IRSTI 67.09.91

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https://doi.org/10.55956/JQBP6004

STRENGTH AND DEFORMATION CHARACTERISTICS OF SLAG CRUSHED STONE OF COAL THERMAL POWER PLANTS

Abstract. The fractionability and modulus of deformation of individual fractions of ash and slag crushed stone samples (in a dry and saturated state) taken from the dumps of Novosibirsk CHP-3 (burning coals of the Kansk-Achinsk coal basin), as well as Novosibirsk CHP-2 and Seversk CHP (burning coals of the Kuznetsk coal basin) were determined. to assess the factors affecting the mechanical strength of ash and slag rubble, calcination losses, the content of hazel and needle particles, dusty clay particles and clay in lumps were additionally determined.

The difference in the mechanical strength of samples of material of different genesis was revealed. The graphs obtained during the tests are evaluated, on the basis of which the characteristics of the deformability of the material (at different sizes) are calculated. The factors influencing the mechanical strength of ash and slag rubble are determined. Dependences linking the deformation parameters of ash and slag rubble and the results of determining their fractionability are obtained.

Some mechanical and physical parameters of ash and slag rubble have been established, based on which the directions of possible application in the construction of highways have been clarified. A mathematical

dependence has been found for predicting the deformation modulus of ash and slag rubble, which is necessary for the design of structures made of this material.

Keywords: construction, motor roads, road pavement, ash and slag mixtures, slag crushed stone, crushability, deformation modulus.

Lunev A.A. Strength and deformation characteristics of slag crushed stone of coal thermal power plants // Mechanics and Technology / Scientific journal. – 2023. – No.2(80). – P.22-28. https://doi.org/10.55956/JQBP6004

Introduction. One of the main sources of heat and electricity production worldwide is fossil coal [1-5]. A significant part of energy industry experts are of the opinion that alternative energy sources are the future of energy, however, according to experts, in the coming decades there are no prerequisites for a global change in approaches to energy production, which means that coal will remain [6].

Coal burning in boilers of thermal power plants is associated with the formation of 10 to 50% of heat generation waste (by–products) – ash slag (fly ash, ash-slag mixture - ZSHS, microspheres). In the Russian Federation, over 24 million ash and slag wastes (ASH) are generated annually, which is 40% of all industrial

waste [2]. According to experts, in the Russian Federation only 8-10% of the ash slag formed during the year is disposed of (in some countries up to 100%), most of it is placed on specialized hydraulic structures – ash dumps [6].

The technology of storage of ash waste in ash dumps has a number of serious drawbacks:

- in the summer, the surface of the ash dump can dust and pollute the surrounding area;
- the placement of ash dumps requires the exclusion of suitable land from economic turnover;
- storage of waste in dumps is associated with the risk of collapse of dams, which lead to catastrophic disruption of ecosystems in the event of accidents [3-5] (despite the fact that studies have proven the safety of this class of materials) [6].

In addition, ZSHS is a material with special properties, the use of which is possible in many areas of the economy: reclamation of farmland, extraction of aluminum compounds, production of rare earth elements manufacture of composite materials, production of concrete [6], construction of highway structures and construction of ground structures.

The purpose of the study is to assess the mechanical strength of ash and slag rubble and determine the factors affecting it.

To achieve the goal , several tasks have been set:

- determine the fractionability of fractionated ash and slag crushed stone from the burning of Kansk-Achinsk and Kuznetsk coals;
- determine the deformation characteristics of ash and slag rubble;
- conduct tests to identify losses during calcination, the content of bream particles, clay in lumps and the content of dusty particles that may affect the properties of crushed stone;
- analyze the results obtained and determine the factors affecting the mechanical strength of crushed stone.

Research methods and conditions. The most common ASM in the Russian Federation are ash slags from the burning of Ekibastuz, Kuznetsk and Kansk-Achinsk coals. The formation of coarse-grained slag is more typical for thermal power plants operating on Kuznetsk and Kansk-Achinsk coals. Therefore, the following were selected for the study

- Novosibirsk CHPP-2 (the station operates on Kuznetsk coal, dense slag is formed in the boilers);
- Novosibirsk CHPP-3 (the station operates on Kansk-Achinsk coals, dense slag is formed in the boilers) [6];
- Seversk CHPP (the station operates on Kuznetsk coal, porous slag is formed in the boilers).

Three types of ash and slag crushed stone were studied in the experiments: dense slag of the Novosibirsk CHP-2, dense slag of the Novosibirsk CHP-3 and porous slag of the Seversk CHP. The appearance of the materials under study is shown in Fig. 2.

The crushing capacity of the selected ash and slag crushed stone was determined according to the GOST 8269.0-97 method by testing samples of ZSM prepared in the laboratory. «Samples of ordinary ash and slag crushed stone were dried from constant humidity and divided into standard fractions of crushed stone (5-10; 10-20; 20-40 mm in size) by sieving the material on appropriate sieves. Part of the sample material was kept in water for 2 hours for further testing in a saturated state.

Table 1

The chemical composition of the materials exposed to the research (ASM)» [6].

Type of burnt coal	Chemical composition by oxides, % by weight (including LOI)								
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	SO_3	LOI
Bituminous coal of the Kuznetsk coal mining field	50-64	18-30	4-15	2-10	0.5-2.5	1.3-2.4	0.5-1.3	0.3-2.2	3-22
Brown coal of the Kansk-Achinsk coal mining field(Borod)	40-55	4-10	6-14	20-35	3-6	0.3-1.5	0.2-0.5	0.9-5	2
Note: LOI — loss on ignition (content of combustibles)									

Due to the limited amount of material for research, the determination of fractionability was carried out for fractions 5-10 and 10-20 in a cylinder with a diameter of 75 mm, and for fractions 20-40 in a cylinder with a diameter of 150 mm [6]. Tests in a cylinder with a diameter of 75 mm were carried out in an automated press IR 5081-5 (Fig. 3), and in a cylinder with a diameter of 150 mm – in a hydraulic press. During the tests, video and audio recordings were made, necessary for differentiating the experimental stage depending on the intensity of particle crushing

Research results. During the research, samples of each fraction of the material in dry and water-saturated states for each type of material were analyzed. The results of the studies are shown in the graph (Fig. 1). Based on the results obtained (Fig. 1), the strength grade of the studied samples of ash and slag rubble was approximately assigned. Due to the absence in the regulatory framework of the Russian Federation

The increase in the stress level in the ash and slag crushed stone array from the value corresponding to the boundary of the elastic stage to the level of 3300-7250 kPa [6] (depends on the particle size and their genesis) caused intensive crushing of the slag crushed stone, which was mainly due to the destruction of the pinched particles and was accompanied by significant stamp precipitation. With a further increase in the stresses in the sample, the transition to the stage of crushing attenuation began. The noted stress level in the two stages described above was significantly higher than in road structures, so these stages were unsuitable for assessing deformation parameters.

At the initial stage of loading (elastic stage), the destruction of particles was practically not fixed, and the maximum stresses did not exceed those caused by the impact of transport loads.

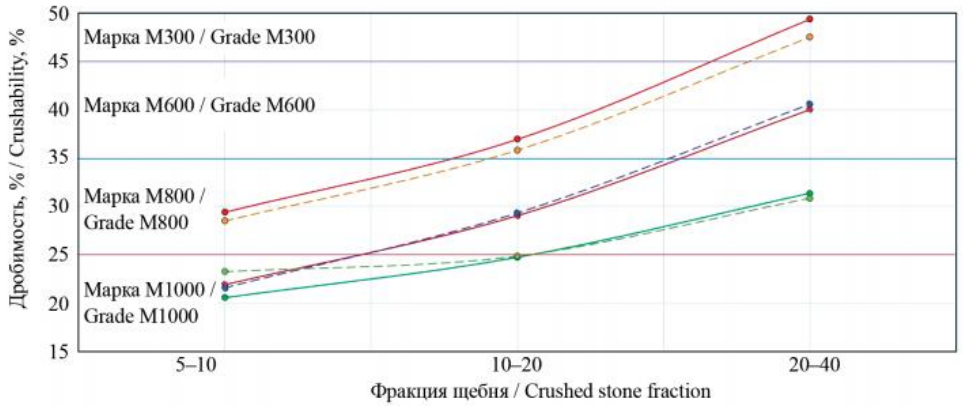

Fig. 1. Crushability broken down by the fractions generated in the course of burning Kuznetsk coal: ● – dry and dense; ● – saturated and dense; ● – dry and porous; ● – saturated and porous; broken down by the fractions generated in the course of burning Kansk-Achinsk coal: ● – dry and dense; ● – saturated and dense

It should also be noted that the tests were carried out on non-compacted samples of the material, therefore, the values obtained during the tests are likely to be the minimum possible deformation modules for the material under study.

It is not possible to determine the modulus of elasticity from these experiments, since during the tests, compaction and repacking of particles obviously occurred. Apparently, it is required to conduct comparative tests to identify the elastic modulus of this material according to the test method with a static or dynamic stamp and compare them with the obtained values of the deformation modulus.

The content of bream particles in the studied samples taken at the dumps of the Novosibirsk CHPP turned out to be lower than at the Seversk CHPP dump (CHPP-2 dump – from 2 to 5%, CHPP-3 – from 0 to 3%, Seversk CHPP – from 7 to 20%). In all samples there was no clay in lumps, and the content of dusty particles did not exceed 1.5%. The content of calcination losses in the studied samples varied from 0.6 to 2.1%, with higher values corresponding to a smaller fraction.

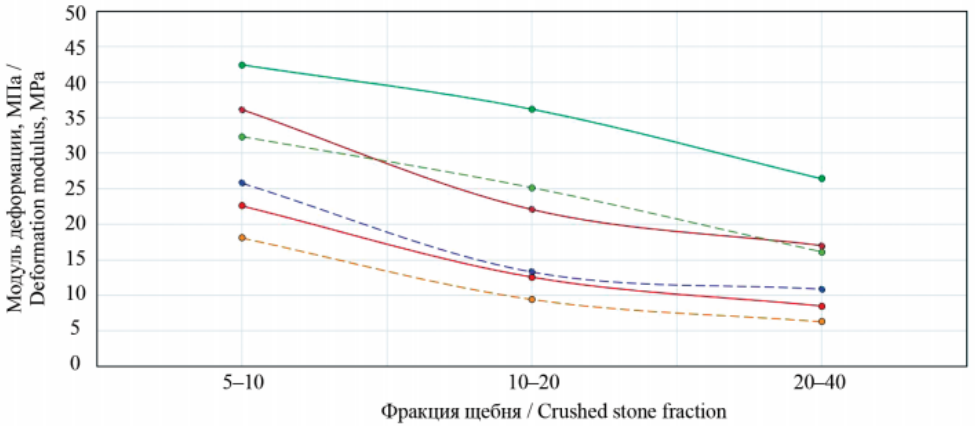

Fig. 2. Deformation moduli of slag crushed stone samples generated as a result of burning the Kuznetsk coal: ● – dry and dense; ● – saturated and dense; ● – dry and porous; ● – saturated and porous; generated as a result of burning the Kansk Achinsk coal: ● – dry and dense; ● – saturated and dense

The peculiarities of the Griffiths crack development mechanism explain the lower strength of crushed stone particles obtained from the burning of Kuznetsk coal [6]. Increased melting point of rock-forming components in Kuznetsk coals.

Discussion of the results. As part of the discussion, possible prospects for the development of the topic under consideration can be made.

The results of the evaluation of the crushing capacity of ash and slag crushed stone obtained from the burning of Kansk-Achinsk and Kuznetsk coals show that:

- the studied material changes its strength grade depending on the genesis and grain size from M300 to M1000;

- ash-slag crushed stone significantly changes its mechanical strength depending on the fraction (the fractionability of the 20-40 fraction can be up to 67% higher than the 5-10 fractions of the same material);

- the amount of fragmentation is practically not affected by the humidity of the test sample, since its effect was observed only in one series of experiments and may be random;

The results of the evaluation of the deformation modules of ash and slag crushed stone obtained from the burning of Kanskoachinsky and Kuznetsk coals demonstrate that:

- humidity reduces the deformation abilities of ash and slag rubble, and the decrease is in the range from 20 to 39%. Large values are characteristic of dense slag from a liquid slag removal system with a glazed surface, and smaller values are characteristic of porous slag from a dry slag removal system;

- ash – slag crushed stone from dense slag, which is formed in the liquid slag removal system and has a glazed surface, has the highest modulus of elasticity, and crushed stone from porous slag obtained in the dry slag removal system has the lowest.

Conclusion. It should also be noted that in the course of research, stable correlations were found between the size of the crushing capacity and the modulus of elasticity of ash and slag crushed stone (in a dry and saturated state), which, although they require verification, allow for an enlarged assessment of the bearing capacity of this material by the size of the crushing capacity.

The study showed that from the point of view of mechanical strength (and based on the results of additional studies), these materials can be used for the construction of the roadbed, the construction of additional layers of the foundations of road clothes, in the structures of the bearing layers of the foundations of road clothes, and are also probably suitable for planning work and backfill material.

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Material received on 02.06.23.

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КҮЛ-ҚОЖДЫ ҚИЫРШЫҚ ТАСТЫҢ БЕРІКТІГІ МЕН ДЕФОРМАЦИЯЛЫҚ СИПАТТАМАЛАРЫ КӨМІР ЖЫЛУ ЭЛЕКТР СТАНЦИЯЛАРЫ

Аңдатпа. Новосибирск ЖЭО-3 (Канск-Ачинск көмір бассейнінің көмірін жағатын), сондай-ақ Новосибирск ЖЭО-2 және северс ЖЭО (Кузнецк көмір бассейнінің көмірін жағатын) үйінділерінен іріктелген күл-қож қиыршық тас үлгілерінің (құрғақ және сумен қанықкан күйде) жекелеген фракцияларының ұсақталуы мен деформация модулі анықталды. күл-қожды қиыршық тастың механикалық беріктігіне әсер ететін факторларды бағалау үшін кальцинация кезінде шығындар, фундук пен ине бөлшектерінің, шаң-саз бөлшектері мен саздың құрамы қосымша анықталды.

Әртүрлі генезис материалының сынамаларының механикалық беріктігінде айырмашылық анықталды. Сынақ жүргізу кезінде алынған графиктер бағаланады, олардың негізінде материалдың деформациялану сипаттамалары есептеледі (әр түрлі мөлшерде). күл-қожды қиыршық тастың механикалық беріктігіне әсер ететін факторлар. Күл-қожды қиыршық тастың деформациялық параметрлерін және олардың ұсақталуын анықтау нәтижелерін байланыстыратын тәуелділіктер алынды.

Тірек сөздер: құрылыс, автомобиль жолдары, жол киімдері, күл-қож қоспалары, күл-қож қиыршық тас, ұсақтау, деформация модулі.

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ПРОЧНОСТНЫЕ И ДЕФОРМАЦИОННЫЕ ХАРАКТЕРИСТИКИ ЗОЛОШЛАКОВОГО ЩЕБНЯ УГОЛЬНЫХ ТЕПЛОВЫХ ЭЛЕКТРОСТАНЦИЙ

Аннотация. Определены дробимость и модуль деформации отдельных фракций образцов золошлакового щебня (в сухом и насыщенном водой состоянии), отобранных с отвалов новосибирской ТЭЦ-3 (сжигающей угли канско-ачинского угольного бассейна), а также новосибирской ТЭЦ-2 и северской ТЭЦ (сжигающих угли кузнецкого угольного бассейна). для оценки факторов, влияющих на механическую прочность золошлакового щебня, дополнительно устанавливались потери при

прокаливании, содержание лещадных и игольчатых частиц, пылеватоглинистых частиц и глины в комках.

Выявлено различие в механической прочности проб материала разного генезиса. оценены полученные при проведении испытаний графики, на основе которых вычислены характеристики деформируемости материала (при разной крупности). обусловлены факторы, влияющие на механическую прочность золошлакового щебня. Получены зависимости, связывающие деформационные параметры золошлакового щебня и результаты определения их дробимости.

Установлены некоторые механические и физические параметры золошлакового щебня, исходя из которых выяснены направления возможного применения при строительстве автомобильных дорог. Найдена математическая зависимость для прогнозирования модуля деформации золошлакового щебня, необходимая для проектирования сооружений из данного материала.

Ключевые слова: строительство, автомобильные дороги, дорожная одежда, золошлаковые смеси, золошлаковый щебень, дробимость, модуль деформации.