,0169	0,0169	0,0169	0,0169	0,0169	-
Hearing loss	$P_{t,k}$	0,071	0,091	0,103	0,116	0,199	0,0005
	$S_{t,k}$	3	3	3	3	3	3
	$M_{t,k}$	0,5	0,5	0,5	0,5	0,5	0,5
	R_{OS}	0,1065	0,1365	0,1545	0,174	0,2985	0,0007
Electrical shock	$P_{t,k}$	0,0002	0,0002	0,0002	0,0002	0,0002	0,0002
	$S_{t,k}$	10	10	10	10	10	10
	$M_{t,k}$	0,1	0,1	0,1	0,1	0,1	0,1
	R_{OS}	0,0002	0,0002	0,0002	0,0002	0,0002	0,0002
Thermal burns	$P_{t,k}$	0,0196	0,0196	0,0196	0,0196	0,0196	-
	$S_{t,k}$	3	3	3	3	3	-
	$M_{t,k}$	0,1	0,1	0,1	0,1	0,1	-
	R_{OS}	0,00588	0,00588	0,00588	0,00588	0,00588	-
Chemical burns and freeze burns	$P_{t,k}$	0,0082	0,0082	0,0082	0,0082	0,0082	-
	$S_{t,k}$	3	3	3	3	3	-
	$M_{t,k}$	0,1	0,1	0,1	0,1	0,1	-
	R_{OS}	0,00246	0,00246	0,00246	0,00246	0,00246	
Exposure to harmful substances	$P_{t,k}$	0,0101	0,0195	0,0096	0,0215	0,0219	-
	$S_{t,k}$	10	10	10	10	10	-
	$M_{t,k}$	0,1	0,1	0,1	0,1	0,1	-
	R_{OS}	0,0101	0,0195	0,0096	0,0215	0,0219	-
Total estimated R_{OS}		0,19424	0,23364	0,24174	0,27314	0,39804	0,05313

Table 2 – Data required for the R_{AH} estimation

Accidental scenario	Probability, Pt,h	Consequence severity, St,h	Damage area, м2	RAH
Explosion	2,7·105	100	82448	2,99·10-3
Fireball		100	32206	1,17·10-3
Pool fire		10	1600	5,81·10-6

Table 3 – Estimated total integrated risk level (Rj) values for each j-th job profile

j-th job profile (occupation)	$t_{j,k}$ on k-th workplace						Parameters		
	W_1	W_2	W_3	W_4	W_5	W_6	R_{OS}	R_{AH}	R_j
Unit supervisor	0,15	0,25	0,045	0,045	0,1	0,34	0,1686	0,0035	0,1721
Unit mechanic	0,14	0,02	0,125	0,04	-	0,50	0,0996	0,0029	0,1025
technological unit operator	0,07	0,1	0,13	0,13	-	0,47	0,1289	0,0032	0,1321
Compressor unit machinist	-	0,63	-	-	-	0,27	0,1615	0,0034	0,1649
Processing pump machinist	-	-	0,19	0,46	-	0,25	0,1849	0,0035	0,1884

A semi-quantitative method for integrating Occupational Safety and Accident Hazard risk has been developed and tested at the plant of propane deasphalting sludge of «Naftan» JSC. The model can be applied at processing plants characterized by different units featuring different risk types.

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TECHNOLOGY OF RECEIVING ELEMENTAL SULFUR FROM HYDROGEN SULPHIDE ACID GASES AT OJSC «NAFTAN»: ENVIRONMENTAL ASPECTS AND FEATURES OF THE TECHNOLOGY

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Sulfur-bearing compounds are very detrimental to the environment and to industrial process equipment. They are formed during the purification of hydrocarbon gases from acidic components and usually convert into sulfuric acid or elemental sulfur. Currently industrial production of sulfur is mainly performed by using the Claus process. Utilization of sulfur, obtained during the process of oil refining, is a problem of great environmental significance.

Currently OJSC «Naftan» is at the stage of «reconstruction and modernization program of OJSC «Naftan» for 2010 – 2015», which is based on the latest achievements in the field of oil refining and takes into account the rapidly changing market demands in order to improve efficiency of enterprise performance. Project of delayed coking unit construction is underway, the purpose of which is to increase the depth of oil refining up to 92 – 94 % and the output of additional volumes of light petroleum products.

Due to implementation of technology of environmentally clean diesel fuel production, with sulfur content of 10 ppm (0.001 wt.%) at the hydrotreating units L-24/7 and LCH-24/7 with «Merox» unit, and also due to the introduction of value-added oil refining process (construction a delayed coking unit) the amount of generated hydrogen sulfide increases and it should be utilized.

With an increase of oil refining (up to 12 million tons) and implementation of all the tasks specified by «Development Programme», the production of hydrogen sulfide will become approximately 8800 nm^3/h by 2015[1].

Today hydrogen sulfide, produced at facilities of OJSC «Naftan», is utilized at:

– «unit of sulfuric acid production» I and II stages;

– «unit of sulfuric acid regeneration».

The total designed capacity of the plant is 4800 nm^3/h.

Existing units of hydrogen sulfide utilization work practically with full designed load. Their capacity currently can't be increased above the designed.

In this respect, problem of sulfur-containing gases utilization at the enterprise has become crucial.

Novopolotsk industrial complex has a significant impact on the environment of the city, primarily due to the emission of pollutants into the air and discharges into surface water and groundwater. Powerful industrial development of Novopolotsk not only increases the anthropogenic load on the environment, but also has a negative impact on the living conditions of the population. Table 1 presents data of pollutants emissions into the air in Novopolotsk over the past 13 years [2].

Table 1 – Dynamics of pollutants emissions into the atmosphere in Novopolotsk, thous. tons/year

	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013
From stationary sources	51,5	54,2	64,0	80,0	58,6	63,9	50,3	51,2	67,8	53,5
Per capita, kg	481	519	599	750	548	614	480	485	636	498

These table data show the total amount of emissions and amount of emissions per capita. Of course, the real impact of emissions on population cannot be submitted to simple arithmetic. In reality, it is necessary to take into account the remoteness of the industrial area from the residential one (at least 4 – 5 km), and a wind rose, which allows to dissipate most of the emissions opposite in direction to residential areas. However, emissions of pollutants are large enough to have their negative impact on ecosystems and human health.

Gaseous and liquid substances dominate in the structure of pollutant emissions into the atmosphere of Novopolotsk (99,5 %), the share of solid accounts only for 0,5 %. The main share among them are volatile organic compounds (VOCs – 52,4 %), hydrocarbons without VOCs – 7,5 %. Other substances are distributed as follows: sulfur dioxide – 25,5 %, carbon oxide – 5,0 %, nitrogen dioxide – 8,5 %, other liquid and gaseous substances – 0,6 % (Table 2).

Table 2 – Average annual concentrations of pollutants in ambient air, mg/m^3

Controlled substance	2005	2009	2010	2011	2012	2013
Solid particles	30	<15	<15	<15	<15	<15
Sulfur dioxide	2	1	2	1	1	3
Carbon monoxide	902	1633	1509	835	330	577
Nitrogen dioxide	38	45	40	42	47	54
Formaldehyde	8	7	7	6	3	3
Phenol	0,7	0,6	0,6	0,9	1,0	1,0
Ammonia	2	9	5	8	10	8
Hydrogen sulfide	1,5	1,4	1,2	1,0	1,0	1,2

In this way, the above information shows that Novopolotsk refers to the type of cities with the highest density of harmful substances emissions in the Republic of Belarus. The main sources of air pollution are the enterprises of oil refining, chemical industry, power engineering, and motor vehicles. The largest volume of pollutant emissions from stationary sources in Novopolotsk falls on OJSC «Naftan». A significant contribution to air pollution in the city is also made by the following companies: Plant «Polymir» OJSC «Naftan», Novopolotsk CHP.

The Claus process continues to be the most widely used process for the conversion of H_2S to sulfur. The task of Claus processes is to recover elemental sulfur from hydrogen sulfide and, more generally, from byproduct gases originating from physical and chemical gas and oil treatment units in refineries, natural gas processing, and gasification plants, to quote a few. They consist of a thermal reaction furnace, a waste heat boiler, and a series of catalytic reactors (converters) and condensers (Fig. 1).

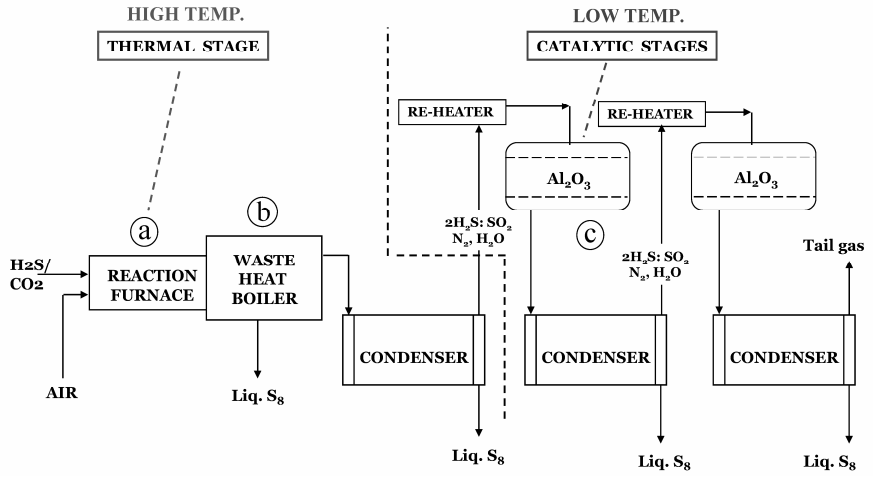

Fig. 1. The schematic structure of a typical Claus unit

The reactions occurring in the furnace are numerous, and several authors have attempted to delineate the important ones. The overall reaction characterizing the process is as follows [3]:

$$2H_2S + O_2 \rightarrow S_2 + 2H_2O. \quad (1)$$

In the first step or thermal stage, one-third of the H_2S is completely oxidized to SO_2 in the reaction furnace, located at the front end of a unit. The production of significant quantities of elemental sulfur (S_2) during the thermal decomposition of H_2S is also beneficial. In fact, the sulfur produced in the furnace makes up 60 – 70 % of the total amount of sulfur condensed at the plant. The main H_2S oxidation reaction is:

$$H_2S + 3/2O_2 \rightarrow SO_2 + H_2O. \quad (2)$$

The reaction furnace is followed by the waste heat boiler (WHB), where heat is recovered by cooling the furnace product gases. In the second step or the catalytic stage, unreacted H_2S is then combined with SO_2, reacting via eq. 2, over an alumina catalyst to form elemental sulfur in fixed bed reactors by the following reaction:

$$2H_2S + SO_2 \leftrightarrow 3/2S_2 + 2H_2O. \quad (3)$$

Since this reaction is exothermic, decreasing the temperature leads the equilibrium reaction toward right hand, i.e. more sulfur yields. On the other hand, low temperatures decrease the reaction rate. Therefore, an appropriate catalyst must be used to increase the reaction rate. However, high sulfur yields still necessitate a multistage process with interstage cooling and sulfur condensation [4].

Sulfur formed in each stage of the Claus unit is condensed and recovered to achieve maximum conversion in the catalytic reactors. The unrecovered sulfur, in elemental or combined form (H_2S, COS, CS_2), is combusted to SO_2 in the tail gas incinerator which is then emitted to the atmosphere. Tail gas clean-up units are added sometimes prior to incineration to increase the sulfur recovery and minimize emissions.

One of the furnace functions is the destruction of any contaminants what may foul downstream equipments. In oil refinery operations, NH_3 is formed as a byproduct and is then directed to the sulfur recovery facility for destruction. Incomplete pyrolysis or combustion of NH_3 in the furnace results in NH_3 and NO carryover into the catalyst beds. Ammonia can form ammonium salts, which can plug or foul the catalyst beds, other equipments, or piping. Although the formation of SO_3 occurs in the catalyst bed regardless of the presence of NO, the presence of NO in the beds acts as a catalyst for the conversion of SO_2 to SO_3, which in turn causes catalyst sulfation. Of the primary causes of catalyst activity loss, catalyst sulfation is regarded as the most significant. It is therefore critical to convert as much NH_3 to N_2, H_2, and H_2O as possible [5].

For ammonia destruction, an empirical rule of thumb in industry is that furnace temperature should be greater than 1200-1250°C. The furnace temperature must be below the temperature limitation of conventional refractories of 1600°C and above the minimum stable furnace temperature of 926°C. The reaction furnace temperature should not exceed 1380 °C in order not to exceed the maximum temperature limitations of the equipment materials [6].

In the Claus process, other sulfur compounds will be formed, such as carbon disulfide (CS_2) and carbon oxysulfide (COS), and these compounds can often contribute from 20 to 50 % of the pollutants in the tail-gas. Furthermore, presence of O_2 traces in the CS_2-H_2O mixture caused a decrease in the activity of alumina and titania catalysts due to sulfate formation. Therefore, COS and CS_2 should be hydrolyzed in the catalytic converter, as shown below:

$$COS + H_2O \leftrightarrow H_2S + CO_2, \quad (4)$$

$$CS_2 + 2H_2O \rightarrow 2H_2S + CO_2. \quad (5)$$

The temperature of the first catalytic reactor is maintained at about 350°C to hydrolyze COS and CS_2, while that of the subsequent reactors is just above the sulfur vapor dew point. Transition metal oxides can be used to modify gamma-alumina to form a catalyst that is effective at temperatures higher than the dew point of sulfur. However, thermodynamics provide a strong incentive to operate the catalytic converters at low temperature as a lower temperature should increase the exothermic reaction efficiency. Therefore, the temperature of the process gas at the inlet of the catalytic converters should be such that the effluent gas temperature is about 14 – 17°C higher than the expected outlet sulfur dew point and high enough for hydrolysis of COS and CS_2 for the first catalytic converter only (about 350°C) [7].

Figure 2 shows the theoretical conversion of H_2S to elemental sulfur by the Claus reaction as a function of temperature.

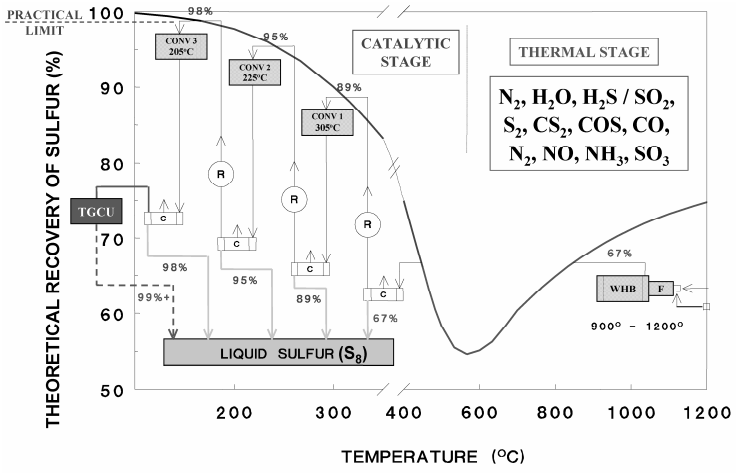

Fig. 2. Theoretical Conversion of H_2S to Sulfur by the Claus Reaction

The temperature of reaction furnace of a typical Clause Sulfur Recovery Unit is adjusted to ensure suitable NH_3 destruction. Moreover, the inlet temperatures of SRU converters are determined in order to achieve proper conversion without any processing problems. The process temperatures are important in designing the Claus sulfur recovery units.

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UDC 665.7.038.2

PRODUCTION OF SULFONATE ADDITIVES FOR LUBRICATING OILS FROM PETROLEUM AND SYNTHETIC FEEDSTOCKS

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This article gives a brief overview of the stages of production and mechanism of action of sulfonate additives (detergents). The prospect of switching to synthetic raw materials in the production of high-alkali sulfonate additives at the enterprise JV «LLK-Naftan» is considered.

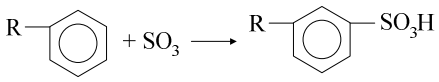
JV «LLK-Naftan» has the largest and most complex facilities for production of lubricant additives in the CIS area. The assortment of manufactured additives and additive packages for lubricating oils includes products of different functional groups capable of providing a wide range of operating properties of modern and prospective lubricants. A special place among the additives, according to their universality of application, efficiency, production volumes, occupy sulfonate additives that have detergent, dispersant, neutralizing and anti-corrosion properties.

The main purpose of detergent and dispersant additives is to prevent the deposition of oxidation products and their consolidation on metal surfaces, reducing the amount of residue, and carbon deposits on the details.

The synthesis of additives depends on the choice of raw materials and a sulfonating agent. As a raw material for petroleum sulfonates (C-150, C-300) highly purified oil distillates are used. Sulfonate additives CCK-300, CCK-300D, CCK-400, and CCK-400D NSSK-30 are produced on the basis of synthetic materials, for example, sulfonate additive CCK-300 is synthesized on a synthetic alkyl benzene sulphonic acid.

The production process of sulfonate additives consists of the following steps:

1) Oil-sulfonation with gaseous sulfur trioxide:



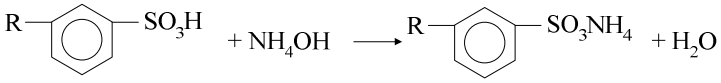
Adverse reactions:

$SO_2 + H_2O \rightarrow H_2SO_3$;

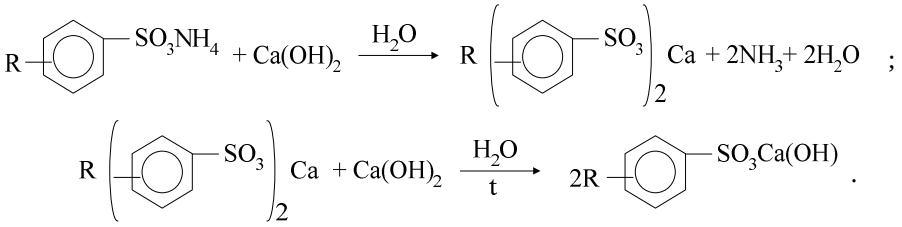
$SO_3 + H_2O \rightarrow H_2SO_4$.

2) Separation of the acid tar from oil.

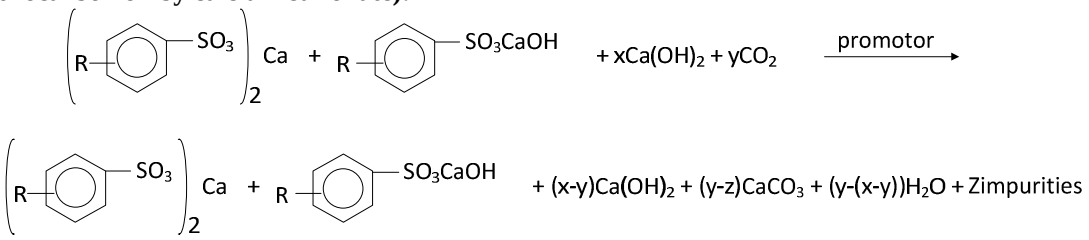
3) Neutralization of the sulfonated oil and extraction of ammonium sulfonate:



4) Stage of exchange reaction (exchange decomposition reaction) and partial receiving of calcium sulfonate salt as a result of «thermal stabilization»:



5) Carbonation (receipt of the colloidal dispersion of hydroxides and calcium carbonate stabilized in hydrocarbon oil by calcium sulfonate):



where x, y, z – coefficient

Carbonation step should be conducted so that the overbased products obtained colloidal stability of not less than 80 %.

6)Stripping reaction of methanol and water after the step of carbonation.

7) Purification of carbonated product from mechanical impurities.

The Stage of mechanical purification is important for products with a maximum colloidal stability.

8) Distilling of the solvent from the additives after the purification step [1].

The mechanism of action of detergent additives (detergents) can be explained by their adsorption on the surface of the insoluble particles in the oil. As a result, a sheath is formed on each particle of hydrocarbon radicals which are converted in the volume of oil. It prevents the coagulation of particles of pollution, and their contact with each other. Polar molecules of additives form an electric double layer, which gives similar charges to the particles on which they are adsorbed [2]. Due to this the particles repel and the probability of their incorporation in large aggregates decreases (Fig. 1).

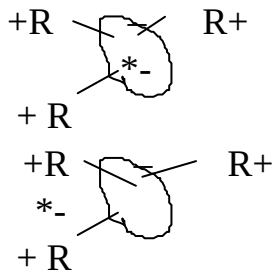


Fig. 1. The mechanism of action of detergent additives

Level of the ability of the detergent to neutralize the acid is characterized by its base number. The higher the value of the base number, the better the effect of the detergent. Model of the structure of the overbased sulfonate is shown in Figure 2.

Overbased sulfonate additives of JV «LLK-Naftan» company are involved in the production of multifunctional packages for multigrade engine oils for passenger cars and commercial vehicles.

The traditional additives production technology at JV «LLK-Naftan» by sulfonation petroleum feedstock has a number of drawbacks [3]:

– Insufficient dispersing properties and low thermal stability of resulting additive.

– The low output of the desired product.

– A significant share of by-products.

– Low environmental efficiency of the technology.

Switching to the industrial production of sulfonates based on synthetic raw materials provides the following advantages:

1. The reduction of the technological production chain (the stages of raw materials sulfonation with sulfuric anhydride, separation of acid tar from oil, neutralization of the sulfonated oil, extraction of ammonium sulfonates are excluded).

2. The increase of target product output by 52 %.

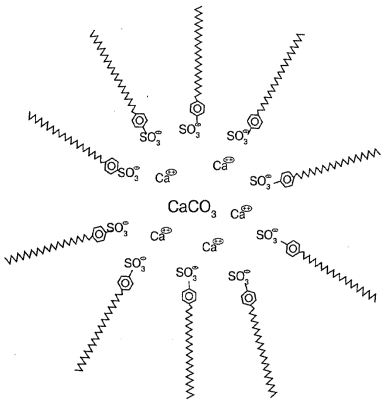


Fig. 2. Model structure overbased sulfonates

3. Ensuring the company's competitiveness in the long term.

4. Increase of profit by 60 %.

5. Solution to the problem of realization of by-products obtained during the process of sulfonate additives production.

6. Independence from the «Naftan» in terms of supply of raw materials for the sulfonation.

7. Will enable JV «LLK-Naftan» to become one of the largest producers of oil for modern engines of automotive technology in Eastern Europe.

Thus the transition to the synthetic base production of overbased sulfonate additives is economically and technologically practical.

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UDC 665.76

OUTLINE OF LOCAL ADDITIVES PRODUCTION PROBLEMS

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The article describes the actual problems of local additives manufacturing. Analysis of the lubricants quality is performed.

In order to satisfy the consumer needs in respect of car market production, today engineers are obliged to construct that sort of internal-combustion engines which will provide durable and good mechanism working under extremely severe conditions. However, perfection of engines construction leads to increasing of the load which present-day lubricants must withstand to satisfy the requirements of modern technique. Simultaneously the environmental aspect is considered which consists in the toughening of requirements imposed on the quality and composition of the lubricants produced. It is impossible to update the quality of marine, motor and gear oils without inserting of high-quality additives of different functionality in their composition for the reason that additives give the required functional properties to oils. Nevertheless, there are tendencies to reduce the content of additives in commercial oils and to increase its quality defined by the environmental requirements for the relevant products. In this way a difficult task is set before the manufacturers of additives, which includes the production of goods which will be competitive on the world market because of their high quality and at the same time will be characterized by low additives content.

One of the ways to improve the oils quality is to expand the range of additives. Unfortunately at present additives packages are formed and inserted into base oils only depending on their functional effects. However, the fact that the presence of several additives may cause changes in the intermolecular interactions of the solutions of additives in the oil as well as the solubility of additives in different base oils is not taken into account. Eventually all this factors lead to deterioration in the quality

of oils and to colloidal stability of oils with additives. Very often the sequence of inserting of the additives packages components and mixing modes are not taken into account. All this may result in the reduction of sedimentation stability of commercial oils under operating and storage conditions. Some portion of additives precipitates from the oil solution forming a precipitate on the surface of engine parts. Consequences of such phenomena are varied in the nature, for instance: deterioration of oils filtrability, filters clogging and others, in general deterioration of performance properties.

Therefore one of the ways to improve the quality of additives and their packages is to increase their colloidal stability. However it is necessary to improve production technologies in order to achieve the desired quality of additives. It includes optimization of dosage and the order of components inserting into the reaction mixture, organization of deeper and more perfect additives purification from mechanical impurities, selection of more effective solvents added at various stages of additives production technology, usage of high-tech methods to affect the colloidal state of additives dispersions in oil.

In order to maintain the colloidal stability in oil solution additives must be minimally subject to external factors that may change intermolecular interactions of additives in the volume of oil. Most of additives like detergent surfactants have hydrophilic and hydrophobic groups. Polar group (hydrophilic) determines the functional effect of additives and nonpolar group (hydrophobic) determines its solubility in the oil [1]. In this way nonpolar groups must provide the maximum possible solubility margin of the additive particularly in the process of the oil exploitation in the engine during which oil viscosity changes and accumulation of oxidation products leading to the additives association takes place.

Increasing of polarity of dispersion medium leads to decrease of oxidation products association, which accumulate in the process of oil exploitation and to increase of additive solubility in the oil solution which in its turn increases colloidal stability (fig. 1).

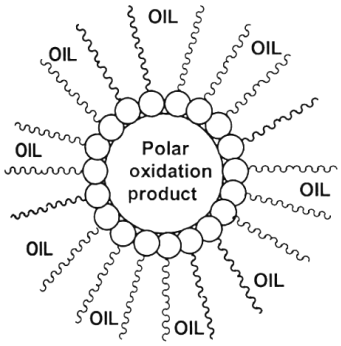

Fig. 1. Additive solubility in the oil solution

With increasing content of impurities the number of potential coagulation centers also increases which leads to integration of the additives particles and subsequent precipitation of them together with mechanical impurities particles in accordance with Stoke´s law.

With increasing content of coagulation centers additive particles adsorption from dispersion medium also increases owing to presence of uncompensated surface energy. Adsorption-desorption balance which takes place on the surface of coagulation centers stipulates particles growth. An increase of the number and of the size of particles leads to their more intense interaction, coagulation structures connection and as a result to the formation of coagulation carcass. This phenomenon is accompanied by surface tension changing at the interfacial surface and promotes gradual precipitation of dispersive phase out of dispersion medium. This phenomenon stipulates decline of additive package colloidal stability.

Additives perform three basic functions in oils, they restore oil properties which were lost or depressed during oil purification, improve original properties of the base oil and impart new properties to oil which it didn't possess originally. Additives belong to high-tech products which are characterized by the fact that their development costs are comparable with the costs their production development. Consumer properties of these products continuously increase therefore they have higher price on the world market than the price of other petrochemicals. Main foreign companies producing additives are Lubrizol, Exxon Chemicals, Chevron Chemicals, Texaco, Rohm and Haas, Shell and Infineum [2].

However financial crisis in 1998 has once again proved that orientation on imported additives packages is perspectiveless. Price for additives is increasing with the same rate as their consumption level. This negatively affects the price and realization of locally produced lubricants. Therefore much attention is to be paid to the quality improvement and diversification of locally produced additives.

One of the major tasks set before domestic additives manufacturers is to develop production of domestic antifoam, depressor, antioxidant and other high-quality additives the absence of which forces to focus on foreign market of additives.

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UDC 331.45

THE HEALTH STATUS EVALUATION OF EMPLOYEES OF THE ADMINISTRATIVE DEPARTMENT IN A PETROCHEMICAL COMPANY

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The structure and dynamics of illnesses with a temporary loss of working ability have been analyzed in the current article. The research refers to the employees of the main office of the plant «Polymir» JSC «Naftan». It has been revealed that in the research period in the main office no professional diseases were registered. It has been discovered that the long-term average annual morbidity rate for the employees is close to the average morbidity rate with a temporary loss of working ability (further referred to as TLWA).

At present a lot of attention is given to the active investigation and forecasting of the level of professional risks of the workers in oil refineries. The main group is formed by the employees of the chief production and the auxiliary units of oil refineries, and the control group is formed by the administrative departments of the enterprise (the main office), more rarely the control group can be formed by other service personnel.

When discussing the results of the research in regard to the dynamics of the professional and occupational pathology in the above mentioned control groups, the authors are confined to the statistics on the general structure and morbidity dynamics with the aim of comparing it with the key figures for the main professional groups without specifying the morbidity structure and morbidity dynamics within certain medical entities.

The studying of morbidity with a temporary loss of working ability of the employees in the main office has been carried out by analyzing the statistics data of annual reports on the employees' temporary incapacity to work (form f16-u). The data on general sickness rate were taken into consideration. The data on the number of sickness cases per 100 workers on average and per each medical entity were also considered. Apart from that, the average length of 1 disability case specifying the number of days, the wastage indicator as a result of temporary inability to work specifying calendar days per 100 employees, as well as the dynamics of the number and gender composition of the studied groups of employees in the period from 2003 to 2011 were considered.

In the course of the research it has been revealed that in the specified period the number of employees of the main office stayed nearly the same, however in the years 2010 – 2011 the number of women in the working team sharply declined: in 2003 women accounted for 73,28 % of the team, in 2011 the figure went down to 41,05 %. On average within the period from 2003 to 2011 women accounted for 63,5 % of the team in the main office.

The fact that women prevail over men in the team composition of the main office, suggests a higher rate of endocrine diseases, genitourinary diseases and tumours, when compared to the other departments [1, 2]. At the same time due to the decreasing number of women in the team of the main office in 2010 – 2011, a decrease in morbidity rate of endocrine diseases, genitourinary diseases and tumours is expected. In table 1 you can see the data on the temporary dynamics of disease for the employees of the main office of the studied petrochemical company.

Table 1 – Morbidity with temporary loss of working ability in the main office of the oil refinery

Year	Number of cases per 100 employees	Number of calendar days per 100 employees	Average length of 1 case of TLWA, days
2003	94,28	797,08	8,45
2004	84,20	714,30	8,48
2005	94,09	795,96	8,46
2006	96,75	836,14	8,64
2007	95,40	865,99	9,08
2008	91,88	928,11	10,10
2009	99,98	890,89	8,91
2010	63,74	597,53	9,37
2011	38,87	349,17	8,98
Average	84,35	752,80	8,94

According to the evaluation scale of the TLWA indicators, which was suggested by Y.L. Notkin in 1977, the morbidity level of the main office employees can be estimated as close to the average. In particular – the TLWA frequency index is average, the temporary loss of working ability rate is lower than average. At the same time from 2006 to 2009 the morbidity level in the main office remained average, in 2010–2011 – it was lower than average, in 2003 and 2005 – the morbidity level in the main office was transitional.

From the data in table 2 it is clear that the qualitative structure of TLWA of the main office employees in the petrochemical company, which is identical to the standard for the given industry, covers 16 medical entities.

Table 2 – The structure of TLWA in the main office of the petrochemical company

Medical entity	Average number of cases per 100 employees, per year год	Average number of days of disability per 100 employees, per year	Average length of 1 case, days per year
Respiratory diseases	52,32	362,96	6,94
Musculoskeletal diseases	7,66	71,42	9,33
Poisoning and injuries in the workplace	3,05	69,81	22,93
Disease of blood-circulatory and cardio-vascular systems	4,24	39,72	9,37
Diseases of digestive organs	2,22	24,41	11,02
Genitourinary diseases	3,87	40,87	10,57
Skin diseases and subcutaneous tissue	1,43	13,82	9,68
Diseases of the eye and the appendages of the eye	1,66	14,31	8,63
Diseases of the ear and the adnexum mastoideum	0,63	5,55	8,83
Tumours	2,06	36,94	17,92
Infectious and parasitic diseases	0,31	4,13	13,18
Mental diseases and disorders	0,22	2,13	9,49
Nervous system diseases	0,43	5,37	12,47
Endocrine diseases	0,37	7,04	18,87
Blood diseases and blood-forming organ diseases	0,06	1,28	22,12
Reproductive disorders among women	3,84	53,04	13,81
Total	84,35	752,80	8,94

The percentage ratio of the groups in the general structure of TLWA for the main office of the studied petrochemical company is slightly different from the analogous data for the chief industries and for the enterprise as a whole. The first rank place in the structure of TLWA in the main office is occupied by respiratory organ diseases (63,49 % of all the cases of TLWA), the second place – pathology of the musculoskeletal system (9,3 %), the third place – diseases of blood-circulatory and cardio-vascular systems (5,04 %). Further we see genitourinary diseases (3,96 %), poisoning and injuries in the workplace (3,71 %), the sixth place belongs to reproductive disorders among women (3 %), the seventh place is taken by diseases of digestive organs (2,69 %). There exists a rather high level of tumours (2,51 %, 8th rank place), also a high level of diseases of the eye and the appendages of the eye (2,01 %, 9th place). There is a low level of diseases such as skin diseases and subcutaneous tissue (1,73 %, 10th place), diseases of the ear and the adnexum mastoideum (0,78 %, 11th rank place), as well as endocrine system diseases (0,46 %, 13th place). Nervous system diseases occupy the 12th rank place (0,53 %). Infectious and parasitic diseases (0,39 %) occupy the 14th place, mental disorders (0,28 %) occupy the 15th place. Blood diseases and blood-forming organ diseases are the rarest (0,07 %, 16th place).

It must be noted that the 1st and the 2nd rank places of respiratory organ diseases and the pathology of the musculoskeletal system in the structure of TLWA are typical of petrochemical companies. As a rule, the third medical entity, which is typical of the chief industries of the petrochemical enterprises, is the group of poisoning and injuries. It is characteristic of the employees of administrative services that the personnel carry out their professional duties in comfortable environment, which excludes the necessity of climbing to great heights from the floor (ground). It also excludes the possibility of industrial injuries as a result of contacting the technological equipment. Due to this, the indexes are lower compared to the indexes of the chief industries in the group of poisoning and injuries in the main office of the petrochemical company.

At the same time the percentage of respiratory organ diseases in the structure of TLWA, in terms of the number of cases per 100 persons, and in terms of the number of days of disability is maximum – 63,49 and 48,21 % respectively. Consequently, the pathology of respiratory organs is leading for the petrochemical company, which includes also the employees of the administrative department. The respiratory organ diseases are represented by acute respiratory infections (91,70 % of the level, 88,90 % days of inability to work), flu (5,68 %; 6,06 %), pneumonia (0,30 %; 1,01 %), and other diseases of upper respiratory passages (1,27 %; 1,77 %), chronic bronchitis (0,48 %; 1,18 %) and bronchial asthma (0,57 %; 1,08 %).

In the group of poisoning and injuries there are mainly individual injuries of soft tissues in different parts of the body (41,16 % of cases), individual fractures of upper limbs and lower limbs (34,85 %), burns and freezing injuries as well as other cases (11,08 %), multiple and combined injuries (5,55 %). Next to this there are intracranial injuries (5,21 %),

dislocations (1,50 %). Other nervous system injuries (0,65 %) are the rarest in this group. During the whole period of study there were no cases of poisoning. No consequences of toxic impact, of injuries, burns, freezing or any consequences of head injuries were detected. On the whole in the period from 2003 to 2011 the level of occurrence of poisoning and injuries in the main office team changed very little. Since 2009 there has been a tendency to the level decreasing, however at the same time the index of temporary inability to work among the employees has been increasing.

Based on the results of the work, the following conclusions have been drawn:

1. The long-term average annual morbidity rate is 84,35 cases of TLWA and 752,80 days of loss of working ability per 100 employees, and in accordance with Y.L. Notkin's scale dated 1977 is close to the average level of TLWA.

2. Respiratory diseases are the leading pathology of the main office of the studied petrochemical company. They account for 63,49 % cases of TLWA and 48,21 % of total disability. The second rank place is occupied by musculoskeletal diseases, their percentage in the total structure of TLWA on the basis of the number of cases per 100 employees and on the basis of the number of disability days is 9,3 и 9,74 % respectively.

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MINIMIZATION OF BACKLASH IN THE THREADED CONNECTIONS IN BORING CUTTING TOOLS

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The article is devoted to modeling of precision treaded connections in SolidWorks software. Experiments were carried out to reduce the backlash in threaded connections of boring tools.

In metalworking boring heads are widely used for making precise holes. They allow to set the size of the tool with high precision and to achieve high-precision machining and quality. The possibility to control the size of the tool can improve processing efficiency by reducing tooling costs and improve performance through the use of modern tool materials as cutting teeth such as hard metal, mineral ceramics and superhard materials that allow the use at higher cutting mode [1].

Progressive tools are adjustable single-blade boring prefabricated heads, equipped with replaceable indexable carbide inserts.

Figure 1 shows an example of a structure of a typical single-tooth boring head for boring holes in the range 30 ... 150 mm.

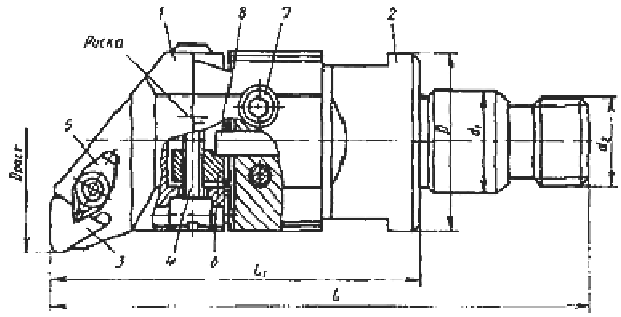

Fig. 1. Single-tooth boring head for boring holes with a diameter of 30 ... 150 mm

These heads consist of a head body 2 on the front side of which there is a corner recess of the «dovetail». In the recess a tool holder 1 is accurately placed, it has a possibility of radial displacement. In based tool holder a

replaceable indexable carbide insert 3 is mounted, it has triangular or tetrahedral shape with rear corners. A plate fastening according to its design is performed using a stuck 5 and a screw or screws through the hole in the plate.

Geometric parameters of the insert: entering angle φ = 90 ° for triangular plate and 75 ° for tetrahedral plate, front angle γ = 0, rear angle α = 8 – 10 °.

The housing of the head is provided with an adjusting screw 4. Along the screw 4 the guide rail 6 moves, which serves to focus the holder 1. When the screw 4 rotates the guide rail 6 acts on the pin 8, and the holder 1 is moved in the radial direction, thereby ensuring accurate adjustment of the head to the desired size treatment. After setting the required size, the holder 1 is firmly fixed in the slot due to the elastic deformation of the body 2 while tightening the screw 7. To create a possibility for deformation of the «dovetail» type groove the housings have a longitudinal slot. The housing and the holder are hardened to HRC 32-40. Accuracy of adjustment available in the operating conditions of up to ± 0,01 ± 0,02 mm depends on the diameter and experience of an operator.

On the basis of analysis of boring tool structures it can be concluded that in modern engineering boring tools can be divided into boring cutters, microbur and boring heads.

Tools with indexable inserts in accordance with GOST 19042-80 or ISO 1832 (it could be also found forms of indexable inserts that differ from these standards) are most common nowadays. It helps to improve reliability of cutting tools, intensify cutting modes, and provide quick-tool change in case of wear, which is especially important for automated production.

The most promising direction in boring tool design and application is creation of instrumental systems based on a modular principle.

Particular attention is paid to the construction of unites for micrometric adjustment and moving cutting blades, as well as cartridges or cutting blocks.

One of the main problems of these systems is their lack of rigidity and accuracy due to the presence of more joints than in the solid tool. One of the most effective ways to improve the accuracy of the blocks is to use elements for adjusting the dimensions of cutting tools, such as microbur. But the main drawback in the design of microburs and other instrumental system blocks having a micrometer screw as a regulatory element is a gap in the micrometer screw pair. Reducing instrument inaccuracies in setting the size by means of the micrometer screws is made by imparting the preload in the threaded connection, however, a question of influence of microbur design parameters to create necessary interference, and thus the precision and rigidity in the connection, has not been studied enough.

There are many ways to make the preload in the micrometer screw connection of microbur. This variety is shown most thoroughly in the patent №2349426 [2].

According to this patent the boring head consists of a micrometer screw, playing the role of the tool holder 1. On one end of the tool holder 1 there is a groove for indexable insert 2, fixed, for example with a clamp 3 with help of screw 4, and on the other end a key 5 is set. The key 5 can slide along the keyway of a mandrel 6 and prevents rotation of the tool holder 1 around its axis. A limb 7 and a bushing 8 are conjugated with tool holder 1. The limb 7 is set in the rotatable housing 9. A vernier 10 is made at the end of the housing 9 for precision adjusting of the tool holder 1. Between the sleeve 8 and the housing 9 an elastic member 11 is mounted (Fig. 2).

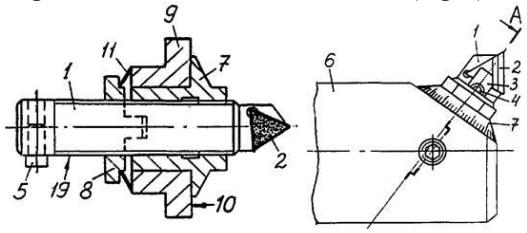

Fig. 2. Boring head assembly and section view

The elastic element 11 can be made as diaphragm spring, curved washer or wavy washer. The elastic element 11 can also be made as one part with sleeve 8 as: a diaphragm spring (Fig. 2) with rolling bearings 12, a slotted spring (Fig. 3) with an abutment surface 13 on the housing 9, etc.

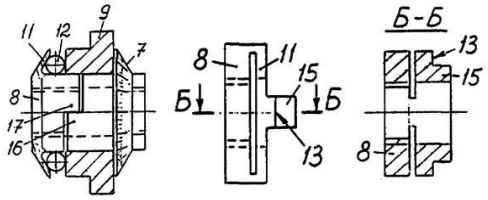

Fig. 3. Elastic elements

The limb 7 interacts with the sleeve 8 (transmits torque) through slots 14 and ridges 15, performed respectively in limb 7 and sleeve 8. Shoulders 16 and 17 may also transmit torque (Fig. 3) due to halved cutouts at the ends in limb 7 and sleeve 8, respectively. In the central limb opening 7 excluding threads precise circular recess 18 is made as a cylindrical inner surface with diameter d (Fig. 4).

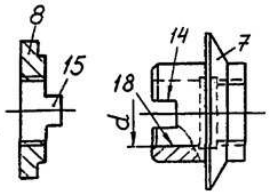

Fig. 4. The limb with a circular recess

In the tool holder 1 the thread tops are processed (cut) without violating the average diameter of the thread and the diameter d of the recess18, and form an outer cylindrical surface 19 of diameter d (Fig. 5).

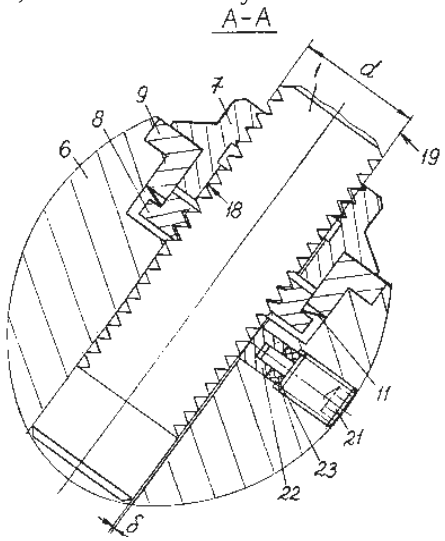

Fig. 5. Boring head. Cut A-A

However, the resilient member in the form of a slotted spring is the easiest to manufacture.

During the projecting process and development of the new boring instruments with micrometer adjustment of the cutting blade the main task was to solve the problem with clearance adjustment (to reduce to the necessary size) in the thread connection of the boring head. It was revealed that some factors influence the clearance size, namely the parameters of the slots on the housing of the bushing and the stresses of prior pressing or wedging (for prior preload).

A plan-matrix of the complete factorial experiment (CFE) was done for the purpose of estimation of slots influence on the accuracy of the thread connection. In our case there were three factors: width of the slot, step and depth of the slot. To reduce the number of models we used two levels of each factor. Thereby we had 8 models [4]. The plan-matrix of CFE is shown in table 1.

Table 1 – Plan-matrix of CFE

Sample #	The width of the slot, mm	The step of the slot, mm	The depth of the slot, mm
1	1	1	18
2	1	1	21
3	1	1,5	18
4	1	1,5	21
5	1,5	1	18
6	1,5	1	21
7	1,5	1,5	18
8	1,5	1,5	21

This connection was subjected to structural analysis using the built-in SolidWorks tools. Wedging of bushing slots and simultaneous pressure on the axis of the screw inside the bushing were modeled (Fig. 6, 7).

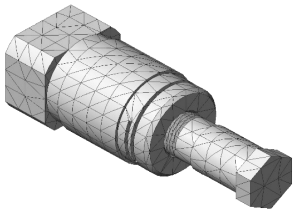

Fig. 6. Screw-bushing connection divided into finite elements in SolidWorks

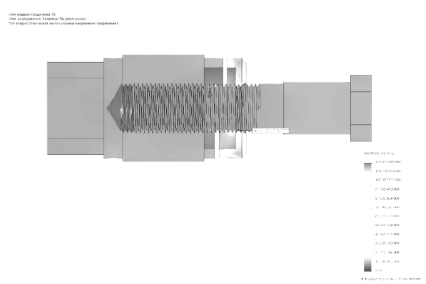

Fig. 7. Map of the stress distribution obtained in SolidWorks

After analyzing the connections using the finite element method, we can conclude that during the slots wedging and the simultaneous action of an axial force on the screw (component of the cutting force) prior preload is formed on the split bushing. This happens at certain values of slots wedging force and it is sufficient to minimize gaps and backlash in the threaded pair.

After the research and calculations had been done using SolidWorks software, experiments were conducted on natural samples of split bushings.

During the experiment split bushings were wedged with the help of measuring plates, and then the torque in the threaded connection was measured by means of screwing and unscrewing of the screw (Fig. 9).

Fig. 9. Measurement of torque with a torque wrench

After analyzing the structure using finite element method in the program SolidWorks, you can draw preliminary conclusions about the acceptability of such a compensation of gaps in the threaded connection of micrometer screws in precision cutting tools. However, due to the nature of calculations in SolidWorks Simulation it is impossible to model a situation of split bushing compression and the following screwing the screws. Thus, further modeling was carried out on real models. During experiments it was found that threaded connections moments occur at the same step and width of slots, but at a more favorable depth of slots. However, when the width of slots equals to two steps of the thread and the step of slots equals to two steps of the thread, the bushing changes from the elastic deformation into the plastic deformation zone. Thus, we can conclude that the slots on bushings should be no more than 1.5 steps of the thread and have a maximum depth (for a square in cross-section).

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UDC 621.893

ANALYSIS OF NANOSCALE ADDITIVES INCLUDED IN THE LUBRICATING OIL REALIZING THE EFFECT OF TRIBOLOGICALLY FRICTION SURFACES

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Considered modifying nano-sized additives of lubricants used to improve wear resistance of the friction surfaces of machines and mechanisms.

Losses from friction and wear in developed countries reach 4 – 5 % of national income, and overcoming the friction absorbs worldwide 20 – 25 % of the energy produced per year [1]. Providing the required level of coefficient of friction, decreasing the wear of the friction surfaces and preventing clogging of the friction depends on the nature and properties of the lubricant and its components.

Traditional methods of improving the wear resistance and durability of friction include the use of mineral, vegetable, animal and synthetic lubricants, parts of magnesium alloys, magnetic traps of wear particles, the magnets impact on grease and others Continuous improvement of the load-speed modes of machine operation, exhausted the possibilities of these methods. Therefore, the scientists face the task of further improving the design of parts and assemblies, methods of maintenance and repair.

Currently one of the priorities of improving the durability of the friction surfaces is the development of lubricants, realizing the effect of tribomodification. The modification of the friction surfaces is mainly due to the introduction in to lubricants nano-sized additives. These additives are solid insoluble substance with a characteristic size of from 0,1 nm to several tens nm, which support high antifriction and antiwear properties of the lubricant material in the process of friction.

Foreign and domestic scientists developed many different compositions based on the minerals of natural and artificial origin, which received the name geomodifires of friction (GMT). Getting on the friction surface along with oil or grease, they initiate the process of formation in friction surfaces of nano-sized structures with high wear resistance and low coefficient of friction. As a result of application of concentrated suspension GMT on the basis of serpentine with the dispersion of a natural mineral from 0,01 to 5 micrometer in all mechanisms and devices the wear of friction is reduced on 50 – 70 %, the losses due to friction are reduced 1,5 – 2 times and vibroactivity is reduced on 50 – 100 % [2]. This is due to the increase in the effective contact area and the formation of the original structure of the dynamic ultra-thin layer of hydrocarbon chains of particles GMT and wear products of less than one micrometer (quasiliquefied l layer).

On the basis of serpentine and concomitant impurities the compound for treatment of friction pairs, was developed. It includes the fine powder of diamond or stones, and metal-containing additive which is a mixture of fine powder of metals, selected from the metal base and the metals, forming a stable system with the base material taken from a number of Cr, Ni, Mo, Nb, Ti and their alloys [3]. This combination of components provides for the formation of strongly bound with the friction surface of a modified hardened surface layer of specified composition, and this makes it possible to achieve a stable reduction of wear and friction coefficient and improv the technical parameters of machines and mechanisms. For example, for the pair of friction steel 45 – steel 45, the surfaces of which are treated by this composition, by the following technical and operational characteristics are characterized: hardness 390 – 410 HRC, the coefficient of friction 0,006 – 0,008, compensation for wear of 1 – 3 mm [3].

Modern nano-sized additives also include ultrafine diamond-graphite powder (UDP-AG). Diamond plays the role of abrasive material on the account of which during operation the process of submicrocutting of single microsystems takes plays and that leads to a noticeable increase of the effective contact area of friction pairs. The smaller the particle size of the diamond powder, the more of them get into the area of frictional contact, and this offers more anti-wear performance. Presented in work [4] results show that the introduction of UDP-AG into plastic lubricant CIATIM-201 enhances its anti-friction properties, allows to reduce the operating temperature of the friction on 13 – 15 % and the coefficient of sliding friction on 25 – 32 % (Fig. 1) and to reduce the roughness of the rubbing surfaces in 1,5 – 2 times.

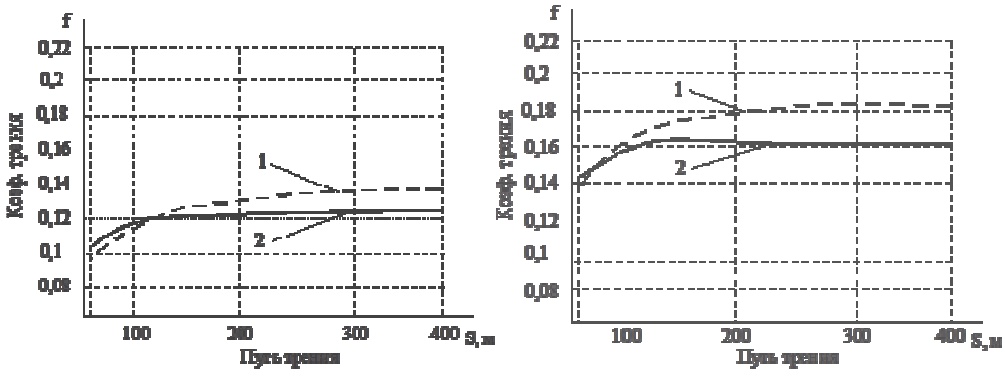

Fig. 1. Dependence of the change of friction coefficient on road friction lubrication CIATIM-201 at a load of 150 N and 250 N (b): 1 – without filler; 2 – filled with UDP-AG [4]

UDP-AG in lubricating oil is often used in combination with ultra dispersed and other additives. In this case, the nature of their interaction and concentration determine the properties of lubricants, as well as technical and operational characteristics of treated by this compound friction surfaces.

When UDP of iron and UDP-AG are used together the diamond-metal composite is formed on the friction surface. It combines high hardness (resistance to wear), cladding properties (thickness up to 4 micrometer), as well as a synergistic effect (the coefficient of friction at the stage of break-in does not exceed 0,23 for the pair steel3-steel3) [5]. Investigations of lubricant containing UDP-AG (0,2 – 5 %) in combination with fine salt of sulfate tin show a 2 time decrease in the wear rate and the coefficient of friction is decreased by 12 – 15 %. At the same time, the load capacity is increased by 25 %. In the case of reducing the concentration of UDP-AG friction regime is the same as with usual lubricants without additives. If the concentration is greater than 5 %, the friction passes into unstable mode of boundary friction, combined with an increase in coefficient of friction and wear [6].

The staff of the scientific-production Association «Altai» developed and conducted a series of industrial tests of antifriction grease for abrasive materials, which included ultradispersed diamond and molybdenum disulfide. As a result of application of the lubricant with cluster diamonds the efficiency of the operation of grinding and sharpening increases by 10-25 %, and the purity of the treated surface in 1,5 – 2 times, while the ecological conditions of work are improved [7].

At the end of the last century in the UK Neil Gretton developed and widely used a special liquid SLIK-50 on the bases of polytetrafluoroethylene (PTFE), but then its use was suspended. But even now PTFE is a part of many lubricants as a polymeropoulos composition. As a result, on the friction surface a thin (about 1 micrometer) structured coating is formed. It provides increased adhesion, anti-wear and anti-friction effects. The efficiency is preparations is determined by the level of ultradispersed PTFE, dispersion of particles in the solvent, the presence of surface-active substances (surfactants), reinforcing the mechanical interaction. Many modifications of PTFE (polyflon, algoflon, teflon-3, vidar and others), are also developed. They have found application in automobile and chemical industries, but also in many other areas.

Currently there is also a large number of lubricants, with dispersed ferromagnets. Transition metals and some of their intermetallic compounds, such as iron-nickel, iron-cobalt are of practical importance. Magnetite is the most widely used. It has good adsorption ability with respect to surfactants, and is also capable of forming a colloidal dispersion with high magnetization. Magnetite is a constituent of many metalloplastic lubricants. The separating layer, preventing the interaction of parts of friction in such greases, forms particles of metals or metal-containing compounds, filling the microscopic irregularities of friction surfaces and thus reducing the amount of contact pressure. Such additives are fine powders of zinc, bronze, copper, lead and some others with a particle size of 10 – 40 micrometer. Salts of monocarboxylic acids with metals or metal powder which is industrial waste of electrochemical electroplating processes containing copper and mixed with oleic acid are also used. When metalloprotease film is formed in the contact zone the accelerated migration of magnetic particles from the volume of lubricant takes place. That reduces wear, friction torque, and improves anti-wear resistance of friction [8].

Discussed in the article nanoscale additives can significantly improve the wear resistance of friction surfaces (70 %), technical and operational performance in 1,5 – 2 times, reduce the time and improve the quality of their extra earnings, lower the temperature of working units (up 15 %), noise and vibration, which significantly contributes to increasing the reliability and durability of machines and mechanisms.

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UDC 528.5

PROSPECTS OF GRAPH THEORY USAGE IN THE ECONOMICAL AND GEOGRAPHICAL ASPECTS OF TERRITORY PLANNING

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In article problems of using graph theory to solve some tasks of economical and geographical planning are considered. The abilities of geographical information systems (GIS) are also discussed. More attention is given to the potential of graph theory application in the planning of territorial industrial complexes and clusters.

Graph theory is the section of discrete mathematics that studies graphs, groups of non-empty sets of nodes and edges (each edge connects only two nodes). In spite of large number of unsolved problems and unproven hypotheses fields of usage are wide enough. Among them are: social networks and communications, information technologies and geographic information systems (GIS), etc.

Speaking of GIS, the geographical objects (any objects located on the earth, under or above its surface): existing or designed buildings, installations, blocks, even settlements can be treated as nodes of graph; and roads, engineering networks, power lines as edges of the graph. Applying different calculations on the graph allows finding the shortest detour, planning the best route, defining a «service area» of shops, malls, ambulance stations, fire stations.

Modern GIS have a big arsenal to solve any tasks of spatial planning. The solution of some of them, such as optimization of transport costs by distributing stops and determining the shortest path between these stops, considering limiting factors (time, capacity machines and maximum travel time) becomes more illustrative using graph theory. A number of modern GIS software has extensions dealing with the principles of graph theory. ArcGIS has «Network Analyst», Quantum GIS contains «Road Graph». Such modules have been successfully used by enterprises and organizations, governments, allowing them to carry out their activities more efficiently and to make grounded strategic decisions. The graph theory is useful and efficient when choosing the place for industrial complex, service center, and transport and logistics center from several options, when analyzing the geography of supplies.

On the other hand, «Network Analyst» (as well as extensions on the bases of some other GIS software) has a significant feature: it is well designed to solve traffic problems, especially for public transport and is less convenient for logistics. So the analysis, for example, of nearby shops, it performs easily using such parameters as distance, elapsed time, and not so easily when considering the cost of goods, range, etc. But latter are taken into account by the consumer as well, when choosing a store, in which he will go shopping. Therefore such modules are not so convenient for solving the whole spectrum of economic and geographic problems including logistics in full.

For these purposes, where the modules of GIS software are not so efficient, it is better to address to special software, for example software «Grafoanalizator» (current version 1.6) for Windows or «Rocs» (current version 1.12) for UNIX-like operation systems. One can build directed graph with weights of edges and nodes. However, the choice of criteria for weights of nodes and edges determination.

The choice of criteria for determining the weight of edges and nodes depends on the tasks and objectives of planning. Conditionally we divide the tasks of spatial planning at the macro (regional) and micro (enterprise) level. At the macro level, we will evaluate the potential of the regions, settlements. The weight of the node will include:

– the population of the village, the region;
– the quantity and quality (skills, qualifications) of workforce;
– number of enterprises by economic sector,
– availability of scientific institutions, higher and secondary special education, enterprises and organizations of scientific and technical sphere;
– other criteria if applicable.

The weight of edge will consist of:
– distance between cities in kilometers;
– the value of migration streams between nodes in a thousand people per year;
– the volume of mutual trade between enterprises «nodes» in currency per year;
– the frequency of interactions / business contacts between enterprises and organizations of «nodes»;
– other criteria if applicable.

Optionally instead of graphs one can use the gravity model, by analogy with Newton's law of universal gravitation [1], which states that two points attract each other with a force that is directly proportional to the product of the two masses and inversely proportional to the square of the distance between them.

In this case, the mass will represent a set of values of the evaluation criteria. Taking pairs and calculating the value of their «mutual attraction» one can compare settlements and get an idea of the weight of settlement in regional economical system and its relations with other localities/regions.

Let's call micro-level, planning at the level of companies and organizations, such as planning a cluster or an industrial complex. The key features of the cluster are: the geographical proximity of participants and the presence of companies in the same or related industries (cluster members). The correct choice depends on the effectiveness of the cluster as an economic agent; strengthening the competitive advantages of firms and the region. To date, the problem of selection of participants, cluster formation is relevant and one should consider it. For cluster formation the following factors are important:

– the presence of enterprises of small, medium and large enterprises, specializing in working in particular sector;

– the presence of companies operating in related sectors;

– the presence of businesses and organizations serving the cluster members, but do not participate directly in the production (banks, insurance sector, consulting companies and others.);

– satisfactory financial and economic condition of enterprises;

– availability of educational and scientific institutions that provide training (retraining) of specialists and have the research base on the profile of the cluster;

– the geographical proximity of the participants;

– the possibility of the existing or the ability to quickly create a new transport and logistics network;

– the presence of centripetal tendencies among potential cluster members.

One should clarify: technological proximity, contiguity production, geographical proximity are criteria, which distinguish cluster and the holding.

The assessment of potential clusters is made by two steps. The first step is evaluation of enterprises and organizations. It is sufficient to assess the innovative activity or innovation potential, the coefficient of absolute liquidity, financial independence ratio, asset turnover ratio and other parameters, if necessary. Innovation activity includes: interaction with science, design bureaus; investment activity; active renewal of productive assets; the presence and number of innovations successfully completed during the last 3 – 5 years. Evaluation of enterprises and organizations is expressed by weight of a node.

The second step is assessment relations between enterprises and organizations. Weight of the edge will reflect the frequency and amount of interaction between enterprises and organizations, the degree of contiguity of production, and other factors.

However, the cluster activity is affected by such factors as the macroeconomic, fiscal, monetary policy of the state at a given time, the investment climate, even personal relationships between management of companies, force majeure. An effort of cluster members is not enough to run the project and these conditions are difficult to express in some quantitative terms. All the same, the results can be used in selecting potential participants of cluster, in planning of new members, in coordinating the cluster, industrial and innovation policy in the regions. Potential investors can assess the attractiveness of the enterprise and the region for investments. And most importantly, we should remember that an important feature of mathematical methods is that they use to explore the mediated reality. They are used exclusively in the form of models – in some formal abstractions. Soviet economist, Nobel laureate L.V. Kantorovich said that mathematical models can reflect the structure, relationships and the dynamics of the observed phenomena, and it's important to observe constantly their corresponding properties of the simulated reality [2].

So, we came to a conclusion that the standard tools of geographic information systems are not so suitable for solving the problems of economic and geographical planning. Graph theory has application prospects for solving this type of problems, but the list of criteria and their quantitative expression affecting the weight of edges and graphs currently requires further study in order to clarify and verify the above statements and provide opportunities for the practical use of these hypotheses.

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UDC 648.15.495

APPROACHES TO THE DESCRIPTION OF PROCESSES IN THE MAIN PIPELINE TRANSPORT

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It was suggested to use technical regulatory legal acts as the basis for constructing process diagrams for safety evaluation of processes in the main pipeline transport.

At the stage of identification of hazardous factors that may affect the risk evaluation at the sites of the main pipeline transport for clarity and convenience of the procedure it was suggested to describe a model of network of operating processes at an enterprise [1].

Processes can be described by a variety of methods and approaches. As a result of process modeling languages review for quality management it was found that IDEF0 language was the best for describing business processes at the enterprise. Therefore this language was used during the risk evaluation at the sites of the main pipeline transport. IDEF0 notation was developed and based on the methodology of structural analysis. It was successfully used in a variety of industries and proved to be as an effective means of formalized description, design, analysis and improvement of business processes and complex systems.

One of the main advantages of IDEF0 methodology is correspondence to the approach to the international standard ISO 9001: 2000 concerning the description of the quality management systems and thus the system safety assessment [2]. Considering that security is one of the indicators of quality, it is advisable to use these methods and adapt them to the description of the network of processes during their safety evaluation. The main feature of the proposed approach is the selection and description of processes in which the emergence of security "loss" as well as the processes of transmission of these "losses" to other processes b means of information and material relations take place.

Processes directly or indirectly influence safety and dangerous situations. Such processes according to the ideology of documents ISO 9000 [3] as part of the main pipeline transport are the processes of the life cycle services which directly influence safety. In addition, such processes must include management processes, supply processes, measurement processes. These processes in case of abnormal functioning indirectly influence the occurrence of dangerous situations through making incompetent decisions and orders, inaccurate measurements, the supply of substandard materials, etc. In this case incompetent orders are transferred through the chain of processes at the enterprise that result in the emergence of accidental situations in the lifecycle processes.

The purpose of constructing a functional model is necessary and sufficient formalized description of all sub processes as well as the nature of relationships between them. This model is able to provide a broad picture of processes and flows of information and materials.

The description of network of processes was carried out through operation of the linear part of the main pipeline. Selecting the operation of the linear part of the main pipeline as the life cycle stage was conditioned by the fact that operation illustrates the maximum number of hazards. A pipeline is a linearly extended object with a random spatial distribution of defects which are more difficult to detect than in platform objects.

The process of operation of the linear part of the main pipeline in graphical form can be written on the bases of two sources of information.

According to the first one the description of the main pipelines operating by mean of diagrams of interrelated processes with inputs and outputs can be based on real enterprise operating of the main pipeline transport. According to this method it is necessary to talk to and obtain information from employees at all levels of the enterprise which makes it possible to see systemic processes and operating mechanism of the enterprise, existing information flows at the enterprise, professional relationships between the staff in the team.

According to the second method a source of information in the description of the company is presented by technical regulatory legal acts. Enterprise operating is organized on the bases of technical regulatory legal acts. All requirements for the content, quality of raw materials and staff, types of work, the sequence of actions in the organization and execution of works which can be found in technical regulatory legal acts define enterprise operating. In other words, the technical regulatory legal acts represent a verbal model of the enterprise.

Technical regulatory legal acts are developed by consensus of scientific institutes, leading specialists of enterprises, ministries and specialized agencies based on the latest achievements of science and technology, new developments in production organization, modern safety requirements. For this reason the adequacy of the model of enterprise operating as reflected in the technical regulatory legal acts is in no doubt.

The advantage of using technical regulatory legal acts as the basis for constructing process diagrams lies in the fact that these acts constitute formal documents with a concise precise objective content and are set out in

the form of the system. Using the results of interviews with the enterprise staff as a source of information for networking processes may be accompanied by subjectivism, non-systematic presentation of information, may be time-consuming. Against this background the first method of using technical regulatory legal acts was chosen as a source of information for constructing process diagrams of operation of the linear part of the main pipeline.

At the same time processes construction language (IDEF0) lacks such an element as an opportunity to define objects' attributes. Thus the constructed model of operation of the linear part of the main pipeline serves as an information basis for further analysis and evaluation of the integral risk of the whole process.

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UDC 648.12.452

SAFETY MANAGEMENT OF PROCESSES IN THE MAIN PIPELINE TRANSPORT

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It was suggested to create a fund of technical regulatory legal acts that would allow to increase the safety of processes in the main pipeline transport.

It is necessary to carry out quantitative risk evaluation in the main pipeline transport to identify hazardous processes and to draft arrangements that will help to prevent hazards. This approach should be implemented in the safety management system of processes in the main pipeline transport.

Different control and safety systems can be distinguished. In the technical regulatory legal acts of the Republic of Belarus such concepts as total safety system, products safety management, flights safety management system, information safety system, fire safety system.

One of the most urgent tasks in the main pipeline transport is the management of industrial safety due to the fact that industrial hazard is the characteristic of this means of transport. The requirement to establish safety management systems are stated in Russian technical regulatory legal acts.

Safety work [1], environment [2] and quality control [3] management systems are the closest to each other in relation to content and requirements adequacy. They are part of the overall management system which includes planning, responsibilities, methods, procedures, processes, resources.

Due to the fact that security is one of the quality indicators and service hazard arises in processes, safety management system of processes must be considered in the framework of service quality management system which uses a process approach. Management responsibility, resource management, life cycle processes, measurement, analysis and improvement are the basic elements in the model of the quality management system. This model is based on the methodology known as the Deming Cycle PDCA [4] which represents an iterative sequence of operations such as planning, implementation, verification, i.e. actions that will lead to continuous improvement.

As shown in the model of quality management system and in Deming Cycle the most important processes are those which are carried out by senior management. Therefore from the entire list of processes responsible management and planning are in the first place. Within these processes senior management sets policies and objectives, ensures the implementation of the required processes, provides resources, analyzes and makes decisions on improvement measures.

Executing senior management decisions passes through information channels by means of documented control actions. Documentation conveys the idea of the decision and the sequence of actions that must be done in the implementation of decisions of the senior management.

Controlling actions by means of documentation may be transmitted through external and internal information channels. The external information channel contains documentation which is worked out by the government. The internal channel includes documentation which is worked out within the company on behalf of senior management.

Attaining quality and value to products or service value takes place in the processes of a lifecycle. At the same time in the processes of lifecycle the loss of quality in the form of hazard formation which arises from the

influence on raw materials by means of mechanisms of controlling actions. In this case the process of the incoming raw materials, raw materials changing mechanism, controlling action and output in the form of products or service can be regarded as a model of hazard formation.

In this case the process of the life cycle at the provision of service as well as other processes is regulated by entrance into process management, i.e. controlling action. Consequently entrance into the process management plays the most important role in attaining quality to products or service and at the same time the loss of quality products or service which means hazard formation. All components of the process, personnel actions, mechanisms work, parameters of incoming raw materials and outcoming products or service are under the influence regulatory documents.

Thus competently elaborated regulatory acts allow avoiding accidental situations in the main pipeline transport. Taking into account the priority of regulatory acts in providing safety, accidental situations which occur in the main pipeline transport indicate the need to improve the existing technical regulatory legal acts. Accidents may occur due to poor elaboration of requirements for processes, lack of some requirements for processes or lack of the whole technical regulatory legal act for the process.

To reveal the lack of technical regulatory legal act for a number of processes in the main pipeline transport is possible be means of compiling a total database of technical regulatory legal acts and their systematization according to legal status, life cycle processes, the type of transported product, object localization.

At present there is no documented system of views with priorities of standardization and ways of improvement of present fund of technical regulatory legal acts in the main pipeline transport. The creation of this documented system would allow increasing safety of processes in the main pipeline transport.

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STIFFNESS OF BLOCK-MODULAR CUTTING TOOLS

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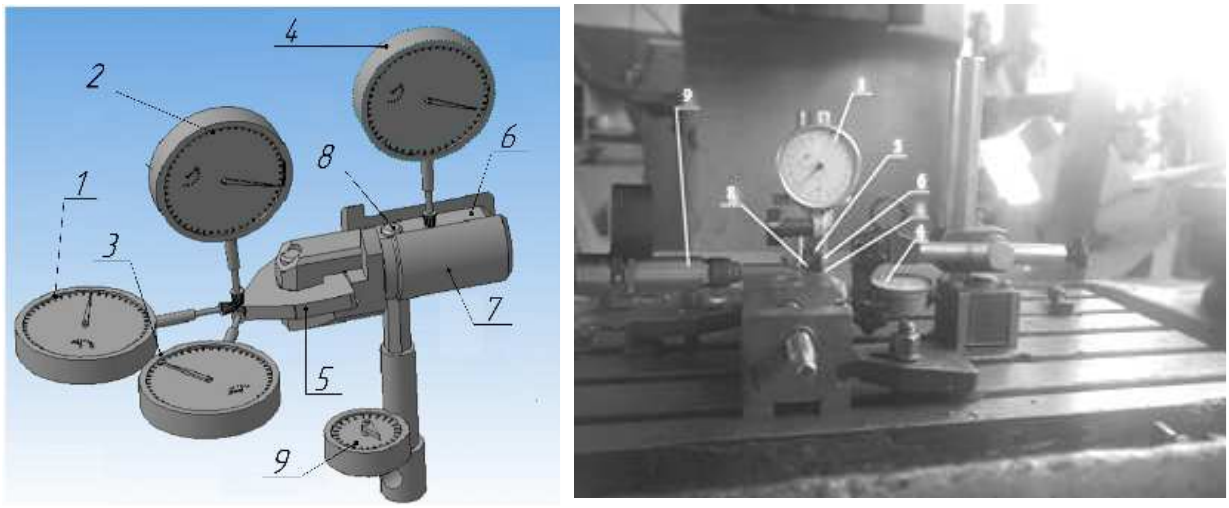
The results of experimental studies of clamping mechanisms stiffness are presented, recommendations to improve clamping system are given.

Reliability of prefabricated cutting tools is determined to a large extent by the reliability of fixing plates in the housing. There are several structures of clamping mechanisms according to the working conditions of cutting tools and peculiarities of their manufacture [1, 2]. The existing systems of cutting plates fixing are shown most thoroughly in [3, 4, 5]. These systems reflect the current trends in the designing of cutting tools: high precision of cutting plates manufacturing, closed grooves precisely manufactured to place cutting plates, cutting plates clamping mechanisms with a minimum number of structural elements, such as a screw or a lever. Implementation of such systems in terms of domestic tool production is not always possible, as it requires special equipment and precise high-quality components. Therefore, it is urgent to establish a system of cutting plates fixing that is efficient for domestic production conditions and is not inferior in reliability to the best foreign systems.

During the experimental verification of the obtained calculation data the displacement values of cutting plate and those of a strap were fixed at different points for different clamping forces of the screw (figure 1). In particular, the displacement values of the cutting plate (pos.5) in the tangential, radial and axial directions were measured by indicators (pos. 1, 2, 3). The displacement values of the strap (pos. 6) were measured by indicator (pos. 4). The clamping force of the screw (pos. 8) was created by a torque wrench (pos. 9).



a *b*

Fig. 1. 3D-model (*a*) and the experimental unit (*b*) for measuring displacement of a cutting plate and a strap:
1, 2, 3, 4 – dial test indicator; 5 – cutting plate; 6 – strap; 7 – cutting block; 8 – clamping screw;
9 – torque wrench

The results of displacement measurements of a cutting plate and a strap in the cutting block are presented as graphs in figure 2.

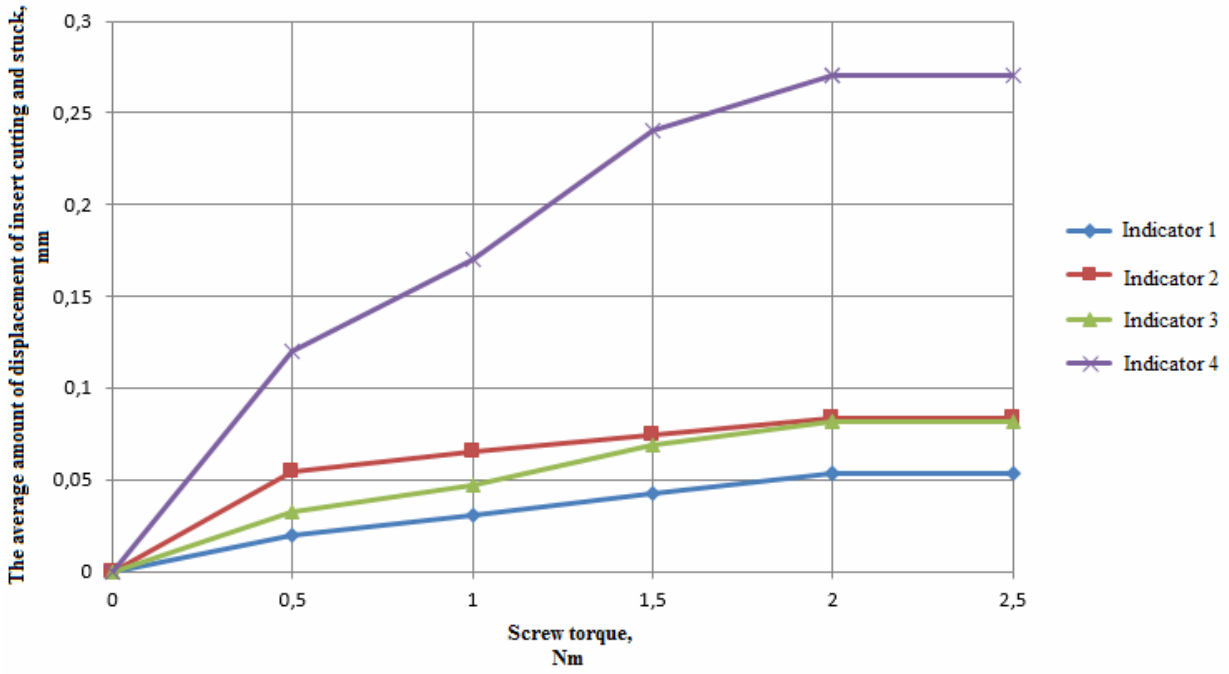


Fig. 2. The dependence of displacement values of the cutting plate and the strap in the cutting block on the torque wrench load

As shown in the graphs, the cutting plate displacement values are minor and minimal in the radial direction. At a load of about 2 Nm displacement is not observed, which indicates sampling of gaps between the plate, the sides of the groove and the screw. The strap has greater displacement than the cutting plate, which requires changings in the structure of the former. Calculations of cutting block structure stiffness were made according to the obtained displacement values and efforts applied to the screw. The calculations were made as the ratio of the clamp value to the displacement value of the unit. The results of experiments and calculations are presented in figure 3.

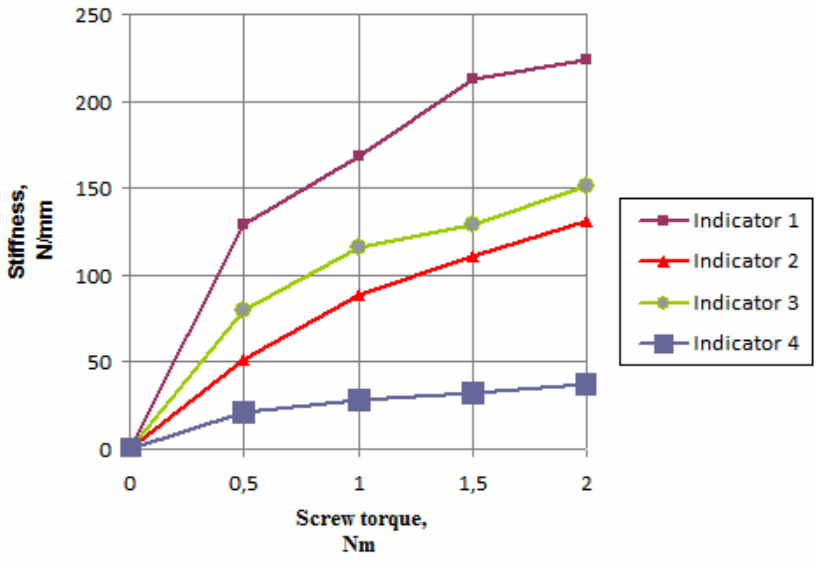
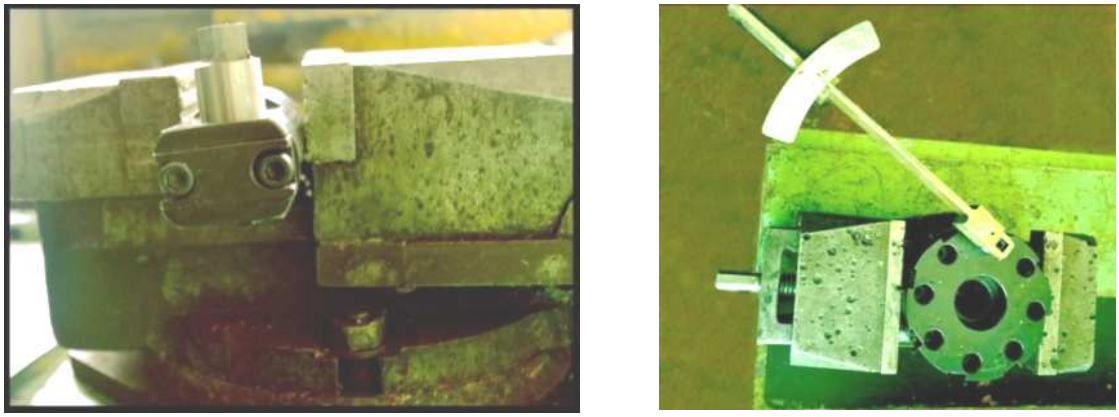


Fig. 3. The dependence of cutting block structure stiffness
on the screw torque 1, 2 and 3 – cutting plate in the radial, tangential and axial directions, 4 – strap

As shown in the graphs, at a certain screw torque (within 1 – 2 Nm) the cutting plate has maximum stiffness of fixing and the strap has minimum stiffness of fixing.

Reliability of the cutting block fixing in the housing module were experimentally tested with stuck-screw clamps (figure 4, *a*) and single and double wedge-screw (figure 4, *b*) mechanisms. A certain torque was applied to the cutting block, which simulated the torque of cutting force. The applied torque caused turning of the cutting block. The tightening torque and the value of the applied torque were consistently fixed during the experiment.



a *b*

Fig. 4. Experimental units for studying of the clamping mechanisms:
a – stuck-screw; *b* – single and double wedge-screw

Figure 5 shows the results of the experiment.

As shown in the graphs, turning torque of the cutting block in the clamping mechanism increases according to the value increase of screw torque of clamping mechanism, and at maximum torque value the cutting block displacement in clamping mechanism does not occur. Moreover, a reliable fixing in double wedge-screw mechanism of cutting block occurs when the tightening torque is 5 Nm, while in the single wedge-screw and stuck-screw it is only at 12,5 Nm and 15 Nm respectively.

Thus, experimental results confirm the efficiency of block-modular cutting tool structures.

1. The presented clamping mechanism ensures reliable fixing of the cutting plate with minimum values of screw torque.
2. Double-wedge screw mechanism for cutting block clamping is the best one out of the studied mechanisms as it provides 2 – 3 times greater torque.

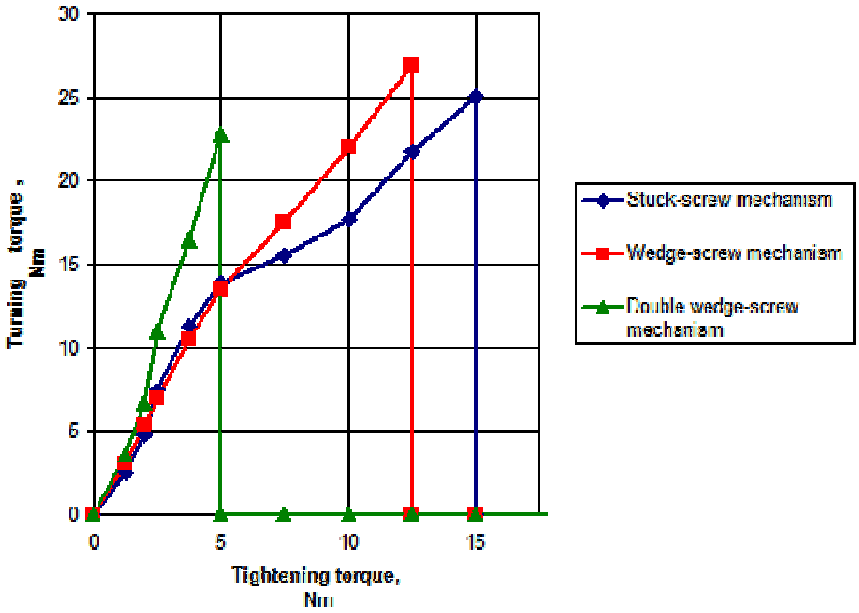


Fig. 5. The dependence of turning torque of the cutting block on tightening torque

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EVALUATION OF THE ACCURACY OF THE GLOBAL GRAVITY MODEL EIGEN-6C2 IN COMPARISON WITH THE MODEL EGM2008 IN RELATION TO POLOTSK GEODYNAMIC PROFILE

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Polotsk geodynamic profile was created in 2004 on the basis of geological, geophysical and seismological studies [1, 2, 3], carried out in Polotsk-Kurzeme zone of tectonic faults. This belt isolated relatively recently in the body of the East European Platform group of geologists and geophysicists of the Institute of Geochemistry and Geophysics of Belarus on the basis of gravity, magnetic anomalies and seismological data [1].

Polotsk geodynamic profile includes 12 leveling benchmarks, the centers of which are laid at a depth of 3.0 meters (Fig. 1). Eleven leveling benchmarks were laid in 2004. № 59 leveling benchmark included in the previously established network of state high-precision leveling.

As you know, the height anomaly is one of the characteristics of the anomalous gravity field distribution on the earth surface which can judge the degree of homogeneity or heterogeneity of the local gravitational field of the Earth in the study area. Assuming that the inhomogeneity of the gravitational field in the target geodynamic profile caused by the presence of inhomogeneities in the earth's crust, it is expected that changes in height anomalies in the profile will be observed, first of all, on the faults.

Today thedetermining of the height anomaly is possible in two ways: using gravity data and a combination of satellite and leveling measurements.

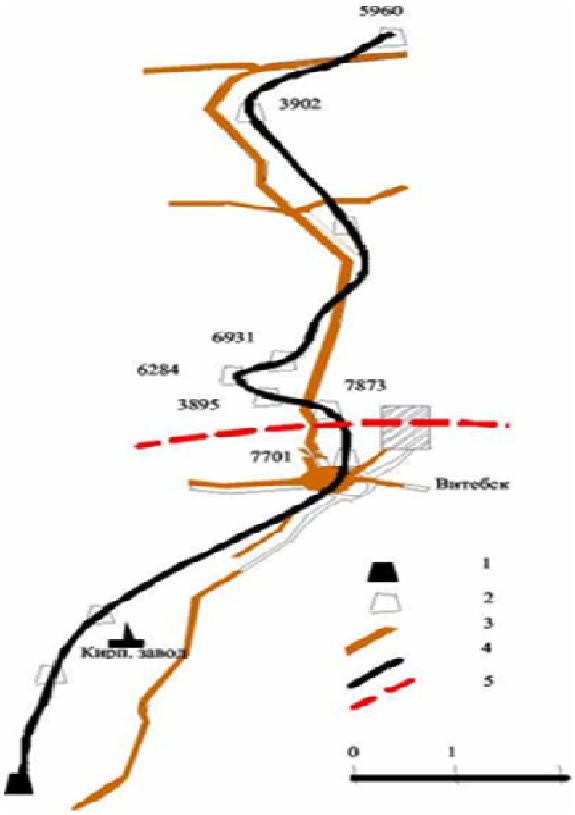

Fig. 1. Scheme of leveling benchmarks on Polotsk geodynamic profile:
1 – leveling frame public network; 2 – over laid leveling frame; 3 – the road;
4 – line leveling; 5 – the expected fault

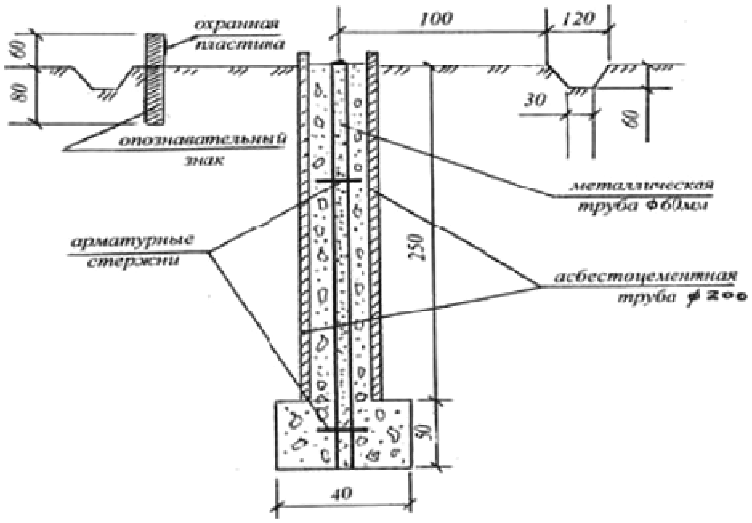

Fig. 2. The design leveling benchmarks on Polotsk geodynamic profile
(basic dimensions are in centimeter)

In accordance with the theory of Molodensky anomaly heights anywhere in the earth's surface is calculated as the difference between geodesic H_M and normal heights H_M^Y [4]:

$$\zeta^M = H_M - H_M^\gamma. \quad (1)$$

The simplest method is based on a combination of satellite and leveling measurements. With the help of satellite measurements obtained geodetic height H_M, and with leveling, reduced to a system of normal heights – normal H_M^Y. In summary:

$$\zeta = H_{SAT} - H_{LEVELING.} \tag{2}$$

To calculate the height anomalies using gravity data there is a strict theory and methods of computation Molodensky [5]:

$$\varsigma = \frac{R}{4\pi\gamma\iint\limits_W (g-\gamma+\delta g)\cdot S(\psi)dw}, \tag{3}$$

where $(g - \gamma)$ – gravity anomaly;

R – radius of the sphere, which is the same surface of the geoid [4];

δg – refines the amendment;

$S(\psi) = \cos\frac{\Psi}{2} - 6\sin\frac{\Psi}{2} + 1 - 5\cos\psi - 3\cos\psi\cdot\ln(\sin\frac{\Psi}{2} + \sin\frac{\Psi}{2})$ – function Stokes;

Ψ – spherical distance from the current point to the point that defines the perturbing potential.

As a result, estimated accuracy of the global gravity model EIGEN-6C2 in comparison with the model EGM2008 for Polotsk profile anomalies by comparing the heights of frames obtained using gravity models EIGEN-6C2, EGM2008 and height anomalies derived as the difference between geodetic and normal heights.

Coordinates of the points for which the heightanomalies were determined are presented in Table 1.

Table 1 – Coordinates of the points

pointname	**latitude**	**longitude**	**height (meter)**
2898	N55°32'38,9"	E28°47'12,5"	159,998
3895	N55°32'27,8"	E28°46'45,0"	163,352
3902	N55°34'42,2"	E28°46'47,4"	150,085
59	N55°30'19,6"	E28°44'54,6"	149,273
5960	N55°35'19,6"	E28°47'22,7"	162,723
6931	N55°32'39,9"	E28°46'45,5"	161,913
7100	N55°33'41,2"	E28°47'03,2"	152,858
7130	N55°30'46,4"	E28°45'44,0"	154,649
7701	N55°31'53,9"	E28°47'04,8"	163,448
7873	N55°32'15,5"	E28°47'01,9"	165,143
8372	N55°31'12,7"	E28°45'58,6"	155,879

For height anomalies in designated areas by model EIGEN-6C2 and EGM2008 used data Calculation Service siteInternationalCentreforGlobalEarthModels – ICGEM. Height anomalies models derived from theory Molodensky approximate formula Bruns (4) [6]. The values of height anomalies relative to WGS-84 ellipsoid obtained by the gravity model are presented in Table 2.

$$\zeta \approx \frac{T}{\gamma}. \tag{4}$$

Table 2 – The height anomalies obtained from the gravity model

pointname	ζ EIGEN 6C2	ζ EGM2008
59	20.639	20.613
7130	20.612	20.586
8372	20.595	20.570
7701	20.556	20.532
7873	20.547	20.523
3895	20.546	20.522
6931	20.540	20.516
7100	20.507	20.483
3902	20.483	20.459
5960	20.456	20.432

The anomalies of heights obtained from the gravity model EIGEN-6C2 and EGM2008 regarding point №59, taken as a stable shown in Table 3.

Table 3 – Values of height anomalies regarding point № 59

pointname	59	7130	8372	7701	7873	3895	6931	7100	3902	5960
EIGEN-6C2 Increments, мГл	0	-0,027	-0,044	-0,084	-0,093	-0,093	-0,099	-0,133	-0,156	-0,183
EGM2008 Increments, мГл	0	-0,027	-0,043	-0,081	-0,090	-0,091	-0,096	-0,130	-0,154	-0,181

Comparable with gravimetrical data information about the anomalies of heights was got with the use of results of GPS-measuring and geometrical leveling. Information is got by comparison of differences of geodesic heights between leveling benchmarks of profile and leveling benchmarks № 59, certain from satellite data, with exceeding between these pointfound from the geometrical leveling. Thus, in second case the anomaly of height was determined on a formula (4) [7]:

$$\zeta_I = (H_I^{\circ} - H_{№59}^{\circ}) - \sum_{№59}^{I} h \,, \tag{4}$$

where ζ_I – is an anomaly of height on current репере in relation topoint № 59;

H_i° и H_{59}° – geodesicheights of current point of profile and point № 59, got from satellite data;

Σh – total exceeding on a profile between point № 59 to current point, found from the geometrical leveling.

Values of anomalies of height in relation to a point № 59 (anomalies of heights in relation to the ellipsoid of WGS-84), got on results GPS-measuring and leveling, presented in a table. 4.

Table 4 – Anomalies of height in relation to a point №59, got on results GPS-measuring and leveling [7]

pointname	heightofkvazigeoid, m
59	0
7130	-0,032
8372	-0,052
7701	-0,085
7873	-0,098
3895	-0,104
6931	-0,106
7100	-0,134
3902	-0,151
5960	-0,197

For 10 points statistical treatment is conducted. The differences of values of anomalies of heights, got from the models of EGM2008 and EIGEN6c2 and differences of geodesic and normal heights were processed (geodesic heights in relation to the ellipsoid of WGS-84). The results of treatment are presented in a table 5.

Table 5 – Statistical treatment of differences of values of anomalies of heights

Errors	Model of EIGEN-6C2 by comparison to EGM2008	Model of EGM2008 by comparison to GPS measuring and geometrical leveling	Model of EIGEN-6C2 by comparison to GPS measuring and geometrical leveling
[Δ]/n, см	0,21	0,73	0,52
+Δ, max, см	+0	+0,3	+0,5
-Δ, min, см	-0,3	-1,6	-1,4
СКП, см	**0,23**	**0,90**	**0,75**

It is possible to mark coming from the results of statistical analysis, that the law of distribution of differences of anomalies of heights is near to normal. The difference of surfaces of a geoid (in models) and a quasigeoid (received as a difference of geodetic and normal heights) makes 0,73 sm and 0,52 sm for the EGM2008 and EIGEN-6C2 models causes systematic shift of models concerning results of satellite definitions and geometrical leveling respectively.

Proceeding from the done work it is possible to draw the following preliminary conclusions:

Data of anomalies of heights are obtained by means of the gravitational EIGEN-6C2 and EGM2008 models, and by means of a combination of GPS and geometrical leveling. According to these data it is possible to claim that the correct use of these gravitational models yields quite decent results which can be used and without attraction of other data.

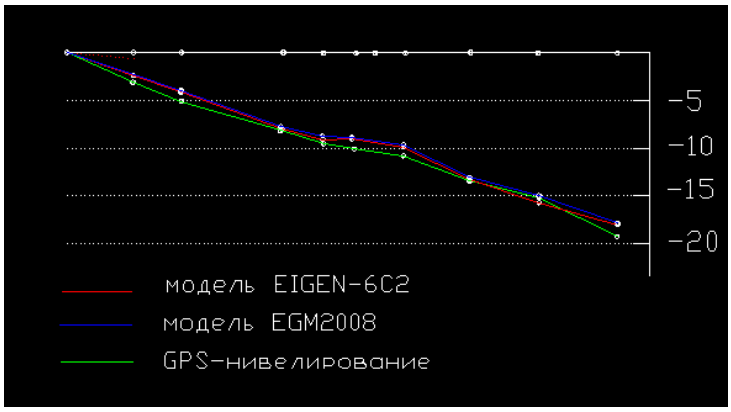

Fig. 3. The schedule of anomalies of heights concerning point 59

The proved EGM2008 model doesn't concede on the accuracy of the latest gravitational EIGEN-6C2 model. These models have very similar characteristics and yield almost identical results. Because the EGM2008 model is long enough used and showed good convergence with results of satellite and leveling measurements in the territory of Belarus, we can't unambiguously recommend the new EIGEN-6C2 model for replacement of the EGM2008 model yet in those works in which the EGM2008 model was used.

The made analysis shows the need of far deeper study of the new EIGEN-6C2 model with attraction of the additional information of bigger volume covering all territory of the republic, and bigger density of data: satellite measurements, high-rise component of the republic, data of gravitation measurementsThe regional model of a geoid of Republic of Belarus of the accuracy of 2 – 3 cm has to be an ultimate goal of such research. As a basis perhaps the EIGEN-6C2 model can also serve.

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PNEUMATIC TRANSPORT OF CRUSHED PEAT

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Traditional area of peat use as a fuel, which was important in recent years, especially in the post-war period, remains in demand and now. Peat is also unique and often indispensable raw material for the production of a number of high-tech and high import-substituting products (bio-stimulants, growth substances and feed additives, sorption materials for absorption of harmful and toxic hazardous substances, including heavy metals and radio nuclides from water and gases, natural dyes, rust converter, complex biologically active granular and

liquid fertilizer with trace elements, etc. Constantly increasing demands on the culture of production and hygienic working conditions, the need to reduce capital costs and maintenance costs of continuous transport equipment put on the agenda the issue of wider use in industry and agriculture systems, pneumatic conveyance of different granular media. Experience of enterprises in various industries shows promising applications of pneumatic transport to move the dust, granular, fibrous and small piece goods, and the possibility of its use for transporting various media.

RB industry produces peat moss, packs it in small packages for sale to the public and for export in large plastic bales. This peat is used as a nutrient soil.

Currently, the movement of peat in the shop and outside is made by the belt conveyor, which is represented in the picture. (Fig. 1).

Fig. 1. Conveyor belt for transporting peat

Disadvantages of this method:

- Loss of transported material;
- Dusty environments and the surrounding area;
- Large size installations;
- High operating costs.

The advantages of pneumatic conveying systems over other types of transport equipment are well-known. They are compact, simple in design, easy to fit into a variety of processes, and are characterized by the absence of waste and waste transported materials, high hygienic conditions of their transporting, the possibility of full automation and improvement of working conditions. The advantage of pneumatic conveying of granular media is that it can be used in conjunction with a variety of mass-transfer and technological processes, such as cooling and drying of transported material, its grinding and separation, purification from all contamination. Pneumatic installations allow the movement of granular media on a complex trajectory, unloading material from a variety of delivery vehicles and picking it up from out of the way places, issuing the material at various points, a reliable weather protection and protection of the environment from excessive dust emissions. Pneumatic conveyor equipment is easy to use and easy to control.

The disadvantages of pneumatic transport include a relatively high specific energy consumption, wear of pipes and other elements of installations in contact with the transported material.

In general pneumotransport installation depending on the functions they perform, can be divided into two groups [1]:

1. Aspiration craft facilities located within the industrial premises, which remove the bulk material from processing equipment, and then transport it inside the plant or outside it. For these purposes, suction and suction-injection installations of low pressure are mainly used.

2. Transport installations operate purely transport functions, i.e. move the two-phase flow inside the plant in the process stream through the territory of the enterprise and beyond. These settings depending on the type of transported material, its concentration and the distance of transporting may range conveying suction, pressure air suction and injection wells. In addition, pneumotransport installation can be stationary and non-stationary. Stationary installations are designed mostly for departments, shops and enterprises in general. For the design of mobile pneumatic systems it is necessary to know basically the same input data as for stationary. However, due

to the fact that the demand is made to move different materials, differing from each other by their physical and mechanical properties all of these units are designed for use in a variety of conditions than stationary.

Pneumatic suction installation type is easy to manufacture and install and can take material from several places.

In pneumatic conveying suction installation gas is sucked together with the material and on the way they are mixed. Next, two-phase flow "air-particle bulk material" moves in the transfer line to the consumer separating apparatus where the material is separated from the carrier medium, which enters the blowers. From blowers carrier medium is released into the atmosphere. Fig. 2 shows a schematic diagram of the pneumatic suction installation type [1]. Separation of material can be carried out by two-step purification of the transported gas from hard particles depending on the initial concentration of impurities.

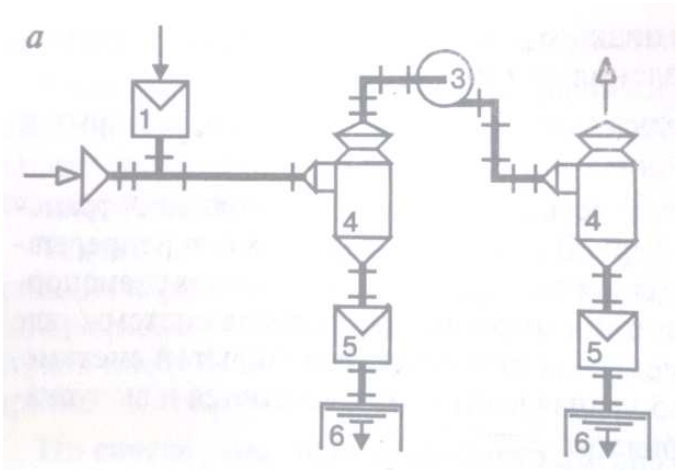

Fig. 2. Schematic diagram of the pneumatic suction installation:
1, 5 – feeder; 3 – blowing machine; 4 – separator; 6 – hopper

In addition to the pneumatic suction action installations with one picking up place and one unloading device, it is possible to use scheme for the material supply in to different places with the installation of various types of switches on the transport pipelines. Such setups are especially justified when you want to feed the conveyed material from multiple locations into one.

The major disadvantage that limits the use of pneumatic systems, is large power consumption in comparison with other types of continuous transport. This is largely due to the arbitrary choice of the air flow rate, the concentration of fuel mixture and pipe diameter.

For all the pneumatic lift (vertical pnevmotransport) air velocity and diameter of the pipeline can be selected, in which power consumption is the lowest. Wherein the selected predetermined speed v and the performance Gm of the pipeline material diameter D is determined from concentration aeromixture μ.

The energy consumption of pneumatic transportation depends on the air flow and pressure loss. In order to reduce the air flow it is advisable to choose the largest possible concentration. However, with increasing μ the pressure losses rise. Consequently, the choice of the value μ must be adequately justified. Considering the above, to determine the optimal values (from the condition of the least power consumption) v, D and μ must have dependencies $p_{cm} = f(v, D, \mu)$ and the data about pipeline blockage boundary.

There have been several experiments on the separation of peat in the vertical collector-reservoir and the cyclone in a pilot setup, which is located in the ventilation laboratory of EE "PSU".

For the experiment, a nutrition soil on the basis of high-moor peat produced by the enterprise UE "Vitebskoblgas" was used. A portion of peat without separation into fractions was passed through a vertical collector-reservoir [2] and the cyclone and it was found that the cyclone collects fines and the collector-large fraction respectively. I.e. peat separated in the cyclone is a better quality (no sticks, debris and virtually no fiber connections). Capture efficiency coefficient of such an installation is: in the collection-reservoir $\eta = 78\%$, and in the cyclone $\eta = 67{,}1\%$. The overall installation efficiency is $\eta = 92{,}7\%$.

By reducing the loading time increased concentration of sample was obtained and there was a higher collection efficiency in the collection reservoir, $\eta = 86{,}9\%$, while in the cyclone $\eta = 70\%$. The overall efficiency of the setup turned $\eta = 96{,}2\%$.

When the sample passes only through the separation cyclone $\eta = 98\%$ entrapment was obtained. The experimental results are presented in Figure 4 histogram.

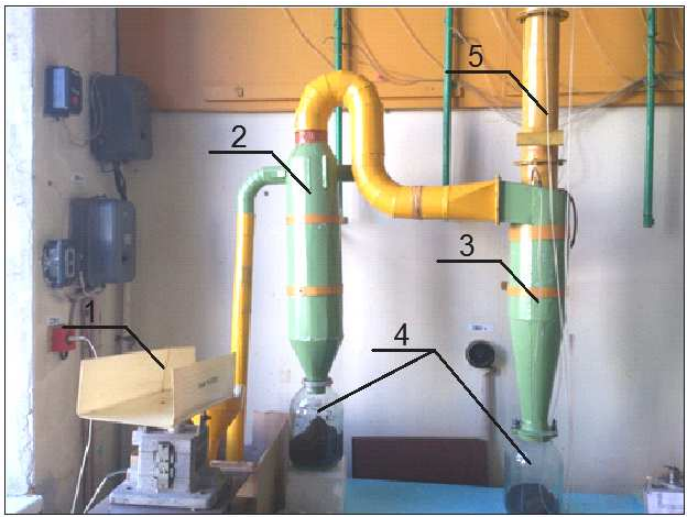

Fig. 3. Experimental setup:
1 – feeder; 2 – vertical collector-reservoir; 3 – cyclone; 4 – bunker; 4 – exhaust pipe

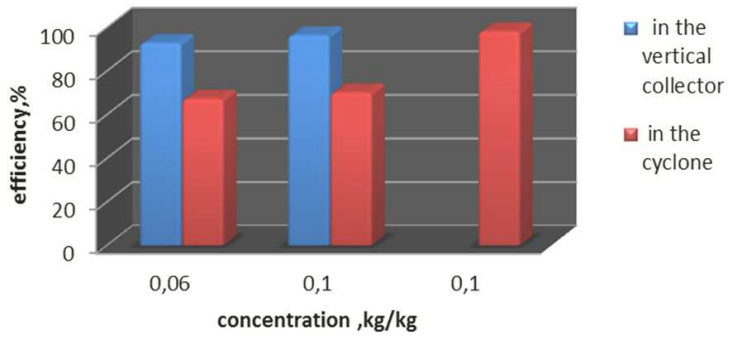

Fig. 4. Material separation efficiency in the experimental setup

A portion of peat was sifted through a sieve and 6 fractions of different diameters were obtained. Each fraction was passed through the setup, and the mass of the particles of each fraction separated in the collector-reservoir and in the cyclone was determined.

To determine a sustainable transport velocity of the particles terminal velocities of peat particles of different diameters were determined in a pilot setup in the ventilation laboratory of EE "PSU".

Dependence of the terminal velocity of particles on the fraction diameter is shown in Fig. 5.

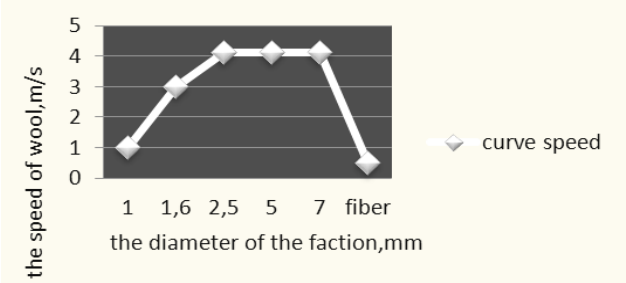

Fig. 5. Dependence of the terminal velocity on the fraction diameter

1. The use of two-stage separation of the two-phase fuel mixture of peat by means of a vertical collector and a cyclone leads to a separation of the material and sedimentation in the reservoir-collector of large fractions and debris, and the cyclone gets fine fraction. Total separation efficiency is around $\eta = 92 – 96\%$.

2. When using only a cyclone for peat separation the cleaning efficiency is about η = 98%. The two-stage separation may be due to the need to obtain high-quality granular fractions of peat without dust and fiber connections used, for example, for growing seedlings of plants and other purposes.

3. The terminal velocity of particles increases sharply with increasing their diameter from 1 mm to 2.5 mm It remains constant from 2.5 to 7 mm and drops sharply for fiber connections.

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UDC 620.97

ALTERNATIVE ENERGY SOURCES

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Human life is unthinkable without energy. We are all accustomed to the use of fossil fuels, such as coal, gas and oil as sources of energy However, as we know, their reserves in nature are limited. And sooner or later they will run out. The answer to the question "what to do in anticipation of the energy crisis?" has already been found: it is necessary to look for other energy sources – alternative, non-traditional, renewable [1]. What are the main alternative energy sources available currently?

Scientists warn of possible exhaustion of known and available oil and gas reserves, depletion of other essential resources such as iron ore and copper, nickel, manganese, aluminum, chromium, etc. Today the world energy is based on non-renewable energy sources. Great hopes in the world are pinned on the so-called alternative energy sources, the advantage of which is that they are renewable and environmentally friendly [2].

Such sources may include [3]:

- solar energy,
- wind energy,
- the energy of tides,
- the inner heat of the Earth,
- biomass fuels.

Let us consider the most relevant types of alternative energy sources for the Republic of Belarus.

Solar energy

The method of generating electricity from sunlight has been known for over a hundred years. The phenomenon of PV was first observed by Edmond Becquerel in 1839. Conducting a series of experiments on electricity, he plunged two metal electrodes in a conductive solution and subjected the setting to sunlight. Some electrical voltage occurred between the electrodes. The development of solar cells in Bell's laboratory in the early 50-es revolutionized the electronics industry. Space industry would be almost helpless without them. Light solar energy generators allowed to approach the problem of creating artificial Earth satellites in a completely different way. In addition, solar energy can be used in solar houses [4].

Solar installations can be designed for heating and hot water supply of residential houses. Solar power systems can save expensive mineral fuel through judicious use of solar energy.

The idea of the solar house (the house in which heat supply, cooling and hot water supply are carried out with the help of solar energy) has become widely known. Perhaps the perfect example of such a house is a traditional Japanese house. Both in summer and in winter it has an acceptable temperature for living. However, real solar houses with a fully developed system of heating and cooling are still relatively few. It is not easy to make them economically viable. However, it is evident that the natural reserves of oil and coal in the world are not enough for the long term and further technical program is inextricably linked with the need to conserve energy.

Wind energy

Apparently, for the first time wind energy was used to move sailing ships, and later – for lifting water and grinding grain. It is believed that the first wind turbines were built in China, Japan and Tibet more than

2 thousand years ago. The ancient Babylonians used them for the drainage of wetlands. In Egypt and the Middle East wind water-elevators and mills were built.

However, wind energy was seriously dealt with much later. In Russia this kind of energy became an object for research only after the revolution [5].

Abroad, wind turbines are most widely used in Australia, New Zealand, Latin America, Greece, etc.

Despite larger capital investments wind turbines are more efficient than thermal plants due to low operating costs (costs are 6 times lower). Hence, the costs are compensated during 1 – 1.5 years. In addition, the service life of wind turbines (relatively slow machines) is much longer than that of heat engines. Therefore, the unit costs of metal per unit of production for the entire period of service, as well as depreciation costs are lower.

The reasons behind the desire to expand the use of wind energy are [4]:

– the rapid growth of energy demand with limited resources of liquid and solid fuels and potential hydropower resources;
– the sharp increase in the prices of mineral fuels;
– the greater use of coal, oil and gas (in chemical industry for the production of synthetic materials);
– significant achievements in the field of aerodynamics and mechanics, aircraft engineering and chemistry, electrical engineering, etc. allow to create better and more efficient wind turbines.

Wind turbines can be most widely used in agriculture for charging rechargeable batteries, desalination of saline water, pumping water for drinking, aeration of basins.

In addition, electrical low-power wind turbines, along with charging the batteries, can energize the beacons and buoys, protect gas and oil pipelines against corrosion. The use of autonomous wind farms operating in isolation is limited to energy supply of water lifting and drainage installations.

Biofuels

Biofuels are biological fuels, various organic materials that emit heat in the process of decay, which is used for heating greenhouses, hotbeds and warmed soil. Manure, household waste, core (bark, taken from trees), sawdust, flax shive, waste textiles, dry leaf, undecomposed peat are used as initial substances.

In contrast to traditional oil or gas, biofuels are produced from renewable biological materials such as plants, manure or waste [6].

Types of bio-fuels. Bioethanol is a biofuel substitute for gasoline. It is made from crops, mostly wheat in the United Kingdom, sugar beet and maize, soya beans and sugar cane in the United States and South America.

Biodiesel is a biofuel substitute for diesel. It is made from oil crops – mostly rapeseed in Europe and palm oil in South-East Asia.

Two of the above forms are the so-called "first generation biofuels", as they are produced from the crude material, which can be used in food production.

Biogas is a biofuel to replace natural gas. It is produced from organic waste, including waste from livestock farms and waste collected from municipal, commercial and industrial sources that have undergone the process of anaerobic decomposition. In Europe biogas is produced from animal waste, and due to the emission of landfill gas.

Benefits of using. The main practical use of alternative bio-fuels is that they can be combined with traditional "fossil" fuel and used in existing energy systems, such as engines in cars and trucks.

In the use of biofuels instead of fossil fuels there are two main environment-saving factors. First, biofuel is a renewable resource, so it is a long-term, relatively cheap and reliable source of energy. Secondly, biofuel emits far fewer greenhouse gases in its production cycle and use [7].

The so-called "second generation biofuels", synthetic fuels, although derived from biomass, simulate chemical characteristics of fossil fuels. This allows us to integrate it into the existing fuel system more deeply. It also can be made with a higher proportion of wooden biomass, such as straw.

Increasing environmental pollution, the disruption of thermal balance of the atmosphere are gradually leading to global climate changes. The energy shortage and limited fuel resources show the inevitability of the transition to non-traditional, alternative energy sources with increasing sharpness. They are environmentally friendly and renewable, their basis is the energy of the Sun and Earth, water and air.

The role of energy in maintaining and further development of civilization is undeniable. Today, active research of all possible renewable energy sources is being conducted. In some cases, the results even seem to be very optimistic and allow to hope for some changes.

Energy is not only one of the most discussed concepts today; in addition to its main physical content, it has numerous economic, technical, political and other aspects. Mankind needs energy, and the demand for it increases every year. However, the reserves of traditional fossil fuels (oil, coal, gas and others) are exhaustible. The reserves of nuclear fuels, such as uranium and thorium are also limited.

There are two ways: austerity in the expenditure of energy and the use of unconventional renewable energy sources.

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COMPUTER SIMULATION OF STATIC ELECTRON BEAM ENERGY ANALYZER USING IBSIMU PACKAGE

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The possibility of computer simulation systems of electron and ion optics by means of the open source computer code IBsimu was considered. The results were get and their analysis was carried out within the applied task of restoring the values of the initial energy of beam electrons.

There are many simulation packages that allow the solution of problems of electron optics and, in particular, to carry out the simulation of processes of extraction and transportation of electron and ion beams from plasma sources. Possibilities and methods of these packages differ markedly. Many packages are developed in academic institutions, while others are only available on a commercial basis. All of them can be divided into three groups [1] :

a) A computer code includes simulation of appearance and disappearance of charged particles in plasma;

b) a computer code that allows to calculate the trajectories of charged particles (i.e., provides an exceptional opportunity to solve the problem of electron optics);

c) a computer code with a simplified model of plasma, which gives the opportunity to solve the problem of of extraction of electron and ion beam from plasma source and the problem of its further transportation, focus, etc.

Plasma simulation packages often use methods of continuous media (hydrodynamic), or the so-called method of "particle in cell" (particle in cell (PIC), integration methods of Monte Carlo or hybrid methods. The development of plasma models is very time consuming and calculations take a lot of computer time.

Packages that build trajectories of charged particles, providing a solution to problems of electron and ion optics, often work within the formalism of transfer matrix method. Moreover, the packages are able to solve the problem of associated arbitrary electric and magnetic fields calculation. The most well-known examples of this group of packages include the following: SimIon, Cobham Vector Fields and Integrated Engineering Software Lorentz. These packages have broad opportunities, but are spread only on commercial bases.

The third group, i.e. packages allowing to extract beams of plasma sources with restrictions are PbGuns and IGun (work in two-dimensional and cylindrically symmetric geometry, allowing to simulate plasma sources of positive and negative ions), Kobra-INP (works with three-dimensional geometry and extraction from plasma positive ions). The disadvantages of these packages also include their commercial nature. Package IBsimu, which belongs to the same group, but which is distributed freely, was used in this research.

IBSimu – Ion Beam Simulator package was developed at the University of Jyvaskyla, Finland, Kalvasom T. (T. Kalvas) and posted on the Internet for public access [2] under the GNU General Public License (GPL). This package is a library of classes and methods, which is written in the programming language C++ and is available for use under the operating systems Linux and Windows.

The main feature of this package is to calculate the electrostatic field and potential distribution determination by solving the Poisson equation (1) by means of finite element method. One-, two- and completely three-dimensional tasks are available. The description of the distribution of space charge of the beam particles in

position vectors and velocity space, taking into account independent magnetic field is considered by solving the Vlasov equation (2).

$$\nabla^2\varphi = -\frac{\rho}{\varepsilon_0}, \tag{1}$$

$$\vec{v}\cdot\nabla f - \frac{q}{m}\left(\vec{E}+\vec{v}\times\vec{B}\right)\cdot\frac{\partial f}{\partial \vec{v}} = 0. \tag{2}$$

A simple electrostatic energy analyzer for electron beam extracted from the plasma source was simulated in this research by means of IBSimu package. Despite the simplicity of such a device, its manual calculation is nevertheless difficult even for classical geometry of planar capacitor. Boundary effects are complex, their role can be reduced by increasing the length of the electrodes and reducing the distance between them [3]. In case if the shape of electrodes is different from flat surfaces, and an electrostatic field between them is not uniform, analytical calculation becomes generally impossible, and the task requires a numerical solution.

The simulation was performed in a two-dimensional geometry of two cases - an electrostatic field which was close to homogeneous (planar capacitor) and an inhomogeneous electrostatic field generated by the electrode with a tip. The length of the simulation volume was chosen similar to the volume of the beam extraction camera in a real setting. Feynman and Dirichlet's boundary conditions were used and the numerical tasks decomposition grid parameters were chosen on the basis of two factors: special considerations of the task and at the same time the use of little computer calculation time.

The results of the simulation of electron beam separation by the electrostatic field between two flat surfaces are shown in Figures 1 and 2.

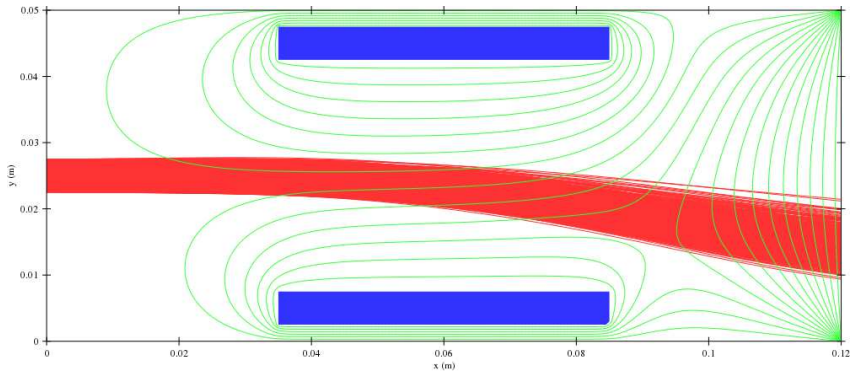

Fig. 1. Passing of electron beam through the deflection potential difference of 100 V. 10,000 particles with average energy of 400 eV and beam current density of 0.05 A / m2. The beam is red, the electrodes of the deflection system are blue, equipotential lines of the electrostatic field are green

The simulation results of the electron beam separation inhomogeneous electrostatic field are shown in Figures 3 and 4.

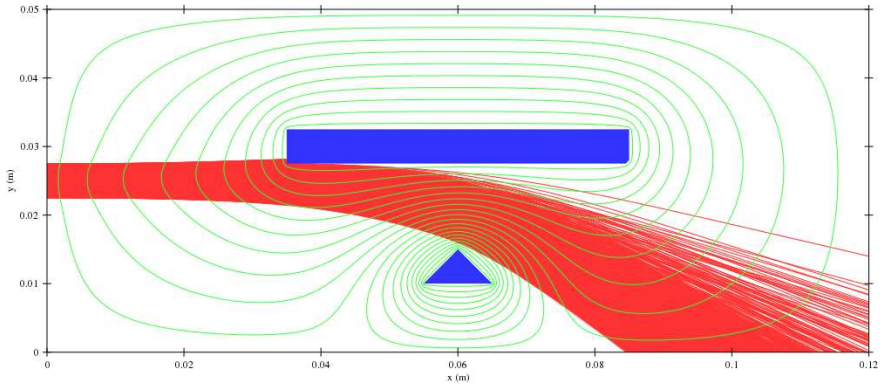

Fig. 3. The passage of an electron beam through a nonuniform deflecting electrostatic field. The potential difference between the electrodes is 200 V 10,000 particles with an average energy of 400 eV and beam current density of 0.05 A / m2. Beam is shown in red, the electrodes of the deflection system – blue, equipotential lines of the electrostatic field – green

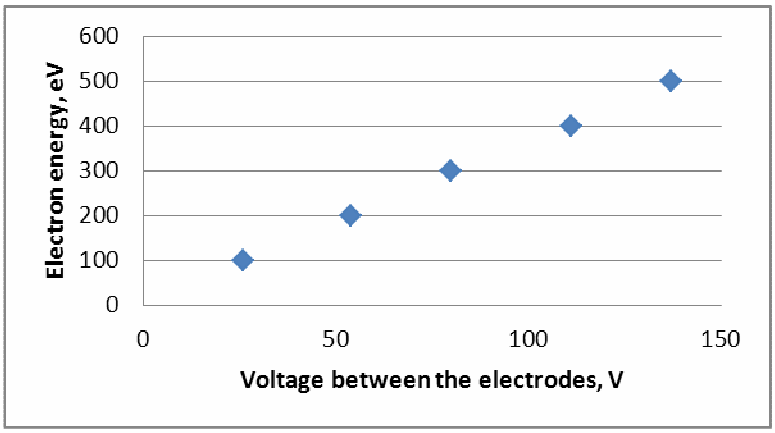

Fig. 4. The dependence of the electron energy on electrodes potential difference for selection in the aperture of Faraday cup

Computer simulation IBSimu package is a powerful and available tool for solving problems of electrophysics, connected with transportation of charged particle beams. In this research the simulation of electrostatic analyzer with two different electrodes was carried out. The shape and position of the electrodes can be randomly chosen, so that the solution of this problem may be optimized depending on the real conditions available in the electron gun.

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UDC 658.264 = 111

THE METHODS OF FUNCTIONAL COATINGS APPLICATION ONTO FLAT SEALING SURFACES OF THE STOP VALVES PARTS

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The actuality and effectiveness of the stop valves worn-part reclamation are presented. The results of the comparative analysis of the known techniques of protective finishing onto the sealing surface for valves service properties restoration are given. The classification of anti-abrasion coating application methods are given depending on their properties and characteristics. Factors and conditions influencing the abrasion resistance of the coating material and its adhesion with the detail base material are defined. The usage of the freezing out coating process onto the flat sealing surfaces of the stop valves parts are shown.

In practice the service life of the stop valves parts is frequently less than the standard one, what is predetermined by many reasons, namely, by stiffening of operation conditions: the increase of temperature and working medium (water, steam, drilling and bore-hole fluids, natural gas, hydrocarbon oils), its corrosive power. Due to the high rate of the working medium vibro-impulsive loads, cavitation and flowing section elements erosion of valves emerge, against this background of high temperatures such damaging factors as abrasive erosion and mechanochemical wear intensify.

The current concern lies in the issue of increasing the durability of the stop valves used in pipeline transportation systems (oil-and-gas, heat-and-power), since their insufficient endurance capability can be the reason for the environment pollution, increases the scope of repair-and-renewal operations, parts repair stock.

Special importance is paid to the matter of pipeline valves parts service life improvement in the respect of the used materials and know-how. This can be exemplified by prefabrication of parts with sealing surfaces from

volume-alloyed materials with further heat treatment and application of electrochemical coating methods or surface impregnation. However the possibilities of the employed abrasion-resisting materials and the known technologies of their application to a considerable extent re used up, that's why the employment of more enabling technology to assure high durability of quickly wearing parts of the stop valves is a perspective trend.

Practically the low post-repair performance period of the repaired stopping-control valves due to intensive destruction of the restored coating on sealing surface takes place. The frequent reason for this is faulty adhesion of the protective coating with the material of the restored part, and in some cases insufficient coating hardness as well.

Thereupon the elaboration of new and the improvement of the applied restoration processes of pipeline valves parts worn-out surfaces, providing secure adhesiveness between the coating material and the part is of great practical consequence.

The solution of this task is connected with the necessity of carrying out of the system comparative analysis proceeding from requirements to functional coatings.

Parts subject to wear out fall under two groups: parts forming friction couples; parts destruction of which is called by the working medium (liquid, abrasive particle, gas etc.) [1].

The shutter parts are the most loaded elements of a valve, the probability of its failure depends on the sealing reliability [2].

The coating structure; geometrical and physical-mechanical condition of the coating facial layer; coating material compatibility with the counterbody in friction couple belong to the main factors defining the durability of the parts protective coatings [1].

The main requirement raised to the geometrical condition of the coating facial layer applied to the given groups of the valves parts is the quality of the working surfaces, for instance, the sealing surface roughness shall be not less than Ra = 0,16 μm [3].

The main performance requirement to the parts of stop valves is high abrasion resistance of the coating surface cover.

The biggest influence on it is given by the presence of carbides and borides in the microstructure of the coating.

Valves parts operation conditions contribute to working surfaces gripping leading to score marks resulting in intensive destruction of the sealing surfaces. One of the main ways to reduce contact surfaces gripping is the increasing of their hardness.

Thus the main criteria for choosing the method of restoration are the hardness of the protecting coating and its adhesion with the base material.

From many ways of increasing pipeline valve parts abrasion resistance by means of protective coating application [4] one should single out thermal spray coating and surfacing.

However for the sprayed coating the mechanical interlocking and a low level of cohesive resistance at the boundary "coating-base" are characteristic. Protective coating and base material cohesive resistance is increased by means of surface preparation for the coating with the help of "ragged" threading, abrasive flow treatment, etc.

To obtain sufficiently solid and anti-abrasion coating with good bond between coatings and a base surfacing and diffusion alloying are widely used. However the last strengthening method due to the low thickness of the obtained coatings is not suitable for application of functional coatings restoring geometry of the worn-out part.

The surfacing process has got wide application for parts restoration and quite sufficiently explored [5]. This method has a number of advantages [5], the following ones are important in the respect to stop valves parts restoration:

- possibility to apply coatings of a big thickness with high efficiency;
- absence of restrictions in sizes of the facing surfaces;
- possibility to apply a wide range of wear-proof coatings;
- possibility to combine with other restoration techniques.

While repairing the valves of heat-and-power and oil-and-gas equipment the protective coatings surfacing in the majority of cases is performed by means of arc method. Nevertheless the quality of the pad weld is not always assured high and stable due to the considerable depth of penetration, which leads to undesirable interfusion of the base and built-up metals.

Based on the usage of the highly concentrated sources of energy contemporary methods don't have this disadvantage. Laser, plasma and electron-beam techniques of surfacing provide inconsiderable depth of penetration and the width of the heat affected zone.

Plazma technique of protective coating application is the most widely used [6].

Nevertheless performing plazma surfacing of the wear-resistant coatings it is impossible to adjust the degree of the base metal penetration.

Comparative analysis of the methods of protective coatings application on the wearing sealing elements of the stop-control valves by means of the surfacing method shows that each of them has significant disadvantages to eliminate which certain conditions able to assure the formation of the superficial protective coatings with a set of necessary properties have to be provided.

Thus to obtain quality coatings applied by means of electron-beam and laser surfacing it is necessary to perform surfacing of the coatings with preheating and in some cases with concurrent heating of the base metal to reduce the residual tensions as well as to reduce the probability of cracks emergence in the built-up layer. Though the introduction of the preheat leads to the rise in price of the technique.

The important role in the formation of the protective coating is played by the processes of damping the surface of the solid metal by the molten and of temperature fields distribution in time during the whole process of surfacing. Under electron-beam, laser, arc and plazma surfacing the damping is of "dot" nature. At that regardless that the thermal energy source is approximated to the quick-acting in the process of protective coating application by the given methods, nevertheless it can be viewed as dot method with concentric distribution of temperature fields because of its immediate action.

As a base material for the fabrication of the shutter part with sealing surfaces usually chromium steel is used, that's why to prevent chrome burning-out the surfacing shall be performed quickly avoiding the breaks and reheating.

The disadvantage of the "dot" damping in the process of surfacing by the point source vividly emerges on the stage of the metal bond formation, when the physical contact and chemical interaction of both the part material and the coating take place.

Based on the outcome of the comparative analysis of the protective coating surfacing methods it is possible to note that to receive quality combination of the coating metal with the base metal and minimal content of the elements of the base metal in the surfacing metal while surfacing it is necessary to assure:

- minimal depth of penetration of the base or to exclude it completely;
- damping the surface of the solid metal by the molten all along the building-up surface;
- minimal duration of solid and liquid phase contact.

None of the considered surfacing methods assures the observance of the total set of the necessary conditions which allow obtaining the qualitative result – required service properties of the applied functional coatings under the high efficiency of the restorative process.

If to consider the pipeline valves from the point of view of shutter unit design, so, according [7], taking into account the quantity of the units used stop valves make up 80% of all the valves. Herewith taper-seat valves with flat sealing surfaces are used in the main. That's why one of the promising techniques of stop valves parts surfaces restoration is the method of freezing-out, which allows restoring their geometrical parameter in a single cycle with high efficiency [1].

Freezing-out method lies in dipping the flat fluxed surface of a detail for on definite time into fusion of the process alloy with bigger temperature. As a result of the ongoing thermal processes the coating is formed on the surface by means of crystallization of the alloy layer and a solid bond is assured when the emergence between the activated atoms of the base metal and process alloy.

Nevertheless the traditional method of freezing-out is characterized by low bond strength between the coating and the base related to insufficient deoxidation of the base surface.

To eliminate this disadvantage it is necessary to improve the method of coating by means of freezing-out with a degree of deoxidation of the base surface sufficient for a strong metallic bond formation.

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A NOVEL METHOD FOR LARGE SCALE SYNTHESIS OF PORPHYRINS USING GENETICALLY ENGINEERED *E. COLI*

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The biosynthetic method described below presents a significant improvement over the current methods of porphyrin production. It represents a sustainable, environmentally friendly, and economically viable process of making large quantities of protoporphyrin for protovoltaic and other commercial applications.

The effort in moving toward clean and renewable sources of energy has incited interest in solar energy. With the power of 120,000 terawatts, the amount of solar energy hitting the Earth's surface is more than 10,000 times the world's total energy use [1]. The sun provides more than enough energy to satisfy our energy needs, it is just a matter of harnessing it. Currently, solar energy accounts for only 1% of the total energy use. The challenges associated with increasing this fraction are: 1) increasing the efficiency of photovoltaic devices; 2) making the production and installation costs of solar panels more economically viable. **Organic photovoltaics** may offer the answer to the second problem. Organic photovoltaic materials offer the advantage of lower cost, easier processing, and desirable physical characteristics, such as light weight and flexibility, which make them an attractive alternative to traditional inorganic photovoltaic materials [2].

Some of the organic compounds that have gained interest for their potential application in photovoltaic devices are conducting polymers. Conducting polymers have overlapping pi-orbitals that allow greater electron mobility through an extended conjugates system [3]. Examples of such polymers are polyacetylene, polyaniline, polythiophenes, and polypyrroles. Another emerging field of research is **small-molecule organic solar cells**. Like polymers, small-molecule organic material can be easily processed; in addition, small molecules are easier to synthesize and purify than polymers, they are monodisperse, and have higher carrier mobilities. Polymer-fullerene materials, based on polythiophene, phthalocyanine, or oligo(p-phenylenevinylene), offer high power conversion efficiencies in the range of 5 – 10% [2]. Although their performance is lower than in some polymeric semiconductor systems, small-molecule organic photovoltaics hold a great promise for overcoming the technical and economic challenges of the field. Among the molecule classes that have a high potential for use in photovoltaic materials are porphyrins and phthalocyanines [4]. Here I will focus on porphyrins as an example of small-molecule photovoltaic material.

Chlorophyll is a molecule present in the cells of plants and algae that is involved in multiple steps of photosynthesis, including light harvesting, energy and electron transfer [4]. It is nature's solar cell in the sense that it allows conversion of solar energy into other forms. An important molecular component of chlorophyll is porphyrin, which is a cyclic tetrapyrrole derivative that gives chlorophyll its green color and is responsible for conductive its properties. Polypyrroles are a known class of conducting polymers, attractive for its high thermal stability and conductivity. Porphyrins, having extended conjugation and the ability to coordinate a metal ion, surpass polyporroles in their range of absorption [5]. Recent applications of porphyrin dyes for dye-sensitized solar cells have shown solar conversion efficiencies approaching silicon based photovoltaic devices [5], [6].

Porphyrins have many other applications. They can be used as redox catalysts, dyes, sensors, and photodynamic therapy agents [7], [8], [9]. Of particular interest is **protoporphyrin** [Fig. 1], a cyclic tetrapyrolle and an immediate metal-free precursor to heme b. Protoporphyrin can bind different metals ions, including iron, magnesium, zinc, nickel, and copper, each complex exhibiting a different UV-vis absorption, as well as fluorescence excitation-emission, profile [Fig. 2] [10]. This property presents a possibility to modify the absorption range by simple change of ligand, which could be of great utility in photovoltaic applications. Protoporphyrin has also been used for molecularly imprinted polymer (MIP) applications as a functional co-monomer, along with methacrylic acid, to produce a "memory" material, which can help detect the binding of the template molecule used during polymerization based on spectroscopic changes upon complexation [11]. Based on the molecule's functional versatility, I have chosen to focus my research proposal on protoporphyrin. This molecule can be further functionalized, which expands the range of its potential applications.

The **traditional synthesis** of porphyrins involves complex chemistry carried out in solvents and under strict reaction conditions. These are exemplified by the Ruthemund sealed-tube anaerobic reaction in pyridine at 200 °C (ca. 5% yield), the Adler–Longo reaction in propionic or acetic acid under aerobic conditions (10 – 30% yield), and the MacDonald coupling of dipyrroles (10 – 20% yield) [7]. Recent proposals for green synthesis methods include a one-step synthesis of meso-Tetraarylporphyrins from pyrrole and aryl aldehydes without solvents or catalysts using air as oxidant by the Gong group [7]. However, the proposed method involves high temperature (> 200 °C) in gas phase. Another green chemistry approach for synthesis of tetraphenylporphyrin was developed by the Momenteaub group. It involves heating in microwave oven pyrrole and benzaldehyde

adsorbed on a solid acidic support [12]. This method is very quick (10 minutes), involves dry media conditions, and simple purification; however, this method is also carried out at high temperature and involves the use of chloroform, benzoaldehyde, and hexane, which are hazardous to human health.

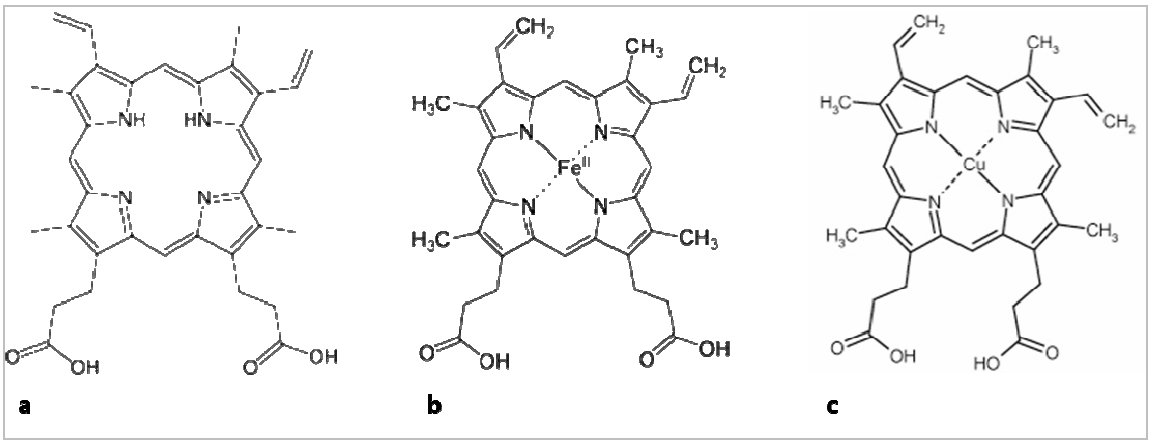

Fig. 1. Structures of *a* – protoporphyrin; *b* – heme b; *c* – protoporphyrincomplexed with copper ion

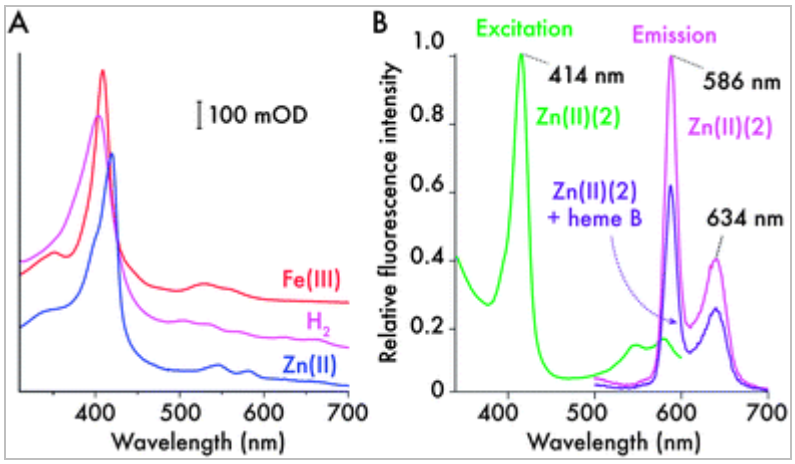

Fig. 2: *a* – UV-vis and *b* – fluorescence spectra of free; Zn- and Fe-bound protoporphyrin

Biosynthesis of porphyrins is an attractive **green alternative** to synthetic methods. Enzymatic reactions have extremely high efficiency, excellent substrate specificity, and regioselectivity, allowing precise control over spatial orientation of functional groups. In addition, most enzymes can function in mild conditions (ambient temperature, physiological pH), limiting the need to use of expensive metal-based catalysts, hazardous chemicals and solvents. Pathways for synthesis of porphyrin derivatives are present in major classes of organisms. In non-photosynthetic eukaryotes such as animals, insects, fungi, and protozoa, the pathway begins with the reaction of the amino acid glycine with succinyl-CoA from the citric acid cycle. In plants, algae, bacteria (except for the α-proteobacteria group) and archaea, it is produced from glutamic acid [13]. Normally, however, the production of porphyrins is limited by the cell's physiological needs. In order to overcome this limitation and be able to produce porphyrins in industrial quantities, the biological pathway needs to be modified using synthetic biology tools.

I propose a **novel method for large scale synthesis of porphyrins** using genetically engineered *E.coli*. This method offers the advantage of using renewable feedstocks, environmentally benign chemicals, and low-energy production requirements. These improvements are in accordance with the principles of green chemistry defined by the ACS [15]. In addition to being sustainable and clean, the described biotechnology approach offers a promise of bringing down the cost of these materials, especially in the light of the long-term prospect of petroleum shortage. I hypothesize that large-scale production of protoporphyrin for commercial applications can be carried out using recombinant *E.coli*. The strategy for this project is to utilize molecular biology and genetic engineering tools for *E.coli* genome manipulation in order to increase the amounts of compound produced.

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LABOUR PROTECTION. GENERAL INFORMATION ABOUT FIRES. FIRE SAFETY AT ENTERPRISES

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Labour protection is a system of preservation of life and health during labour activity. Labour protection must not be identified with safety engineering, industrial hygiene, occupational health, because they are elements of labour protection, its constituent parts.

The tasks of labour protection are:

1) Establishing of a system of laws and normative legal acts in the field of labour protection;
2) Control over law compliance and normative legal acts;
3) Evaluation and analysis of conditions and safety of labour;
4) Analysis of injuries and illnesses, investigation and registration of accidents at work;
5) Training and instructing employees in rules and safety requirements;
6) Creation of measures for improving working conditions and performing of norms and rules of labour safety.

An important question in the field of labour protection is to provide safe work at enterprises, and in particular to ensure fire safety.

Fire is the uncontrolled process of burning, which is accompanied by the destruction of material values and it poses a danger to people's lives. The causes of fires at industrial facilities can be divided into two groups. The first is a violation of fire safety conditions or careless handling of fire, the second one is a violation of fire safety in the design and in the construction of buildings.

Fire is a chemical reaction between combustible substances and oxygen (or other kind of oxidizing environment). There are three components necessary for the occurring of fire. They are combustible material, oxygen, and the initial heat source with sufficient energy to start the combustion reaction.

Fire may cause several different hazards. The first one is increased temperature in the combustion zone. It can cause thermal burns of humans' skin and internal organs as well as loss of bearing capacity of buildings and

structures. The second factor is emission of significant amounts of harmful combustion products into the air in working areas. In most cases it leads to poisoning of people.

So, fires cause huge material damage and often entail death. Therefore, protection against fire is the most important duty of every member of society and it is held on the state scale.

Fire protection aims to find the most efficient, cost-effective and technically based ways and measures of preventing fires and their liquidation with minimal damage using the most rational forces and means of extinguishing.

Fire safety is certain conditions that prevent a possibility of fire, and if it occurs, the necessary measures must be taken to eliminate the negative influence of fire hazards on people, buildings and material values.

Fire safety can be ensured by measures of fire prevention and active fire protection. Fire prevention includes a set of measures to prevent fire or to decrease its effects. Active fire protection is measures to ensure the successful fire fighting or a dangerously explosive situation.

A set of forces and means, as well as legal organizational, economic, social, scientific and technical measures form a system of fire safety.

The basic elements of fire safety system are public authorities, local governments, businesses and citizens involved in fire safety.

Causes of fires at industrial sites are:

- casual handling of fire (40%);
- violation of rules of electrical equipment operation (18%);
- violation of rules of devices application and operation of the heating furnace (7%);
- violation of rules of operation of heat-generating devices and units (19%);
- arsons (10%);
- other (6%).

Responsibilities of enterprises

Managers and other officials at the sites in accordance with their responsibilities perform the following functions:

- providing fire safety and fire-fighting mode;
- providing fire protection training in a proper time according to the instructions;
- creation of freelance fire formations and organizing their work;
- keeping fire equipment in working order;
- providing a plan of actions and practical training for workers in case of fire;
- adopting measures against violators of fire safety requirements, and others.

Fire prevention

Fire barriers include walls, partitions, floors, doors, gates, hatches and windows. Fire walls must be made of non-combustible materials, have a fire-resistance rating of not less than 2.5 hours, and must be built on the foundation. Fire walls must be designed sustainable, taking into account the risk of unilateral collapse of floors and other structures during fire.

Fire doors, windows and doors in fire walls must have fire-resistance rating of not less than 1.2 hours, and for fire overlaps at least 1 hour. Such overlaps must not have openings and holes through which combustion products can enter during fire.

Evacuation routes

When designing buildings it is necessary to provide safe evacuation of people in case of fire. People must leave the building within the shortest possible period of time, which is determined by the shortest distance from their location to the exit to the outside.

The number of emergency exits in buildings, premises and each floor is determined by planning, but there must be at least two. Emergency exits must be placed dispersedly. In this case, elevators and other mechanical means of transportation of people are excluded from the planning. The width of the sections of evacuation routes must be at least 1 m, and the doors on escape routes at least 0.8m. The width of the outer doors of staircases must at least be equal to the width of the flight of stairs, the height of the passage on escape routes must be not less than 2 m. Buildings with a height difference should be provided with fire ladders.

Following these requirements will ensure fire safety, save lives and health of workers, as well as a quiet labour activity of management and employees at enterprises.

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ICT, ELECTRONICS, PROGRAMMING

UDC 519.854

ALGEBRAIC APPROACH TO THE SOLUTION OF RENUMERALS OF COMBINATORY TASKS

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Abstract – In the article available means showed the way of the solution of combinatory tasks on transfer based on use of internal symmetry of the body given in a condition that, in turn, reflects close connection between objects of research of the theory of final groups and the combinatory analysis. A key step of the solution of similar tasks – heuristic finding of shifts.

The theory of enumerations developed by Polya and other mathematicians is widely used in quantum physics, equipment, cybernetics, organic chemistry, biology. One of basic provisions of this theory is Burnside's lemma. That to formulate it, we will define concept of an orbit of permutation group.

Let $G = \{\alpha_0 = \varepsilon, \alpha_1, ..., \alpha_{k-1}\}$ – permutation group on a set $M = \{1, 2, ..., n\}$. The subset $O \subset M$ is called as *an orbit of group* G, if:

1) action of permutations of G on the elements of O does not bring them out of O;
2) any two elements of O can be transformed into each other by some permutation of G.

Burnside's lemma [1]. *For any permutation group performed the equality*

$$t(G) = \frac{1}{|G|}\sum_{\alpha \in G} \chi(\alpha),$$

where $\chi(\alpha)$ *– number of fixed points of permutations,* $t(G)$ *– number of orbits of permutation* G*, acting on the set* M.

It's easy to prove that every permutation group has the orbit. It's clear that any two orbits of the group are either disjoint or coincide. It follows that the set M is the union of disjoint subsets – orbits of the group G. In connection with the division M into the orbit of the permutation group G, two questions arise.

1) How many orbits has the group G on the set M?
2) What is the length of each of these orbits?

The answer to the second question can be found using Lagrange's theorem. The answer to the first question gives Burnside's lemma.

Consider the problem of the number of ways that you can paint the top of the cube in four colors.

Discuss the condition and solution of this problem. One vertex can be painted in four ways. For other vertex coloring are all the same four ways that don't depend on the color of the remaining vertices. According to the rule works have

$$\underbrace{4 \cdot 4 \cdot \ldots \cdot 4}_{8\ раз} = 4^8 = 65536$$

ways of coloring the vertices of a cube in four colors. So it is possible to solve the problem, if we have all the vertices are different, that is, the cube is fixed in space and its vertices are numbered.

If the cube can freely rotate, some ways of a coloring become isomorphic each other, that is at turns of a cube coincide (fig. 1). It is clear that when calculating ways for coloring the vertices are isomorphic options need to be exclude.

Turns of a cube can be carried out round its axes of symmetry. The set of turns at which the cube itself is combined, forms group of symmetry under multiplication of turns. Turns are described by permutations. For example, the rotation of the cube in fig. 1 corresponds to a permutation

$$\begin{pmatrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 \\ 5 & 1 & 4 & 8 & 6 & 2 & 3 & 7 \end{pmatrix} = (1\,5\,6\,2)(3\,4\,8\,7).$$

Orbit of vertex will call a sequence of vertices obtained repeated performance of the same turning. *A cycle* is called the smallest sequence of vertices orbit that maps initial vertex into itself. For example: $(1\,5\,6\,2)$ – the cycle of vertex 1 at turn of a cube on a corner $\pi/2$ round an axis O_1O_2 (fig. 1).

If as a result of turn color of vertex hasn't changed, it's called *a fixed point* of rotation. Otherwise – *moving point*. To apply Burnside's lemma to the solution of a task, you need to determine the number of fixed points of each permutation.

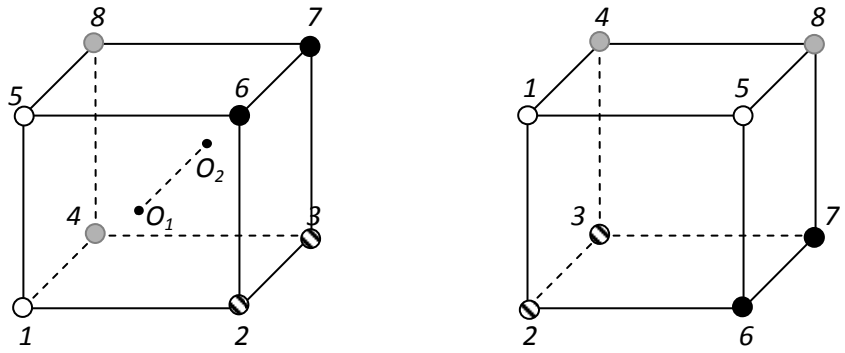

Fig. 1. Rotate the cube on a corner $\frac{\pi}{2}$ around the symmetry axis connecting the O_1 and O_2 centers of the opposite faces

For example, concerning permutation $\alpha = (1\,2\,3\,4)(5\,6\,7\,8)$, a coloring of vertices from one color and a coloring of vertices from two colors, in one of which are colored the vertices of the first cycle in the other - the vertices of the second cycle, will be fixed points. Count all the possible options:

$$4 + A_4^2 = 16 = 4^2 .$$

Arguing similarly, we conclude that the number of fixed points of permutations α equal 4^k, where *k – type permutation* (sequence of lengths of cycles of decomposition of permutation in product of cycles).

Let the cubes of the same size, which are fixed in space, having different coloring of the vertices form a set M. Then $|M| = 4^8$.

We show that the group G of rotations of the cube consists of 24 permutations. We number the vertices of the cube (fig. 2).

In table 1 will write down permutations corresponding to rotations around the cube axes connecting opposite vertices (fig. 2).

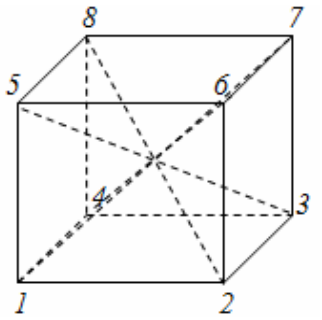

Fig. 2. Cube with axes connecting opposite vertices

In table 2 we will place permutations corresponding to rotations the cube around axes a, b, c, connecting the centers of opposite faces (fig. 3).

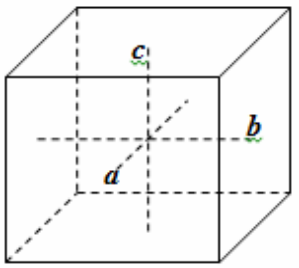

Fig. 3. Cube with axes connecting the centers of opposite faces

Table 1

axes	angle	permutation	decomposition into product of cycles	type permutation
1-7	$\frac{2\pi}{3}$	$\begin{pmatrix}1&2&3&4&5&6&7&8\\1&5&6&2&4&8&7&3\end{pmatrix}$	(2 5 4)(3 6 8)(1)(7)	< 3, 3, 1, 1 >
1-7	$\frac{4\pi}{3}$	$\begin{pmatrix}1&2&3&4&5&6&7&8\\1&4&8&5&2&3&7&6\end{pmatrix}$	(2 4 5)(3 8 6)(1)(7)	< 3, 3, 1, 1 >
2-8	$\frac{2\pi}{3}$	$\begin{pmatrix}1&2&3&4&5&6&7&8\\6&2&1&5&7&3&4&8\end{pmatrix}$	(1 6 3)(4 5 7)(2)(8)	< 3, 3, 1, 1 >
2-8	$\frac{4\pi}{3}$	$\begin{pmatrix}1&2&3&4&5&6&7&8\\3&2&6&7&4&1&5&8\end{pmatrix}$	(1 3 6)(4 7 5)(2)(8)	< 3, 3, 1, 1 >
3-5	$\frac{2\pi}{3}$	$\begin{pmatrix}1&2&3&4&5&6&7&8\\6&7&3&2&5&8&4&1\end{pmatrix}$	(1 6 8)(2 7 4)(3)(5)	< 3, 3, 1, 1 >
3-5	$\frac{4\pi}{3}$	$\begin{pmatrix}1&2&3&4&5&6&7&8\\8&4&3&7&5&6&2&6\end{pmatrix}$	(1 8 6)(2 4 7)(3)(5)	< 3, 3, 1, 1 >
4-6	$\frac{2\pi}{3}$	$\begin{pmatrix}1&2&3&4&5&6&7&8\\8&5&1&4&7&6&2&3\end{pmatrix}$	(1 8 3)(2 5 7)(4)(6)	< 3, 3, 1, 1 >
4-6	$\frac{4\pi}{3}$	$\begin{pmatrix}1&2&3&4&5&6&7&8\\3&7&8&4&2&6&5&1\end{pmatrix}$	(1 3 8)(2 7 5)(4)(6)	< 3, 3, 1, 1 >

Table 2

axes	angle	permutation	decomposition into product of cycles	type permutation
a	$\frac{\pi}{2}$	$\begin{pmatrix}1&2&3&4&5&6&7&8\\5&1&4&8&6&2&3&7\end{pmatrix}$	(1 5 6 2)(3 4 8 7)	< 4, 4 >
a	π	$\begin{pmatrix}1&2&3&4&5&6&7&8\\6&5&8&7&2&1&4&3\end{pmatrix}$	(1 6) (2 5) (3 8) (4 7)	< 2, 2, 2, 2 >
a	$\frac{3\pi}{2}$	$\begin{pmatrix}1&2&3&4&5&6&7&8\\2&6&7&3&1&5&8&4\end{pmatrix}$	(1 2 6 5)(3 7 8 4)	< 4, 4 >
b	$\frac{\pi}{2}$	$\begin{pmatrix}1&2&3&4&5&6&7&8\\5&6&2&1&8&7&3&4\end{pmatrix}$	(1 5 8 4)(2 6 7 3)	< 4, 4 >
b	π	$\begin{pmatrix}1&2&3&4&5&6&7&8\\8&7&6&5&4&3&2&1\end{pmatrix}$	(1 8) (2 7) (3 6) (4 5)	< 2, 2, 2, 2 >
b	$\frac{3\pi}{2}$	$\begin{pmatrix}1&2&3&4&5&6&7&8\\4&3&7&8&1&2&6&5\end{pmatrix}$	(1 4 8 5)(2 3 7 6)	< 4, 4 >
c	$\frac{\pi}{2}$	$\begin{pmatrix}1&2&3&4&5&6&7&8\\4&1&2&3&8&5&6&7\end{pmatrix}$	(1 4 3 2)(5 8 7 6)	< 4, 4 >
c	π	$\begin{pmatrix}1&2&3&4&5&6&7&8\\3&4&1&2&7&8&5&6\end{pmatrix}$	(1 3) (2 4) (5 7) (6 8)	< 2, 2, 2, 2 >
c	$\frac{3\pi}{2}$	$\begin{pmatrix}1&2&3&4&5&6&7&8\\2&3&4&1&6&7&8&5\end{pmatrix}$	(1 2 3 4)(5 6 7 8)	< 4, 4 >

Table 3 contains a permutation of the cube corresponds to a rotation around axes l_1, l_2, l_3, l_4, l_5, l_6, connecting the midpoints of opposite ribs (fig. 4).

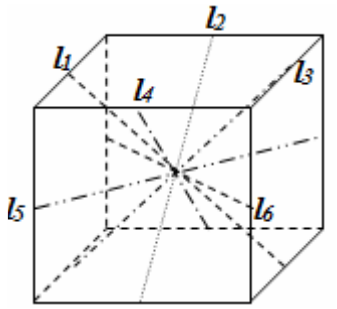

Fig. 4. Cube with axes connecting the midpoints of opposite edges

Table 3

axes	angle	permutation	decomposition into product of cycles	type permutation
l_3	π	$\begin{pmatrix}1&2&3&4&5&6&7&8\\4&8&5&1&3&7&6&2\end{pmatrix}$	(1 4) (2 8) (3 5) (6 7)	< 2, 2, 2, 2 >
l_2	π	$\begin{pmatrix}1&2&3&4&5&6&7&8\\7&8&4&3&6&5&1&2\end{pmatrix}$	(1 7) (2 8) (3 4) (5 6)	< 2, 2, 2, 2 >
l_1	π	$\begin{pmatrix}1&2&3&4&5&6&7&8\\7&3&2&6&8&4&1&5\end{pmatrix}$	(1 7) (2 3) (4 6) (5 8)	< 2, 2, 2, 2 >
l_4	π	$\begin{pmatrix}1&2&3&4&5&6&7&8\\2&1&5&6&3&4&8&7\end{pmatrix}$	(1 2) (3 5) (4 6) (7 8)	< 2, 2, 2, 2 >
l_5	π	$\begin{pmatrix}1&2&3&4&5&6&7&8\\5&8&7&6&1&4&3&2\end{pmatrix}$	(1 5) (2 8) (3 7) (4 6)	< 2, 2, 2, 2 >
l_6	π	$\begin{pmatrix}1&2&3&4&5&6&7&8\\7&6&5&8&3&2&1&4\end{pmatrix}$	(1 7) (2 6) (3 5) (4 8)	< 2, 2, 2, 2 >

In Table 4we define thenumber of fixed pointsfor each type ofpermutations.

Table 4

typepermutation	the number of permutations of this type	number of fixed points
< 1, 1, 1, 1, 1, 1, 1, 1 >	1	4^8
< 2, 2, 2, 2 >	9	4^4
< 3, 3, 1, 1 >	8	4^4
< 4, 4 >	6	4^2

By Burnside's Lemma we obtain:

$$t(G) = \frac{1}{24}(4^8 + 9 \cdot 4^4 + 8 \cdot 4^4 + 6 \cdot 4^2) = 2916 .$$

Consequently, there is a 2916 different ways of coloring the vertices of a cube in four colors.

In article developed a method based on the use of Burnside's lemma, which allows the use of algebraic tools for solving problems on sets of a more general nature than the set of natural numbers, which are formulated and solved problems of classical combinatorics.

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UDC 621.37.037

SUPERRESOLUTION OF RADIATION SOURCES ON THE BASIS OF KEYPON'S METHOD

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The results of theoretical analysis of super resolution of light sources using antenna arrays with the help of Keypon's method have been presented. Digital techniques to ensure effective noise reduction features and high-quality processing of radar signals have been applied. The function of the angular resolution of authorization objects is analyzed. The results of studies for one or two light sources are given. Recommendations are given to reduce the computational complexity of algorithms. The results of the research can be used in radio position finding and radiolocation.

One of the most important tasks of the radar is to measure the angular coordinates of the radiation source of the desired signal, which is based on the determination of the direction of arrival of electromagnetic waves emitted or reflected by the target.

The relevance of the study is determined by the fact that for modern radar stations severe restrictions on the weight, dimensions and power consumption are imposed, which excludes the use of high-power transmission devices and limits the size of the web array.

Keypon's method was proposed in 1969 to resolve the spectral components of the discrete spectrum [1]. Using the analogy of the frequency and spatial spectra method was proposed for estimating the angles of arrival of signals using an antenna array.

Model signals received from the N antenna array elements may be represented as follows:

$$Z = \sum_{k=1}^{J} a_k S(\varphi_k) + X \ , \tag{1}$$

where J – the number of discrete sources;

a_κ, φ_κ – complex amplitude and angle of arrival of the waves corresponding to index k;

$S(\varphi_\kappa)$ – N-dimensional vector signals received from the power grid with the number k;

X – N-dimensional noise vector own antenna array elements;

Z – N-dimensional vector of the received signal.

The model assumes that the complex amplitudes of waves of different sources are statistically independent, i.e.

$$< a_k a_m^* > = \begin{cases} \sigma_k^2 (k = m); \\ 0 (k \neq m). \end{cases} \tag{2}$$

Since the discrete sources, the signals in the elements of the array for each source are assumed to be correlated (correlation coefficient equal to unity). This means that the signal vector $S(\varphi_\kappa)$ of each source is deterministic and describes both the nature of the wave front and the configuration of the antenna array. Noises in its elements are assumed to be uncorrelated and equal in power. The problem is formulated as follows: it is necessary to find the weight vector W, which minimizes the average power output of the antenna array with the proviso that, for some angle of arrival φ transmission ratio is fixed and the lattice is, for example, a unity. Mathematically, this task can be written as follows:

$$\min_w < \left| W^H Z \right|^2 > \text{ provided } W^H S(\varphi) = 1 . \tag{3}$$

It is the task of a conditional extremum.

To solve it, we need to create a functional Lagrange

$$\Phi(W) = < \left| W^H Z \right|^2 > - \chi \left(W^H S(\varphi) - 1 \right). \tag{4}$$

The χ – undetermined Lagrange multiplier.

The first term in (4) can be written as

$$< \left| W^H Z \right|^2 > = W^H < ZZ^H > W = W^H M W, \tag{5}$$

where $M = < ZZ^H >$ – correlation matrix of the signals at the input of the antenna array.

For the adopted model signals (1) it is easy to calculate the correlation matrix under the condition (2).

As a result, we obtain

$$M = \sum_{k=1}^{J} \sigma_k^2 S(\varphi_k) S^H (\varphi_k) + \sigma^2 E. \tag{6}$$

The σ^2 – the average noise power in a single element antenna array.

In view of (5), the expression (4) is transformed into

$$\Phi(W) = W^H M W - \chi\left(W^H S(\varphi) - 1\right). \tag{7}$$

The gradient of the functional equate to zero and obtain the following equation:

$$MW = \lambda S(\varphi). \tag{8}$$

Hence we find the weight vector:

$$W = \chi M^{-1} S(\varphi), \tag{9}$$

where M^{-1} – inverse correlation matrix of the input signals.

Now the weight vector (9) should be substituted to a desired condition (3), and the undetermined factor χ then can be found in the form of

$$\chi = \left[S^H(\varphi) M^{-1} S(\varphi)\right]^{-1}. \tag{10}$$

The final solution of the problem is obtained by (10) substituted into (1). As a result, the weight vector that minimizes the average power output according to Keypon's criterion will have the form

$$W = \frac{1}{S^H(\varphi) M^{-1} S(\varphi)} M^{-1} S(\varphi). \tag{11}$$

In an optimal state, when the weighting coefficients of the antenna array are established in accordance with (11), the average output power is found by substituting (11) into (5). This value is the function of the resolution, which we denote $\eta_1(\varphi)$.

Thus, for Keypona's method the resolving function is found to be

$$\eta_1(\varphi) = \frac{1}{S^H(\varphi) M^{-1} S(\varphi)}. \tag{12}$$

An average power output can be measured. Therefore, this value is of interest in terms of the angular resolution of sources.

1. Suppose that the space has a single source. This example is useful to consider, although in case of a single source the question of angular resolution does not make sense. In this case the correlation matrix (6) takes the form

$$M = \sigma_1^2 S(\varphi_1) S^h(\varphi_1) + \sigma^2 E. \tag{13}$$

Figure 1 shows the function (12). The calculations were performed for the linear equidistant antenna array with the number of elements of N = 16 and a half-wave length between elements.

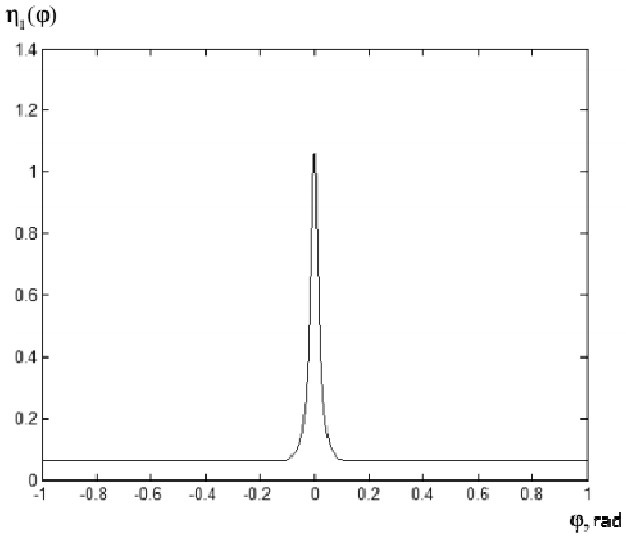

Fig. 1. The average power output of the antenna array of the angle φ

It was assumed that a plane wave coming from the source in a direction normal to the antenna array, i.e. $\varphi_1 = 0$. The average power of the desired signal and the noise floor in each element taken respectively $\sigma_1^2 = 1$, $\sigma^2 = 1$.

2. Let us now assume that the space has two sources. Then, the correlation matrix of the received signals (6) has the form

$$M = \sigma_1^2 S(\varphi_1) S^h(\varphi_1) + \sigma_2^2 S(\varphi_2) S^h(\varphi_2) + \sigma^2 E. \quad (14)$$

Assume that both sources have the same average power in each antenna array element. We also assume that the ratio of signal power to the power source noise floor in each cell is equal to unity, i.e. $\sigma_1^2 = 1$, $\sigma^2 = 1$; the angles of arrival of waves are assumed to be equal: $\varphi_1 = \pi/64$, $\varphi_2 = -\pi/64$.

As before, assume that the measurement of angles of arrival of the waves is performed by linear equidistant array of 16 elements ($N = 16$) and a half-wave length interelemental $d/\lambda = 0{,}5$. Let's apply Keypon's method (12), which does not require a priori knowledge of the number of sources, and is based only on the knowledge of the correlation matrix of the input signals. The results are shown in Figure 2.

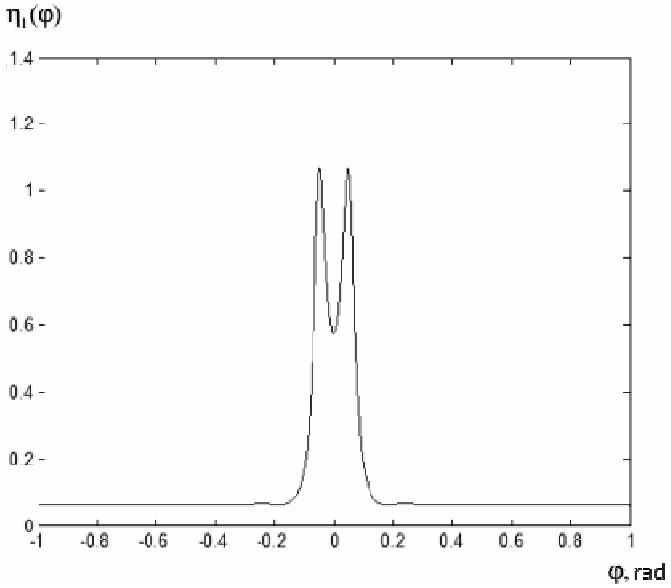

Fig. 2. The average power output of the antenna array depending on the angle φ with $\sigma_1^2 = \sigma_2^2 = \sigma^2 = 1$

Keypon's method has the following advantages:

- does not require a priori knowledge of the number of radiation sources;
- less computational complexity of the algorithm than the maximum likelihood method;
- has a higher resolution than the maximum likelihood method;
- less influence of random amplitude and phase errors.

However, the method has some disadvantage:

- the worst accuracy rates than the method of "thermal noise";
- this method does not allow to estimate the number of radiation sources.

The analysis of Keypon's method for super resolution has been performed. There have been developed recommendations based on a symmetric matrix that help reduce the computational complexity of algorithms, which allows to simplify the digital implementation of these algorithms. The research results can be used in radar systems.

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UDC 004.932

ANALYSIS OF MOTION DETECTION IN VIDEO FOR EARLY FOREST FIRE DETECTION

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Reliable and early detection of forest fire can significantly reduce the damage caused to forestry. Using of machine vision systems, namely video fire detectors, belongs to promising area forest fire recognition. Motion detection is the key step for smoke and flame monitoring in video. This document describes some methods of movement detection in video sequences, including comparative analysis of opportunities to find moving regions, their advantages and disadvantages.

Forest fires are one of the main problems in regions with hot climate and extensive vegetation. The work in [1] reports that, each year, about 0.1% of the world forest surface is destroyed by fires. In most cases, manned surveillance towers are adopted to watch forest areas which present the greatest risk of fire. Lookout towers equipped with cameras are a more feasible approach, since many cameras from different locations and points of view can be monitored by a single control station.

Recently, many research projects have studied the possibility to develop automatic fire and smoke detection systems based on sensor networks or machine vision techniques, in order to achieve a better efficiency and a shorter alarm response time. These approaches have the advantages of a great distance vision, absence of latency, and the possibility to extract more information (such as position, size, growth, and kind of fire and smoke) [2].

This article presents a comparative analysis of moving regions detection methods in order to identify their strengths and weaknesses.

Two approaches to detect moving objects in video images are commonly used now: background subtraction methods [3, 4] and the Gaussian mixture model based on background subtraction methods [5, 6].

Using background subtraction methods is the most common approach to detect moving regions in the video image, obtained using a stationary camera. The essence of these methods is the per-pixel comparison of the current frame with a pattern that is usually named as a background model. Background model, which is a description of the scene without moving objects, must be constantly updated to reflect the changes that are not associated with the movement of objects.

In most cases the adaptive system is used to evaluate the background and threshold values. The background estimation is computed as follows:

$$B(x, y, t+1) = \begin{cases} aB(x, y, t) + (1-a)I(x, y, t), if\ (x, y)\ stationary \\ B(x, y, t), is\ a\ moving\ pixel \end{cases}$$

where $I(x; y; t)$ represents the intensity of the pixel at location $(x; y)$ in the t-th frame of the frame sequence I, $B(x; y; t)$ is the previous estimated background intensity at the same pixel position, a – is a positive real constant close to one. Initially, $B(x, y; 0)$ is set equal to the first frame $I(x; y; 0)$.

The motion detection of a pixel is determined as follows. A pixel positioned at $(x; y)$ is assumed to be moving if it satisfies the disequations:

$$|I(x, y, t) - I(x, y, t-1)| > T_1(x, y, t)$$
$$|I(x, y, t) - I(x, y, t-2)| > T_1(x, y, t)$$

where $I(x; y; t-1)$ is the intensity of the pixel at the location $(x; y)$ in the $(t-1)$-th frame I and $T_1(x; y; t)$ is a threshold updated at each frame, according to the equation:

$$T_1(x, y, t+1) = \begin{cases} bT_1(t) + (1-b)(c\,|I(x, y, t) - B(x, y, t)|), if\ (x, y)\ stationary \\ T_1(t), if\ (x, y)\ is\ a\ moving\ pixel \end{cases}$$

where c is a real constant greater than one and b is a positive constant close to one. Initial threshold values are set to a predetermined non-zero value. In order to detect even slow moving regions, as described in [3], it is possible to use two different background estimations, $B^{fast}(x; y; t)$ and $B^{slow}(x; y; t)$. $B^{fast}(x; y; t)$ is updated at every frame and $B^{slow}(x; y; t)$ is updated every second. For every pixel $(x; y)$, the value $D_M(x; y; t)$ representing its motion is computed as follows:

$$D_M = \begin{cases} 0, & if \left|B^{fast} - B^{slow}\right| \leq T_{low} \\ \dfrac{\left|B^{fast} - B^{slow}\right| - T_{low}(t)}{T_{hight} - T_{low}} & if \;\; T_{low} \leq \left|B^{fast} - B^{slow}\right| \leq T_{hight} \\ 1 \; if \; T_{hight} \leq \left|B^{fast} - B^{slow}\right| \end{cases}$$

where $0 \prec T_{low} \prec T_{hight}$ are threshold values. The result is a matrix $D_M(x,y)$ with values in the range $[0; 1]$. The resulting matrix D_M is threshold in order to reduce the computational time and by considering regions with low values of movement.

This approach is simple and fast method for determining the motion in the video sequence. However, since it is using the frame difference, then it is characterized by all the shortcomings of the frame difference method: high sensitivity to noise and inaccurate reproduction of the form of moving objects.

A technique of moving object detection, that recently became popular, is a Gaussian mixture model based on the method of background subtraction [5].

In order to adapt to the changes, you will need to update the training set by adding new samples and discarding old ones.

Selects a reasonable time period *T* and at time t we have: $X_T = \{x^t, \ldots, x^{(t-T)}\}$. For each new sample is updated set of training data X_T and reestimate $p(x|X_T, BG)$. However, among the samples from the recent history there could be some values that belong to the foreground objects and the need to mark this estimate as $p(x^{(t)}|X_T, BG + FG)$. Using GMM with *M* components:

$$p(x^{(t)}|X_T, BG + FG) = \sum_{m=1}^{M} \pi_m N(x; \mu_m, \sigma_m^2 I)$$

where $\mu_1, \ldots, \mu_M$ are the estimates of the means and $\sigma_1, \ldots, \sigma_M$ are the estimates of the variances that describe the Gaussian components. The covariance matrices are assumed to be diagonal and the identity matrix, I has proper dimensions. The mixing weights denoted by π_m are non-negative and add up to one. Given a new data sample $x^{(t)}$ at time t the recursive update equations are [6]:

$$\pi_m \leftarrow \pi_m + \alpha(o_m^{(t)} - \pi_m)$$
$$\mu_m \leftarrow \mu_m + o_m^{(t)}(\alpha/\pi_m)\delta_m$$
$$\sigma_m^2 \leftarrow \sigma_m^2 + o_m^{(t)}\left(\frac{\alpha}{\pi_m}\right)(\delta_m^T \delta_m - \sigma_m^2),$$

where $\delta_m = x^{(t)} - \mu_m$. Instead of the time interval T, that was mentioned above, here constant α describes an exponentially decaying envelope that is used to limit the influence of the old data. Retaining the same notation having in mind that approximately $\alpha = 1\backslash T$. For a new sample the ownership $o_m^{(t)}$ is set to 1 for the 'close' component with largest π_m, and the others are set to zero. Define that a sample is 'close' to a component if the Mahalanobis distance from the component is for example less than three standard deviations. The squared distance from the m-th component is calculated as: $D_m^2(x^{(t)}) = \delta_m^T \delta_m / \sigma_m^2$. If there are no 'close' components a new component is generated with $\pi_{M+1} = \alpha, \mu_{M+1} = x^{(t)}$ и $\sigma_{M+1} = \sigma_0$, where σ_0 – is some appropriate initial variance. If the maximum number of components is reached we discard the component with smallest π_m.

The presented algorithm presents an on-line clustering algorithm. Usually, the intruding foreground objects will be represented by some additional clusters with small weights π_m. Therefore, can be approximate the background model by the first *B* largest clusters:

$$p(x^{(t)}|X_T, BG) = \sum_{m=1}^{M} \pi_m N(x; \mu_m, \sigma_m^2 I)$$

If the components are sorted to have descending weights π_m, we have:

$$B = \arg\min_b \left(\sum_{m=1}^{b} \pi_m > (1 - c_f)\right)$$

where c_f – is a measure of the maximum portion of the data that can belong to foreground objects without influencing the background model.

Using the Gaussian mixture distribution to present the background model has a list disadvantages. Firstly, the method is not adapted to passing changes in light, that is natural for some videos. Second, the initialization of distribution parameters is time-consuming.

A relatively large number of parameters requires selection of the most optimal values for specific data.

This document contains a comparative analysis of existing methods of automatic detection of moving smoke areas on video sequences. Noted, that the most popular methods of motion detection methods are based on background subtraction. Gaussian mixture model based on the method of background subtraction solves the problem to noise and inaccurate reproduction of moving objects' forms, but it is not adopted to rapid changes in lighting as well as the distribution parameters initialization is rather time-consuming procedure. Thus, refining of the algorithms in predetermined directions is needed to improve the detection of moving areas.

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MODELING ELLIPTICAL SLOT ANTENNA IN THE PROGRAM HIGH FREQUENCY SYSTEM SIMULATOR

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This article presents the results of modeling an elliptical slot antenna in the software High Frequency System Simulator (HFSS). It was investigated the dependence the characteristics of the antenna on the change in thickness of the substrate. For research as substrate material is selected the dielectric with permittivity $\varepsilon = 3$, thickness of 1.575 mm, 2 mm, 3 mm. The results are presented in the graphs: the standing wave ratio (SWR), polar pattern, input impedance. It shows the structure of the antenna with the description of its parts. The regularities of changes in the characteristics of the elliptic slot antenna according to the variations of dielectric thickness are identified. Recommendations are given for the development of ultra-wideband antennas used in selecting the thickness of the dielectric. The results can be used to construct broadband antennas in telecommunication systems.

Development and creation of antennas which correspond to contemporary market requirements assumes the usage of progressing instruments and methods which permit to carry out engineering calculations for identification of functionality and operating characteristics of the future device. The basic method for this has currently become computer simulation.

Using contemporary software packages any shape of antenna can be drawn easily on your computer and all kind of materials can be prescribed, and after that you will get the needed characteristics. Moreover antenna can be searched and optimized for specific conditions and requirements while changing its operating factors. After all, on the real antenna changing many operating factors is either very difficult or almost impossible.

One of the instruments that is allowed to carry out the designing of antennas, to calculate its performance attributes, to make a computer experiment which models conditions of the real world is the program High Frequency System Simulator (HFSS).The investigation of the dependence of the characteristics of the elliptical slot antenna on the change in thickness of the substrate was conducted in this program.

Antenna construction. The appearance of both side A and B elliptical slot antenna is demonstrated on figure 1 (A and B) correspondingly.

The antenna is accomplished on dielectric baseboard 4, on one side is metal elliptic resonator 1 with connected power line 2, on the other side all along the whole area of dielectric is metal screen 5 with elliptic slot 6. Antenna stimulation originates from discrete port 3 with impedance 50 Ohm.

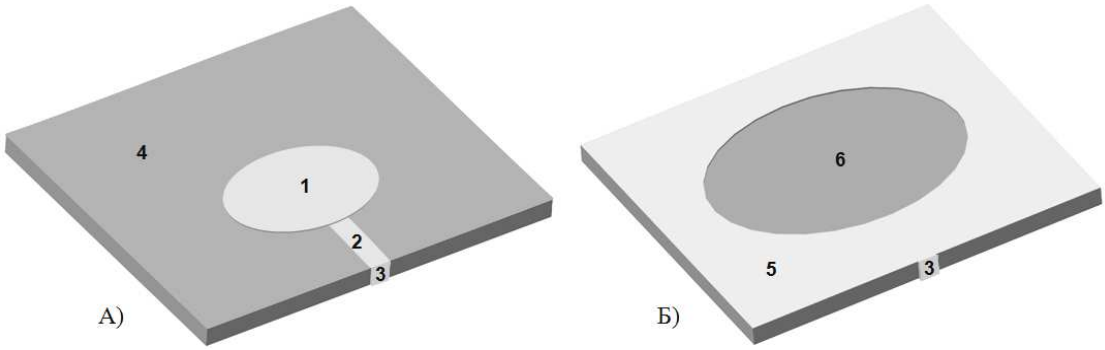

Fig. 1. The appearance of the sides of antenna :
1 – elliptic resonator; 2 – power line; 3 – discrete port; 4 – dielectric baseboard of antenna;
5 – earth surface; 6 – elliptic slot

Resonance wave-length of elliptic resonator can be found from expression:

$$\lambda_{рез} = \alpha\pi\sqrt{s_{эфф}}\, e / \sqrt{q_{mn}^{s,e}} \ ,$$

where $e = \sqrt{a^2 - b^2} / a$ – eccentricity of ellipse; $q_{mn}^{s,e}$ – n root even or odd function Mathieu first type order *m* [1].

Elliptic shape resonator has good spectral band qualities and basically is used in nonresonance microstrip antenna [2].

The results of research. The material of dielectric in HFSS was chosen Rogers RO3003 with permittivity ε = 3, thickness of 1.575 mm, 2 mm, 3 mm. As a material of emitting area was chosen copper 0,3 mm thin. The length of antenna is 40 mm, width 35 mm. Researching band is 2,5 GHz – 20 GHz.

During modeling the following characteristics were received: polar pattern, standing wave ratio (*SWR*), reflection coefficient from antenna admission (*S*11). They are shown on the figures 2 – 4 correspondingly.

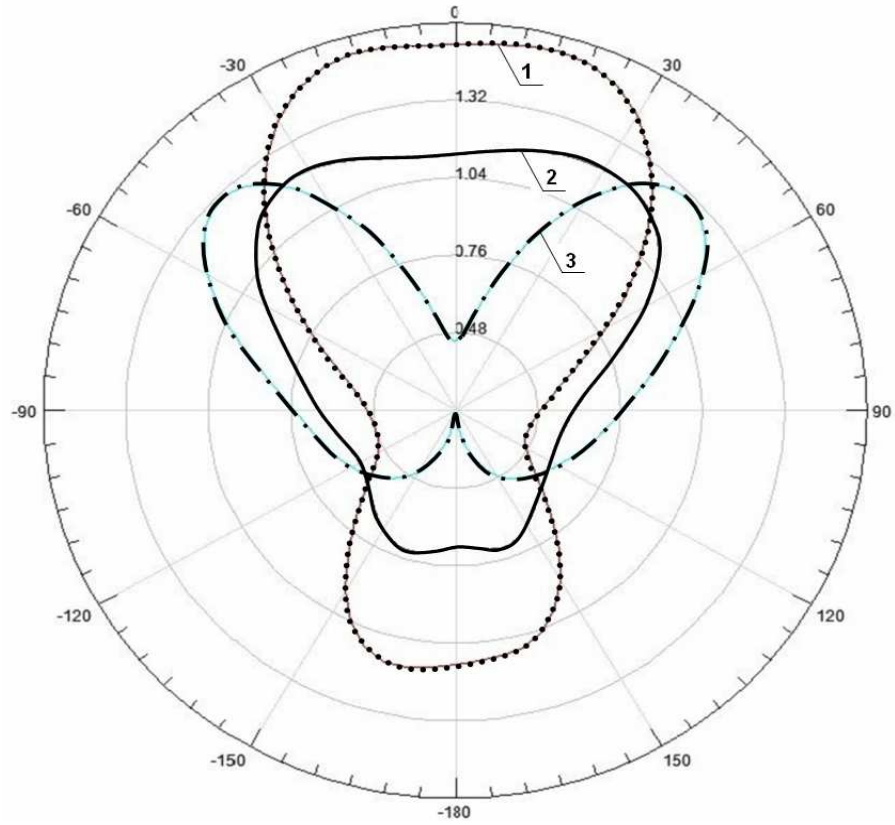

Fig. 2. Antenna polar pattern:
1 – dielectric width 1,575 mm; 2 – dielectric width 2 mm; 3 – dielectric width 3 mm

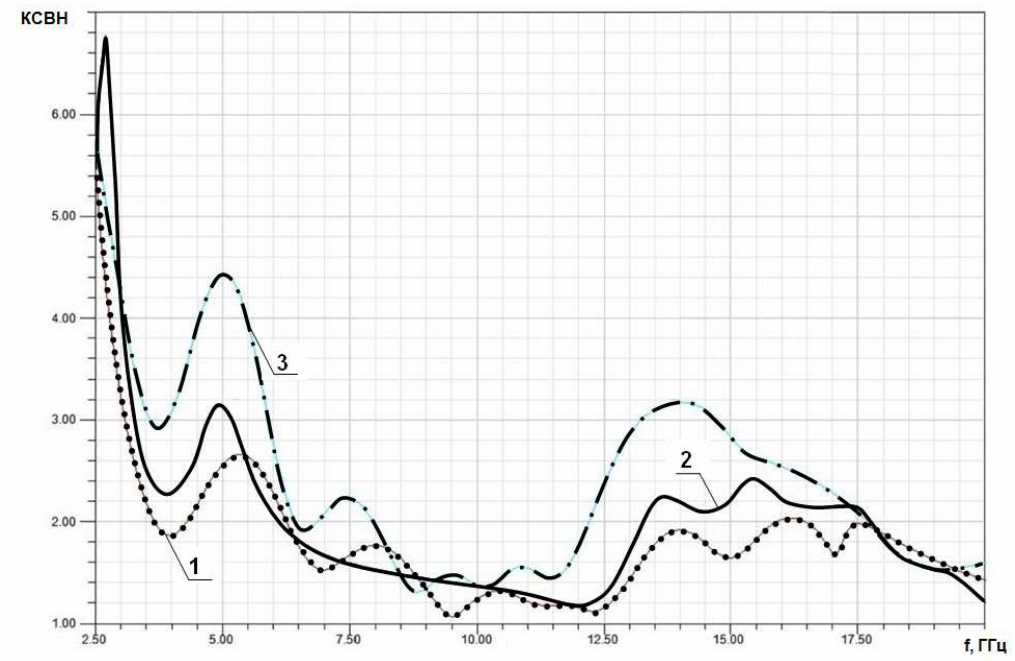

Fig. 3. The standing wave ratio (SWR):
1 – dielectric width 1,575 mm; 2 – dielectric width 2 mm, 3 – dielectric width 3 mm

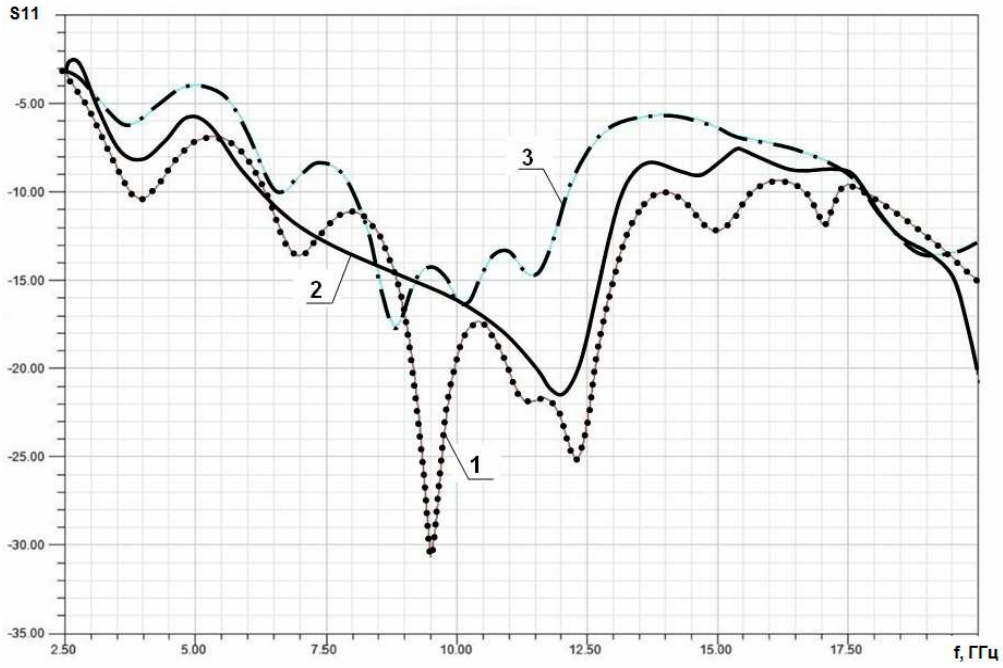

Fig. 4. Reflection coefficient from antenna admission:
1 – dielectric width 1,575 mm; 2 – dielectric width 2 mm; 3 – dielectric width 3 mm

For dielectric with width 1,575 mm antenna directional gain equals 1,44, antenna radiate into straight and reverse directions, the width of polar pattern is 91°.

For dielectric with width 2 mm antenna directional gain equals 1,17, the width of polar pattern is 106° and in direction of 0° is a small crevasse of polar pattern till 1,13 and antenna radiates small amounts into reverse direction .

For dielectric with width 3 mm into direction 0° antenna has crevasse of polar pattern. According to the diagram antenna radiates aside -50° and 50°.

Antenna with the dielectric width 1,575 mm shows good matching qualities on the part of frequency from 6,2 GHz to 20 GHz, but more uniform meaning SWR can be seen on frequency 9,5 – 12,5 GHz.

Antenna with the dielectric width 2 mm shows good matching qualities on the part of frequency from 6 GHz to 13,3 GHz and 17,6 – 20 GHz.

Antenna with the dielectric width 3 mm shows good matching qualities on the part of frequency from 8 GHz to 12,4 GHz and 17,6 – 20 GHz and meaning SWR is changing from 1,3 to 2.

In the antenna with dielectric thickness 1.575 mm, the reflection coefficient decreases from the entrance of -3 dB at 2.5 GHz to -30 dB at 9.5 GHz.

With further increase in the frequency value of S11 rises. The magnitude of the reflection coefficient varies from -31 dB to -10 dB. at a frequency of 9.5 GHz an extreme point (minimum) with the value of *S*11 exists.

In the antenna with the dielectric thickness of 2 mm, the reflectance decreases from the entrance of -2.5 dB at 2.5 GHz and -23 dB at 12 GHz.

With further rise in frequency the value of S11 will increase. The magnitude of the reflection coefficient varies from -23 dB to -15 dB. at 12 GHz. An extreme point (minimum) with the value of S11 exists.

In the antenna with a dielectric thickness of 3 mm, the reflectance decreases from the entrance of -3 dB at 2.5 GHz and 17.5 dB at 8.7 GHz. With further increase in frequency the value of S11 will increase. The magnitude of the reflection coefficient varies from -17.5 dB to -10 dB at a frequency of 8.7 GHz and has the minimum point value S11.

In the course of the simulation it is set that:

– The thickness of the dielectric base elliptical slot antenna affects its band width. When the thickness of the band used tapers, set the optimum thickness of the dielectric in which the antenna has the highest broadband, which is 1,575 mm. The operating frequency band in this case is 6.2 – 20 GHz, i.e. band width is 13,8 GHz.

– The analysis showed that the thickness of the dielectric also affects the directional properties of the antenna. Increasing the thickness of the dielectric leads to the expansion pattern diagram corresponding to the smallest width of the substrate thickness 1,575 mm, when the level 2 equals to 0,707 and 80°. When the substrate thickness of 3 mm is a division of the main lobe and 2 in the direction of the maximum observed failure pattern.

– As a result of the simulation set the thickness of the insulator has an impact on the value of VSWR. By increasing the thickness of the substrate matching properties deteriorate and uneven frequency response SWR increases significantly. Good agreement with the feeder link antenna is observed in the dielectric thickness of 1,575 mm.

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METHOD OF ESTIMATING PROTECTION FROM SPEECH SIGNALS LEAKAGE THROUGH LOW-FREQUENCY TECHNICAL CHANNELS OF INFORMATION LEAKAGE BASED ON THE CORRELATION FUNCTION

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There have been studied the parameters of a measuring broadband chirped signal in bands of equal intelligibility and offered the estimation of protection of informatization object from speech information leakage through low-frequency technical channels of leakage by a broadband chirped signal based on the correlation function in the bands of equal intelligibility. Source data for implementation of the method of estimating the parameters of a broadband chirped signal on new principles in terms of influencing factors have been obtained.

The level of protection of informatization object is objectively assessed by release of weak measuring signals from the high level noise in channels of speech information leakage. To assess protection of channels of speech information leakage harmonic signal is widely used as a measuring, substantiated correlation theory of speech intelligibility [1]. State standard RST 34.101.29-2011 establishes the use of harmonic measurement signal when splitting the spectral density of the speech signal by 20 bands of equal intelligibility. The analysis of the literature [1,2] showed, that the use of a harmonic signal solves this problem with a high precision, frequency resolution and high sensitivity. However, for a speech signal with a frequency range from 100 Hz to 10 kHz estimation by only 20 harmonic components does not exclude some methodological errors. Method for estimating channels of speech information leakage by broadband chirp signal processing with time-frequency Wigner transformation [2, 3] excludes methodological errors, inherent harmonic signals and improves the methodological precision, frequency resolution and sensitivity, which requires significant additional processing time.

The **aim** is to develop on a new principle the evaluation method of protection against leakage of speech signals through the low-frequency technical channels of information leakage which is based on the correlation function in terms of high level noise and other influencing factors.

For this we have researched the characteristics and parameters of broadband chirped signal when splitting the spectrum of the speech signal by 20 bands of equal intelligibility and assessed the impact of base size and duration of the signal on sensitivity and accuracy.

The research of broadband chirped signal`s parameters in 20 bands of equal intelligibility. Unlike harmonic signal a broadband chirp signal allows extending the capabilities of protection evaluation of speech and controls the deformation of the spectral density in the bands of equal intelligibility, which the speech signal spectrum is splitting, rather than at isolated points on the real axis.

Using the expression of [4], 20 broadband chirp signals is formed and investigated in the bands of equal intelligibility with various initial values of their base and duration.

According to [5] initially base B of signals is set as a permanent and the residence time T_s of every single broadband chirp signal in the bands of equal intelligibility is determined for values of base B = 200, 500, 5000. It has been established that broadband chirp signal has the smallest variations of frequency deviation $\Delta f_{N=3}$ =140 Hz in the third N_3 band equal intelligibility, and the largest $\Delta f_{N=20}$ =2750 Hz – in the twentieth N_{20} band equal intelligibility. Frequency deviation broadband chirped signal in the twentieth N_{20} band equal intelligibility is almost 20 times more than the frequency deviation of the signal in the third N_3 band equal intelligibility. This difference significantly affects the estimate signal formed for a constant value of base.

If we talk about the total time of 20 broadband chirp signals at the value of the base B =200, it is equal to T_{total} =16,86 s. However, with this value of base it is not possible to do evaluating in the band equal intelligibility in the same conditions, because the duration of broadband chirp signal in the band N_{20} will be T_s =0,07 s, whereas, in the band N_3 the duration of broadband chirp signal will be T_s =1,43 s, that means the difference in energy of signal more than 20 times. In order to assess broadband chirp signals in equal conditions it is necessary to use a constant value of base not less than the B =5000, however, at such value of base, the total time of all 20 wideband signals in all bands equal intelligibility will be T_{total} =421,79 s, that does not allow to achieve a set goal.

According to [5] and on condition, that the value of the signals duration T_s is set as a permanent, the base value of every single broadband chirp signal in the bands of equal intelligibility is defined for values of signal duration T_s =1,2,4,6 s. According to the research it has been found, that for duration T_s =4 s base broadband chirp signal in the third band N_3 (the narrowest) is equal to B =560, whereas, in the band N_{20} (the widest) base is equal to B =11000. Increasing the base signal allows to reduce the level of oscillation of the spectral density chirp signals in the last bands of equal intelligibility and does not change the quality of the assessment. Thus, the total time equal in duration signals all in 20 bands of equal intelligibility is $T_{total} = T_s \cdot 20 = 2 \cdot 20$ =40 s when the duration of the signal T_s =2 s and accordingly, T_{total} =80 s when the duration of the signal T_s =4 s.

The result of research broadband chirp signals in 20 bands of equal intelligibility with constant value of base has determined, that with increasing bandwidth, duration of broadband chirp signals decrease and using broadband chirp signals with constant value of base is not expedient. Proposed to use identical in duration and having different values of base signals. This greatly reduces the total time estimation of channel of information leakage.

Parameter estimation broadband chirp signal based on the correlation functions. Analytical description of signals and their spectra are the most important and comprehensive characteristics on which signal characteristics were obtained: the autocorrelation function (ACF) and the cross-correlation function (CCF).

The autocorrelation function – a time function, which allows to estimate the level of similarity of two signals and has the dimension of energy. ACF is given by [4]:

$$R_{1,2}(\tau) = \int_{-\infty}^{\infty} s_1(t)\, s_2(t-\tau)\, dt \ , \qquad (1)$$

where $s_1(t)$ и $s_2(t)$ – the input and output signals; τ – time shift between the signals; $R_{1,2}(\tau)$ – ACF of two signals $s_1(t)$ и $s_2(t)$. Function (1) further allows to estimate the level of similarity of two signals, as well as their relative position on the time axis. At the time, when the output signal $s_2(t)$ is the most similar to the input signal $s_1(t)$, the correlation function will have a maximum. The width of this maximum – twice the length of the initial pulse and is symmetrical about the centre. If $s_1(t) = s_2(t)$, the expression (1) for $R_{1,2}(\tau)$ is an expression ACF of signal $s(t) = s_1(t) = s_2(t)$:

$$R(\tau) = \int_{-\infty}^{\infty} s(t)\, s(t-\tau)\, dt \ . \qquad (2)$$

Figure 1 shows the ACF and its envelope broadband chirp signal with a frequency f_0 =640 Hz (Δf =140 Hz, N_3), base B =280 and duration T_s =2 s. ACF allows to assess the level of compliance (correlation) signal with its time-shifted copy. The main property of the ACF – at time offset τ equal to zero, it defines the energy of signal.

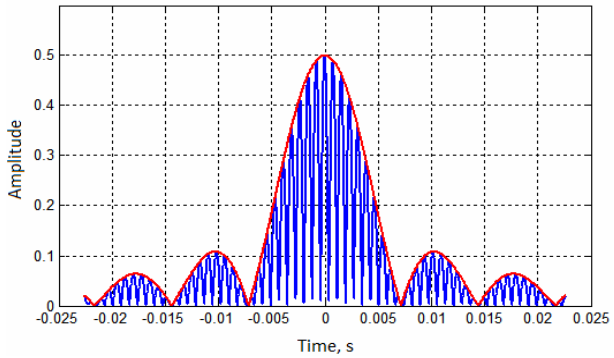

Fig. 1. ACF and its envelope of the signal at the input of channels of speech information leakage

The energy of the signal shows total energy released in the resistor R =1Ohm for a specified time. Unjammable reception is possible on condition when the necessary energy of the desired signal in the optimal receiver is provided, and its magnitude is in its turn, increases with: increasing time signal processing; increasing the amplitude of the signal $s(t)$; expanding the range of the signal.

To estimate the parameters of the broadband chirp signal at the output channel of speech information leakage with high accuracy it is required to consider a random signal delay relative to input of the measuring signal, due to its passage through the propagation medium and equipment delays. Even a small random delay 10-200 ms duration significantly increases the error of the estimate output parameters. The method based on the estimation of parameters of the cross-correlation between broadband chirp signal, passed through the propagation medium with a specified delay, and measuring broadband chirp signal eliminates errors associated with the delay of the signal in channels of speech information leakage. Figure 2, *a*) shows the ACF function of the signal at the output of channels of speech information leakage. Figure 2, *b*) – CCF function between the measuring signal at the input and output signals in channels of speech information leakage. Random delay time is determined by the difference between the maximum cross-correlation function between the signal at the output of channels of speech information leakage and measuring broadband chirp signal, and the maximum of the autocorrelation function of the measuring broadband chirp signal. This time span is the delay of the broadband chirp signal at the output of channels of speech information leakage.

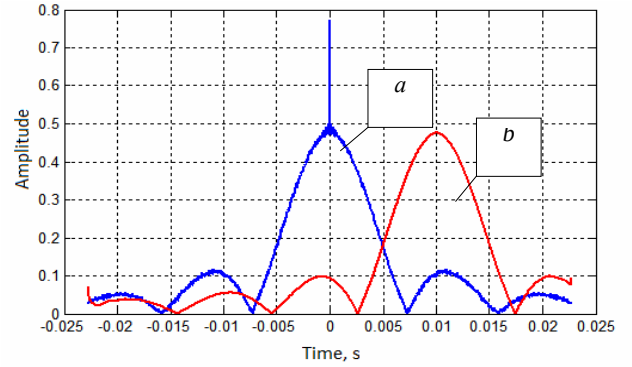

Fig. 2. The joint display ACF and CCF:
a) ACF signal at the output of channels of speech information leakage;
b) CCF between the generated measuring signal and the signal at the output of speech information leakage

Sensitivity defined as the ratio of change of output value signal/noise Q_{out} to the value signal/noise Q_{in} causes it to change the input signal. The dependence of the output value of the signal/noise ratio from change of the input values of the signal/noise ratio can be represented by [6]:

$$Q_{out} = f(Q_{in}), \tag{3}$$

where $Q_{in} = \left(\frac{P_s}{P_n}\right)_{in}$ – ratio of the power of the measurement signal to noise power at the input; P_s, P_n – power of broadband chirp signal and power of noise.

For broadband chirp signal in the bands of equal intelligibility Q_{out} is given by [6]:

$$Q_{out} = 2 \cdot E / N_n, \tag{4}$$

where E – the energy of the signal at the output of channels of speech information leakage; N_n – power spectral density of noise in the band equal intelligibility broadband chirp signal.

By the formula [5] on the basis of correlation functions were obtained results output parameters broadband chirp signal in the bands N_1,..., N_{20} and sampling frequency F_s = 44100 Hz.

The values of the ultimate sensitivity for each k band at a constant base value B = 200,300,500,600 was obtained [5]. It has been established that at B = 200 in bands N_{19} (T_s =0,09 s, Δf =2240 Hz), N_{20} (T_s = 0,07 s, Δf = 2750 Hz), the signal is almost not detected. When the B = 500 in bands N_{19} (T_s =0,22 s), N_{20} (T_s = 0,18 s) signal is detected, however, the system has very low sensitivity. According to the results of the experiments, the optimum value of base in bands N_{19}, N_{20} should be not less than 5,000. If we consider the ultimate sensitivity in other bands of equal intelligibility, then at values of base above 500 the value of maximum sensitivity increases insignificantly, thus further increasing the value of base is impractical, because with increasing value of base, the total time of broadband chirp signals increases rapidly. In Figure 3 shows the dependence of the coefficient of variation [7] of the maximum sensitivity with a constant value of base signals.

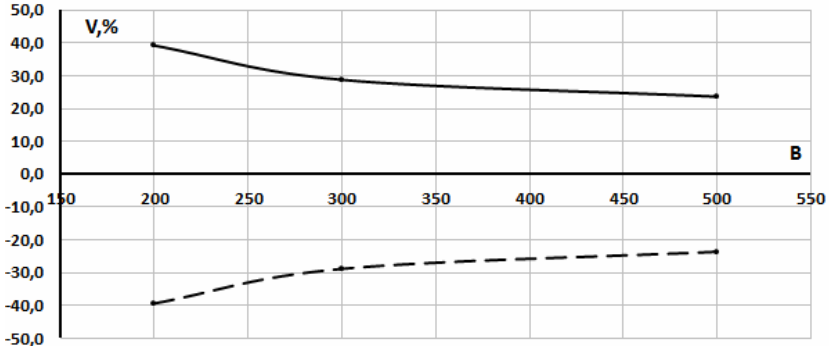

Fig. 3. Coefficient of variation of the maximum sensitivity of measuring instrument output broadband chirp signals in noise at a constant value B

Further values of the limiting sensitivity were obtained for each k band with at a constant value of the signal duration T_s = 1, 2, 4, 6 s [5]. Figure 4 shows the dependence of the coefficient of variation of the maximum sensitivity with a constant value of signals duration. From Figure 4 it follows that under the condition that the duration of the signal has a constant value and the value of the base size is different for each of the k band, the coefficient of variation decreases with the increasing duration of signals.

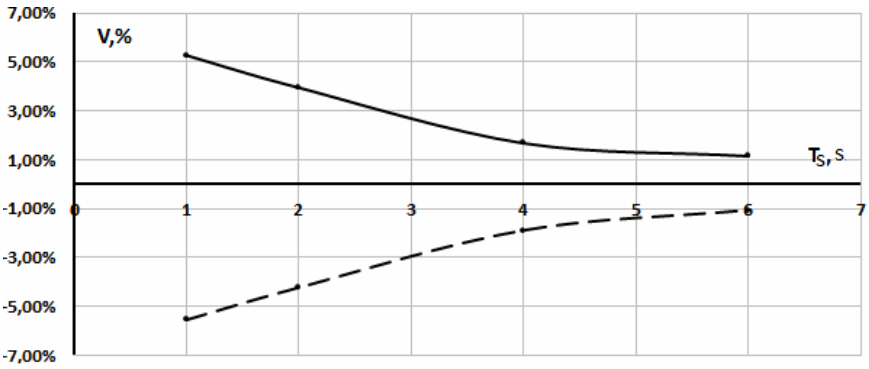

Fig. 4. Coefficient of variation of the maximum sensitivity of measuring instrument output broadband chirp signals in noise at a constant value T_s

To estimate the parameters of broadband chirp signal in conditions of high-level noise, in order to save the total evaluation time of channels of speech information leakage, it is reasonable to use 20 test signals in each band of equal intelligibility duration T_s = 4 s. This time allows keeping as a constant, reached earlier parameters by maximum sensitivity, high accuracy and fine structure of the processed measurement signal.

It has been justified, that the method of assessment of protection against leakage of speech signals through low-frequency technical channels of information leakage based on the correlation functions of broadband chirp signal for values of duration $T_s \geq$ 4 s provides the value of the maximum sensitivity and accuracy in all bands of equal intelligibility, reached earlier by method of assessing by broadband chirp signal with processing time-frequency transformation Wigner and allows to simplify the procedure for automated measurements, reducing the time of security estimation of channels of speech information leakage in 30 times.

Using a 20-broadband chirp signals, identical in duration, but with different values of the base size allows to reduce time assessment in each band of equal intelligibility more than 5 times compared with the processing time of 20 broadband chirp signals with a constant value of base and the variable value of duration time. Considering the fact, that in assessing the protection of channels of speech information leakage, the duration of the formed measuring harmonic signal in each band of equal intelligibility, is regulated T_s = 1, 10, 25 s, then the use of identical in duration (for example, T_s = 4 s) broadband chirp signals with different value of bases, allows to reduce assessment time in each band of equal intelligibility from 6 s to 20 s.

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THE INTRODUCING TO SEARCH EMPLOYEES IN SOCIAL NETWORKS

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The article represents basic principles of recruiting, advantages and disadvantages of searching employees in social networks. As a result we see the importance of the formation of a special expert system for searching empoyees.

A complex process of personnel management (which includes such components as monitoring of the organization's personnel needs, recruitment, personnel selection, release, development, evaluation and personnel certification) becomes important in modern conditions of market economy forming and economic efficiency increase of enterprises. Particular attention of companies is paid to the recruitment process, because organisation's efficiency, competitiveness and profitability at the market of goods and services depend on how efficient the organization is staffed [3].

Personnel selection should be based on the following principles [4].

- The requirements for the vacant position are necessary to be known.
- The requirements should not always be tough, characteristic similarities are often enough.
- It is necessary to avoid subjectivity in the selection (patronage or bias).

A program of personnel inspection both at the stage of selection and during the operation with staff is being worked out to ensure the personnel safety. The program includes:

- Professional selection.
- Candidates study.
- Verification of the information provided.
- Complex analysis of all the information received.
- Checking activities and psychological testing of the candidates for managing positions.
- Working out of psychological portraits of organization leaders.
- Revelation of the unsuitability of the candidates for employment for certain positions.
- Acceptance with a probation term.

Based on the above-described requirements two iterations of professional selection of the candidates can be singled out: live and distant.

Live iteration is based on direct interaction with the candidate and it is usually the final stage that includes an interview or tests.

Distant iteration is of the greatest interest for us because it includes the selection based on submitted applications and the search for the candidates.

Resources and methods are required to carry out the selection. The methods of selection are focused on its various directions and have different fitness assessment.

Among classical resources we can name labor exchanges or own database of companies, formed from a variety of sources and own experience. Their main drawback is the presence of highly specialized information, often not enough for a full analysis, besides the relevance of such data is in doubt.

In 2003 – 2004 a tendency called "social networks" started to gain popularity in society.

Social Network is an online service or a web site, intended for the construction, reflection and organization of social relationships, the visualization of which is social graphs.

The term "social network" was introduced in 1954 by a sociologist from Manchester School James Barnes in his work "Classes and Meetings in Norwegian Island Parish".

We classify social networks according to their structural and functional organization. The type of interpersonal contacts, in which a particular network specializes, can act as an attribute that uniquely affects the structural and functional organization of the network.

On this basis the following types of social networks, existing today, can be singled out.

Universal networks. They are the most popular among users. Their main function: search for people (friends, relatives, acquaintances, business partners, colleagues and even future employees) and further communication with them.

Social networks of the diary type. They are usually called blog-platforms, because the user's profile is a blog. Blog (abbr. from the English Weblog – is an online journal or diary of events) – is a regularly updated web-site.

Network specializing in objective interpersonal contacts. Objective in this context are social networks, the appearance of which does not depend on the deliberate desire of the user. Contacts can be different: between relatives (kinship networks), students (student networks), partners and colleagues (professional networks) [6].

According to the description of social networks we can concluded that they can contain any information about a person and, what is more important, timely information. It is they that are one of the main sources of information for the search and selection of the candidates in modern conditions.

A recent study, the aim of which was to find out to what extent social networks are popular with recruiters, was carried out by the portal of employment www.hh.ru in September 2010. 500 HR-specialists were surveyed. Most experts (57%) admitted that they used social networks for staff searching. However, the percentage of those who does not consider social networks as one of the ways to find employees is 43%. This is mainly due to the fact that today there other, more usual variants of recruitment. This fact is confirmed by the research results: 61% of HR-managers are quite satisfied with traditional methods of search, and therefore they do not have any need to search for staff through social networks. Each fifth of recruiters admitted that the search for employees through social networks requires much time, for which it is necessary to allocate additional resources which eventually makes such a search unprofitable. 10% of employers refused to search through social networks, because they believe that the majority of the candidates in social networks do not meet the requirements for their jobs (mainly it is the companies operating in medicine and building).

As might be expected, those employers who carry out an active search for candidates, rather than waiting for feedback from applicants, are more successful in their search. Although their number divided almost equally: 53% of employers expect activity from the candidates, 47% show it themselves [7].

Based on the aforesaid, we distinguish advantages and disadvantages of social networks as a new way of recruiting.

Advantages for employers in comparison with traditional methods are:

- The relevance of the information provided.
- Substantial money saving.
- The ability to receive the information generally not specified in the résumé: style of communication, social circle, mood, friends, hobbies, social status, family, etc.;
- The search in thematic groups, classifying the candidates according to a circle of interests;
- Special-purpose candidate search (you can search for people of certain occupations, companies, including in other cities and countries);

But at the same time this method has quite a lot of disadvantages [8]:

- The ignorance of search techniques in social networks;
- Blocking the account for non-friends or providing with the minimum information (if the person does not want to report excess information) do not allow to create a full idea about the candidate;
- Time-consuming;
- Low efficiency in certain cases (for example, the potential candidates of certain groups do not have their social network accounts);
- The need for a strategy of active search for the candidates (it is more effective than waiting for a response from the applicant).

Thus, the issue of the study consists in the definition and formalization of the requirements for the candidates for employment, the identification of required metrics in social networks, based on public data provided by the application programming interface (API), and the working out of the prototype of an expert system, which performs basic tasks: the search and analysis of the candidates for employment.

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SOFTWARE IMPLEMENTATION OF DIJKSTRA'S ALGORITHM

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Currently, there are many algorithms to find the shortest way. The most effective of them is Dijkstra's algorithm. This article is devoted to the software implementation of this algorithm and its interface design, convenient for the use of schoolchildren, students and teachers in order to quickly resolve the problem of finding the shortest way.

Navigating troubled people has long been a problem. Navigation history begins from the time of trade caravans, the development of relations between nations, military campaigns. Even at those times rough maps and routes were drawn. Navigation continued to evolve. Later, travelers started to draw maps of the whole world; maps of individual regions appeared. In the XX century science and industry began to develop actively, and it led to the emergence of artificial satellites and allowed to draw a detailed map of the earth. The most recent inventions are navigators that help a person to move in the direction of a certain point, not knowing the exact route, using the communication with the satellite. Navigators are now built into all smartphones and offer a variety of programs, allowing to determine your location and build up the desired route. Also there is a possibility of communication between users with the help of navigators, tracking traffic jams, speed, accidents and even traffic police posts. The most famous ones are «Yandex Navigator», «Navitel», «OsmAnd» and others.

Roads are a network. A network is a connected digraph without loops, the weight of each arc in which is a natural number (the capacity of the arc). The shortest path is a path with the lowest cost in passing (financial, fuel, time, ect.).

One of the algorithms for finding the shortest way is Dijkstra's algorithm. The algorithm was invented by a Dutch scientist E. Dijkstra in 1959 and is today considered one of the most efficient algorithms for finding the shortest way. The algorithm works with networks without negative weight edges (if we have a one-way road it will not take into account going in the opposite direction; it will not let you go along the opposite lane). In terms of software implementation Dijkstra's algorithm is quite simple. It needs reasonable system resources increasing the speed of the construction of the way. One disadvantage is the fact that it is not free. The algorithm is patented and its commercial use is not free of charge.

An overview of analogs of the algorithm

There are several analogs of Dijkstra's algorithm. The most popular ones are:

– Bellman-Ford's algorithm finds the shortest way from one vertex of the graph to all others in a weighted graph. Weight edges can be negative.

– The A* search algorithm finds the least wasteful route from one vertex (primary) to another (target, final) using a searching algorithm based on the first best match on the graph.

– Floyd – Warshall's algorithm finds the shortest way between all nodes of a directed weighted graph.

– Johnson's algorithm finds the shortest ways between all pairs of vertices of a directed weighted graph.

– Lee's algorithm (wave algorithm) is based on the method of widthway search. It finds the way between the vertices of the graph of **s** and **t** (**s** doesn't match **t**), contains a minimum number of intermediate vertices (ribs). Its main application is tracing the electrical connections on the crystals and chips on printed circuit boards. It is also used to find the shortest distance on the map in strategic games.

– Kildall's algorithm also finds the shortest way.

– Kosaraju's algorithm is used for finding ways in directed graphs.

All of the algorithms listed above can be used to find the shortest way, but some of them have found another use. Below we will describe each algorithm in more detail.

Bellman-Ford's algorithm is the algorithm to find the shortest way in a weighted graph. Over time O ($|V| \times |E|$) algorithm finds the shortest way from one vertex of the graph to all others. Unlike Dijkstra's algorithm, Bellman-Ford's algorithm admits edges with negative weights. It was proposed independently by Richard Bellman and Lester Ford.

The A* search algorithm in computer science and mathematics uses a best-first search and finds a least-cost way from a given initial node to one goal node (out of one or more possible goals). As A* traverses the graph, it follows a way of the lowest expected total cost or distance, keeping a sorted priority queue of alternate way segments along the way. It uses a knowledge-plus-heuristic cost function of node x (usually denoted $f(x)$) to determine the order in which the search visits nodes in the tree. The cost function is a sum of two functions:

– the past path-cost function, which is the known distance from the starting node to the current node x (usually denoted $g(x)$);

– the future path-cost function, which is an admissible "heuristic estimate" of the distance from x to the goal (usually denoted $h(x)$).

The $h(x)$ part of the $f(x)$ function must be an admissible heuristic; that is, it must not overestimate the distance to the goal. Thus, for an application like routing, $h(x)$ might represent the straight-line distance to the goal, since that is physically the smallest possible distance between any two points or nodes.

Floyd-Warshall's algorithm is a graph analysis algorithm for finding shortest ways in a weighted graph with positive or negative edge weights (but with no negative cycles) and also for finding transitive closure of a relation R. A single execution of the algorithm will find the lengths (summed weights) of the shortest ways between all pairs of vertices, though it does not return details of the ways themselves.

Johnson's algorithm is a way to find the shortest ways between all pairs of vertices in a sparse, edge weighted, directed graph. It allows some of the edge weights to be negative numbers, but no negative-weight cycles may exist. It works by using the Bellman–Ford algorithm to compute a transformation of the input graph that removes all negative weights, allowing Dijkstra's algorithm to be used on the transformed graph

If Dijkstra's nondecreasing priority queue is implemented as a Fibonacci heap, then Johnson's algorithm work is still O (V ^ 2 \ log $V + VE$). A more simple implementation of a non-decreasing priority queue time work becomes O (VE \ log V), but for sparse graphs this value in the asymptotic limit behaves better than the running time of Floyd-Warshall's algorithm.

Lee's algorithm (wave algorithm) is used in the development of printed circuit boards and is widely distributed in computer games. The problem of finding the shortest way between points A and B in the field of play with randomly placed obstacles is characterized, mostly for today's popular tactical and strategic games. As a secondary problem, it can occur in almost any games such as RPG, quests, logical games (a typical example is "Color Lines"). Why is it necessary to seek the shortest route? In some games, such as "UFO-2", "Laser Squad", the length of the route depends on the number of units of time spent. It means that the more optimal way will be found, the faster the warrior gets to the goal. But, for example, in "Color Lines", the path length is not stipulated by the rules; the only significant fact is the possibility or impossibility of moving the ball. But in this game it will be nice, if the ball goes straight to where it is shot not defiling mysteriously across the game board. The solution to this problem comes to us from a very remote area such as electronics, to be exact PCB laying out.

Kosaraju's algorithm works as follows. Let G be a directed graph and S be an empty stack. While S does not contain all vertices, choose an arbitrary vertex V not in S. Perform a depth-first search starting at V. Each time that depth-first search finishes expanding a vertex U, push U onto S. Reverse the directions of all arcs to obtain the transpose graph. While S is nonempty, pop the top vertex V from S. Perform a depth-first search starting at V in the transpose graph. The set of visited vertices will give the strongly connected component containing V; record this and remove all these vertices from the graph G and the stack S. Equivalently, breadth-first search (BFS) can be used instead of depth-first search.

Statement of the problem and the implementation of the algorithm

When writing a program for Dijkstra's algorithm implementing, we were faced with certain problems. We were looking for a prefabricated version of its implementation. But among open source software we have not found anything worthwhile but for non-working pieces of code. If we talk about finished assemblies, we have found one program working on the algorithm. However, it is impossible to give a matrix of weights there directly, only through drawing a network. Due to the lack of ready code, we wrote it ourselves using the search engine «Google» looking for certain functions and exploring some obscure points. While searching an online service was found to solve problems of Dijkstra's algorithm. Solutions are given there in detail, the matrix is set conveniently. The only drawback is the inability to work offline and no graphic representation.

At the very start a rough outline of the program was written, the so-called "pseudo", including key functions with their responsibilities and interrelations. However, in practice it turned out to be more complicated. Implementing of the algorithm itself was easy, knowing its mathematical representation. It was necessary to

simply "be translated into a programming language." At this stage, the program is a console application in which you want to set a matrix of weights (the program asks for a specific value, the user enters it), and then a starting and final points are requested and the shortest way is calculated. In the future, we plan to issue a more intuitive and simple interface, add a graphical representation of the network, add some modifications of the algorithm.

The program will be useful for pupils and students in order to understand Dijkstra's algorithm while dealing with the problem of finding the shortest way. The program is also useful for teachers to test the solutions pupils and students find quicker. Developing this project, you can get quite an interesting, useful product, besides being unique and versatile.

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APPLICATION OF FUZZY LOGIC IN MODEL OF OCCUPATIONAL RISK ASSESSMENT

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The paper discusses the use of fuzzy logic in the problem of occupational risk assessment.

Soft computing includes fuzzy logic, neural networks, probabilistic reasoning, and genetic algorithms. Today, techniques or a combination of techniques from all these areas are used to design an intelligence system. Neural networks provide algorithms for learning, classification, and optimization, whereas fuzzy logic deals with issues such as forming impressions and reasoning on a semantic or linguistic level.

Fuzzy logic was initiated in 1965 [1] by Lotfi A. Zadeh, professor for computer science at the University of California in Berkeley. Basically, fuzzy logic is a multivalued logic that allows intermediate values to be defined between conventional evaluations like true/false, yes/no, high/low, etc. Notions like rather tall or very fast can be formulated mathematically and processed by computers, in order to apply a more human-like way of thinking in the programming of computers [2].

In 1993 Kosko (Kosko) proved a theorem on fuzzy approximation (FAT – Fuzzy Approximation Theorem) [3], which states that any mathematical system can be approximated by a system of fuzzy logic. Therefore, using natural language rules "If – then" followed by their formalization by means of the theory of fuzzy sets can be any arbitrary accurately reflect the relationship "Input Output" without the use of complex apparatus of differential and integral calculus, traditionally used in the management and identification.

Fuzzy logic has emerged as a profitable tool for the controlling and steering of systems and complex industrial processes, as well as for household and entertainment electronics, as well as for other expert systems and applications like occupational risk assessment.

In the real world, vagueness and ambiguity exist because of the limitations of our language and other factors, such as context and perception. Closely related to this ambiguity is the question of lexical imprecision in natural language; when expressing knowledge, individuals would rather use words than numbers.

Occupational risk assessment deals with uncertain situations, that is, situations in which we do not have complete and accurate knowledge about the system state, such as estimate severity consequences of occupational accidents.

Additionally, legal records, statistical data and site documentation produced by companies are generally insufficient for determining risks. On-site inspections generally use linguistic expressions rather than metrics to assess the safety risks. These facts increase the imprecision and inaccuracies of the occupational risk assessment process, and this imprecision is the reason why we use a fuzzy approach.

For systems in which imprecise and inaccurate information is available, fuzzy concepts and techniques provide suitable ways to collect observed input data and represent it in a uniform and scalable way. Fuzzy sets seem to be quite relevant in three classes of applications: classification and data analysis, reasoning under uncertainty, and decision-making problems.

In our work, we use the lattermost application of decision making because it will allow the combination of all risk factors using aggregation operators to define a general level of risk assessment.

A fuzzy inference system (FIS) essentially defines a nonlinear mapping of the input data vector into a scalar output, using fuzzy rules. The mapping process involves input/output membership functions, FL operators, fuzzy if – then rules, aggregation of output sets, and defuzzification.

The FIS contains four components: the fuzzifier, inference engine, rule base, and defuzzifier. The rule base contains linguistic rules that are provided by experts. It is also possible to extract rules from numeric data. Once the rules have been established, the FIS can be viewed as a system that maps an input vector to an output vector. The fuzzifier maps input numbers into corresponding fuzzy memberships. This is required in order to

activate rules that are in terms of linguistic variables. The fuzzifier takes input values and determines the degree to which they belong to each of the fuzzy sets via membership functions. The inference engine defines mapping from input fuzzy sets into output fuzzy sets. It determines the degree to which the antecedent is satisfied for each rule. If the antecedent of a given rule has more than one clause, fuzzy operators are applied to obtain one number that represents the result of the antecedent for that rule. It is possible that one or more rules may fire at the same time. Outputs for all rules are then aggregated. During aggregation, fuzzy sets that represent the output of each rule are combined into a single fuzzy set. The defuzzifier maps output fuzzy sets into a crisp number. Several methods for defuzzification are used in practice, including the centroid, maximum, mean of maxima, height, and modified height defuzzifier. The most popular defuzzification method is the centroid, which calculates and returns the center of gravity of the aggregated fuzzy set. FISs employ rules. However, unlike rules in conventional expert systems, a fuzzy rule localizes a region of space along the function surface instead of isolating a point on the surface. Also, in an FIS, multiple regions are combined in the output space to produce a composite region. A general schematic of an FIS is shown in Figure.

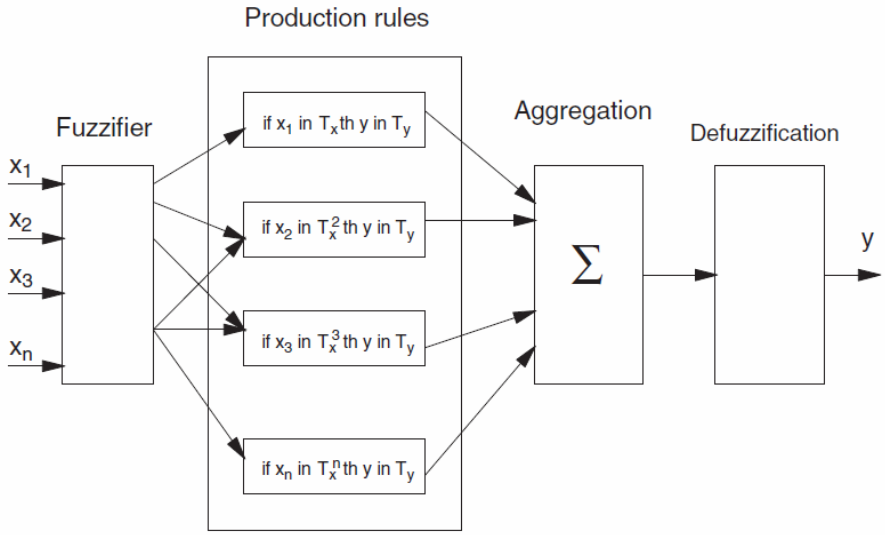

Fig. Schematic diagram of a fuzzy inference system

The fuzzy model includes three fuzzy inference systems FS_1, FS_2 and FS_3 [4].

Input variables of the first fuzzy inference system: the probability (frequency) of hazard (P_i), which considers prescription of accident (K_i), severity of the consequences of hazards influence (S_i) and the duration of hazards exposure (D_i). An output variable of the first fuzzy inference system is a level of occupational risk ($R_{ОПФi}$), which caused by unsafe hazard. The level of occupational risk is used as a basis for making a decision about the necessity of risk management actions.

Two variables are accepted in second fuzzy inference system: class working conditions – ($КУТ_i$) and relative risk ($ОР_j$) for a certain class of diseases. The result of the fuzzy inference system is the second linguistic variable – "professional risk of effect of occupational hazard" ($R_{ВПФi}$).

The first variable of third fuzzy inference system – is hazard index ($ИВ_k$) for definite profession or to the structural subdivision. The second variable FS_3 is number of temporary disability for all illness per 100 employees ($ЗВУТ_k$). An output variable of third fuzzy inference system is "an occupational risk of complex effect of hazards" ($R_{ВПФk}$).

According to the results, employees of following subdivisions are exposed to high level risk of complex influence work environment: tankage facilities, base equipment and repair department. It is necessary to develop preventive control solutions to reduce risk.

The main advantage of using fuzzy logic in our modeling compared with other mathematical modeling techniques is the easy representation and manipulation of empirical knowledge about ill-defined concepts.

Application of the proposed fuzzy model of occupational risk assessment for health workers at oil refinery would prejudge adequate administrative decisions on elimination or limitation impact factors of production in the face of uncertainty as a result improve the quality of functioning of occupational safety management systems.

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ON THE PROPERTY OF PARTIAL UNIFORM GLOBAL ATTAINABILITY OF LINEAR CONTROL SYSTEMS

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In this paper we consider the problem of global Lyapunov reducibility of linear differential systems and shows the main results available to solve this problem. With entered our concept of partial uniform global attainability, we obtain a solution of this problem for three-dimensional systems with discontinuous and rapidly varying coefficients.

Consider a linear non-stationary control system

$$\dot{x} = A(t)x + B(t)u, \quad x \in \mathbb{R}^n, \quad u \in \mathbb{R}^m, \quad t \geqslant 0, \tag{1}$$

with locally integrable and integrally bounded matrix coefficients A and B. Closing the system (1) with the control defined in the form of a linear feedback

$$u = U(t)x, \tag{2}$$

where U is a measurable and bounded $(m \times n)$ – matrix, we obtain a closed system

$$\dot{x} = (A(t) + B(t)U(t))x, \quad x \in \mathbb{R}^n, \quad t \geqslant 0, \tag{3}$$

coefficients are also locally integrable and integrally bounded. Along with (3) we also consider an arbitrary system

$$\dot{z} = C(t)z, \quad z \in \mathbb{R}^n, \quad t \geqslant 0, \tag{4}$$

with measurable integrally bounded matrix coefficients C.

The problem of global Lyapunov reducibility of linear system (3) is to construct for a system (1) a measurable and bounded control (2) that the linear system (3), closed this control will be asymptotically equivalent [1, c. 56 - 57] to system (4). This means [1, c. 57 - 58] that there will be a linear transformation relating system (3) and (4)

$$x = L(t)z,$$

matrix which satisfies

$$\sup_{t \geqslant 0}(\| L(t) \| + \| \dot{L}(t) \| + \| L^{-1}(t) \|) < \infty.$$

There $\| \cdot \|$ – is spectral (operator) norm of matrices [2, c. 355], i.e. matrix norm induced by the Euclidean norm.

The problem of global Lyapunov reducibility was formulated [3] by representatives of the Izhevsk school of mathematics Tonkov E.L. and Zaitsev V.A. in the early 90th years of the 20th century. Professor Tonkov E.L. proposed to seek a solution to this problem assuming uniform complete controllability of system (1).

Definition 1 [3, 4]. The system (1) is *uniformly completely controllable* if there are numbers $\sigma > 0, \quad \gamma > 0,$ that for any $t_0 \geqslant 0$ and $x_0 \in \mathbb{R}^n$ in interval $[t_0, t_0 + \sigma]$ there is a measurable and bounded control u at all $t \in [t_0, t_0 + \sigma]$ satisfying the inequality $\| u(t) \| \leqslant \gamma \| x_0 \|$ and transforming the vector of the initial condition $x(t_0) = x_0$ of the system (1) to zero on this interval.

In 1999, using this approach by Professors Makarov E.K. and Popova S.N. has been proved [5] global Lyapunov reducibility of a two-dimensional system (3) with piecewise continuous and bounded coefficients in the case of piecewise uniform continuity of the matrix B.

Definition 2 [6]. Let M_{nm} is space of real $n\times m$ matrices with spectral (operator) norm; then the matrix function $B:[0,+\infty)\to M_{nm}$ *piecewise uniformly continuous* on the positive semiaxis, if it satisfies the following conditions:

1) the function B is piecewise continuous and bounded on the positive semiaxis;

2) there exists a number $\Delta > 0$, that the length of each interval of continuity I_j $(j\in J\subset\mathbb{N})$ of the function B satisfies the inequality $|I_j|\geq\Delta$;

3) for any $\varepsilon > 0$ there exists such $\delta=\delta(\varepsilon) > 0$, that for each $j\in J$ and for all $t,s\in I_j$, satisfying the inequality $|t-s|\leqslant\delta$, the relation $\|B(t)-B(s)\|\leqslant\varepsilon$. is true.

Remark. In view of Definition 2, the system (1) with a piecewise uniformly continuous matrix of the control can be called slowly varying systems.

Later, on the basis of the results of [5] Popova S.N. shown [6] that for n-dimensional ω-periodic system (1) (which obviously is a slowly varying system) uniform complete controllability is sufficient for the global Lyapunov reducibility of the corresponding a closed system (3).

It should also be noted that in solving the problem of global Lyapunov reducibility [1, 3, 5-7] by classics condition piecewise uniform continuity of the matrix B plays an important role. The refusal of this condition leads to unlimited growth of the desired control $U(t)$ for $t\to\infty$, but this is unacceptable on the basis of formulation of the problem. In this connection there is the question of transferring the results obtained by the classics on the system (3) with discontinuous and rapidly oscillating coefficients, i.e. solution to the problem of the global Lyapunov reducibility for systems (3) with locally integrable and integrally bounded coefficients.

We also note that problem of global Lyapunov reducibility of linear system (3) is a generalization of the problem of global control Lyapunov's exponents [3] of this system, which is responsible for its asymptotic stability, i.e. availability of the system (3) property of the global Lyapunov reducibility is a sufficient condition for global controllability of Lyapunov characteristic exponents of the system. In the turn generalization of the global Lyapunov reducibility of (3) is the problem of uniform global reachability [7].

Definition 3. [7]. Let $M_n := M_{nn}$. For any $r\geqslant 1$ we denote the set of matrices $G(r) := \{H\in M_n : \det H\geqslant 1/r, \|H\| < r\}$.

The system (3) is called *uniformly globally attainable*, if for some $T > 0$ for any $r\geqslant 1$ there exists a number $d = d(r) > 0$, that for each matrix $H\in G(r)$ and random $t_0\geqslant 0$ in the interval $[t_0, t_0+T]$ there exists a piecewise continuous and bounded control U, satisfying $\|U\|\leqslant d$ for all $t\in[t_0, t_0+T]$ in which for the Cauchy matrix $X_U(t,s)$, $t,s\geqslant 0$ of the system (3) with this control is provided equality $X_U(t_0+T,t_0) = H$.

Individual results for solving the problem of uniform global attainability were obtained by V.A. Zaitsev [7], E.K. Makarov and S.N. Popova [5]. However, the general solution of this problem to date has been found.

It is known [7] that the presence of the system (3) properties of uniform global attainability is a sufficient condition for its global Lyapunov reducibility. In this study, we found that for three-dimensional systems a sufficient condition for the global Lyapunov reducibility is a weaker condition than the uniform global attainability – availability of the system (3) properties of partial uniform global attainability.

Definition 4. The system (3) is *partially uniformly globally attainable set of matrices* $G(r)$ *with respect to subsets* $\mathfrak{F}\subseteq GL_n(\mathbb{R})$ *of non-singular square* $(n\times n)$ *- matrices*, if for some $T > 0$ at all $r\geqslant 1$ and $t_0\geqslant 0$ there exists a matrix $F\in\mathfrak{F}$, that for any matrix $H\in G(r)$ there is a number $d = d(r) > 0$ and a control U, satisfying the inequality $\|U\|\leqslant d$ for all $t\in[t_0, t_0+T]$, which for the Cauchy matrix $X_U(t,s)$, $t,s\geqslant 0$ of the system (3) with this control satisfies $X_U(t_0+T,t_0) = FHF^{-1}$.

Definition 5. Let $G_\Delta(r)$ is the set of upper triangular matrices of $G(r)$. Then the system (3) is *partially uniformly globally attainable* if it is partially uniformly globally attainable set $G_\Delta(r)$ with respect to a plurality of orthogonal $(n\times n)$ - matrices $O(n)$.

Thus we proved

Theorem 1. *Let* $n = 3$, $m\in\{1,2,3\}$. *If the system (3) with locally integrable and integrally bounded coefficients partially uniformly globally attainable, then it is globally Lyapunov reducible.*

Also, we found that the property of uniform complete controllability of system (1), in turn, is a sufficient condition for the partial uniform global attainability of the corresponding closed system (3), i.e. proved

Theorem 2. *Let* $n = 3$, $m \in \{1,2,3\}$. *If the system (1) with locally integrable and integrally bounded coefficients uniformly completely controllable, then the system (3) has the property of partial uniform global attainability.*

From theorems 1 and 2, the main result of this work

Theorem 3. *Let* $n = 3$, $m \in \{1,2,3\}$. *If the system (1) with locally integrable and integrally bounded coefficients are uniformly completely controllable, the corresponding closed system (3) is globally Lyapunov reducible.*

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UDC 621.396.13

PULSE MODULATION FOR ULTRA-WIDEBAND COMMUNICATION SYSTEMS

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The basic types of pulse modulation used for ultra-wideband communication systems are considered. The interactions between a modulated signal and additive white Gaussian noise are analyzed. The most noiseproof and optimum types of modulation for practical implementation are defined.

The fundamental direction is to increase the channel capacity for wireless telecommunication systems. Data transmission rate is proportional to the width of signal spectrum. So, for example, sufficient channel bandwidth makes 8 kHz for a voice signal, 180 kHz for high-quality transmission of music, 5 MHz for video [1]. The ideal case is to have a universal communication channel which can be used to transmit any kind of information, which implies a large bandwidth. Channel transmission ultra-wideband (UWB) communication systems or "impulse radio" has a similar property.

Information transfer in UWB communication systems is carried out by means of short pulses of sub-nanosecond duration. One of the major advantages of UWB systems is the lack of direct interference signal propagating with his reflections on various objects. Short pulses extend through different obstacles, because attenuation happens not in the entire range. UWB systems can operate with low average total transmit power due to the high effective gain, so these systems do not interfere with other wireless devices operating in the same band. Since the energy of the UWB signal is distributed in a wide range, the task of detection and interception becomes almost impossible. [2]

For the "mpulse radio" can be used various types of modulation: PPM, PAM, OOK, BPSK [3-4]. Therefore, the organization of UWB communication system appears task of choosing the optimal type of pulse modulation. The solution must satisfy the following conditions:

- high noise immunity;
- ease of implementation of the modulating demodulation equipment;
- high data rate.

In the case of Pulse Position Modulation (PPM) a logical "1" and a logical "0" encoded different positions relative to the reference pulse (Fig. 1 (*a*)). On-Off Keying (OOK) implies the presence of short pulses at "1" and their absence at "0" (Fig. 1 (*b*)). In case of Pulse Amplitude Modulation (PAM) "1" and "0" coded varying amplitude of ultra-short pulses (Fig.1 (*c*)). In the case of Binary Phase Shift Keying (BPSK) a logical "0" and a logical "1" corresponds to a certain phase of the pulse: 0^0 or 180^0 (Fig. 1 (*d*)) [4].

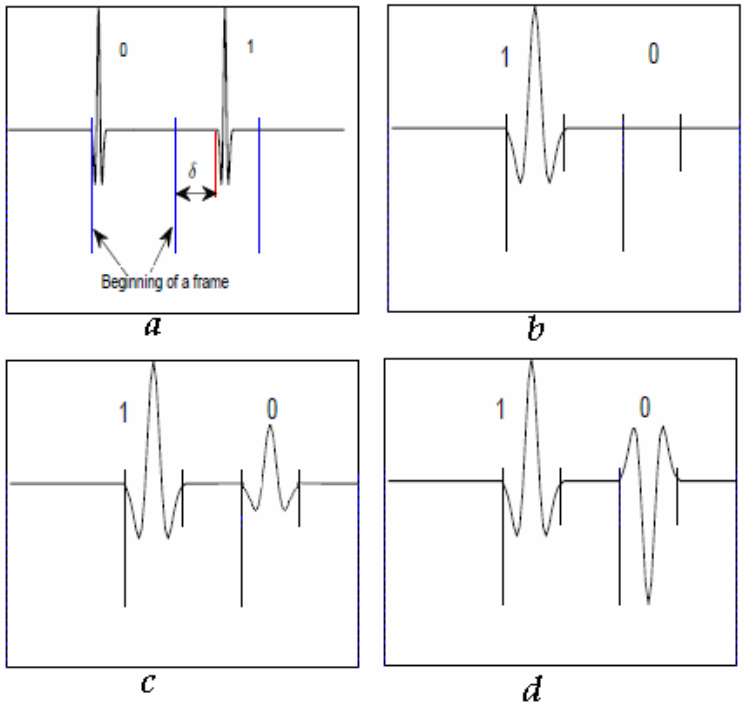


Fig. 1. Types pulse modulation: PPM (*a*), OOK (*b*), PAM (*c*), BPSK (*d*)

The noise affects the signal in the communication channel. The noise type can be different: RF interference, atmospheric noise, thermal noise of the receiver caused by the Brownian agitation. These effects can be described by additive white Gaussian noise. Stability of the transmitted signal to noise ratio is estimated as a function of bit error rate on the receiving side on the ratio of signal to noise in the channel.

For analysis effects of noise on the information UWB signal is used software environment «Matlab», in which by means of «Simulink» created a model of UWB data transmission systems. The structure of the model is shown in Fig. 2.

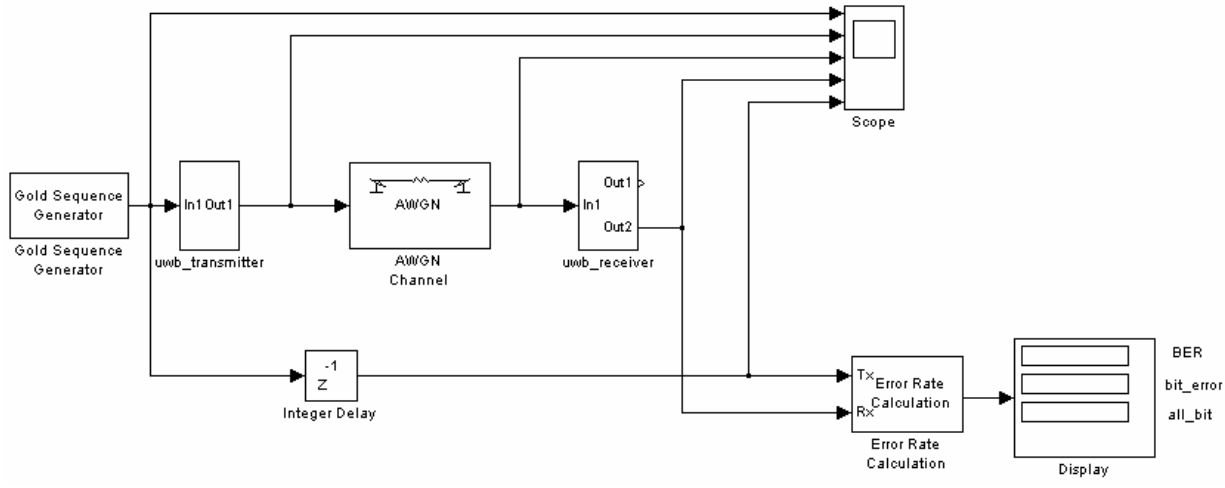


Fig. 2 Model UWB communication system

Block "Gold Sequence Generator" is the source of the transmitted data and represents a Gold code generator. In the blocks "uwb_transmitter" and "uwb_receiver" implemented UWB transmitter and UWB receiver respectively. By means of the block "Error Rate Calculation" with block "Error Rate Calculation" are calculated total number of bits transmitted (all_bit), the number of erroneous bits in the receiver (bit_error) and bit error rate (BER). The calculation results are displayed on the display. Simulation of transmission channel with additive white gaussian noise is carried out by means of the unit "AWGN Channel", where the desired signal is added to the white noise. The variance of noise is described by the equation (1) [5]:

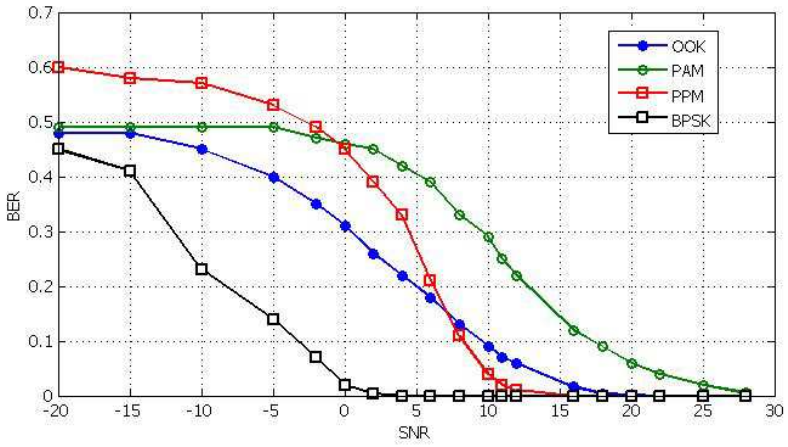
$$\text{NoiseVariance} = \frac{(\text{SignalPower} \times \text{SymbolPeriod})}{(SampleTime \times 10^{\frac{Es/N_0}{10}})}. \quad (1)$$

The probability-density function of Gaussian noise described by the equation (2):

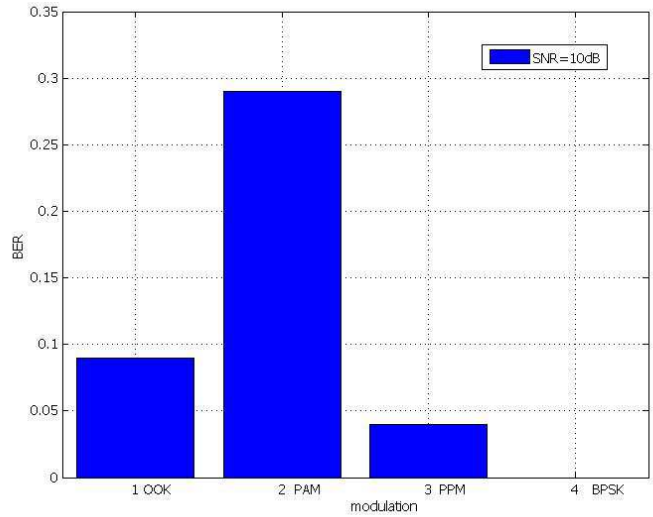
$$p(t) = \frac{1}{\sqrt{2\pi\alpha_u}e^{-\frac{(u-u\cap)^2}{2p_u^2}}}. \quad (2)$$

As the receiver is used strobe receiver model. Amplification of UWB signals in the stroboscopic receiver is provided due to the accumulation of received pulses at a certain time delay. It is known that the signal-noise ratio is proportional to the square root of the average number of pulses (assuming Poisson statistical distribution) [6]. Therefore, all dependencies are removed for the same number of pulses accumulation. The simulation results are summarized in the graph, and shown in Fig. 3 (*a*).

As seen from the graph in Fig. 3 (*b*) the highest noise immunity for the signal-to-noise ratio 10 dB has a system with BPSK keying, and the least – with PAM modulation. The PPM system is second with respect to noise immunity, but has an advantage before BPSK system relatively the complexity of the technical realization. Besides using PPM system becomes possible of coding one pulse delay directly of a combinations symbol that as a result, increase the speed of data rate.



a



b

Fig. 3. The dependence of the bit error rate of the signal to noise ratio in the channel at different modulation types (*a*), the dependence of the bit error rate for the signal-to-noise ratio in the channel equal to 10 dB for different types of modulation

For the implementation of UWB communication system optimal type of pulse modulation will be PPM modulation, considering analysis results of noise immunity of a signal and a condition of simplicity of a technical implementation of system. The use of modern PLDs allows creating a flexible structure of the modulator / demodulator. To achieve optimum sensitivity of the receiver can be varied the number of pulses accumulation while adhering to the specified data rate. The classical approach of coding logical "0" and logical "1" different pulse delay can be replaced with coding single delay directly a certain bit pattern, which will increase the capacity of the channel.

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THE DEVELOPMENT OF THE INFORMATIONAL AND EDUCATIONAL ENVIRONMENT BASED ON GOOGLE APPS FOR EDUCATION

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The article is devoted to the establishment of educational environment based on the platform Google Apps for Education, which would facilitate the work of students and teachers in higher education institutions, as well as enhance study progress control.

High-quality training at university is not possible without study progress control throughout each semester. An effective system of study progress control allows assessing not only each student's implementation of the curriculum at university, but also helps to evaluate the quality of ongoing educational programs, to draw attention to the difficulties students encounter in their studies, and to obtain certain indicators of effective teaching.

If we consider the fact that the 21st century is a century of information technology, it becomes clear that modern information technology can be reasonably used for study progress control at university. For example, you can use cloud services to store electronic registers that can be accessed and searched in an easier way in comparison with paper registers and numerous archives.

Thus, an idea to develop a system that would help to facilitate lecturer's work in relation to study progress control has appeared.

The modern system of university education is gradually adapting the rating system of academic progress assessment. **The rating system of academic progress assessment** is a set of organizational, educational and control measures, based on all sorts of didactic resources available for this or that subject.

Taking into account what has been said above, the establishment of the electronic environment able to control the learning process of students becomes of current importance. Moreover, it can be helpful in final evaluation of students' academic progress together with the rating system.

Since March 2012, Polotsk State University has been developing informational and educational environment based on Google Apps for Education. Since August 2014, this medium was supplemented with a new service – **Goggle Classroom**.

Google class helps teachers save time by organize classes quickly and easily and communicating effectively with students. It allows teachers to create and maintain a task quickly, assign grades, leave comments and communicate with students. In turn, students can keep a job to Google Drive and take the work performed in the classroom and to communicate directly with each other and with teachers.

Creation and submission of assignments

In class, you can work with Google Docs, Google Turn and Gmail. Because of this, teachers can assign tasks and collect works, forgetting about piles of notebooks. They will also be able to see at a glance who has submitted or delayed the assignment and comment on the work individually in real time.

Effective communication

Teachers can make announcements, ask questions and comment in real time. Communication with students during class and after class has never been so effective.

Convenient organization of work

A class is automatically created on the disk folder for each assignment and each student, and students can always see what tasks they need to perform on the following page [5].

The aim of our work is the refinement of Google Classroom functions and adding the following new features to them:

- uploading the results of students' work on the server;
- development of a universal system of settings to work with Google Classroom;
- development of a system of students' knowledge testing.

One of the main tasks of the developed system will be the storing of students' academic progress, so the system is a kind of data storage. Naturally, the system is primarily designed to facilitate the work of the teacher. Google provides the possibility of using their cloud services and applications.

Cloud storage is a kind of online storage where data is stored on multiple servers distributed on the network provided for the use of customers, mainly by a third party. In contrast to another kind of data storage based on its own servers, purchased or leased specifically for such purposes, the number or any internal structure of the servers is not generally visible to a client. The data is stored and processed in a so-called cloud that represents, from the point of view of a client, one large virtual server. Physically, these servers can be located remotely from each other geographically, even on different continents [3].

Naturally, the question of creating such information environment rests on the development of a web application, which is an important issue, since in this case it will be necessary to use third-party libraries from Google and adjust to their standard building web applications.

Web Application Development is the process of creating web pages or sites. Web pages are created using HTML, CSS and JavaScript, they can contain simple text and graphics, recalling a static document. Pages can be interactive or static. Creating interactive pages is a little more complicated, but they allow you to create websites with rich contents. Today, most of the pages are interactive and provide advanced interactive services, such as dynamic visualization or display of difficult structure data [4].

Web application development is carried out using specialized programming languages.

The most common programming languages for writing Web applications are:

- PHP.
- C #.
- Python.
- Java.
- JavaScript [1].

JavaScript is commonly used as an embedded language for programming access to the application sites. Is is most widely used in web browsers as a scripting language to make interactive web pages [2].

It should be noted that libraries that Google has opened for individual completion of their applications require the use of Javascript precisely, so based on that fact and on our own experience and knowledge, Javascript will be used as the task language.

Thus, the modification of the service Google Classroom and the use of Google cloud storage will allow us:

- to improve the quality of education due to the intensification of the educational process, the revitalization of the faculty members and students to maintain and improve the content and teaching methods;
- to strengthen regular monitoring of students' work during the development of the basic educational program in the specialty (direction);
- to increase the motivation of students to the development of educational programs;
- to strengthen the discipline of students;
- to improve student attendance of classes;
- to strengthen independent and individual work of students.

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SCHEMATIC ASPECTS OF PROCESSING BLOCKS OF INFORMATION IN THE ALARM SYSTEM

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The operation principle of a standard alarm system is considered. The block diagram of the alarm system is defined A6-04. The schematics analysis of the main components of this system is given. The ways to improve modern alarm systems are shown.

Now automatic systems of protection are gaining an increasing popularity. The development of automatic protection systems is connected with the fact that every year the requirements of mankind grow and the cost of property increases. In addition, everyone wants to protect their property. The first systems of protection were invented in Ancient Egypt and Japan and had nothing in common with present security systems. Let's consider some outstanding inventions which laid the foundation of modern alarm systems. The first and most important invention was electric current and devices related to it. Thanks to electricity people got an opportunity to transfer information to considerable distances in seconds. Another invention was the creation of a photo cell which could distinguish violators in a zone of protection and switch on the alarm. Then sensors of various physical quantities were invented. They were incorporated in alarm systems improving their functionality. A standard security system includes the following set of sensors:

- motion sensors (IR sensors detect the infrared radiation emitted or reflected from an object, if no motion is being detected, the relay contact is closed, if motion is detected, the relay opens, triggering the alarm; ultrasonic sensors generate high frequency sound waves and evaluate the echo which is received back by the sensor, measuring the time interval between sending the signal and receiving the echo to determine the distance to an object; microwave sensors);
- glass break sensors (acoustic sensors);
- automatic door open/close sensors (such sensors use galvanomagnetic converters or magnetically operated sealed switches);
- smoke detectors;

Modern security systems can also include sets of other sensors if needed. Modern protection systems differ in the quantity of protected zones, system control flexibility, ergonomics. Security systems use wireless data channels, for example GSM, GPRS, radio link, Wi-Fi. However Wi-Fi channel is used only in home security systems as it allows to manage the security system by means of the smartphone. Thus, alarm systems are widely used in industrial enterprises, offices, shops, public institutions and organizations, and also in private houses – "smart home" systems.Let's analyze the block diagram (figure 1) that shows A6-04 alarm system and schematics features of the data processing block.

A signal from sensors goes to the sensing control block from which it is transferred to the information processing block. The information processing block makes calculations and forms output signals which go to the block of the formation of the notification. The information processing block also arm and disarm the security system, activate light and sound signals in case of intrusion. The block of the formation of the notification generates signals of various levels, both analog, and digital, as these signals go on various devices (for example

calls, buzzers and blocks of the secondary signaling – GSM modules). The specialized power unit feeds the system. There is also an emergency power accumulator which is built into the alarm system.

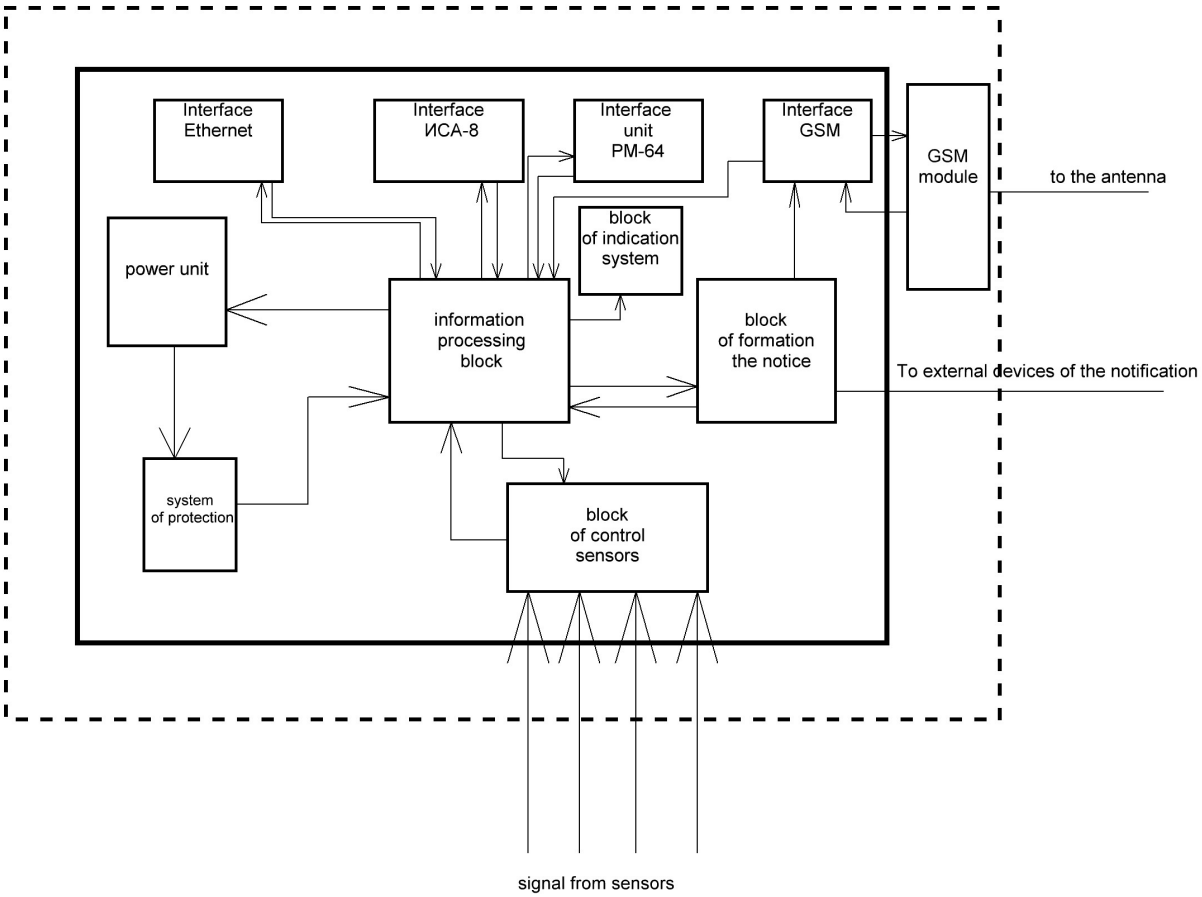

Fig. 1. Block diagram of the information block of processing system of the alarm system

In the diagram there is also a set of interfaces to communicate with various control units. Let's consider each of them. Interface PM-64 represents the interface system which connects the control and measuring (adjustment) panel to the information block. It transfers the security system into different modes. In fig. 2 [3] this panel is presented.

Fig. 2. Control panel

The module of coordination IF-ETHERNET creates distributed systems and transmits data within the local Ethernet network by means of the TCP/IP or UDP protocols [2]. Interface ИСА-8 allows contacting the owner of the security alarm system via the telephone line.

Thus, it is possible to allocate some main units that need updating:

– Information processing block;
– Block of the formation of the notification;
– Sensing control block.

We will consider in more detail the information processing block. Microcontroller ATmega 8 is used to increase of the speed as it is functional, flexible and convenient in use. A couple of registers are connected to the microcontroller to simplify processing and communication with other devices. In the information block there is a

memory chip to store command signals coming from various sources, for example, programming can be carried out by means of PR-1 panel, the command-driven panel or specialized programming units. Thus, due to microcontroller ATmega 8 the delay of signals has been reduced. However, to increase signal processing speed we need to update the program part of the block. The diagram of the information processing block is given in figure 3.

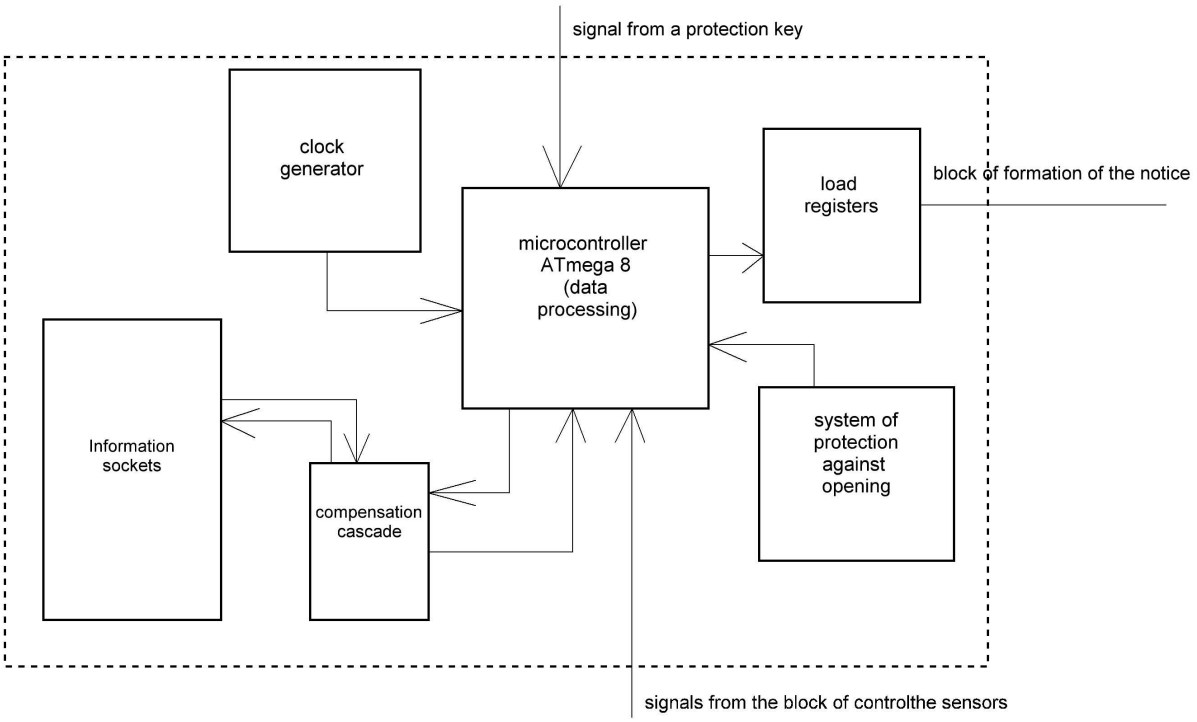

Fig. 3. Block diagram of the module of information processing

The sensing control block represents a set of sockets to which alarm wires from various sensors are connected. It also includes a set of various intensifying devices and proofreaders for noise elimination in a signal. Due to the use of intensifying and correcting cascades it is possible to increase the functionality of the whole system. In the given alarm system there are three sensors, two of which (a motion sensor and a glass break sensor) need strengthening and correcting of an output signal. The schemes of the corresponding intensifying cascades are given in fig. 4, 5.

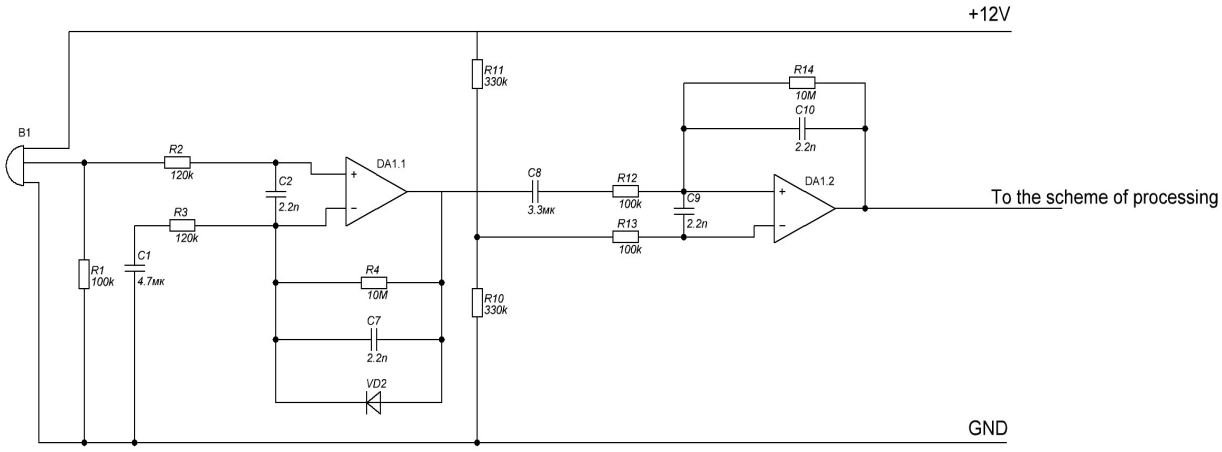

Fig. 4. Electric circuit of strengthening of the motion sensor [6]

To improve the characteristics we choose precision (measuring) operational amplifiers which give both noise reduction and stabilization of the sensor and a sensitive element. Stabilization of sensor parameters normally requires about 5 seconds, however if we apply operational amplifiers LM2904 and OPA2348, this time decreases to 0,5 – 1 seconds. It should be noted that these operational amplifiers have an essential shortcoming – they are extremely sensitive to static electricity which makes them very vulnerable. To overcome this lack it is necessary to cover the chips of amplifiers with antistatic varnish.

The block of the formation of the notification is responsible for signals which will notify in case of break-in. The studied system has a set of channels for the notification. These schemes represent DAC or ADC which form a certain signal at the exit. In the studied alarm system there is a GSM module, so it is also necessary to form a certain signal (inquiry) for it. In the studied system the formation block is constructed on the principle of consecutive approach that gives the chance to establish a good compromise between speed and accuracy.

Security systems must be able to resist to breaking and bypassing the system. For this purpose information security methods are used. In the given alarm system special registers for storage of protection requisites are used (passwords, codes, etc.). It also includes special schemes which interrupt information transfer in communication lines at emergency situations.

To increase protection against electromagnetic fields it is necessary to use screens from materials with high electric conductivity (for example, steel, copper, aluminum, brass). They are in the form of sheets not less than 0,5 mm thick or a grid with cells no more than 4 x 4 mm.

Notification channels are an important part of the alarm system. They include sound, light and information systems of notification. The GSM system has become very popular recently as they are simple to use. In the studied system the GSM module is also installed. The block diagram of the GSM module is submitted in figure 6.

The control element of the device is the ATmega 168 microcontroller of the Atmel company [4]. The signal of violation of the mode of safety goes from the block of formation of the notification to the GSM module. Then a text message is sent by the SIM900 module. This GSM module is connected to the main payment of the alarm system by means of the XP4 socket [2].

GSM modules have a number of shortcomings concerning information security:

– active attacks (the GSM equipment can be exposed to attacks of the equipment imitating the work of base stations);
– impossibility to determine the reliability of data;
– weak enciphering algorithms.

Thus, the local Interface of the GSM module and the area of data transmission to a base station are not properly protected. In fig. 7 the block diagram of data transmission on the GSM channel with designations of security of areas is submitted.

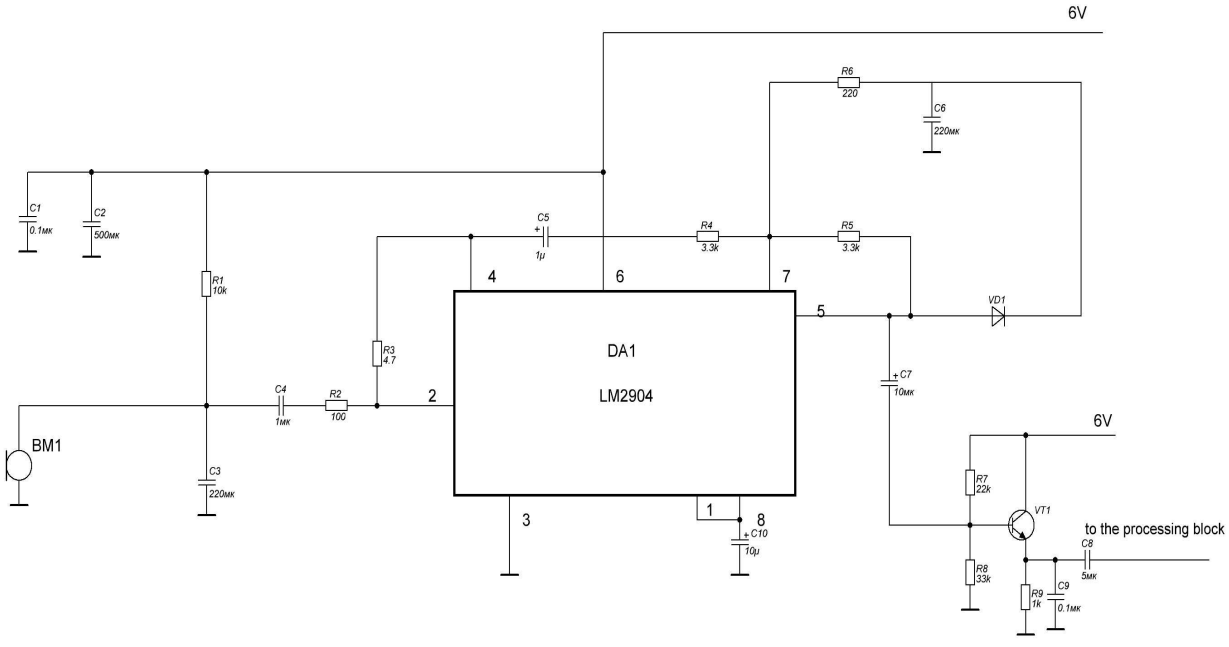

Fig. 5. Electric circuit of the sensor of breaking glass

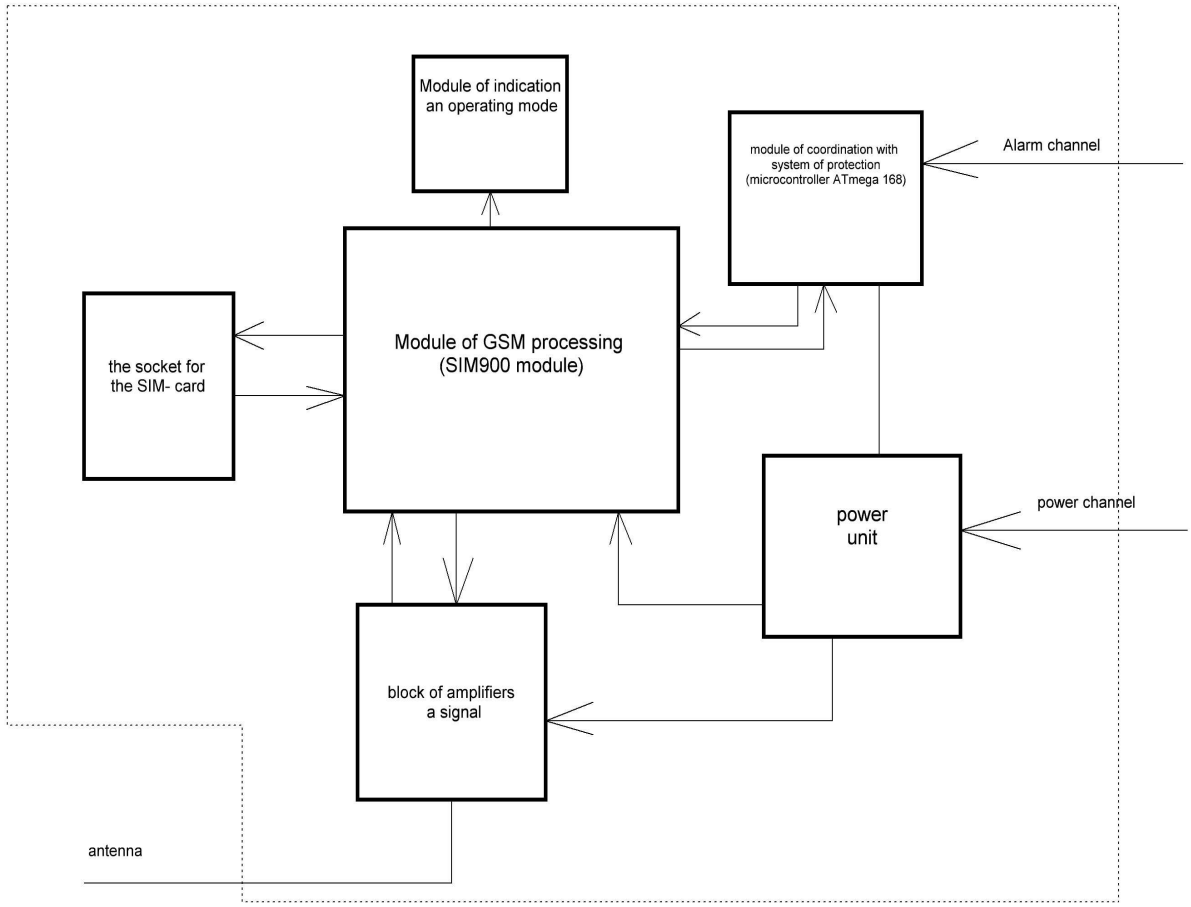

Fig. 6. GSM module electric circuit

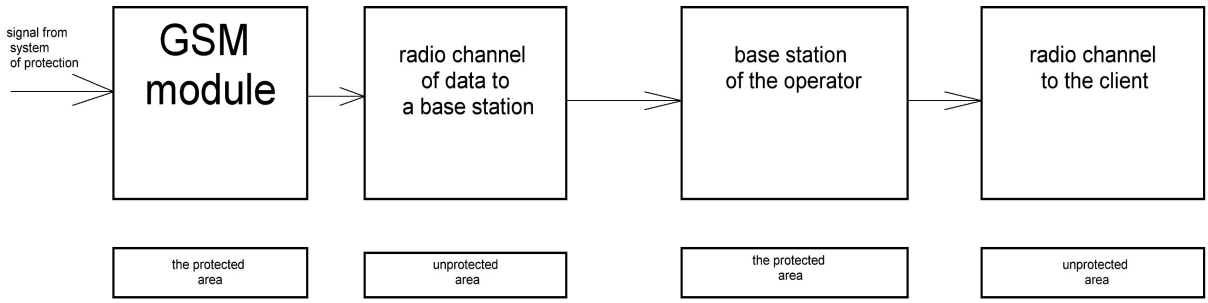

Fig. 7. Data Transmission Process

One of the most widespread methods of increasing protection is the use of the SSL protocol. The SSL protocol is the cryptographic protocol providing safe data transmission on a network. Certain SSL tunnels which provide protection against encroachments [5] are created. And as a result we get the system presented in fig. 8.

Thus, the only unprotected channel is a communication channel from a base station to the client. However SSL – enciphering can be used here. To do this it is necessary to address a telecom operator and connect this function.

GSM modules are constantly improving and their functionality is increasing. It is possible to manage the whole security system via the GSM-channel. As a result we get the dual transfer and reception channel. However to connect this function we need both hardware and software means which makes the device more complex. In the studied module we can get such a dual channel, but we need additional software for the SIM module.

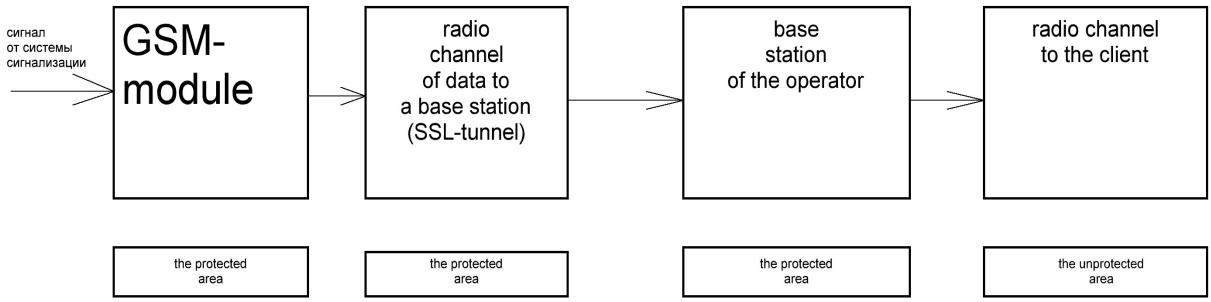

Fig. 8. SSL enciphering

Let's consider GSM modules on J2ME. Java ME (J2ME) is a powerful built-in platform intended for mobile devices and security systems. It allows expanding functionality of GSM modules. Its advantages are the following:

– high level of safety and security of the system according to certificates of X.509;
– built-in debugging facilities;
– high stability, lack of system resets;
– means of difficulty of perception of a code.

Developers can build in the GSM module appendices on the JAVA platform with several peripheral interfaces [6].

In summary let's mention some of the problems which developers of security systems should solve to increase reliability and to reduce unauthorized access to the protected perimeter. Further development of security systems (including the studied A6-04 system) needs more modern and functional element base. Then full microprocessor information processing will be possible. It, in turn, will allow using more modern algorithms of signal processing.

One more important moment is energy consumption reduction. A big problem for security systems is autonomy, i.e. independence of power supplies. It is necessary to look for alternative sources of electric energy more carefully. It is necessary to avoid the breakings connected with loss of electric energy from a network.

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UDC 681.5

PAYMENT RECEIPTS IMAGE PROCESSING FOR DATA INPUT AUTOMATION WITH MOBILE DEVICES

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In this paper we propose an approach for payment receipts image processing obtained from the camera mobile devices. The main steps of the algorithm and the experimental results are presented.

Modern specialized optical character recognition solutions (OCR), developed by ABBYY or Nuance allow organizing complex optical input of financial documents with the help of special scanners or ordinary appliances for making digital images (such as a home scanner, a camera etc.). Despite the fact that all financial institutions try to get

rid of paper document flow, using barcoding systems and distant client service, for observance of legitimacy while working with clients it is still necessary to reflect some information in papers (checks, invoices etc.). That's why the development of OCR systems based on using embedded mobile device cameras is important for optical input of financial information by a client. Images obtained by embedded mobile device cameras have a range of features: a high level of noise, low sharpness, inaccuracy of a color rendition and others.

As a rule, at the stage of obtaining full receipt image, we get a low quality image, which can't be processed automatically. So it is reasonable to obtain a receipt image by its fragments. At this stage we can check image quality using methods of prior quality test [1].

Images obtained by mobile phone camera are usually received in case of poor lighting. For making the acceptable image brightness, one can raise matrix light sensitivity which leads to the appearance of brightness and chromatic noise on the image. The absence of sufficient illuminance of the paper document and shooting conditions, specific to the mobile device (trembling of a camera, etc.) do the image smoothed and low-contrast. To be saved, an image is compressed by algorithms with data lossy (for example JPEG), that often leads to the appearance of artifacts. One more feature of mobile images is the appearance of geometrical and perspective distortions. The source fragment of the document is shown in Picture 1.

Prior image processing is aimed at image quality improvement and contains noise filtering, increase of sharpness and image contrast, alignment and conversion to the format used by the system. For the suppression of uneven lighting during mobile shooting, and also for the normalization of the illuminance local levels the algorithm of SSR (SingleScaleRetinex) [2] is used:

$$R_i(x,y) = \log I_i(x,y) - \log\left[F_i(x,y) * I_i(x,y)\right],$$

where $R_i(x,y)$ – output image, $I_i(x,y)$ – source image; $F_i(x,y)$ – Gauss function.

The method based on the use of Bezier patch [3] is used to eliminate geometrical and perspective distortions. It takes into account implementation on mobile devices and provides the high speed of operation and simplicity.

For adaptive binarization it is recommended to apply modified, robastny to noise, Christian's algorithm. The example of the algorithm applying for the image shown in fig.1 is given in fig. 2. The binarization threshold (T) for the sliding window is calculated as [4]:

$$T = (1-\alpha_1)*\mu + \alpha_2 * \left(\frac{\sigma}{R_\sigma} * [\mu - M] + \alpha * M\right)$$

where $\alpha_1 = k_1 * \left(\frac{\sigma}{R_\sigma}\right)^\gamma$, $\alpha_2 = k_2 * \left(\frac{\sigma}{R_\sigma}\right)^\gamma$, k_1 *and* k_2 – positive constants, at $\gamma = 2$, k_1 *and* k_2 is recommended to be in ranges 0.1 – 0.2, 0.15 – 0.25 and 0.01 – 0.05;

σ – mean squared deviation of brightness in the given window;

R_σ – maximum of mean squared deviation in the given window;

μ – mathematical expectation of brightness in the given window;

M – minimum brightness in the given window.

Fig. 1. Receipt image fragment, obtained with embedded mobile device camera

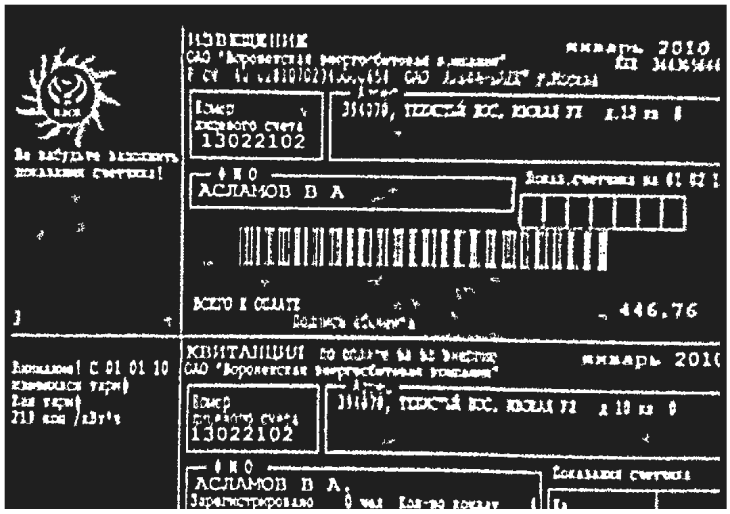

Fig. 2. Example of receipt fragment adaptive binarization with Christian's algorithm

Then automatic image fragments patching from already processed parts is applied by comparison of SIFT descriptors (Scale Invariant Feature Transform). SIFT is one of the most effective characteristic points search algorithms on two or more images, it is invariant to image scale and brightness changes, and is also rather steady against foreshortening changes [5]. As a result of algorithm the set of special points on each couple of images with a set of the descriptors turns out. These points are compared in pairs on adjacent images and if descriptors of two selected points match in repartitions of the given accuracy, two points are accepted as the conjugate. It is possible to read that these points were received as a projection of the same three-dimensional point to the planes of two cameras. The example of operation of algorithm is shown in fig. 3.

Markers separation and search is based on the set of SIFT descriptors and on binary document image. The main markers types are partitioned into 3 main groups concerning their significance for document identification:

- the most significant signs are seals, logos, barcodes, stylized texts;
- the second group includes lines, intersections (angles), text units and separate labels;
- the least significant signs are separate characters.

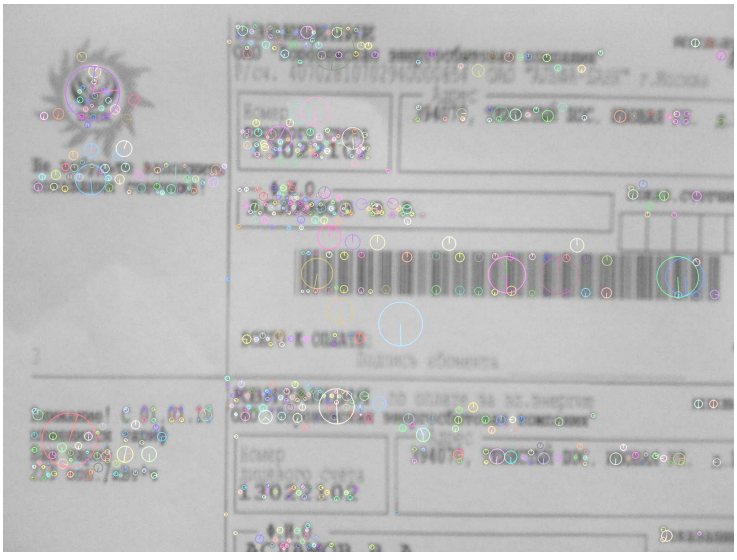

Fig. 3. Receipt image fragment, with SIFT characteristic points found on it

Carried out experiments showed that the provided algorithm of receipt image processing allows to present the document in the form of ordered, well perceptible signs set, and the intermediate algorithm result can be used by character recognition systems without prior processing.

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UDC 519.681

PROGRAM FOR PRACTICAL STUDYING OF GRAPHS

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This paper describes a program that was written to help students better learn the material on the graph theory. The article also contains a summary of the graphs, some algorithms and graph theory.

In mathematics and computer science, graph theory is the study of graphs which are mathematical structures used to model pairwise relations between objects. A "graph" in this context is made up of "vertices" or "nodes" and lines called edges that connect them. A graph may be undirected, meaning that there is no distinction between the two vertices associated with each edge, or its edges may be directed from one vertex to another. Graphs are one of the prime objects of study in discrete mathematics [1].

Discrete mathematics is the study of mathematical structures that are fundamentally discrete rather than continuous. In contrast to real numbers that have the property of varying "smoothly", the objects studied in discrete mathematics – such as integers, graphs, and statements in logic – do not vary smoothly in this way, but have distinct, separated values [3]. Discrete mathematics therefore excludes topics in "continuous mathematics" such as calculus and analysis. Discrete objects can often be enumerated by integers. More formally, discrete mathematics has been characterized as the branch of mathematics dealing with countable sets [3] (sets that have the same cardinality as subsets of the natural numbers, including rational numbers but not real numbers). However, there is no exact definition of the term "discrete mathematics" [4]. Indeed, discrete mathematics is described less by what is included than by what is excluded: continuously varying quantities and related notions.

The set of objects studied in discrete mathematics can be finite or infinite. The term finite mathematics is sometimes applied to the parts of the field of discrete mathematics that deals with finite sets, particularly those areas relevant to business.

Graphs can be used to model many types of relations and processes in physical, biological, social and information systems. Many practical problems can be represented by graphs [2].

In computer science, graphs are used to represent networks of communication, data organization, computational devices, the flow of computation, etc. For instance, the link structure of a website can be represented by a directed graph, in which the vertices represent web pages and directed edges represent links from one page to another. A similar approach can be taken to problems in travel, biology, computer chip design, and many other fields. The development of algorithms to handle graphs is therefore of major interest in computer science. The transformation of graphs is often formalized and represented by graph rewrite systems. Complementary to graph transformation systems focusing on rule-based in-memory manipulation of graphs are graph databases geared towards transaction-safe, persistent storing and querying of graph-structured data [2].

There are some algorithms for working with graphs. They are:

1) Dijksta's algorithm;
2) Floyd-Warshall algorithm;
3) Kruskal's algorithm;
4) Prim's algorithm;
5) Depth-first search;
6) Nearest neighbor algorithm.

The essence of our program lies in the practical study of algorithms working with graphs. The algorithm for study is selected in the program, and after the generation of a graph, the program gives the tips that the user

needs to solve the task by having chosen earlier algorithm. Also in the program, there is a test mode with disabled tips, but there is a time limit for the solution of the task, and by the end of solving the task the number of errors and the full course of solutions are shown.

In the program includes both the generation of a task with a certain level of complexity and the loading of a previously created task.

The screenshot of the program is shown in Figure.

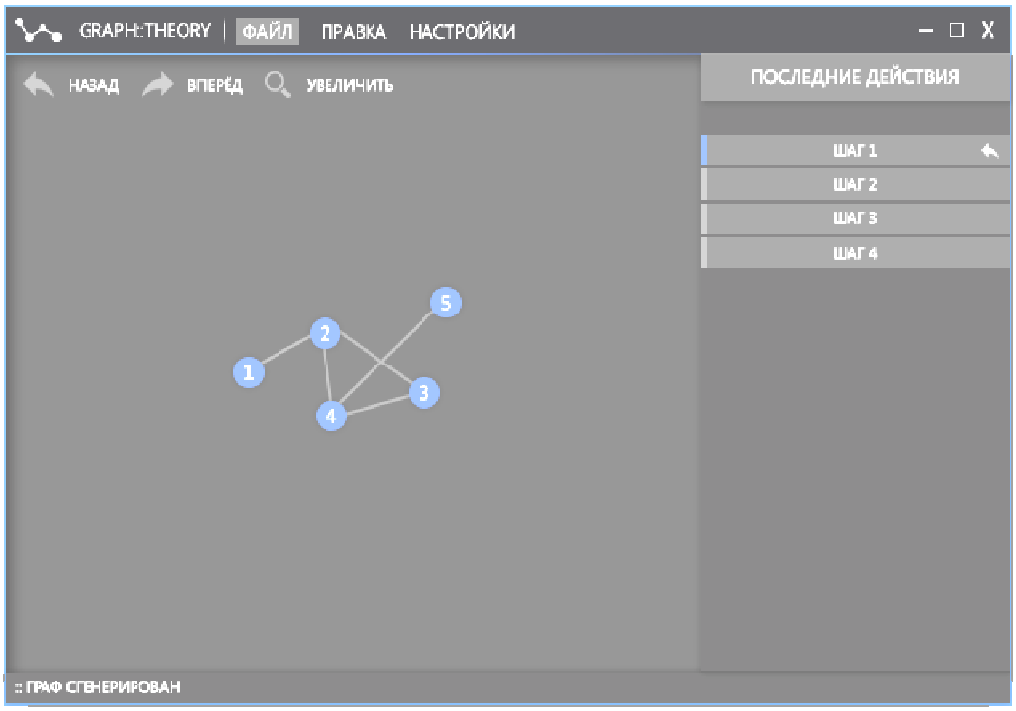

Fig. Screenshot of program

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UDC 622.867.322;614.894

IMITATION OF THE BREATHING APPARATUS OPERATION ON CHEMICALLY BONDED OXYGEN AFTER THE CHANGES IN ITS OPERATION MODE

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Recordkeeping of the initial clogging of the regenerative cartridge [1, 2] is necessary to imitate real situations that arise at the exploitation of the mine rebreather. Among them are the following items: the change of the air filtration rate at the variation of work load, reverse of the air flow if there are pendulum or combined junctions of the airway, and so on.

In this paper we will consider the operation of the breathing apparatus after the change in its operation mode due to the decrease in the filtration rate of the air recovered. Since in the problems considered a new

structure of the working sorbent layer is formed if there is its initial contamination, we will use the formalism offered in [2]:

$$-\omega_{\xi}^{'}(\xi,\tau)=\omega(\xi,\tau)-e^{-\tau}\left[u(\xi,0)+\int_0^{\tau}e^{\tau}\omega(\xi,\tau)d\tau\right],\ \tau\geq 0 \tag{1}$$

$$u(\xi,\tau)=e^{-\tau}\left(u(\xi,0)+\int_0^{\tau}e^{\tau}\omega(\xi,\tau)d\tau\right),\ \tau\geq 0 \tag{2}$$

where $\omega(\xi,\tau)$ and $u(\xi,\tau)$ are the reduced volume concentrations of CO_2 molecules and fixed carbon respectively, ξ and τ are the dimensionless coordinate and time connected with the depth of penetration into the filter x and the operating period of the apparatus t through the ratios

$$\xi=\beta x/v,\ \tau=\beta\gamma t, \tag{3}$$

where v is the rate of filtration, β and γ are phenomenological constants characterizing the rate and resource of the reaction of CO_2 fixation

In the offered arrangement $u(\xi,0)$ is the known initial clogging of the cartridge, which influence on the sorption dynamics is the purpose of the present study.

According to [2], the solution of (1) can be represented as a series in powers of ξ

$$\omega(\xi,\tau)=e^{-\tau}\sum_{n=0}^{\infty}\frac{f_n(\tau)}{n!}\xi^n, \tag{4}$$

which variables coefficients are determined by a recursive procedure

$$f_{n+1}(\tau)=u_{\xi}^{(n)}(0,0)+\int_0^{\tau}f_n(\tau)\,d\tau-f_n(\tau),\ n=0,\,1,\,2\ldots \tag{5}$$

which start is provided by the relation which follows from (4) with $\xi=0$

$$f_0(\tau)=e^{\tau}\omega(0,\tau), \tag{6}$$

providing the influence of a variable boundary condition on the dynamics of sorption activity. The dependence of $\omega(\xi,\tau)$ on the initial clogging $u(\xi,0)$, in accordance with the Maclaurin's formula, was included in (5) through its derivatives at the filter inlet

$$u(\xi,0)=\sum_{n=0}^{\infty}\frac{u_{\xi}^{(n)}(0,0)}{n!}\xi^n. \tag{7}$$

Relations (4) - (6) allow to find $\omega(\xi,\tau)$ by the known $\omega(0,\tau)$ and $u(\xi,0)$, when we substitute the result in (2) we can calculate $u(\xi,\tau)$, thus completing the solution of the heterogeneous and non-stationary problem of sorption dynamics.

In particular, if there is no initial clogging ($u(\xi,0)=0$) the relations (1), (2) will take the form

$$-\omega_{\xi}^{'}(\xi,\tau)=\omega(\xi,\tau)-e^{-\tau}\int_0^{\tau}e^{\tau}\omega(\xi,\tau)d\tau, \tag{8}$$

$$u(\xi,\tau)=e^{-\tau}\int_0^{\tau}e^{\tau}\omega(\xi,\tau)d\tau. \tag{9}$$

Performing integration by parts in (8) we obtain

$$-\omega_{\xi}^{'}(\xi,\tau)=e^{-\tau}\left[\omega(\xi,0)+\int_0^{\tau}e^{\tau}d_{\tau}\omega(\xi,\tau)\right]. \tag{10}$$

It follows from (10) where $\tau=0$

$$\omega(\xi,0)=\omega(0,0)e^{-\xi}. \tag{11}$$

Considering this, it is convenient to look for the solution of (10) in the form

$$\omega(\xi,\tau)=e^{-\xi-\tau}\sum_{n=0}^{\infty}\frac{f_n(\tau)}{n!}\xi^n\,, \tag{12}$$

выделив $e^{-\xi}$ в качестве множителя. Благодаря чему исчезает последнее слагаемое в (5)ю

having singled out $e^{-\xi}$ as a multiplier factor. Thereby the last summand disappears in (5)

$$f_{n+1}(\tau)=\int_0^{\tau} f_n(\tau)\,d\tau\,. \tag{13}$$

With $\xi=0$ condition (16) follows from (12), which at a constant concentration of the solute at the filter inlet ($\omega(0,\tau)=1$) will take the form

$$f_0(\tau)=e^{\tau}\,. \tag{14}$$

The solution of the recurrence relation (13), (14) is

$$f_n(\tau)=e^{\tau}-\sum_{k=0}^{n-1}\frac{\tau^k}{k!},\ n=1,\ 2\ ... \tag{15}$$

Substituting (14), (15) into (12) we obtain the dependence of CO_2 breakthrough on time and coordinate with zero initial clogging of the cartridge and a constant concentration of CO_2 at the filter inlet

$$\omega 1(\xi,\tau)=e^{-\xi-\tau}\left[f_0(\tau)+\sum_{n=1}^{\infty}\frac{\xi^n}{n!}f_n(\tau)\right]=e^{-\xi}\left[1+\sum_{n=1}^{\infty}\frac{\xi^n}{n!}\left(1-e^{-\tau}\sum_{k=0}^{n-1}\frac{\tau^k}{k!}\right)\right]. \tag{16}$$

Using (9) we will find the corresponding (16) clogging of the cartridge

$$u1(\xi,\tau)=e^{-\xi}\sum_{n=0}^{\infty}\frac{\xi^n}{n!}g_n(\tau)\equiv 1-e^{-\tau}\left(1+e^{-\xi}\sum_{n=1}^{\infty}\frac{\xi^n}{n!}\sum_{k=1}^{n}\frac{\tau^k}{k!}\right), \tag{17}$$

wherein

$$g_n(\tau)=1-e^{-\tau}\sum_{k=0}^{n}\frac{\tau^k}{k!}\,. \tag{18}$$

We will assume that before the change in the operation mode of the apparatus the clogging of the cartridge evolved in accordance with the formulas (17) and (18). Then, at the point in time $\tau 1$ the filtration rate α has changed. At the same time, in accordance with (3), the dimensionless length of the cartridge will change at α^{-1}. That is, if we imply ξ as a dimensionless coordinate after the change in the mode of breathing, it is necessary to substitute $u1(\alpha\xi,\tau)$ as the initial clogging in (1), (2). For the recurrent procedure (5) the derivatives of this function by ξ will be required at the inlet of the cartridge

$$\frac{\partial^n u1(\alpha\xi,\tau)}{\partial\xi^n}\Big|_{\xi=0}=\alpha^n\frac{\partial^n u1(\xi,\tau)}{\partial\xi^n}\Big|_{\xi=0}\,. \tag{19}$$

According to (17) we have the equations

$$u1'_{\xi}(\xi,\tau)=-e^{-\xi}\sum_{n=0}^{\infty}\frac{\xi^n}{n!}g_n(\tau)+e^{-\xi}\sum_{n=1}^{\infty}\frac{\xi^{n-1}}{(n-1)!}g_n(\tau)\,,$$

$$u1'_{\xi}(0,\tau)=-g_0(\tau)+g_1(\tau)\,,$$

$$u1''_{\xi}(\xi,\tau)=e^{-\xi}\sum_{n=0}^{\infty}\frac{\xi^n}{n!}g_n(\tau)-2e^{-\xi}\sum_{n=1}^{\infty}\frac{\xi^{n-1}}{(n-1)!}g_n(\tau)+e^{-\xi}\sum_{n=2}^{\infty}\frac{\xi^{n-2}}{(n-2)!}g_n(\tau)\,,$$

$$u1''_{\xi}(0,\tau)=g_0(\tau)-2g_1(\tau)+g_2(\tau)\,.$$

By analogy,

$$u1'''_{\xi}(0,\tau)=-g_0(\tau)+3g_1(\tau)-3g_2(\tau)+g_3(\tau)\,,$$

which allows to observe a common pattern

$$u1_{\xi}^{(n)}(0,\tau)=\sum_{k=0}^{n}(-1)^{n-k}C_n^k g_k(\tau)\,, \tag{20}$$

where C_n^k are the numbers of combinations from n of objects of k.

That is, in accordance with the above stated and the formulas (19), (20) and (18) we shall replace in (5)

$$u_{\xi}^{(n)}(0,0)=u1_{\xi}^{(n)}(\alpha\xi,\tau1)\big|_{\xi=0}=\alpha^n\sum_{k=0}^{n}(-1)^{n-k}C_n^k\left(1-e^{-\tau1}\sum_{m=0}^{k}\frac{\tau1^m}{m!}\right). \tag{21}$$

At the same time, to start the iteration procedure it is necessary to use the formula (14) for a change in the filtration rate does not change the content of CO_2 at the expiration.

We have considered a situation where a three-fold deceleration of the air flow ($\alpha=1/3$) increases the dimensionless length of the cartridge to $\eta=10$. According to [3, 4], this corresponds to the self-rescuer with the mass of the oxygen containing product of 1 kg during the transition from the 10th breathing mode (close to the maximum load during the rapid evacuation of a miner from the accident area) to the 3rd (lower than the average load during a quiet exit of the miner from the accident area).

It can be seen (Fig. 1) that a deceleration in the rate of air filtration done at the moment $\tau1=2.077$ of CO_2 critical breakthrough ($\omega1(\eta,\tau1)=0.375$) has led to a longer stay of carbon dioxide molecules in the layer of the chemisorbent and, as the result, dec;ine of their content in the regenerated air (curve 2). This occurs almost instantaneously ($\tau=0$) (during the flow of the slow front through the filter). Then a gradual (evolutionary) growth in CO_2 concentration begins due to the further gradual exhaustion of the regenerative cartridge absorbing resource. Finally, at moment $\tau=\tau2=2.078$ a critical breakthrough of CO_2 is achieved again (curve 3) in the already weakened operation of the breathing apparatus. We shall note that thus the time of the protective action of the apparatus increases by 100% ($\tau2/\tau1=1$).

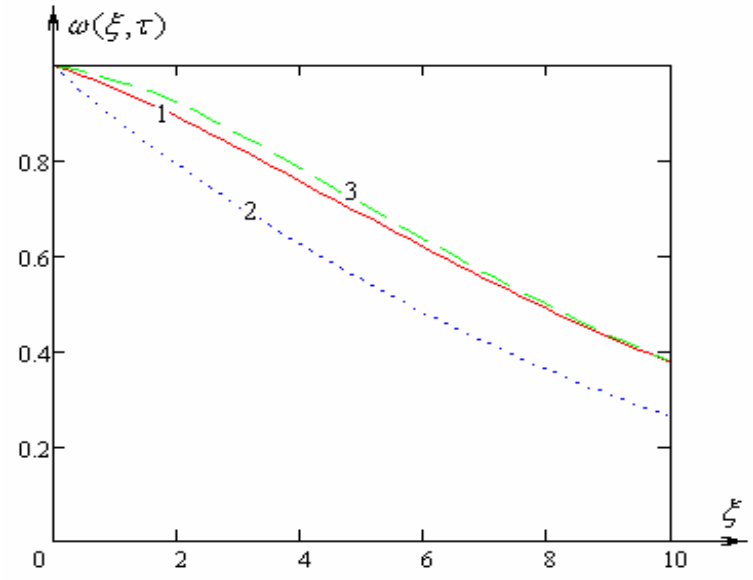

Fig. 1. The change of CO_2 critical breakthrough (curve 1) after air deceleration: 2 – $\tau=0$; 3 – $\tau=\tau2$

It is essential that curve 3 is more convex than curve 1 which describes the reduced concentration at the critical breakthrough, but before the flow deceleration. This means the formation of a new structure of the working layer of the sorbent after the change of breathing mode. Slower CO_2 molecules fix at the same time to a narrower layer of the absorbent. In the result the front part of the working sorbent is loaded and its resource is exhausted more quickly. For this reason, the decline of curve 3 in the front layer of the cartridge is slower than that of curve 1. At the end of the cartridge the curves intercross, the working sorbent layer became narrower after the filtration speed deceleration.

This can be seen by considering the evolution of the fixed carbon distribution in the cartridge (Fig. 2). In contrast to CO_2 breakthrough the change of clogging does not undergo a leap at the moment of the deceleration of the airflow ($u1(\alpha\xi,\tau1) = u(\xi,0)$). Both of these functions describe curve 1.

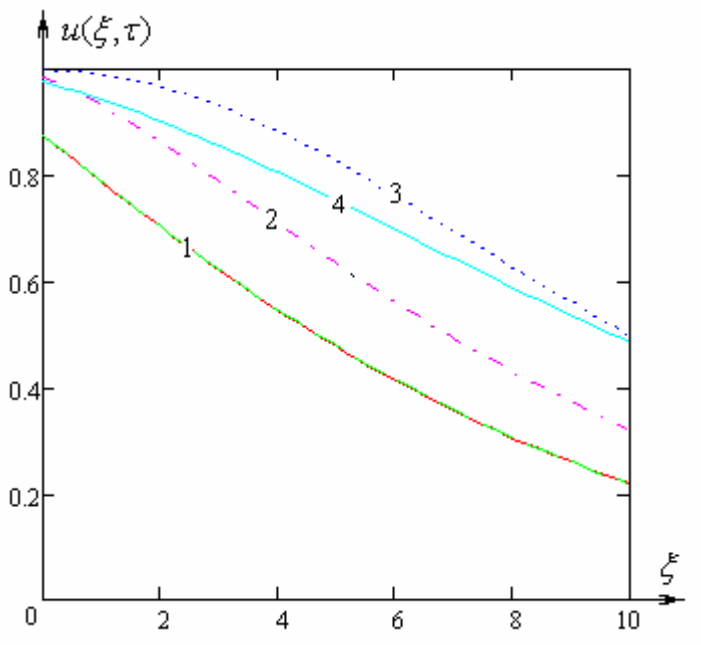

Fig. 2. The evolution of the cartridge workout after the critical CO_2 breakthrough (curve 1) with the deceleration of the airflow 2 – $\tau = \tau2$; 3 – $\tau = 5$ and without it (curve 4)

Curve 2 corresponds to the moment $\tau2$ when the second critical breakthrough is achieved. Obviously, when there is a change of the device mode the moment of the critical breakthrough (increase in lifetime) cannot be used to measure the protective action growth. According to [5] the average clogging of the cartridge should be used for that. In this case, its growth is 28.3%, which is equal to the relative difference of the areas under curves 1 and 2.

Curve 3 corresponds to the moment $\tau = 5$ after the change of the device mode. To compare that, Fig. 3 shows curve 4 which corresponds to the same number of CO_2 molecules, entered into the cartridge after $\tau1$ which works in the former mode $\omega1(\xi,\tau1+\alpha\cdot5)$. Due to the higher speed of filtration the breakthrough is higher, and the degree of the oxygen containing product workout is lower. At this, curve 3 is more convex than curve 4, which confirms again the narrowing of the working layer of the sorbent.

Thus, we have developed a formalism which allows to imitate air regeneration in the rebreather after changing its mode of operation.

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UDC 004.9+004.056

METHODS OF AUTHENTICATION WHEN INTERACTING WITH WEB SERVICES VIA API

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The paper discusses the methods of authentication used when interacting with third-party web services via application programming interfaces on behalf of a user. The methods provide different level of authentication credentials security, different required level of mutual trust among the parties of authentication process and different capabilities in organizing fine-grained separation of access permissions.

The Hypertext Transfer Protocol (HTTP) is an application-level protocol with the lightness and speed necessary for distributed, collaborative, hypermedia information systems [1]. HTTP, alongside with the traditional usage of hypertext transferring and other cases, is used as a transport for RESTful services. Representational State Transfer (REST) is an architectural style to build distributed hypermedia systems [2] that is widely used to design application programming interfaces (API) for rich internet applications (RIA). Such APIs need to provide means for third-party applications to act on behalf of a user via process of user authentication. The authentication method is required to ensure highest level of user credentials security and the least possible required level of mutual trust among the parties of authentication process.

HTTP provides a simple challenge-response authentication mechanism which may be used by a server to challenge a client request and by a client to provide authentication information [1]. This is a general higher-level mechanism that allows various specific implementations. Authentication information challenging is done by a server with the *WWW-Authenticate* header and response code *401* (unauthorized). Providing authentication information by a client is achieved with the *Authorization* header.

The simplest "basic" authentication scheme is based on the model that the client authenticates itself with a user identifier and a password [1]. The user identifier is concatenated with the password separated by a single colon character and the result is encoded within a Base64 scheme. Obtained string is prepended with word "Basic" and the result forms the *Authorization* header value. Thus, to authenticate on behalf of the user with identifier "john doe" and password "0iyrB7bhzZza" the following header should be sent to a server:

Authorization: Basic am9obl9kb2U6MGl5ckI3Ymh6Wnph

This authentication scheme is non-secure in terms of authentication credentials security and is based on assumption that the connection between the client and the server can be regarded as a trusted carrier. Furthermore, the scheme requires a client application to be aware of user credentials and thus it assumes the application to be trusted to by the user. This scheme also requires a server to store user passwords in plaintext or in encrypted with reversible algorithm form. There are highly limited ways to separate access permissions with a basic authentication scheme: the separation can be only achieved by the server by requesting different user passwords for different request URIs.

The Digest Access authentication scheme allows avoiding the most serious flaws of Basic authentication [3]; this is achieved through not sending a user password in plaintext in *Authorization* header when performing authentication. Instead, a hash of the string containing username, password, and unique server-generated nonce is sent as authentication information. MD5 is typically used as the hash algorithm. In its simplest case *Authorization* header value is formed in this manner:

A1 = MD5(username:realm:password)
A2 = MD5(method:digest-uri)
Hash =MD5(A1:nonce:A2)
Authorization-header = Authorization: "Digest"
"username"=username,
"realm"=realm,
"nonce"=nonce,
"uri"=digest-uri,
"reponse"=Hash

Here

username is user identifier;

realm is a string sent by a server in *XXX-Authenticate* header and displayed by client to users so they know which username and password to use;

password is user password;

method is the HTTP request method (GET, POST etc.) used in the current request;

digest-uri is the HTTP request URI used in the current request;

nonce is a server-specified data string which should be uniquely generated by a server each time and sent in *XXX-Authenticate* header.

Thus, to authenticate on behalf of the user with identifier "john_doe" and password "0iyrB7bhzZza" given that the server returned realm *auth@example.com* and nonce *59fb925ffbc8a83d8c0993ee264a946f* and http://example.com/index.html URI is requested with HTTP GET method the following actions should be done to form authentication request:

A1 = MD5(john_doe:auth@example.com:0iyrB7bhzZza) = 4bccf28e28cc61aae0ca0c35154931f0

A2 = MD5(GET:http://example.com/index.html) = 25ed971549a69ec6d4ed9c7884d2f785

Hash = MD5(4bccf28e28cc61aae0ca0c35154931f0:59fb925ffbc8a83d8c0993ee264a946f:25ed971549a69ec6d4ed9c7884d2f785) = c6428a734599e224606b9c13c22a73ef

Authorization-header = Authorization: Digest
username=john_doe,
realm=auth@example.com,
nonce=59fb925ffbc8a83d8c0993ee264a946f,
uri=http://example.com/index.html
reponse=c6428a734599e224606b9c13c22a73ef

Digest authentication scheme cannot be considered secure though it does not assume transferring user password as a plain text and does not require storing user password in reversible form on the server side (instead, *MD5(username:realm:password)* hash can be stored). It still requires a user to trust his or her credentials to a client application and it still provides highly limited means to organize fine-grained separation of access permissions.

The OAuth 2.0 authorization framework enables a third-party application to obtain limited access to a HTTP service on behalf of a user (resource owner) without knowing authorization credentials by orchestrating an approval interaction between the resource owner and the web service [4]. This is achieved through separating the role of the client from that of the resource owner; instead of using the resource owner's credentials to access protected resources, the client obtains an access token — a string denoting a specific scope of access, lifetime, and other access attributes; the access token is then used to access the protected resources hosted by the server. General abstract OAuth 2.0 flow is presented in figure 1 and includes the following steps:

A. the client requests authorization from the resource owner (the client); the request can be made indirectly via the authorization server as an intermediary as it is done in authorization code grant type;

B. the client receives an authorization grant, which is a special credential representing the resource owner's authorization;

C. the client requests an access token by authenticating with the authorization server and presenting the authorization grant;

D. the authorization server authenticates the client and validates the authorization grant and issues an access token for valid authorization grant;

E. the client requests the protected resource from the resource server and authenticates by presenting the access token;

F. the resource server validates the access token and serves the request for valid access token.

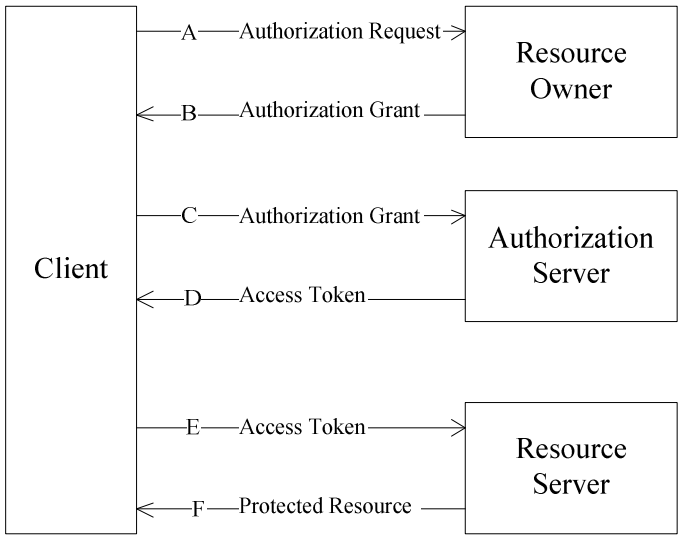

Fig. 1. OAuth 2.0 Protocol Flow

It is not necessary for authorization server and resource server to be separate entities; they may be the same server.

The authorization code grant type is used to obtain access tokens and is optimized for confidential clients [4]. This is a redirecting-based flow and thus the client must be capable of interacting with the resource owner's user-agent (typically a web browser) and capable of receiving incoming requests (via redirection) from the authorization server. Authorization code flow is illustrated in figure 2.

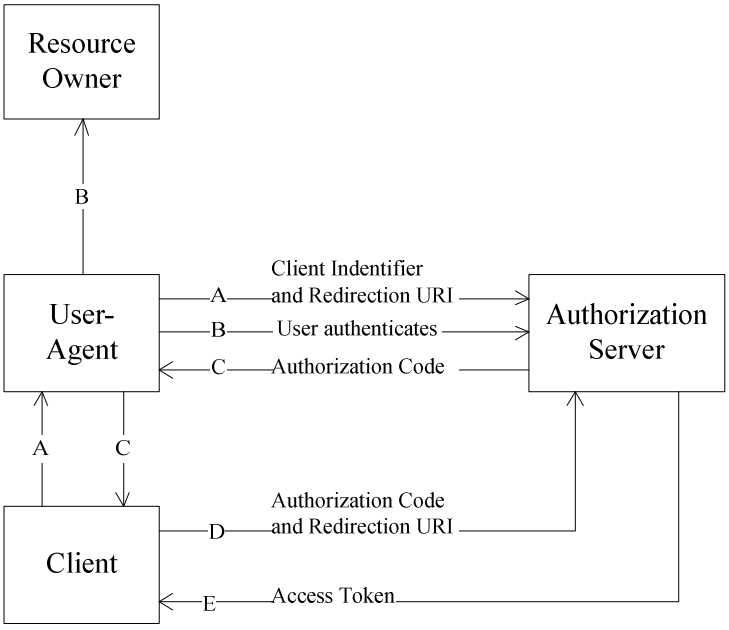

Fig. 2. Authorization Code Flow

The flow includes the following steps:

A. the client directs the resource owner's user-agent to the authorization endpoint; the client includes its client identifier, requested scope, local state, and a redirection URI for authorization server to send user-agent back to after access is granted or denied;

B. the authorization server authenticates the resource owner via the user-agent and establishes whether he or she grants or denies the client's access request;

C. assuming access has been granted by the resource owner, the authorization server redirects the user-agent to the client using the redirected URI provided earlier and including an authorization code and local state provided by the client earlier;

D. the client requests an access token from the authorization server by including the previously received authorization code and redirection URI previously used for verification;

E. the authorization server authenticates the client, validates the authorization code and redirection URI and, if valid, responds with an access token.

Obtained access token then can be used to form the *Authorization* header when accessing protected resources. "Bearer" authentication scheme is used to construct the header [5]. Assuming that access token obtained from the authorization server is *ddb2c93ebcf6098f6ccb08807ed66e02934248a5*, the following *Authorization* header should be passed to the server:

Authorization: Bearer ddb2c93ebcf6098f6ccb08807ed66e02934248a5

OAuth 2.0 authorization framework provides relatively high level of security since it does not require a user to trust his or her credentials to a client application, does not require storing of a user password in reversible form on a server, allows fine-grained separation of access permissions through means of access scopes and explicit user access grant, does not require plaintext password transferring when performing authentication since access token, bound to specific client application, is used. The framework, however, does not define any ways of secure user authentication via user-agent and it is assumed the security is provided by means of encrypted HTTP over SSL protocol.

Summary characteristics of authentication methods are presented in table 1.

OAuth 2.0 authentication method provides the maximum level of security compared to other methods, though it requires more complex client application implementation since the application should be able to interact with user-agent and receive requests via redirection.

Table 1 – Authentication methods summary characteristics

Authentication method property	Basic authentication	Digest authentication	OAuth 2.0 authentication
Client is required to have access to user credentials	Yes	Yes	No
Server is required to store user password in reversible state	Yes	No	No
Plain text credential transferring	Yes	No	No
Fine-grained separation of access permissions	Partial	Partial	Yes
Client is required to be capable of interacting with the user-agent receiving incoming requests via redirection	No	No	Yes

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UDC 681.5

EVALUATION FUNCTION AS A KEY FACTOR IN SOLVING THE TASK OF UNIVERSITY SCHEDULE CREATION

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The paper is devoted to further investigation of local evolutionary method for solving discrete optimization problems, namely, the applicability of this method to the problem of scheduling the university.

This problem is NP-hard and has a strong applied focus. It remains relevant, particularly, for universities in Belarus.[1]

Unsolved problems include the following:

a) effective restructuring of the schedule due to changes in the source data;

b) taking into account the specific constraints dictated by the organization of the process of scheduling in specific universities;

c) acceptable rate of the convergence of the optimization process of scheduling. [4]

The quality evaluation function plays the key role in the evaluation of the quality of the schedule and determining the limits of the optimization process.

The initial data for the drawing up of the educational schedule are:

$A=\{a_i\}$ – set of auditoriums;

$T=<t_i>$ – amount of time – arranged set of study time quanta (quantum – two academic hours);

$W=\{w_i\}$ – set of lecturers;

$P=\{p_i\}$ – set of classes;

$G=\{g_i\}$ – set of student groups;

$U=\{<p_i,g_i>\}PG$ – set of learning plans for student groups;

Thus, the task of drawing up of educational schedule is formulated in the search space

S:A*TWP*, (for Polotsk State University there are about 36 556 977 600 combinations. Using the brute force search it would take about 40 years to solve the problem).

Let us formulate the description of the task. Since the schedule is unacceptable if it contains at least one conflict to the teacher, or a group or audience, it is possible to formulate strict limits

For every $s_1=<a_1,t_1,w_1,p_1>$S and $s_2=<a_2,t_2,w_2,p_2>$S, for each $t_1=t_2$ is true

1. $a_1 a_2$;
2. $w_1 w_2$;
3. $U / \{p_1\}\ U / \{p_2\} =$;

It should be emphasized that the restriction #3 includes the right planning of streaming classes, claiming no intersection of streaming groups.

4. For classes, the duration of which is more than one quantum of scheduled time, it is necessary to introduce an additional constraint on the capturing of sequential quanta.

5. The schedule must be submitted to all scheduled classes from P – this is the requirement of the completeness of the schedule.

6. A pair (w, p) is usually assigned to every lecturer (See. source data). That's why (w,p) in schedule should also exist in the lecturer's N assignment plan.

The problem of the optimal schedule is to find a schedule with the lowest price. We propose to use as an evaluation function the following heuristic function of preferences:

$$Q(S)=(a_1 G_1+a_2 G_2+a_3 G_3+a_4 G_4+a_5 G_5)+(a_5 A_1+a_6 A_2)+(a_7 W_1+a_8 W_2+a_9 W_3)+a_{10} P_1.$$

Here:

G_1 – number of transitions among university buildings during the day for student groups (subgroups);

G_2 – number of gaps in student groups schedules;

G_3 – amount of diversity in classes during the day for students groups (subgroups);

G_4 – amount of deviations from the planning of classes;

G_5 – going beyond the recommended study time calendar;

A_1 – number of gaps in auditorium schedules;

A_2 – degree of utilization of auditoriums during a class;

W_1 – number of transitions among university buildings during the day for lecturers;

W_2 – going beyond the recommended lecturer's working calendar;

W_3 – number of gaps in lecturers' schedules;

P_1 – degree of learning plans coverage by the incomplete schedule;

$a_1, a_2, a_3, \ldots$ – scaling coefficients.

The selection of scaling coefficients can also be different. We have applied the method of expert assessment of the impact of various factors on the general idea of the correct schedule. Maximum penalties are applied for unacceptable violations of our idea of a good schedule .

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FAST ALGORITMS FOR LONG ARITHMETIC

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In modern software industry it is often necessary to work with large numbers. These numbers are generally longer than the dimension of standard data types. Long arithmetic is usually used to solve this problem.

Long arithmetic in computing is operations on numbers, the bit of which exceeds the length of the machine word of the computer technology. These operations are not implemented in hardware. Their implementation is done programmatically using the hardware platformof working with numbers of smaller range.

Representation. In the classic form,an array of integers is used for the realization of long arithmetic, and each number is a decimal one digit from the source of a large number.

We can use the following modification of the implementation of a large number storage. Let's choose a basisβ. Then any number γcan be represented in the following form:

$$\gamma = \alpha_n * \beta^n + \alpha_{n-1} * \beta^{n-1} + \alpha_1 * \beta + \alpha_0.$$

As a matter of convenience of working with such representations of numbers, write-back is commonly used, i.e. α_0 isusually written in the first cell of the array, α_0 in the second one, etc.

Addition. When adding, in long arithmetic corresponding bits of each large number are summed successively, and if the amount exceeds the base, thenthe excess after dividing by the base remains in a given digit, and the next digit increases by 1.One can say that the addition of two large numbers in long arithmetic is performed in a column.

Subtraction. Subtraction in long arithmetic is made similarly to addition. We consistently subtract the corresponding subtrahend bit from the minuend. The only difference is that if the corresponding bit of the minuend is lower than that of the subtrahend, we add the basis to the minuend, and from the next digit we take 1.

Multiplication. There are many algorithms for multiplication in long arithmetic:

- Simple;
- Karatsubaalgorithm;
- Toomalgorithms;
- Fouriermethod.

Simple algorithm involves calculation "in a column". This method is very simple to implement, but it has low speed.

Karatsuba algorithm refers to "fast" multiplication algorithms and allows multiplying of n-digit numbers with the complexity of computing:

$$M(n) - O\left(n^{\log_2 3}\right),$$

$$\log_2 3 = 1{,}5849.$$

For multiplying two numbers in excess of the computer word length, the Karatsuba algorithm is called recursively as long as the number does not become sufficiently small so that they can be multiplied directly. Software implementation of this algorithm implies recursion that, with very large numbers, can cause a stack overflow. With small numbers the algorithm is not efficient.

The algorithm is due for rapid multiplication, which lies in calculating the intermediate results of multiplication by primitive factors. I.e. we divide the second number (in its decimal representation) intothe numbers (0 to 9), then we compute the product of the first multiplier with each primitive factor (in the worst case, we are to make 9 multiplications of the first factor by primitive factors). The final product of the first to the second factor willbe calculated by adding the cyclic at the previous stage product of the first factor with primitive factors. Note, however, that the addition of shift is necessary to make the number of bits corresponding to the number of primitive factors corresponding bits of the second number. In fact, this method is an optimized multiplication "in a column" of on-time performance, but it requires more memory (to store intermediate results). Example:

Let us assume that we need to multiply 11111 and 12323. We divide the second factor in toprimitives. These are numbers 1, 2, 3, 2, 3. This means that we need to calculate the following intermediate results:

– 11111 x 1 = 11111;
– 11111 x 2 = 22222;
– 11111 x 3 = 33333.

Then we rewritethe primitives in reverse order and perform addition of the intermediate results with a shift:

Primitives: 3, 2, 3, 2, 1.

Summation: (33333) +(22222 << 1) + (33333 << 2) + (22222 << 3) + (11111 << 4) = 33333 + 222220 + 3333300 + 22222000 + 111110000 = 136920853.

Further optimization of the algorithm is possible. The essence of optimization is to change the principle of the partition of the second factor into primitives. Primitives will be repeated sequences of numbers. Let us take the previous example and perform multiplication (11111 and 12323). We divide the second factor into primitives. This is the sequence: 1, 23, and 23. Now, we need to calculate the following intermediate results:

– 11111 x 1 = 11111;
– 11111 x 23 = 255553.

Summation: (255553) + (25553 << 2) + (11111 << 4) = 136920853.

Exponentiation. For exponentiation a number which is raised should be multiplied by itself as many times as the exponent. However, the exponent $n > 3$ already requires large computing power. To optimize exponentiation so-called "binary exponentiationis used". The essence of the method is similar to the suggested multiplication algorithm (intermediate calculations are used). The essence of the method is the following:

Provide the exponent in the form of a sum of powers of 2.

Calculate the number of intermediate squares.

Multiply them.

Let us take a detailed look atthe method. Let's assume that we need to calculate x^n.

We provide the exponent in the form of a sum of powers of 2. Each number can be written as:

$$n = \sum_{i=0}^{n} a_i + 2^i = a_0 * 2^0 + a_1 * 2^1 + a_2 * 2^2 + \ldots + a_{n-1} * 2^{n-1} + a_n * 2^n$$

where $a \in \{0;1\}$.

Next, we compute the intermediate squares, i.e. we find x^2, x^4, etc.

Finally, we multiply the intermediate squares together. It is worth noting that the multiplication is carried out only with those intermediate results ,where a_i in the expansion of the exponent is 1.

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UDC 550.8.028

MULTIPATH PROPAGATION PROBLEM ANALYSIS IN DATA TRANSMISSION SYSTEMS

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This article deals with the problem of multipath propagation and electromagnetic wave when it is incident on a layered medium.

For the selection of tangible objects on the background of the environment in practice is usually used the reflective characteristics serving tool to optimize the electrical parameters of the probing signal.

The fall of a plane electromagnetic wave on a flat boundary of two semi-infinite anisotropic media 1 and 2 is illustrated in Figure 1 for the horizontal (perpendicular) polarization when the electric field vector is perpendicular to the plane E_0 fall, and vertical (parallel) polarization when the electric field vector lies in the plane E_0 fall.

Fresnel reflection coefficient for horizontally polarized waves (in the coordinate system *x*, *y*, *z*, shown in Figure 1).

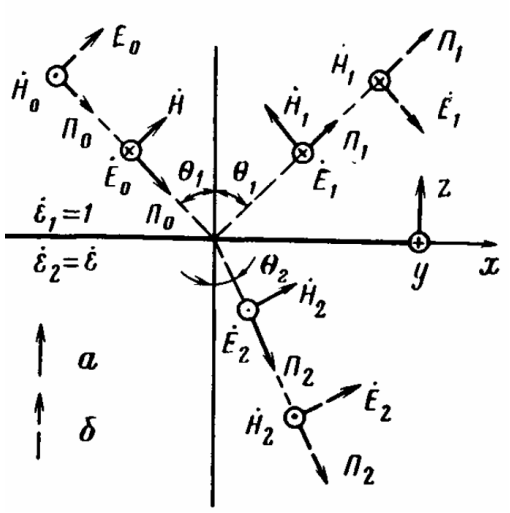

Fig. 1. The fall of a plane wave at the interface with the horizontal (*a*) and vertical (*b*) polarizations

$$\dot{R}_{(1-2)\Gamma} = \frac{\dot{E}_1}{\dot{E}_0} = \frac{\dot{W}_2\cos\theta_1 - \dot{W}_1\cos\theta_2}{\dot{W}_2\cos\theta_1 + \dot{W}_1\cos\theta_2}. \quad (1)$$

Transmission coefficient

$$\dot{T}_{(1-2)\Gamma} = \frac{\dot{E}_2}{\dot{E}_0} = \frac{2\dot{W}\cos\theta_1}{\dot{W}_2\cos\theta_1 + \dot{W}_1\cos\theta_2}, \quad (2)$$

and the complex characteristic impedance (characteristic impedance) of the environment

$$\dot{W} = \frac{\dot{E}}{\dot{H}} = \sqrt{\frac{\mu_0\dot{\mu}}{\varepsilon_0\dot{\varepsilon}}} = 120\pi\sqrt{\frac{\dot{\mu}}{\dot{\varepsilon}}}. \quad (3)$$

Where in a nonmagnetic medium

$$\dot{W} = \frac{120\pi}{\sqrt{\dot{\varepsilon}}} = \frac{120\pi}{\dot{n}}. \quad (4)$$

As for the angles of incidence and refraction, it should be borne in mind that, according to the Snellyusa law for absorbing media

$$\sin\theta_2 = \frac{\dot{\gamma}_1}{\dot{\gamma}_2}\sin\theta_1 = \sqrt{\frac{\dot{\varepsilon}_1\dot{\mu}_1}{\dot{\varepsilon}_2\dot{\mu}_2}}\sin\theta_1 \quad (5)$$

is complex.

In case when ε_1, μ_1 are real, the true value of the angle of refraction is equal to

$$\theta_2 = \operatorname{arcctg}\left[\operatorname{Re}(\operatorname{ctg}\theta_2)\right]. \quad (6)$$

For vertically polarized wave in the coordinate system x, y, z in Figure 1 we have the following expressions

$$\dot{R}_{(1-2)\text{B}} = \frac{\dot{E}_{1x}}{\dot{E}_{0x}} = \frac{\dot{W}_2\cos\theta_2 - \dot{W}_1\cos\theta_1}{\dot{W}_2\cos\theta_2 + \dot{W}_1\cos\theta_1}. \quad (7)$$

$$\dot{T}_{(1-2)\text{B}} = \frac{\dot{E}_{2x}}{\dot{E}_{0x}} = \frac{2\dot{W}_2\cos\theta_2}{\dot{W}_2\cos\theta_2 + \dot{W}_1\cos\theta_1}. \quad (8)$$

It should be noted that sometimes the reflection coefficient for vertical polarization is determined by the ratio of the corresponding magnetic vectors. The sign changes $\dot{R}_{(1-2)\text{B}} = \dot{H}_1 / \dot{H}_0 = -\dot{E}_1 / \dot{E}_{0x}$.

For vertical drop ($\theta_1 = \theta_2 = 0$) and non-magnetic media expressions (1), (2), (7) and (8) take the following forms:

$$\dot{R}_{1-2} = \frac{\sqrt{\dot{\varepsilon}_1} - \sqrt{\dot{\varepsilon}_2}}{\sqrt{\dot{\varepsilon}_1} - \sqrt{\dot{\varepsilon}_2}}, \tag{9}$$

$$\dot{T}_{1-2} = \frac{2\sqrt{\dot{\varepsilon}_1}}{\sqrt{\dot{\varepsilon}_1} + \sqrt{\dot{\varepsilon}_2}}. \tag{10}$$

Let us consider the multilayered model, which takes into account the layered permafrost, alternating layers of sand and clay, and so on. Let us represent it in the form n - 1 layers with uniform impedance $\dot{Z}_2, \dot{Z}_3 ... \dot{Z}_n$ (complex permittivities are respectively $\dot{\varepsilon}_2, \dot{\varepsilon}_3 ... \dot{\varepsilon}_n$) located between two semi-infinite media 1 and $n + 1$.

Multilayered model is presented in Figure 2.

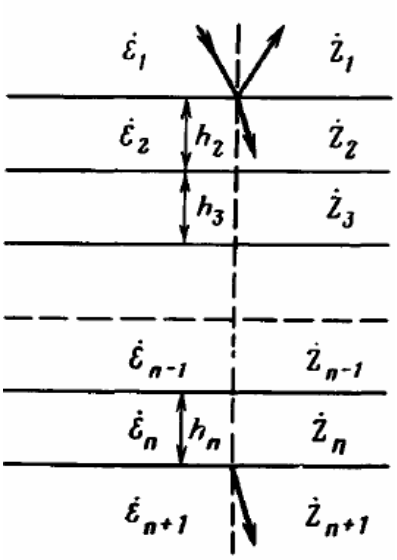

Fig. 2. Multilayered model

Let us assume that there is only a layer with index n, and the medium with index n - 1, as well as that with $n + 1$, extends indefinitely. Then, the input impedance of the upper boundary layer of index n is

$$\dot{Z}_{вх}^{n} = \frac{(\dot{Z}_{n+1} + \dot{Z}_n) + (\dot{Z}_{n+1} - \dot{Z}_n) e^{-2\dot{\gamma}_n h_n}}{(\dot{Z}_{n+1} + \dot{Z}_n) - (\dot{Z}_{n+1} - \dot{Z}_n) e^{-2\dot{\gamma}_n h_n}} \dot{Z}_n. \tag{11}$$

Since while moving through the boundary layer tangential components of the electric and magnetic fields do not change, impedances are saved as well. Therefore, the impedance at the lower boundary of the layer with index $n - 1$ coincides with the input impedance $\dot{Z}_{вх}^{n}$ of the layer with index n.

Gradual transition from one layer to another enables us to find the input impedance $\dot{Z}_{вх}^{3}$ at the upper boundary layer with index 3. The addition of another layer (with index 2) allows us to calculate the input impedance at the upper boundary for the entire system of layers in the form of:

$$\dot{Z}_{вх}^{(n-1)} = \frac{(\dot{Z}_{вх}^{n} + \dot{Z}_{n-1}) + (\dot{Z}_{вх}^{n} - \dot{Z}_{n-1}) e^{-2\dot{\gamma}_{n-1} h_{n-1}}}{(\dot{Z}_{вх}^{n} + \dot{Z}_{n-1}) - (\dot{Z}_{вх}^{n} - \dot{Z}_{n-1}) e^{-2\dot{\gamma}_{n-1} h_{n-1}}} \dot{Z}_{n-1}. \tag{12}$$

Therefore, the final reflection coefficient of the layers is

$$\dot{R} = \frac{(\dot{Z}^2_{вх} - \dot{Z}_1)}{(\dot{Z}^2_{вх} + \dot{Z}_1)}. \quad (13)$$

Let's consider a two-layer medium, which n = 3. The thicknesses of the 1st and the 2nd layers are, respectively, h_2 and h_3, and their propagation constants are $\dot{\gamma}_2, \dot{\gamma}_3$. This medium coefficient (13) is calculated using the formula (12), if we substitute the value $\dot{Z}^3_{вх}$ calculated by formula (11):

$$\dot{Z}^3_{вх} = \frac{(\dot{Z}_4 + \dot{Z}_3) + (\dot{Z}_4 - \dot{Z}_3)e^{-2\dot{\gamma}_3 h_3}}{(\dot{Z}_4 + \dot{Z}_3) - (\dot{Z}_4 - \dot{Z}_3)e^{-2\dot{\gamma}_3 h_3}} \dot{Z}_3. \quad (14)$$

In a particular case when the thicknesses of all layers are equal to zero ($h2 = h3 = 0$), the input impedance of the system $\dot{Z}^2_{вх}$ is equal to the impedance $\dot{Z}_4$, as it should be in case of absence of layers.

The above formulas enables expression (14) to take the following form

$$\dot{R} = \frac{\dot{R}_{1-2} + we^{-2\dot{\gamma}_2 h_2}}{1 + \dot{R}_{1-2} + we^{-2\dot{\gamma}_2 h_2}}, \quad (15)$$

where

$$\dot{w} = \frac{\dot{Z}^3_{вх} - \dot{Z}_2}{\dot{Z}^3_{вх} + \dot{Z}_2} = \frac{\dot{R}_{2-3} + \dot{R}_{3-4}e^{-2\dot{\gamma}_3 h_3}}{1 - \dot{R}_{2-3}\dot{R}_{3-4}e^{-2\dot{\gamma}_3 h_3}}. \quad (16)$$

This method makes it possible to analyze the layered media, specifically, to determine the physical properties of the layer (e.g., dielectric constant) as well as their number. This method can find its application in geology and geolocation to detect all kinds of deposits.

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UDC 519.68

MODEL MANAGEMENT SYSTEM THAT IS BASED ON DATA PROCESSING AND ANALYSIS IN REAL TIME WITH INSTRUMENTS MATLAB

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The block diagram and the practical implementation of model management system based on the processing and analysis of data in real time are considered. Interfaces mutual exchange of data streams of MATLAB and external equipment were considered. The example of using the data in real time with application of the system objects MATLAB is given.

Communication and control systems are the most important aspects of work with hardware and software. Direct communication with equipment and peripheral device allows you to quickly test and verify algorithms, and to carry the necessary changes in projects under development. MATLAB software provides a lot of different ways to interact with sophisticated equipment and peripherals.

The MathWorks system of computer mathematics MATLAB is an interactive environment that uses a high-level language for numerical computation, visualization and programming. It is possible to develop algorithms, to analyze the data and to generate models and applications on the basis of this system [5].

The use of digital oscilloscopes and analog-to-digital converters together with mathematical modeling MATLAB program opens up a lot of promising opportunities in the processing and following use of the measured data for the design of various systems.

The transmission of data flow measured in the process into the MATLAB workspace and ensuring hardware and software compatibility of equipment and a personal computer (PC) are the main difficulty in the implementation of the exchange of data.

The problem of processing a large amount of information, which is based on data that is obtained by measurements, in real time often appears in control systems. This treatment is practically impossible without expensive physical prototypes or equipment. However, even if you have such equipment, development, testing and verification algorithms can be very risky and even lead to damage. Method of constructing a model of the target system and simulation of its work (for example, in the MATLAB) in various modes before launching on real hardware is more reliable and less expensive [1].

The block diagram of a simple management model based on data analysis and processing in real time is presented in Figure 1.

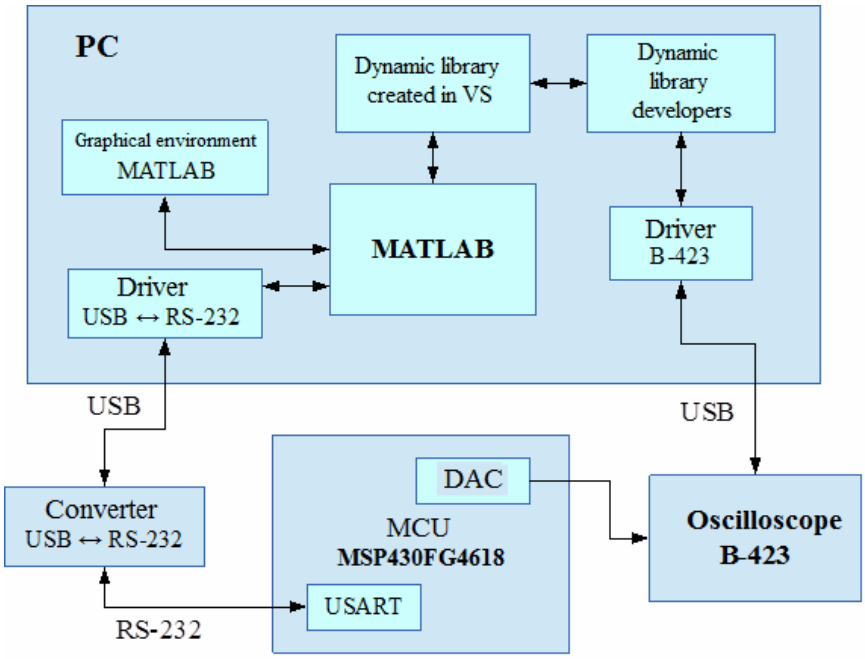

Fig. 1. A block diagram of hardware and software system

The oscilloscope of the Auris B-423 company will be used. Manufacturer does not give us completed solutions for its use in conjunction with MATLAB. However, dynamic libraries (*.dll) are supplied with the software for the development of the off-site software in the use of the equipment purchased.

A microcontroller (MCU) from "Texas Instruments" (series MSP430FG4816) was used as a controlled oscillator. This highly integrated MCU allows you to use almost any combination of family MSP430 peripherals. Connection facility of a variety of integrated peripherals and other devices involves enough opportunities to develop equipment and makes microcontroller an ideal platform for its base [2].

Let's turn to realization the system shown in Figure 1.

1. The interfaces of communication with external equipment.

MATLAB package includes a variety of interfaces for data access, clients, servers, and external routines that are written in other programming languages. The most commonly used interfaces are:

– COM. MATLAB provides access to functions that allow you to create, manage, and delete COM-objects (both client and server).

– .NET. MATLAB provides access to the software platform .NET Framework on Microsoft Windows. It is possible to download the .NET assembly (Assemblies) and to work with objects of .NET classes from MATLAB environment [4].

– DDE. MATLAB provides functions that allow it to access other applications in the Windows, as well as those applications to access data from MATLAB.

– COM-port. Interface to the serial port of MATLAB provides direct access to peripheral devices and scientific equipment connected with the computer through a serial port (COM-port).

– DLL. Interface MATLAB that is referring to the common DLL libraries allows you to call functions that are in the normal dynamic link libraries directly from MATLAB. It also must have a function C-Interface.

USB communication interface is used for connecting the oscilloscope B-423 with a computer, and data communication on which to MATLAB from the oscilloscope can be done in two technologies .NET and DLL. It should be noted that the direct use of a dynamic link library (DLL) external functions (OSCB423Lib.dll) for the oscilloscope in MATLAB was not possible, due to the unknown structure of the developers' library. Therefore, we applied the technology .NET for our model oscilloscope control, and its own dynamic library of simple functions (Osc.dll) in C # environment Visual Studio 2013 was written for that. Written library is a matching link between developers' dynamic library (OSCB423Lib.dll) and MATLAB. Only two functions are amount of the created library: Setting () - for the basic settings of the oscilloscope and Measuring () - for the measurement, and return the data in MATLAB.

COM-port is selected to control the microcontroller interface and provides a simple interface for direct connection of RS-232 communication. Due to the fact that the system was developed on the laptop, not on the personal computer, additional interface was introduced to system – converter USB-RS232.

2. Using MCU to work as a controlled oscillator.

We used 10-bit DAC peripheral module as a signal generator, and the built-in peripheral universal synchronous-asynchronous receiver-transmitter USART was used for verification. A developed program code for MCU was tested with the help of the Code Composer Studio v6 software. [2]

3. Initialization of the oscilloscope to measure.

Connecting of library with the help of .NET technology in MATLAB occurs with the following command in the application's console:

>> NET.addAssembly('путь_к_библиотеке\Osc.dll');

Creating of NET object corresponding to the class of our dynamic link library (Osc.dll) occurs with the help of the command:

>> obj = Osc.Program;

4. Implementation of measurement and transmission of the data stream.

Setting up the oscilloscope for measurement is realized with the command:

>> obj.Setting();

Measurement and transmission of the data stream in the MATLAB workspace are made with the command:

>> X = double(obj.Meas(*ScaleX*, *ScaleY*));

Variables ScaleX and ScaleY are selected to configure the scan, the significance of that will be determined by the number of samplings for a second and the scan potential. Moreover, values that predefined in the library developers are used at the time of the choice of these variables (ScaleY and ScaleX) too.

5. Digital processing of streaming data.

Using streaming and time-lapse processing technology allows to accelerate simulation due to buffering input data into frames and simultaneous processing of multiple samples of data. Acceleration of simulation is also achieved by focusing on the treatment process fixed immediately a lot of data. In MATLAB streaming signal processing is achieved due to the use of system objects (System objects) to represent data-driven algorithms, tools, data input and output of the models. System objects implicitly manage a lot of aspects of the system such as indexing, data buffering and state regulation algorithms. In one program it can be combined system objects with standard functions and operators of MATLAB.

Here is the example of using the system object dsp.FFT () that computes the discrete Fourier transform (DFT) from the samples of the input signal. System object can use one of several types of fast Fourier transform algorithm (FFT). When you create a system object, it is usually indicated by the parameters: the length of the input digital signal, the estimated window, bit- bidirectional order of output samples and the type of algorithm. Creating a system object in the MATLAB console looks like in the following way [3]:

>> hfft = dsp.FFT('FFTLengthSource', 'Property', 'FFTLength', 1024, 'BitReversedOutput', false, 'WrapInput', true, 'FFTImplementation', 'auto');

Object's uses for calculations

>> Y = step(hfft, y);

Here, y- is the input vector of data or the frame in the data stream. Y is calculating vector for this block FFT.

6. Presentation of the measurements' results.

Large quantity of data is usually obtained as the result of made calculation, so it is difficult to analyze it without visual imaging. In this case, graphics capabilities of MATLAB are high-end and manifold. They are often called high-level graphics. This name reflects the fact that the user is not in need to delve into all the details

of direct work with graphics. At the same time, if necessary, the graphic representations of the processed data can always be easily represented in the form of a single Windows-based application.

The example of a graphical display of the processing effect and data flow analysis that was measured with an oscilloscope is shown in Figure 2. Graphs that are superimposed on the graphical user interface:

– A graph that represents the data obtained from the oscilloscope in the form of a temporary representation of the signal;

– A graph that images the processed data from the oscilloscope with the help of system object in the form of a spectrum.

Analysis of the data takes place by four markers that control the maximum and minimum values of the signal amplitude and the maximum signal power and the harmonic frequency at which it is calculated.

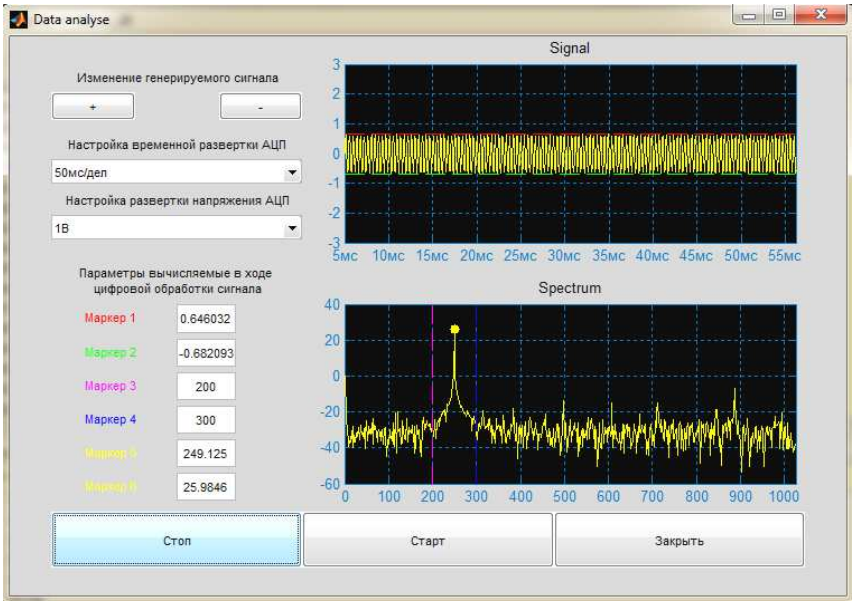

Fig. 2. A graphical interface MATLAB:
Marker 1 – is the maximum amplitude of the signal, expressed in volts; Marker 2 – is the minimum amplitude of the signal, expressed in volts; Marker 3 and Marker 4 – are a setting frequency band management;
Marker 5 and Marker 6 – are a position of a point on the spectral graph

7. Determination of the controlling effect on the signal generator.

MATLAB makes the determination necessary impact on the signal generator based on the analysis of data from the placed markers 3 and 4 (see Figure 3) and calculated values surrounding markers 1, 2, 5 and 6.

Task designed management system to provide retention of the frequency of the oscillations generated within the established using markers 3 and 4. The system can adjust the amplitude of vibrations and frequency through the MCU command via RS-232. The algorithm for deciding on the choice of a team at this stage is quite simple:

– The command to increase the voltage is issued at low values x of the measured voltage;

– The command to change the sweep voltage is issued in that case if the command to increase the voltage does not work for one second;

– The command to change scan at the time base is given in the case if the frequency range defined by the markers will be at the beginning or in the middle of the entire frequency range at the given sampling rate;

– The command to increase or decrease the frequency of the generated oscillations issues according to the position of the calculated value of the frequency with regard to range defined by markers 3 and 4.

As a result of this work, a model block diagram of a control system that is based on the processing and analysis of data in real time was developed.

Integration of oscilloscope B-423 "Auris" for receiving the data stream was realized through the use of .NET technology.

Your own graphical user interface for displaying and analyzing data obtained from oscilloscope in real time and generator control in automatic or manual mode was written.

The example of using the data in real time was presented with the help of the MATLAB system objects.

We have created a model that covers almost all the main stages of management development systems based on the data obtained in real time.

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UDC 681.586.78

SENSORS OF ALARM SYSTEMS

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The standard structure of alarm systems has been considered. The description of the principles of operation of sensors has been provided. Alternative options of touch elements of security system have been shown.

Security alarm is a complex of electronic security devices, which allows to provide object's protection from offences by means of the owner or law enforcement bodies alerting. There are two main types of alarm acute for Belarus: 1) the alarm using MIA security department brigade of the Republic of Belarus call, with monthly pay; 2) GSM-alarm, the activation of which alert message by means of SMS or mobile phone-call is delivered to the owner.

The security alarm system consists of the control unit (with GSM-module or without it) and different sensory devices depending on the guarded object. The system also contains uninterruptible power supply unit with an accumulator battery and security systems' cable. Control-security device may be wire-connected – with sensory devices, as well as unwired – the connection between sensory devices is realized with the help of radiofrequency signal (power supply is wire-connected). Control of radio-security may be realized by means of wireless radio-breloques [1]. Control unit shows current alarm mode ("Attention", "Warning", "Removal"), it's also activates/deactivates with the help of Touch Memory key or SMS-message. Let's look at the principles of sensory devices' working and its configuration. There are three main sensory devices in the system: a movement-detecting device, the device of a door opening/locking fixing process and the one of glass-breaking.

Let's consider a movement-detecting sensory device. It is based on IR-detector, that uses deposition of thermal energy the perimeter breaker emits. Movement-detecting IR-sensors are used for the security of armed bank buildings - cash operating units, depositories. The principle of thermal movement-detecting method is based on the physical theory of electromagnetic waves' radiating by objects, the temperature of which is above the absolute zero point. Movement-detecting and presence sensory devices react on the photocell IR-light occurrence and disappearance. Such IR-light occurrence-disappearance are often caused by human activity, more seldom – by factors which aren't connected with man, for example, by warm air moving from a radiator etc.

That's why false activations are observed with all of the movement-detecting (presence) sensors. Movement-detecting devices are more simple in its construction and they react only on active movements, of a walking man, for example. A general arrangement drawing of IR-sensor work is represented at figure 1 [2].

There are various constructions of movement-detecting IR-sensors, which are intended for specific technical objectives and conditions. The most popular construction of the movement-detecting IR-sensor is given in figure 2 [3].

The principle of movement-detecting sensor on pyroelement is the following: perimeter breaker's thermal stream goes to the Fresnel lens, which focuses radiation on the pyroelement, after that thermal stream is transformed into pyroelement's temperature change. The internal structure of the pyroelement redistributes (charges rearrange themselves) and potential (voltage) appears on the pyroelement's leading-outs. This signal enters sensory device control unit, i.e. cascade of growing and its transformation into digital form.

One of the important parts of modern security system is a door opening/locking sensory device.

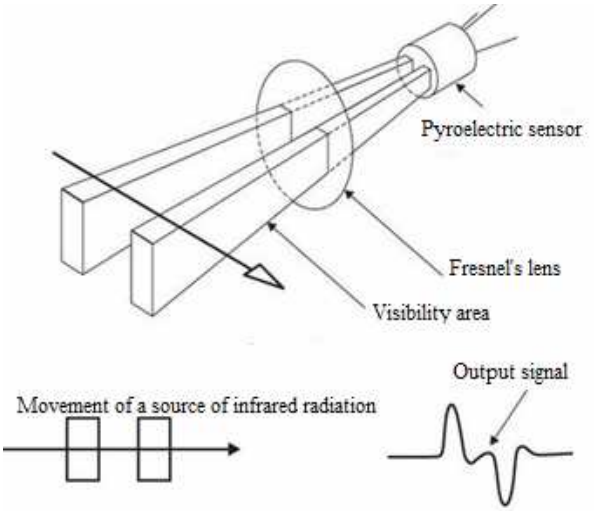

Fig. 1. The block diagram of functioning the movement-detecting sensor on a pyroelement

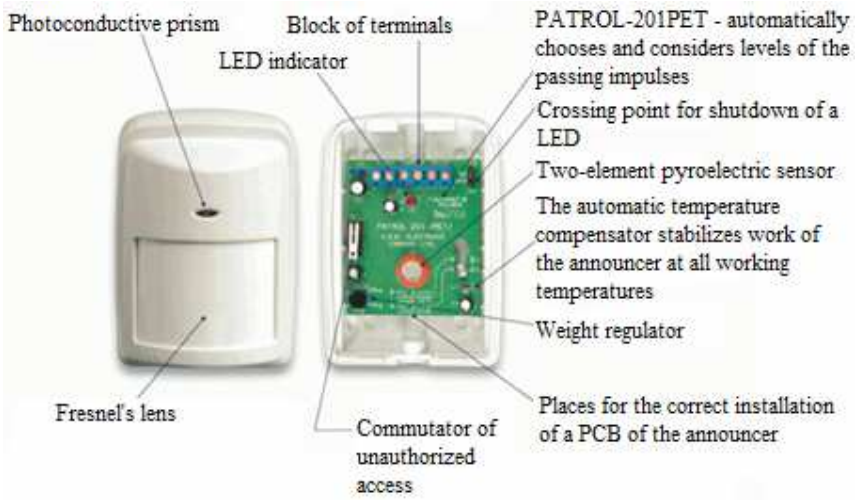

Fig. 2. Construction of movement-detecting IR-sensor

Sealed contact sensor is a special device created for separate objects' protection level increasing. The main active components of such product are sealed contact and magnet, according to which the device was named. The sensor reacts on doors-opening in detached houses or garages, utility rooms. Sealed contact working is based on interreaction of two main elements: permanent magnet as a master element and sealed contact as an actuating element.

Sealed contact is a unique element in radio electronics, which consists of two or three permalloy patterns weld airproof inside of the glass balloon with nitrogen at high preassure. Such construction technology allows to exclude completely any oxidizing process appearance in sealed contact. Sealed contact interface details are covered with special lightweight film made of noble metals, so that low transient resistance, high wear-resistance and the possibility of current commutation is provided.

A master element, or permanent magnet, is fixed on flexible part of the guarded object, an actuating element, or sealed contact, with all commutational tools and wires – on stationary part of the object. When the master and the actuating elements of sealed contact sensor are placed together, sealed contact leads are locked under the influence of magnetic field. In this case sensor works in "Security" mode. If these elements are separate, weakening of magnetic field influence on sealed contact is observed, as a result, leads are disconnected, and the sensor turns to "Warning" mode. The amounts of the distances between the main elements are described in operating instructions of each sensory device, what provides stable forming of the above-described modes.

The principle of operation of the sensor of breaking glass consists in response to fluctuations with a frequency in limits 1,5 kHz, which arise when glass breaks, or higher frequency in cases when glass is cut out by means of the special tool. If the range of noise contains a component, which coincides with a range of glass, which was damaged, it means that the sensor was actuated. In this task as the sensor of breaking glass, will be

used the acoustic sensor. When using the acoustic sensor the electret microphone will be a sensitive element. The signal is amplifies and analyzed by the electronic scheme.

As a result, it is possible to tell, that the system is hi-tech and represents very reliable device. To increase functionality of security system some sensors it is possible to change. We will consider analogs of these sensors and their principle of action.

Movement-detecting sensor DRM-01 can be used as the presence sensor. The sensor allows to define the movement through wooden boards, glass and plastic. Movement-detecting sensor DRM radiates and accepts the reflected high-frequency electromagnetic waves with a frequency 5,8 Hz. The sensor defines changes in the reflected waves caused by movement of object in a controlled zone. It is also defines the movement of object, both on approach, and on removal. The movement in a controlled zone leads to automatic inclusion of lighting. From the moment of inclusion, each movement supports continuous lighting. Only lack of the movement in a controlled zone disconnects time of maintenance of the included lighting. The next movement in a controlled zone or its absence during counting of the set time reckon time at first. Motion of action allows using DRM as presence sensor. After the set time lighting will be switched off automatically. The motion sensor is supplied with the photosensitive automatic breaker which blocks lighting inclusion in the afternoon. The sensor is activated in a verification regime of the movement and readiness for lighting inclusion only after approach of twilight. The consumer by means of a potentiometer can set time of activation of the sensor. In addition there is a possibility of adjustment of the area of the review of the detector in a radius of action of a beam from 3 to 10 m (with an installation height h = 2,5 m), and also adjustment of time of inclusion of lighting in the range from 5 seconds up to 12 minutes. Inclusion of the consumer is signaled by a luminescence of a green light-emitting diode. The movement-detecting sensor can work out of rooms.

Sensor of breaking glass pyronix Break Glass 2000 — it is the acoustic sensor of breaking glass [4]. It is intended for detection of destruction of the glazed surfaces: breaking glass of windows, show-windows, partitions. For minimization of false operations sensor of breaking glass pyronix Break Glass 2000 uses microprocessor algorithm of processing of a signal on HF-LF-components: fixes a characteristic sound of withdrawal panes of glass against pressure difference owing to blow. As a result sensor of breaking glass pyronix Break Glass-2000 have the balanced characteristic of reliability of operation and is calculated on work with the majority of all-widespread types and the sizes of glass, including double-glazed windows, the tempered and armored glass.

The main particularities of the given sensors is that they can provide measurement with a contactless method.

The sensor of opening/closing of doors or windows belongs to contact type of sensors in this system. Wireless sensor of opening of a door/window Ajax WS-401 is intended for detecting of opening of doors, windows, hatches, gate, etc [5]. The sensor consists of two parts – a magnet and the block with sealed contact. The principle of operation of the sensor of opening of a door/window is based on properties of a sealed contact – the element that is carrying out current under the influence of a variation magnetic field. In a normal state, the magnet and the block with the sealed contact are closed. As soon as the door, on which the sensor is installed, opens – the magnet moves away from a sealed contact, contacts are disconnected and геркон ceases to carry out current. When closing a door there are return processes: the magnet comes nearer to a sealed contact, contacts are closed and sealed contact starts carrying out current. In both situations, the sensor works and instantly sends the message on alarm on the central block. Difference of the sensor consists in: it is protected from opening by a tamper, thanks to special algorithm of energy saving works from the battery till five years, response level – 1 cm, there is a possibility of a choice of logic of work (reacts only to opening, or both to opening, and to closing).

Increase of reliability of security systems is an actual problem. Now in the majority of security alarm systems, both import, and a domestic production magneto-contact sensors are used (sealed contact). However, use of sensors on the basis of effect of the Hall, instead of sealed contact promotes increase in reliability of security system (because of lack of any effect of contact) also allows to realize the security sensor with more flexible characteristics (adjustable sensitivity).

Now on the basis of Hall effect many firms make different sensors, as for measurement of directly magnetic induction (teslameters), and for the applied purposes, for example, production automation. However, in security sensors not enough attention, even on pages of producers is paid to use of Hall effect. In these time using of the Hall sensors in security systems allows to increase their reliability and flexibility in comparison with traditional magnetic and contact sensors, and furthermore the simple contact.

We will give advantages from using of the Hall sensors as security sensors, there are:

- default of the closing-disconnecting contacts;
- higher sensitivity on distance;
- possibility of adjustment of sensitivity;
- the dime-size that is important for the hidden installation.

For carrying out tests some versions are chosen movement-detecting infrared sensors various producers. When developing the program of tests were considered State All-Union standard (USSR State standard specification) P 50777-95 (IEC 839-2-6-90) [6]. Tests were carried out on the following items:

– range of action. As "object", the standard student was used by weight 70 kg and length 175 см. An "object" passed across "half line" a way to three meters. Was considered that the device "took" a distance if it reacted to the object moving with a speed from 0,3 to 3 m/s. Range of steady operation on the violator of the protected perimeter at the tested infrared sensors was fluctuate in limits from 0,3 to 12 m. It should be noted that the maximum range when carrying out experiences made 20 meters. The probability of detection of the violator in the range of 12 – 20 meters made 80% in this connection it is possible to consider that this distance isn't a zone of sure operation.

– resistance to an external flare. The movement-detecting infrared sensors has to react only to emergence in an area of coverage of the person and not notice, for example, "spot of sunlight" or light of automobile headlights. For research of this characteristic, various sensors were located in the dark box closed from all directions except a lobby. The beam of a bright lamp went to it, but to exclude influence of infrared part of a range, on the way of a beam established a double double-glazed window of firm Rehau. Practically we modelled a life situation: operation on the passing car. This experiment was made 5 times within 20 seconds. All sensors successfully passed tests as didn't react to external excitement.

– resistance to change of the feeding tension from 187 to 242 V. Fluctuations of mains voltage are very frequent and in rural areas, and in the city. Thus, there is a probability of failures in operation of IR sensors, consisting of a sensitive element and an electronic binding. At a supply voltage variation from lowered for 15% to rather standard raised for 15% (220 V) it was established that these changes had no essential impact on work of a sensitive element of the IR sensor as its food (12 V) was stabilized by the central block A6-04 [1].

Test of sensors of breaking glass were imitated by means of fluctuations of the glass jar filled with small metal subjects – nuts, screws, washers, etc. Change of frequency of sound vibrations was formed by various filling of glass capacity, changing amplitude and time intervals of stirrings.

Also we was made experiment with the sensor of opening/closing of doors. Sealed contact settled down on doors of laboratory as it is specified in figure 3.

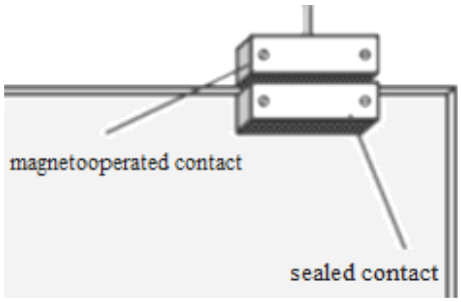

Fig. 3. Scheme of connection of the sensor of opening/closing of doors

Experiment was made as follows:

1. The knot with a permanent magnet the sizes of 25x8x8 mm from пермаллоя was established directly on a door;
2. The module of a sealed contact was fixed on a doorway;
3. When opening a door the distance between a magnet and sealed contact increased, the magnetic energy operating on the module of the sealed contact that led to disconnection of contact in the sealed contact decreased. The maximum distance at which else there is a short circuit of the sealed contact exceed 9 cm.

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