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COMPARATIVE RESEARCHES OF PROPERTIES OF EXPANDED PERLITE MADE FROM PERLITE RAW MATERIALS OF FOGOSH DEPOSIT OF UKRAINE AND DEPOSITS OF GREECE, ARMENIA, TURKEY, GEORGIA

ПОРІВНЯЛЬНІ ДОСЛІДЖЕННЯ ВЛАСТИВОСТЕЙ СПУЧЕНОГО ПЕРЛІТУ З ПЕРЛІТОВОЇ СИРОВИНИ РОДОВИЩА ФОГОШ УКРАЇНИ І РОДОВИЩ ГРЕЦІЇ, ВІРМЕНІЇ, ТУРЕЧЧИНИ, ГРУЗІЇ

СРАВНИТЕЛЬНЫЕ ИССЛЕДОВАНИЯ СВОЙСТВ ВСПУЧЕННОГО ПЕРЛИТА ИЗ ПЕРЛИТОВОГО СЫРЬЯ МЕСТОРОЖДЕНИЯ ФОГОШ УКРАИНЫ И МЕСТОРОЖДЕНИЙ ГРЕЦИИ, АРМЕНИИ, ТУРЦИИ, ГРУЗИИ

Abstract. In the article comparative researches of properties of expanded perlite sand made by improved two-stage RDIBMP technology from perlite raw materials of Fogosh deposit of Ukraine and deposits of Greece, Armenia, Turkey, Georgia are shown. At same middle bulk density, fraction and thermal conductivity the expanded perlite sand, produced from Ukrainian raw material, characterized greater on 50% strength of expanded granules and less on 20-30% water absorption, that lowers the degree of his compacting.These improved operational properties of expanded perlite on the basis of the Ukrainian raw materials have advantage of its application in building, and also in the cryogenic technics and agriculture.
Keywords. Deposits of perlite raw materials, expanded perlite sand, RDIBMP technology, improved operating characteristics, application, building, cryogenic technics, agriculture.
Анотація. У статті приведені результати порівняльних досліджень властивостей спуче-ного перлітового піску, що виробляється за удосконаленої двостадійною технологією НДІБМВ із сировини родовища Фогош України, та із сировини родовищ Греції, Вірменіі, Туреччини, Грузії. При однаковій середній насипної густини, фракції і теплопровідності спучений перліт, одержаний з української сировини, має більшу на 50% міцність гранул і менше на 20-30% водопоглинення, що відповідно знижує міру його ущільненняь . Такі поліпшені експлуатаційні властивості спученого перліту на основі української сировини мають істотну перевагу використання його в будівництві, а також в криогенній техніці і агротехніці.
Ключові слова. Родовища перлітової сировини, спучений перлітовий пісок, технологія НДІБМВ, поліпшені експлуатаційні властивості, використання, будівництво, криогенна техніка, агротехніка.
Аннотация. В статье приведены результаты сравнительных исследований свойств вспученного перлитового песка, произведенного по усовершенствованной двух-стадийной технологии НИИСМИ из сырья месторождения Фогош Украины, и из сырья месторождений Греции, Армении, Турции, Грузии. При сопоставимой средней насыпной плотности, фракции и теплопроводности вспученный перлитовый песок, произведенный из украинского сырья, характеризуется большей на 50% прочностью вспученных гранул и меньшим на 20-30% водопоглощением, что соответственно понижает степень его уплотнения. Эти улучшенные эксплуатационные свойства вспученного перлита на основе украинского сырья имеют существеннное преимущество применения его в строительстве, а также в криогенной технике и агротехнике.
Ключевые слова. Месторождения перлитового сырья, вспученный перлитовый песок, технология НИИСМИ, улучшенные эксплуатационные характеристики, применения, строительство криогенная техника, агротехника.

Ukraine disposes the large supplies of perlite rock - about 100 mln. m^3, which are in Beregovo district of the Zakarpatskaya area. Perlite deposits are exploited by Closed joint-stock company «Beregovo quarry» more than 30 years. From 1992 Industrial developments of Fogosh deposit are conducted from 1992. Approved industrial reserves are 13, 4 mln.m^3 . Presently Beregovo quarry enters in the complement of Limited company «Perlite group».

Requirements, produced to perlite raw material presented in State standard DSTU B V.2.7-62-97 (GOST 25226-96) « Perlite Crushed stone and sand for the production of expanded perlite»

Expanded perlite sand is used in industry most widely. It is produced different bulk density and fractions accordance of State standard DSTU á V.2.7-157:2011 (GOST 10832-2009) «Perlite expanded sand and crushed stone».

Industrial use of expanded perlite sand is predetermined by his operating characteristics. Basic characteristics are bulk density, fractions, thermal conductivity, strength, Water absorption, degree of compacting.

Receipt of expanded perlite with the required operating characteristics depends on properties of applied perlite raw material and features of technology of his heat treatment.

Perlite has many different properties, which influence on the process of their expansion and, as a result, on the high-quality indexes of expanded perlite made from it. Basic chatacteristic of perlite is the maintenance in them of structural water, being the main agent of expansion of rock. Perlite deposits of Armenia, Georgia, Kamchatka, America, Greece, Turkey, related to primary perlite contain from 1,5 to 4,5 % of structural water. Perlite deposits of Ukraine, Russia (Buryatiya), Mongoliya, China, related to secondary perlite, contain from 4,5 to 9,5 % of structural water.

Therefore on the basis of perlite of different deposits, being distinctive characteristics, expanded perlite can be got with the range of quality indexes, which corresponds perlite raw material of only certain deposit.

Presently on the perlite enterprises of Ukraine and Europe perlite raw material of deposits of Greece, Turkey, Hungary, Georgia, Armenia , related to primary perlite, and Fogosh deposit of Ukraine, related to secondary perlite, is used..

Chemical composition and physio-mechanical characteristics of samples of perlite of the above-stated deposits is presented in tables 1 and 2

Improved two-stage technology of RDIBMP /1/ is used on the Ukrainian perlite plants for heat treatment of perlite Fogosh deposit, related to secondary perlite. The feature of heat treatment consists in the following. The heat treatment of narrow factions of raw material is executed by two stage in the separate aggregates. The first stage - preliminary thermo-preparation of raw materials is carried out in the furnace of thermo-preparation of fluidized bed (furnace are developed together with Institutes of Gas National academy of sciences of Ukraine and RDIBMP); the second stage – expansion of the thermo-prepared raw materials is carried out in the shaft furnace (furnace is developed by RDIBMP)

Application for preparation of raw material of such technology allows to regulate the amount of structural water (creator of pores) in perlite rock in necessary limits. Thus, the receipt of expanded perlite sand of the required porous structure is provided. It allows to produce from raw material of Fogosh deposit as easy expanded perlite with bulk density less than 100 kg/m^3 (γ =65-90 kg/m^3) with the developed open porosity, so more than 100 (γ = 100-220 kg/m^3) expanded perlite sand with the mainly-closed porosity with the reduced water absorption (120-150 % on weight, the general) and the increased strength (0,25-0,46 MPa at compression in the cylinder). As a result it is possible to extend the range of quality indexes and simultaneously to get expanded perlite with the required operating characteristics (particle-size, bulk density, strength, water absorption and other).

For research of features of properties of expanded perlite sand, made from raw material of Fogosh deposit, comparative tests were conducted on determination of quality indexes of representative samples of expanded perlite sand with the same of bulk density, made on Ukrainian perlite plants from raw material of Fogosh deposit of Ukraine and deposits of Greece, Turkey, Georgia, Armenia. For comparison of results of tests the samples of expanded perlite sand were dissipated on fractions 0,63-1,25 mm; 1,25-2,5 mm; 2,5-5,0 mm. Then quality indexes have been defined for every narrow fraction of expanded perlite sand, produced from the perlite of different deposits.

The followings basic quality indexes have been defined: coefficient of compacting, compression strength in cylinder, water absorption by mass and by volume, thermal conductivity. The methods of tests correspond the operating methods of tests in Ukraine and CIS countries, and consider the features of methods of the World Perlite Institute.

Determination of coefficient of compacting was conducted on the special mechanical device at shaking of volumetric flask (Φ = 35 mm, V = 250 ml) with a filler to the complete compression of filler. Coefficient of compacting is determined under the formula:

$$K_{comp} = \frac{V_1}{V_2},$$

where V_1 – volume of filler before compacting, ml
V_2, – volume of filler after compacting, ml

For determination of compression strength in cylinder a steel compound cylinder is used with an internal diameter 50 mm and in 100 mm high. Strength of filler at a compression in cylinder (R_{comp}, MPa) determine on an loading index of hydraulic press in the moment of immersion of puncheon in the layer of material on 25 mm. Compression strength in cylinder of filler R_{comp}, MPa (kgs/sm^2) is determined under the formula

$$R_{comp} = \frac{P}{F},$$

where P – loading at the compression of filler at immersion of puncheon to certain risks (25 mm) , H (kg);
F – area of cross-sectional of cylinder, equal 19,6 sm^2

The method of determination of water absorption of filler consists in weighing of material which is placed in a cylinder from a brass net with the size of apertures equal 0,063 mm (Φ = 20 mm, L = 150 mm), before and after finding of cylinder with material in water during 24 hours and calculation of difference on mass.

Water absorptioin, W_m in percents by mass calculate under the formula

$$W_m = \frac{(m_2 - g_{cyl}) - m_1}{m_1} x100,$$

where m_1 – mass of dry test, g;
m_2 – mass of cylinder with a test after saturation by water, g;
g_{cyl} – mass of cylinder, g

Water absorptioin, W_v in percents by volume calculate under the formula:

$$W_v = \frac{W_m x \gamma_{fil}}{1000} x100,$$

where W_m – water absorption by mass, %;
γ_{fil} – bulk density of filler, kg/m^3;

Determination of thermal conductivity of sample of expanded perlite sand conducted by express-method with the use of device of THERM 2227-2.

Results of definitions are presented in table 3 and in figures 1-4

Table 1.

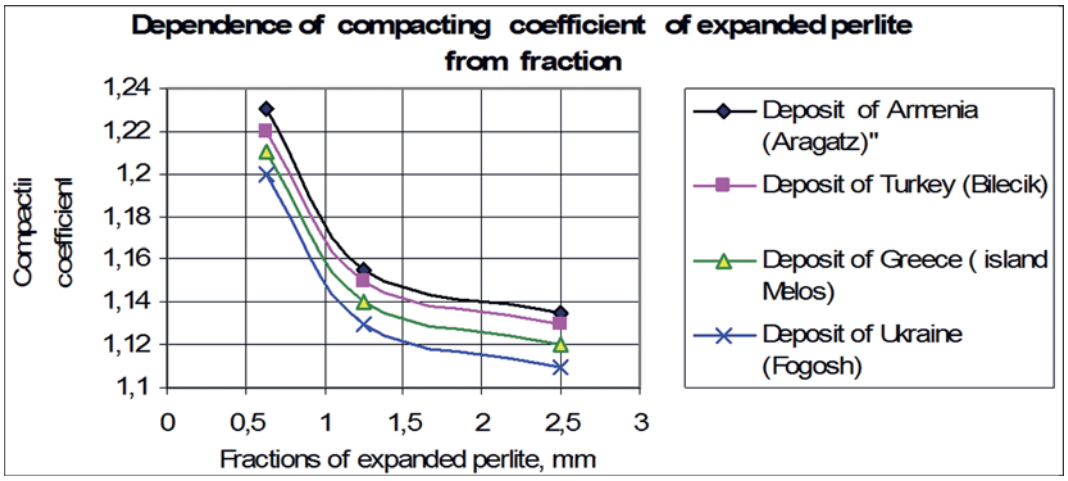
Chemical composition of perlite rock , %

Deposits	Chemical composotion, %									
	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	SO_3	Na_2O	K_2O	Ignition losses
1	2	3	4	5	6	7	8	9	10	11
Fogosh (Ukraine)	71,20	12,30	2,23	0,10	0,88	0,10	0,03	1,84	5,06	5,2-5,5
Greece (Island Melos)	75,24	12,47	1,49	0,14	1,59	0,40	0,03	3,20	2,20	2,50
Bilecic (Turkey)	73,2	12,45	0,92	0,09	0,55	0,26	-	3,35	3,90	3,26
Aragatz (Armenia)	74,15	11,90	0,71	0,10	1,72	0,13	0,27	4,02	4,40	3,52
Paravan (Georgia)	73,28	12,93	0,92	0,13	0,68	0,23	0,00	4,18	3,00	3,66

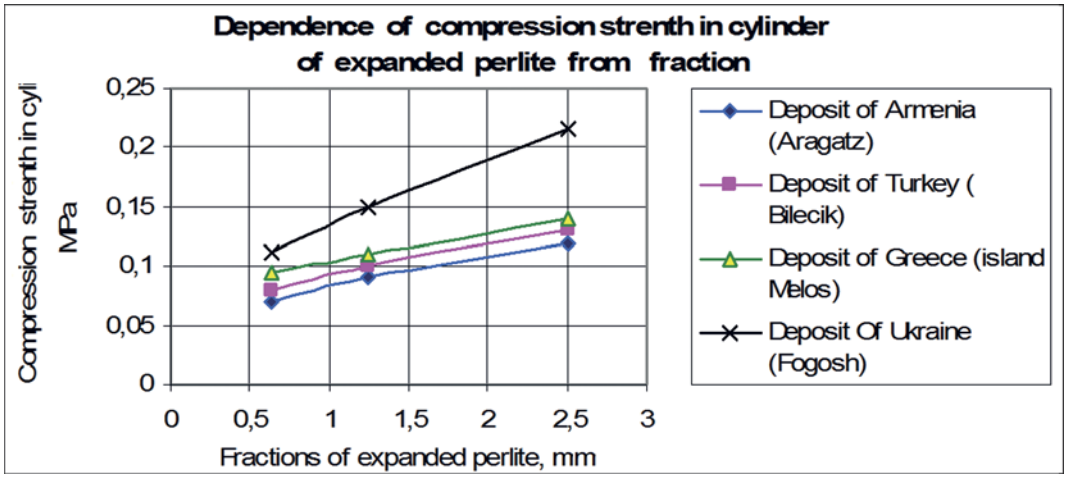
Table 2.

Physio-mechanical properties of pertlite rock

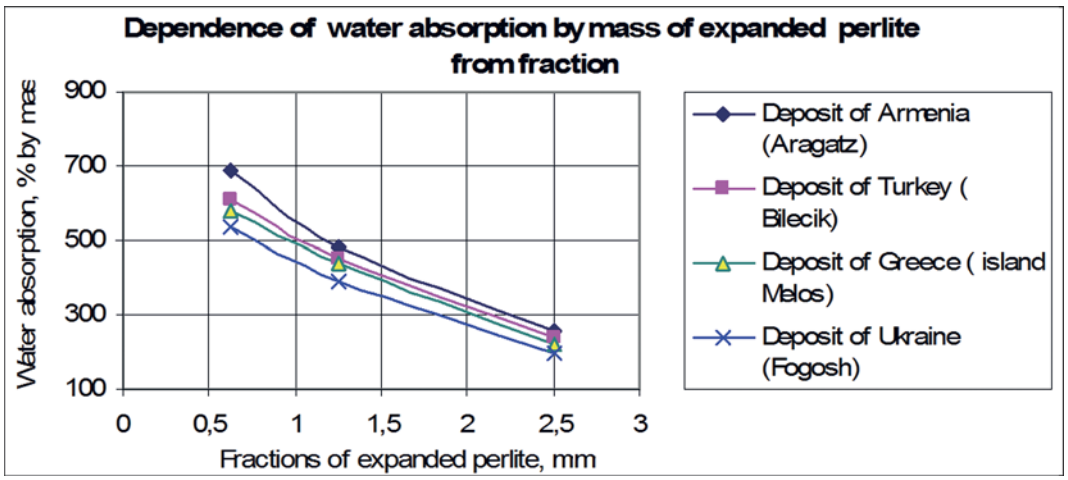
Deposit	Specific density (without porous), g/cm^3	Density of grains (including porous), g/cm^3	Porosity of grains, %	Strength on compression, MPa
Fogosh (Ukraine)	2,38	1,56	34,6	20,0
	2,37	1,75	26,2	
Island Melos (Greece)	2,37	1,70	28,3	17,0
Bilecic (Turkey)	2,37	1,67	29,5	18,0
Aragatz (Armenia)	2,35	1,82	22,6	16,0
Paravan (Georgia)	2, 36	1,59	32,6	8,4



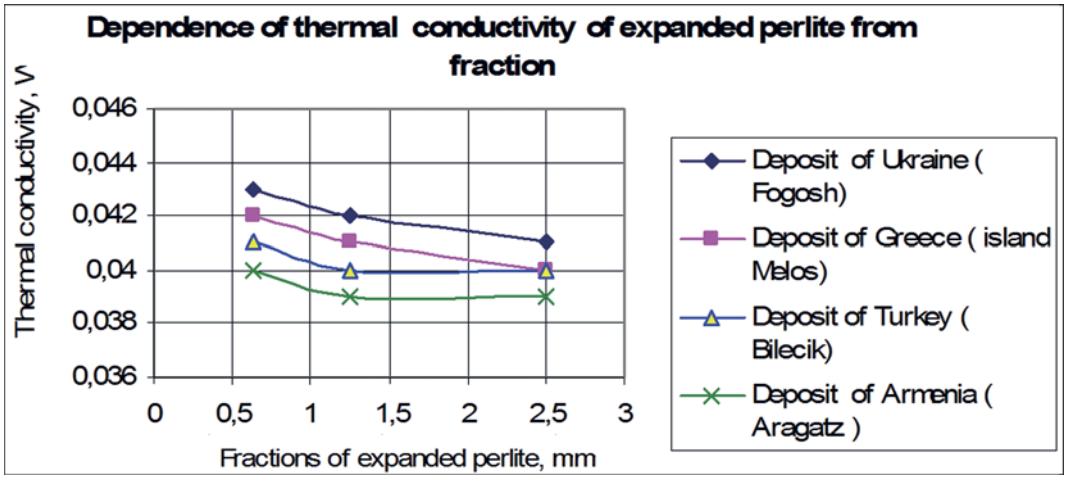
Figer 1



Figer 2



Figer 3



Figer 4

Table 3.

Characteristics of expanded perlite sand made from perlite raw materials of different deposits

Deposits of perlite (bulk density of samples of expanded perlite)	Fraction, mm	Bulk density, kg/m³	Thermal conductivity. Wt|mK	Coefficient of compacting	Water absorption		Compression strength in cylinder, MPa
					%, by mass	%,. by volume	
2	3	4	5	6	8	9	10
Fogosh, Ukraine (γ = 263 kg/m³)	2,5-5,0	182,0	0,049	1,085	96	17,5	0,42
	1,25-2,5	278,4	0,078	1,060	120	33,4	0,58
	0,63-1,25	232,0	0,078	1,107	130	30,7	0,38
Fogosh, Ukraine (γ = 127 кг/м³)	2,5-5,0	158,8	0,046	1,093	150	23,8	0,36
	1,25-2,5	114,8	0,044	1,118	330	37,9	0,21
	0,63-1,25	104,0	0,048	1,153	425	44,2	0,15
Fogosh, Ukraine (γ = 89 kg/m³)	2,5-5,0	71,2	0,042	1,135	240	171	0,175
	1,25-2,5	77,6	0,040	1,137	425	33,0	0,15
	0,63-1,25	83,0	0,043	1,175	490	40,7	0,12
Fogosh, Ukraine (γ = 72 kg/m³)	1,25-2,5	67,2	0,038	1,145	450	30,2	0,13
	0,63-1,25	71,2	0,042	1,21	530	37,7	0,11
Greece, Island Melos (γ = 82 kg/m³)	2,5-5,0	90,0	0,040	1,16	250	22,5	0,13
	1,25-2,5	75,0	0,040	1,17	455	34,1	0,10
	0,63-1,25	65,0	0,039	1,27	580	37,7	0,08
Bilecic, Turkey (γ = 85 kg/m³)	2,5-5,0	93,2	0,040	1,13	250	23,3	0,125
	1,25-2,5	86,0	0,041	1,15	450	38,7	0,11
	0,63-1,25	72,2	0,042	1,22	610	44,0	0,095
Aragatz, Armenia (γ = 83kg/m³)	2,5-5,0	99,7	0,040	1,13	230	22,9	0,16
	1,25-2,5	87,2	0,040	1,15	455	39,7	0,11
	0,63-1,25	59,2	0,039	1,21	690	40,8	0,07
Paravan (Georgia) (γ = 47 kg/m³)	1,25-2,5	38,7	0,031	1,23	1051,7	40,7	0,036
	0,63-1,25	46,2	0,038	1,22	1061,6	49,0	0,032

As shown from the received data (tabl.3; fig.1-4), the quality indexes of expanded perlite , made from perlite raw material of Fogosh deposit (Ukraine), in comparison to the indexes of quality of expanded perlite , made from raw material of deposits of Greece, Turkey, Armenia, Georgia have substantial advantages.

Comparative analysis of the main characteristics of expanded perlite sand for the samples of identical fraction (0,63-1,25 mm) and bulk density (82-89 kg/m³) made from perlite raw materials of different deposits shows the following:

-for expanded perlite sand made from Fogosh deposit of Ukraine Coefficient of compacting is equal to 1,175; Compression strength in cylinder is equal to 0,12 MPa, Water absorption is equal to 490 % by mass, Thermal conductivity is equal to 0,043 Wt|mK:

-for expanded perlite sand made from deposits of Greece, Turkey, Armenia, Georgia Coefficient of compacting is in a range 1,21-1,27 ; Compression strength in cylinder is in a range 0,07-0,08 MPa , Water absorption is in a range 580-690 % by mass, Thermal conductivity is in a range 0,039-0,042 Wt|mK.

-expanded perlite sand made from Georgia perlite raw material of Paravan deposit characterizes by the least bulk density (γ = 46,2 kg/m³) and, as a result, the least strenth of particles (R = 0,038 MPa) and most water absorption (W = 1062% by mass)

Thus, at same middle bulk density, fraction and thermal conductivity there is expanded perlite sand, produced from Ukrainian raw material, characterized greater on 50% strength of expanded granules and less on 20-30% water absorption, that lowers the degree of his compacting.

These advantages of Fogosh perlite deposit (Ukraine) have the special value in building, where the basic requirements are increased strength characteristics, reduced water absorption and minimum compacting, that predetermines stability of heating engineering characteristic /2,3/

Except for the increased strength of expanded perlite from raw material of Fogosh deposit (Ukraine) is undeniable advantage for using in cryogenic technics, that is instrumental in stability of heating engineering charcteristics due to diminishing of growing of granules of perlite shallow under own weight, and in agriculture, where the term of exploitation of perlite mixture depends and degree of aeration of soil and ability to keep moisture and nutrients depends on strength of granule.

Thus, expanded perlite , made on RDIBMP technology from raw material of Fogosh deposit, have the improved operating characteristics and it is recommended to apply in various industries – in building, cryogenic technics, agriculture, metallurgy and other areas /2, 3/.

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