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Х А Б А Р Л А Р Ы

ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
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NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

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EXPERIMENTAL INVESTIGATIONS OF THE COARSE-GRAINED SOIL IN THE DAM OF THE PSKEM HEP

Abstract. This paper presents the results of laboratory and field compaction of coarse-grained soil. A vibratingplant with a diameter of 300 mm was used for laboratory compaction and the field compaction was carried out with a 27 tons smooth roller of the SANY type. Laboratory experiments were carried out with pattern mixtures using a standard soil compaction device SOYUZDORNII. A dependence chart of the dry soil density on moisture content is plotted and the maximum of the obtained dependence is identified, the corresponding values of the maximum density and optimal moisture content are found to determine the maximum density and optimal moisture content in the laboratory.

In field conditions and with soil compaction by a 27-ton roller in four six to passes, the density is ρ=2.19 t/m3with 50 cm layer thickness, the density is ρ=2.10 t/m3 at a thickness of 70 cm and the density is ρ=2.04 t/m3with a layer thickness of 80 cm.In addition, the paper demonstrates effectiveness of the applied method of drilling and blasting in a quarry to obtain stone material of the required grain composition. Scientific work was carried out as a result of experimental studies.

Key words: density, humidity, vibrating plant, placement, dam, stone material.

Introduction. The maingoal of construction of soil hydraulic structures from local materials is to ensure high-quality soil placement.

In general, the quality of materials for earth-and-rock dams is specified by their density, strength, deformability and filtration characteristics.

It is necessary to determine the control parameters ofplacement at each project individually to meet these requirements as justification of the control parameters for soils placement in the dam body requires extensive experimental works for each project. This takes into account a large number of parameters: grain composition, humidity, layer thickness, density, etc.

Materials and methods. Studies of the behavior of coarse-grained materials under heavy loads are of particular importance for rock-and-earth dams, and the selection of soil characteristics used in the construction of a soil dam is one of the main stages of constructions ince the reliability and efficiency of the construction will depend on this.

The standard compaction method was used for determination of soil density in laboratory conditions.

In the field conditions on the experimental site, the density was determined by the pit-hole method. In this case the volume of the pit was measured by pouring water onto a pre-lined polyethylene film 0.2 mm thick (see Fig. 1).

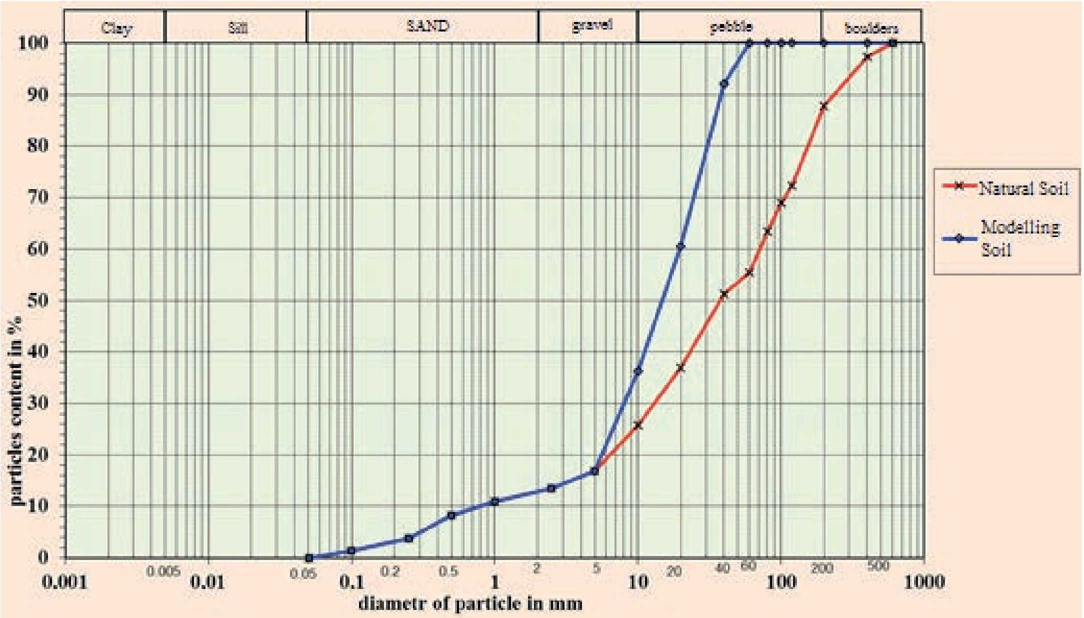

Fig.1. Soil Modeling Method (designed by "Hydroproject" JSC).

The investigation goal is to develop and select a method for the development, placement and compaction of soil materials for the dam body in natural conditions, providing the highest density and the lowest filtration coefficient of materials.

Theallotted tasks were solved by erecting experimental embankments and performing the necessary minimum of laboratory works.

Preliminary laboratory tests were carried out before the experimental placement on the experimental sites which made it possible to determine the dependence of moisture content and soils density during various work expended.The results of laboratory determinations of the maximum density were used to define the degree of compaction of a given soil in a particular construction [1].

Unlikefield conditions the laboratory compactionwas carried out not by rolling, but by compacting the soil using a standard compaction device.

For costs reasons the experimental embankment is dumped directly at the construction site on the left bank of the Pskem River. To that end the vegetative layer was cut off on a horizontal section, the surface was leveled and compacted with a 27-ton smooth roller of the SANY type. The layout of the base was carried out subject to possible deviations from the horizon of the base up to 5 cm.

The selected 100x100 m site was thoroughly compacted with a vibratory roller in 6-8 passages along one track. The prepared site was leveled in the measuring sections every 10 m at each point. The experimental embankment site was marked for a retaining prism, filters of the first and second layers and for the core. The site was cut along the outline. 40 pieces of 1.5 m F16AIII reinforcement steelwere used as recesses to designate platforms and alignments. Then the densities of the base were defined by the cutting ring method. The structure of the dam includes: a retaining prism made of stone, filters of the first and second layers of pebbles and a core of loamy soil [2-3].

At present, rock-and-earth dams are the most widespread among other types of high earth dams. Investigations of the behavior of coarse-grained materials under heavy loads are of particular importance for high rock-and-earth dams. The selection of soil characteristics used in the construction of a soil dam is one of the main stages of design since the reliability and efficiency of the construction will depend on this.

The soil density of the retaining prism on the experimental site was defined out as follows.

The retaining prisms of the dam of the Pskem HEP are planned to be built of the rock mass. The deposit No. 7a is planned to be usedas a quarry for retaining prisms it is located in the upper pool on the left bank, 2.0-3.0 km from the dam site.

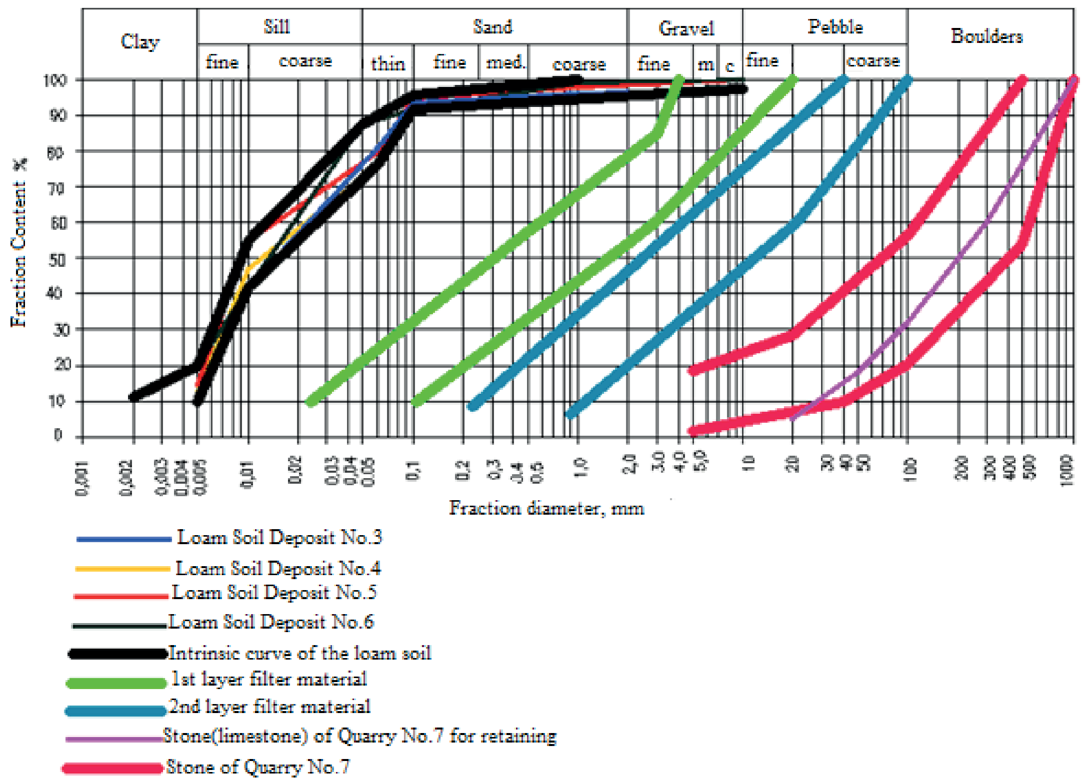

Fig.2. Chart of design curves of the grain size composition of embankment materials of the Pskem Dam (Dam.1910-10-102. "Hydroproject" JSC 2020).

The soil is transported on a largedump truck of BELAZ type with payload capacity up to 40 tons [4-7].

The soil of the experimental construction site was leveled by a bulldozer with uncompacted layers 50, 70, 80 cm thick. After leveling the soil was watered from a water carrier at a rate of 200 liters per 1 m3. The layers were compacted with a smooth roller weighing 27 tons of the "SANY" type, vibration on and off, at low speed. Thedensity was determined by the "pit-hole" method, two pits on each layer, after every second penetration.

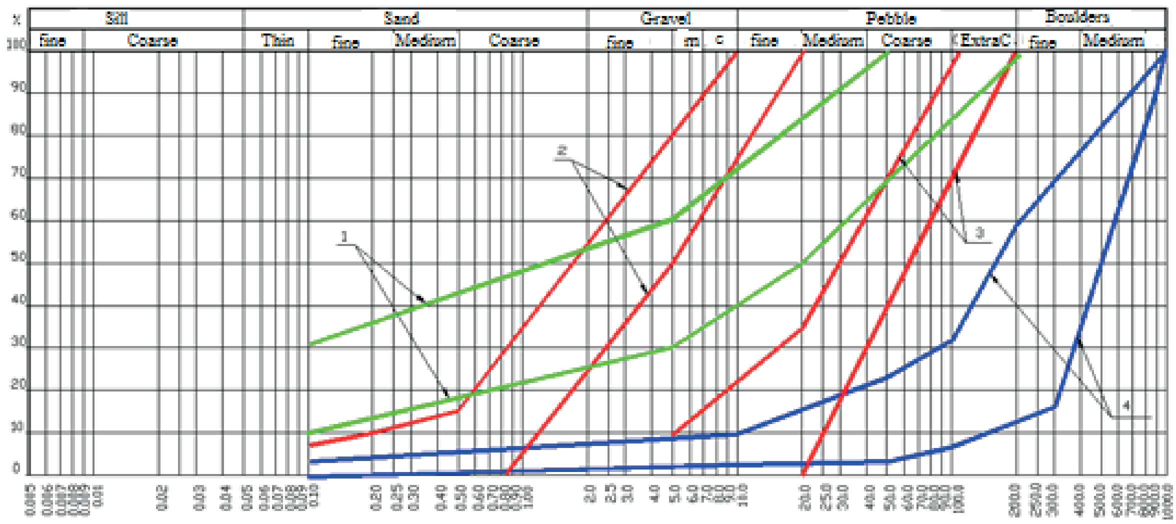

Fig.3. Mont Cenis Dam.1-shield; 2-first filter layer; 3-second filter layer; 4-stone masonry.

The investigation contained the method for sampling stone materials and processing the measurement results described below. Samples from the layer aretaken from the surface of its occurrence as follows:

- a carefully leveled horizontal platform 1.5x1.5 m is prepared, a metal frame 1.1x1.1 m is installed in it and a "pit-hole" goes to the depth of the tested layer or density determination horizon;

- the material taken from the pit was weighed and dispersed into fractions. The volume of the pit was measured by pouring water onto a pre-lined polyethylene film 0.2 mm thick, the surface of the "pit-hole"

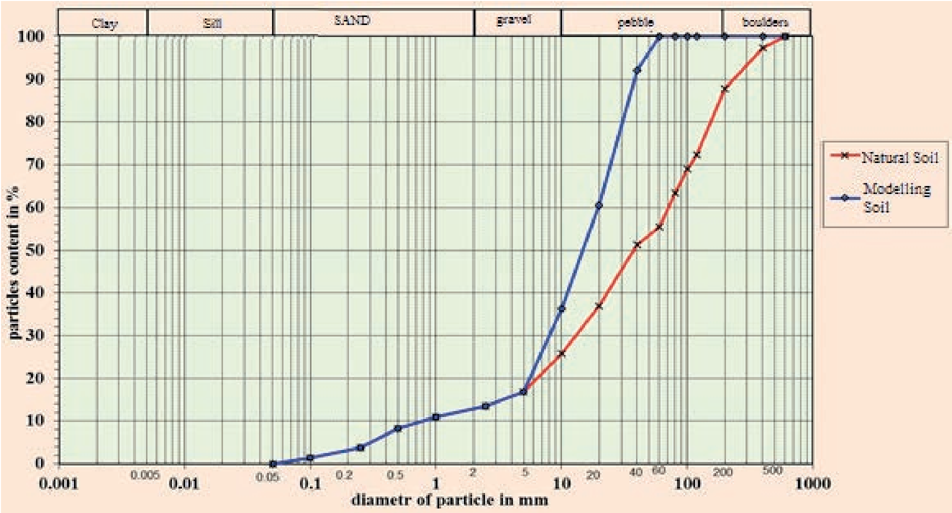

Fig.4. Soils Modelling Method (designed by "Hydroproject" JSC).

The volume-weight of the soil is determined as the quotient of the weight of the sample divided by the volume of the pit

$$\rho_d^w = \frac{\rho}{V}$$

Wher e ρ-weight, kg; *V*-volume, liter; ρ_d^w - volume-weight of the humid soil.

Considering that the humidity in the stone material has slight impact on the density, therefore, it can be ignored. If the content of fine earth (fr<5 mm) is more than 5% it is necessary to determine its moisture part and make a correction for all samples, i.e. the amount of water in the material must be subtracted from the total weight of the sample.

The humidity of the selected material is determined by sampling and drying 2 kg of weighed material with fractions less than 20 mm in an oven.

The sample representativity is defined by the volume of the holein relation to the maximum size of the inclusions and is regulated by GOST 28514-90.

The overall assessment of the quality of the placed natural soil is made according to the total grain size accumulation curvedetermined by sizing on the experimental site [8-9].

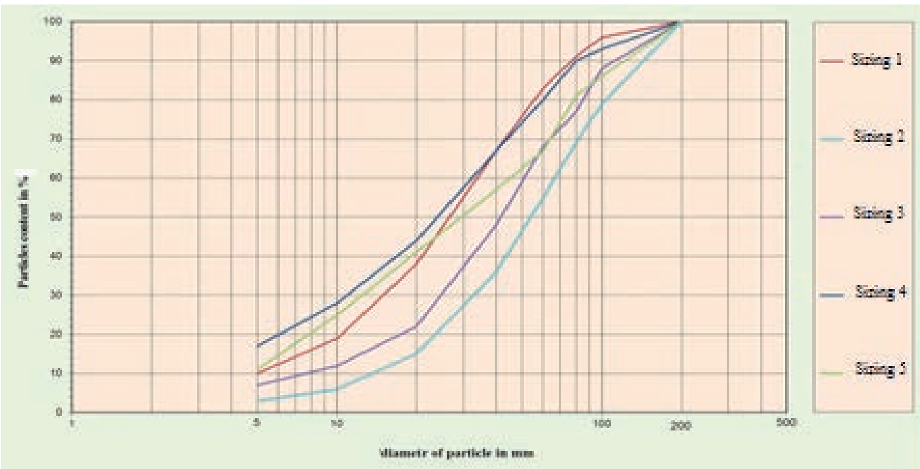

Fig.5. Grain size composition and density of the stone material placed in the experimental embankment.

Coarse-grained soils are one of the most high-potentialconstruction materials. As known, coarse-grained soils compose the retaining prisms of rock-and-earth dams and occupy an average of 60-70% of the total volume of the dam.

The use of coarse-grained soils requires reliable knowledge of their physical and mechanical features and construction characteristics. The use of these soils is complicated by a number of specific factors; labor intensity, large particle sizes, sample volumes, the need to use large-scale instruments.

A preliminary assessment of the compactibility of coarse-grained soil is carried out by the standard compaction method on a standard device in accordance with the regulatory requirements (GOST-34-72-646-83).

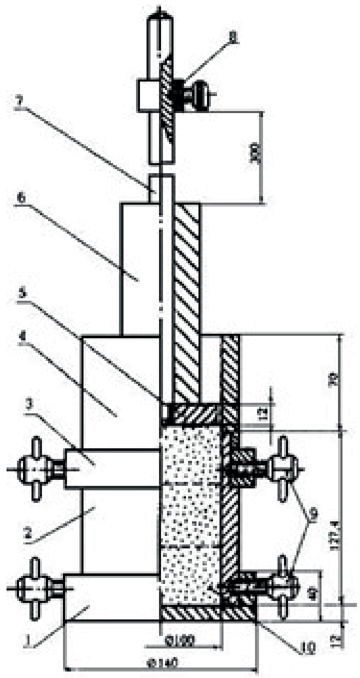

Fig.6. 1 - pallet; 2 - split form; 3 - clamping ring; 4 - cap; 5 - anvil; 6 - 2,5 kg weight; 7 - guidebar; 8 - stopper ring; 9 - clamping screws; 10 - soil sample.

In the meantime the size of separate fractions reaches up to 700-1000 m. This forces experimenters to switch to modeling the grain compositions of natural soil and perform experimental determinations on model mixtures when studying coarse-clastic soils in laboratory conditions [10].

The objective of modeling the grain composition of natural soil is accomplished in such a way that makes possible to use model mixtures in laboratory devices of acceptable sizes. At the same time the characteristics of model mixtures should best match the characteristics of natural soil.

Generalization of the investigation experience of coarse-grained soils brings us to conclusion that the ratio of the diameter of the device to the size of the maximum fraction should not be less than five $d_{\text{пр}} \geq 5d_{max}$.

The maximum size of fractions should be 60 mm for a standard device d=300 mm (Figure 6) [11].

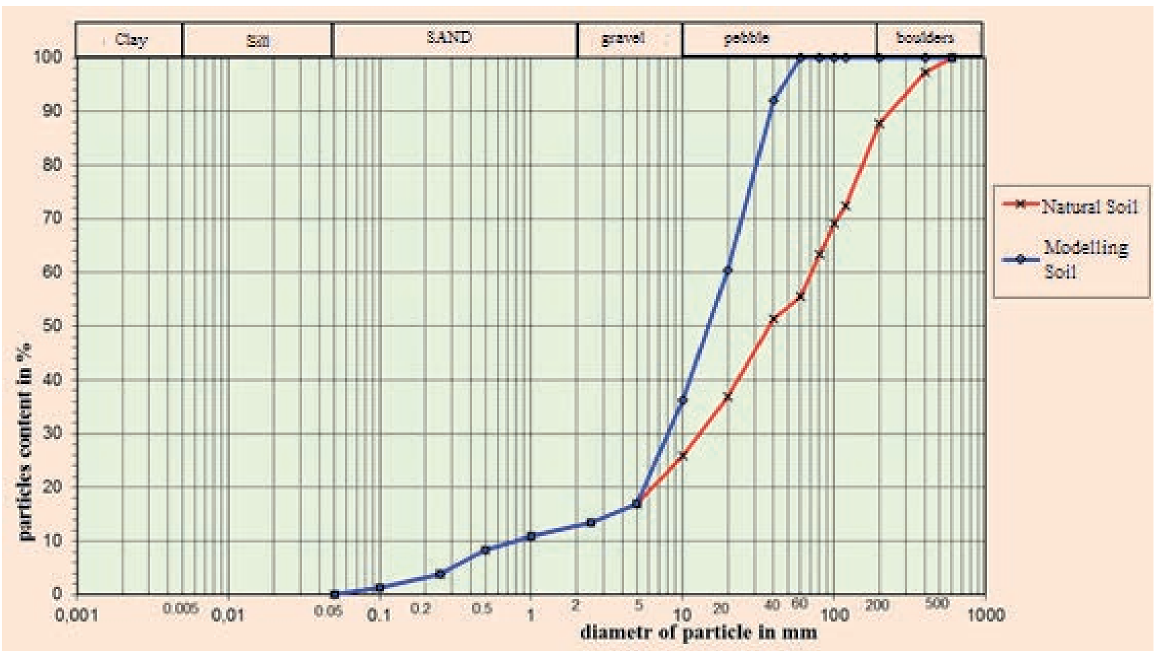

Fig.7. Grain size compositions of naturalpebbled soil of Quarry No.2 and model soil.

Itis recommended to keep the percentage of fractions in model mixtures less than 5 mm or 10 mm for assigning a grain composition in these mixtures. Therefore two points are fixed on the chart of the grain composition of the model mixture - the content of fine earth and the maximum fraction, see Fig.5. This method of modeling coarse-grained soils was developed by “Hydroproject” JSC.

Implementation of the method of modeling coarse soils requires the percentage of fractions less than 5 mm being equal both in the model and natural soils. The maximum fraction is determined by the minimum container size used. Therefore two points are fixed on the chart of the grain composition of the model mixture - the content of fine earth and the maximum fraction. In this case, a modeling method is used and it excludes randomness of the selection of fractions from 5 to 60 mm in size. Intermediate points on the chart are obtained by a proportional decrease of fractions in natural soil calculated by the formula:

$$\rho_d^{\text{м}} = \frac{\rho_i - \rho_{<5}}{\rho_{\text{i}}^{\text{н}} - \rho_{<5}}(100 - \rho_{<5}) + \rho_{<5}$$

where $\rho_d^{\text{м}}$ - percentage of fractions in the model mixture;

$\rho<5$-percentage of fractions <5 мм;

$\rho_{\text{i}}^{\text{н}}$-percentage of fractions in natural soil.

Model mixtures are made for each material type that is tested on a standard compaction unit. Themixtures are moistened before compaction so that the moisture content of the fine earth in the mixture is at least 5-6%. Then the mixture is loaded into the container of the vibrating plant (Figure 6), it is leveled and the distance between the surface soil and the top of the device is measured with a measuring ruler at five points. The bar of the measuring ruler is rotated by 90^0 and five more points of the soil surface are measured.

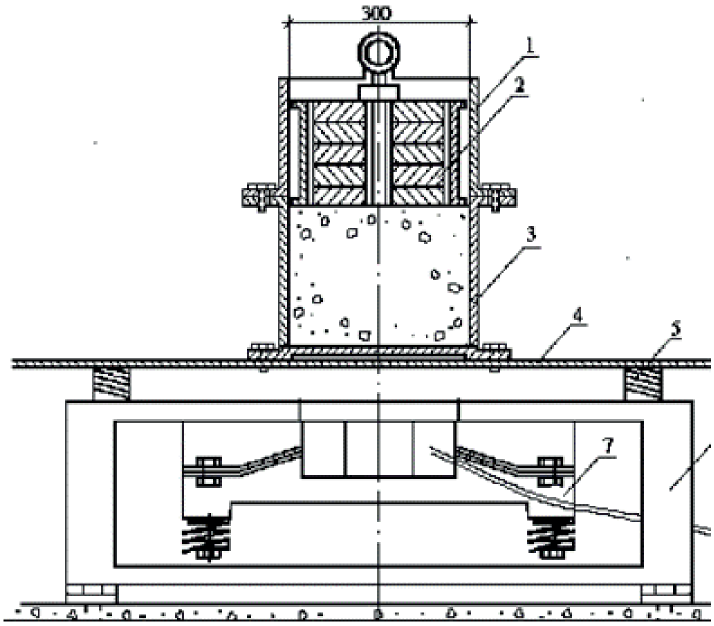

Fig.8. Vibratory soil compaction unit: 1-guide cylinder; 2-load; 3-container; 4-metal plate; 5-spring; 6-frame; 7-vibrator.

The average of the 10 points defines the position of the sample surface of the top of the device and the difference between the position of the bottom and the ground determines the height of the sample.

Thevibrator fixed to the bottom of the platform is turned on after the installation is assembled and the container is vibrated for 8 minutes. Then the ballasting package and rubber gasket are removed, the surface is measured at ten points from the upper edge of the container used for calculation of the volume of the compacted sample - the maximum density [12-13].

Determination of the limiting densities of addition will allow to plot a chartfor the function of two parameters: the fine earth content in the mixture of the model grain composition “m” and the density “*ρd*”.

The chart $\rho_d = f(m)$ is plotted basing on the specific differences uniformly covering the entire set of quarry soil (the content of fine earth is along the abscissa axis, the density is along the ordinate axis). The graph has an extreme value of density at a certain content of fine earth in the composition of the tested mixtures. Testing mixtures with different content of fine earth makes it possible to define the optimal content of fine earth (Figure 7).

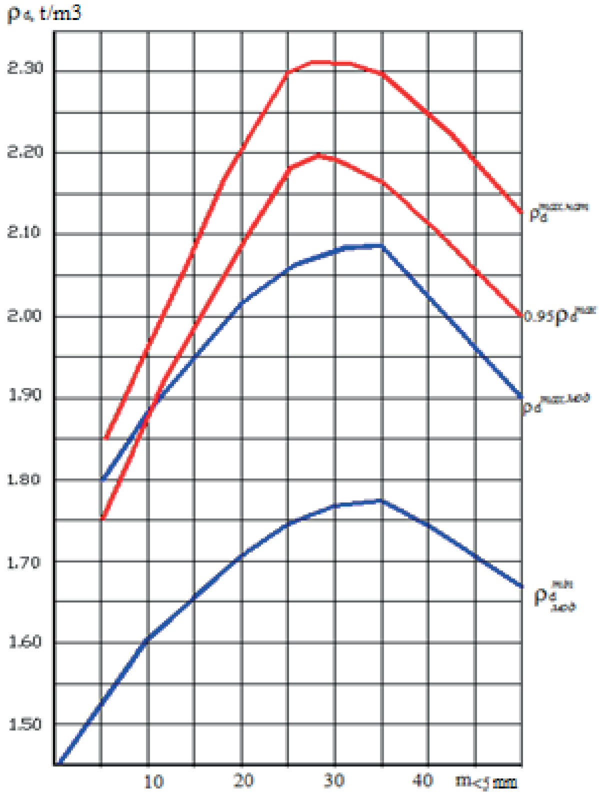

Fig.9. Chart of the dependence of the extreme bulk densities in the soil composition fraction d <5 мм.

The compaction results of model mixtures and their extreme bulk densities as well as the maximum densities of natural and required packing densities are equal to 0.95 ρ_d^{max}

Table 1

Mixture No.	Compositionfr.<5 mm, in %	Compositionfr.<20 мм, in %	Model mixtures density, t/m3		Natural soil	Required densities
			ρ_d^{mix}	ρ_d^{max}	ρ_d^{max}, t/m3	ρ_d^{mp}, t/m3
3	10	33	1.63	1.88	2.00	1.84
2	18	64	1.68	1.98	2.13	2.02
1	25	35	1.74	2.06	2.25	2.18

The results of Table 1makes possible to obtain relative densities of stone from quarry No. 7a for grain compositions with fine earth from 10 to 25%

Table 2 - Results according to the experimental data

According to experimental data	Fine earth content, %	Relative density, t/m3			
		I_d=0.70	I_d=0.75	I_d =0.80	I_d=0.85
	25	1.95	1.97	1.99	2.00
	18	1.88	1.90	1.91	1.93
	10	1.80	1.81	1.82	1.84

Table 3 – Summary table of relative densities of stone from quarry No. 7 for grain compositions containing fine earth from 5 to 25%

On formula of	Mixture No.	Fine earth content, %	Density index, t/m3			
			I_d=0.70	I_d=0.75	I_d=0.80	I_d=0.85
L. Rasskazov	1	25	1.89	1.92	1.95	1.99
	2	18	1.87	1.90	1.94	1.97
	3	10	1.85	1.88	1.91	1.94

M. Pavchich	1	25	2.06	2.08	2.11	2.13
	2	18	2.01	2.03	2.06	2.09
	3	10	1.97	1.99	2.02	2.05
Experiment	1	25	1.95	1.97	1.99	2.00
	2	18	1.88	1.90	1.91	1.93
	3	10	1.80	1.81	1.82	1.84

The analysis of the table shows that the relative density calculated according to the formulas of M. Pavchich is closest to the actual density of natural material.

Experimental data are given for model compositions with a maximum fraction diameter of up to 60 mm. An increase in the size of fractions in the rock mass to 600-800 mm will increase the density of the mixture by 0.1-0.015 and the experimental data will approximate the natural composition of the mixture or similar densities obtained by the formulas of M. Pavchich [14-16].

Results and discussion. The results of defining the soil density of the retaining prism on the experimental site in relation to the number of roller passages and the layer thickness are shown in the following graphs (Fig. 10,11,12).

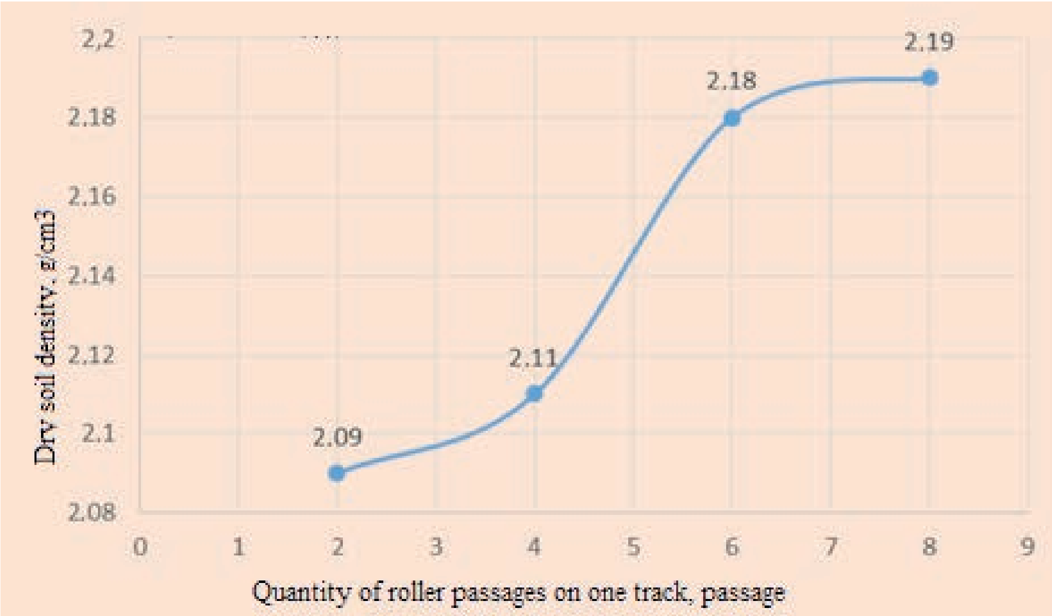

Fig.10. Chart of the dependence of the density of dry soil with a layer thickness of 50 cm on the number of passages of a smooth roller (26000 kg.) with the vibrator turned on, water irrigation 160 l / m3 WB, stone

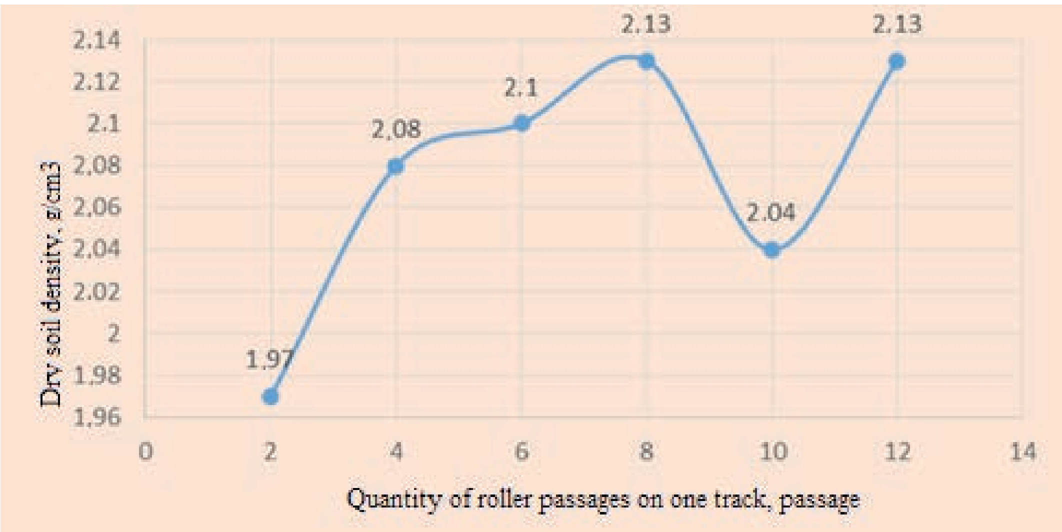

Fig.11. Chart of the dependence of the density of dry soil with a layer thickness of 80 cm on the number of passages of a smooth roller (26000 kg.) with the vibrator turned on, water irrigation 160 l / m3 WB, stone.

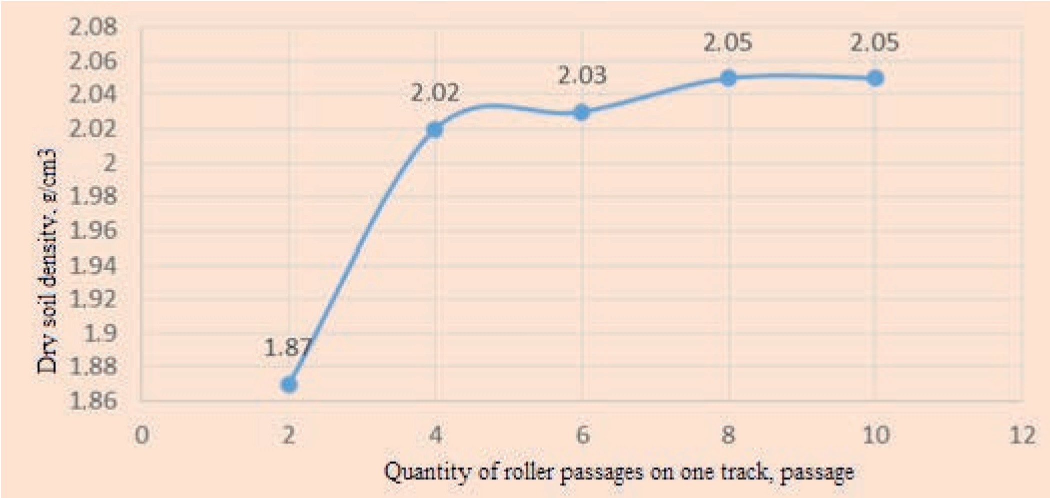

Fig.12. Chart of the dependence of the density of dry soil with a layer thickness of 70 cm on the number of passages of a smooth roller (26000 kg.) with the vibrator turned on, water irrigation 160 l / m3 WB, stone.

Thus, retaining prisms (stone) made of the rock mass were placed in layers of 50, 70, 80 cm with moisture from a water carrier and compaction with a 27-ton roller in four to six passes, the average density with a layer thickness of 50 cmis ρ_{dcp}=2.19 t/m^3, the average density is ρ_{dcp}= 2.10 t/m^3 at a thickness of 70 cm, and the average density is ρ_{dcp}=2.04 t/m^3 at a thickness of 80 cm. The data were obtained on the experimental site with a grain composition containing fractions of a maximum diameter up to 200 mm. (Fig. 13).

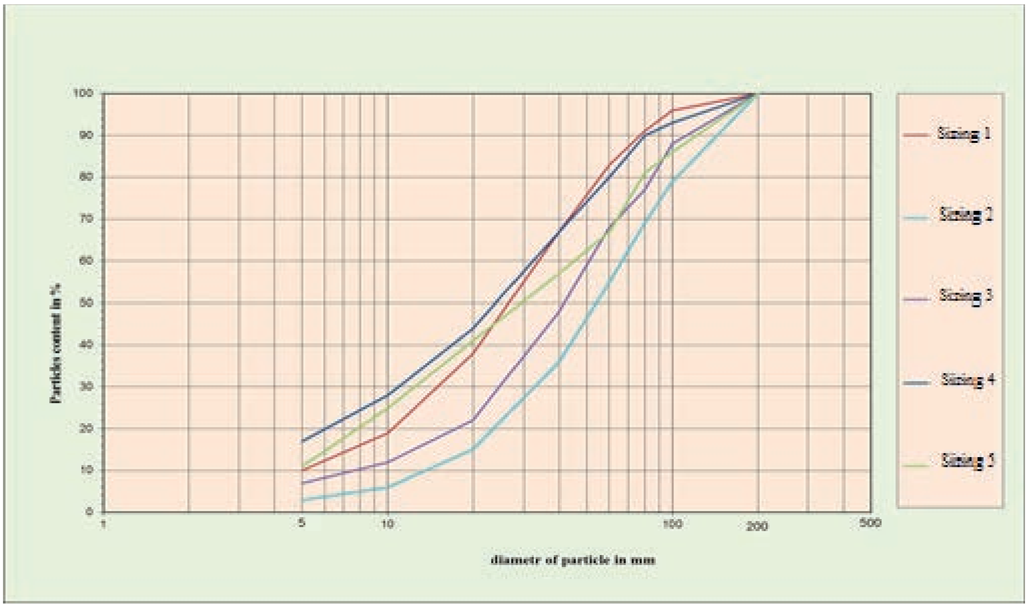

Fig.13. Grain size composition and density of the stone material placed in the experimental embankment.

The grain size composition of the resulting stone material by applying experimental optimal curves becomes assessable when developing stone quarries by blasting.

At the same time, we may assess the effectiveness of the applied method of conducting drilling and blasting operations in a quarryensuring the production of stone material of the required grain composition. The total information on the grain composition of the stone material may be obtained by means of experimental blasting works and the method of explosions is defined, as well, to obtain the required fractions.

The obtained data shows that the most rational method providing a relatively high density is the method of placing the stone material in layers of maximum 1.0 meters thickness with routine wetting at a flow rate of 150-300 l / m3 and compaction with a vibrating mechanism of a long range of operation.

It is a good practice for segregation prevention that the stone material is placed by means of large capacity dump trucks with a more or less uniform distribution on the layer surface followed by leveling with bulldozers [17].

It is seen from the granulometric compositions and densities of the stone material placed in the experimental embankment that the relative outflanking of the layer of stone material in the embankment reduceses with an increase in fine-grained fractions (less than 5 mm) in the soil composition. Italsoreduces from 8.6 mm to 6.2 mm with an increase in fine earth from 5% to 18%at loads of 4.0 Mpa. When the fine earth is insufficient in the soil composition the porosity of the rock mass is quite high and the deformation of the material is significant. The most optimal portion of fine earth in the soil composition is 18–25% that provides outflanking of maximum 6 mm [18].

Conclusions. 1. Retaining prisms made of the rock mass were placed in in layers of 50, 70, 80 cm with moisture and compaction with a 27 ton roller in four to six passes, the average density with a layer thickness of 50 cm is ρdcp=2.19 t/m^3, the average density isρ_{dcp}= 2.10 t/m^3 at a thickness of 70 cm, and the average density isρ_{dcp}=2.04 t/m^3 at a thickness of 80 cm. The data were obtained on the experimental site with a grain composition containing fractions of a maximum diameter up to 200 mm.

Thrust prisms from the rock mass were laid in layers of 50, 70, 80 cm with moistening and compaction by a 27-ton roller in four to six passes at a layer thickness of 50 cm, density p_dsr =2.19 t/m3 at a thickness of 70 cm, average density p_dsr =2.10 t/m3, at a thickness of 80 cm, average density p_dsr = 2.04 t/m3.

2. We may assess the effectiveness of the applied method of conducting drilling and blasting operations for quarry exploitation ensuring the production of stone material of the required grain composition.

3. The most rational method providing a relatively high densityis the method of placing the stone material in layers of maximum 1.0 meters thickness with routine wetting at a flow rate of 150-300 l/m3 and compaction with a vibrating mechanism of a long range of operation.

4. It is a good practice for segregation prevention that the stone material is placed by means of large capacity dump trucks with a more or less uniform distribution on the layer surface followed by leveling with bulldozers.

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ПСКЕМ ГЭС БӨГЕТІНДЕГІ ІРІ ТҮЙІРЛІ ТОПЫРАҚТЫ ЭКСПЕРИМЕНТТІК ЗЕРТТЕУ

Аннотация. Бұл жұмыста ірі түйіршікті топырақты зертханалық және далалық тығыздау нәтижелері ұсынылған. Зертханалық тығыздау үшін диаметрі 300 мм діріл қондырғысы қолданылды, ал далада тығыздау салмағы 27 тонна SANY типті тегіс роликпен жүзеге асырылды. Зертханалық тәжірибелер СОЮЗДОРНИЯ топырағын тығыздау үшін стандартты құрылғыны қолдана отырып, үлгілі қоспалармен жүргізілді. Құрғақ топырақ тығыздығының ылғалдылыққа тәуелділігі графигі құрылып, алынған тәуелділіктің максимумы анықталып, зертханада максималды тығыздық пен оңтайлы ылғалдылық мөлшерін анықтау үшін максималды тығыздық пен оңтайлы ылғалдылық мөлшеріне сәйкес мәндерді қарастырылды.

Дала жағдайында қабаттың қалыңдығы 50 см болған кезде топырақтың 27 тонналық роликпен тығыздалуы алты өту тығыздығы ρ=2.19 т/м3 қалыңдығы 70 см болған кезде тығыздығы ρ=2.10 т/м3 және қабаттың қалыңдығы 80 см болған кезде тығыздығы ρ=2.04 т / м3 болды.

Сонымен қатар, қажетті астық құрамының тас материалын алу үшін карьерде бұрғылау-жару жұмыстарының қолданылатын әдісінің тиімділігі көрсетілді. Ғылыми жұмыс эксперименттік зерттеулер нәтижесінде жүзеге асырылды.

Түйінді сөздер: тығыздық, ылғалдылық, діріл қондырғысы, орналастыру, бөгет, тас материал.

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ОПЫТНО-ЭКСПЕРИМЕНТАЛЬНЫЕ ИССЛЕДОВАНИЯ КРУПНООБЛОМОЧНЫХ ГРУНТОВ ПЛОТИНЫ ПСКЕМСКОЙ ГЭС

Аннотация. В данной работе приведены результаты лабораторного и полевого уплотнения крупнообломочного грунта. Для лабораторного уплотнения применялся вибрационная установка, диаметром 300мм, в полевых условиях уплотнение произвели гладким катком весом 27 тонн типа SANY. Лабораторные опыты проводили с модельными смесями при помощи прибора СОЮЗДОРНИИ стандартного уплотнения грунтов. Для определения максимальной плотности и оптимальной влажности в лаборатории строится график зависимости плотности сухого грунта от влажности и находят максимум полученной зависимости соответствующие ем увеличены максимальной плотности и оптимальной влажности.

В полевых условиях при толщине слоя 50 см уплотнение грунта 27-тонным катком зачеты ре шести проходов плотность ρ=2.19 т/м^3 при толщине 70см плотность ρ=2.10 т/м^{3}и при толщине слоя 80 см плотность ρ=2.04 т/м^3.

Кроме того, показана эффективность применяемого способа буровзрывных работ в карьере для получения каменного материала требуемого зернового состава. Научная работа осуществлялась в результате экспериментальных исследований.

Ключевые слова: плотность, влажность, вибрационная установка, укладка, плотина, каменного материала.

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