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STRENGTHENING ROAD SOILS BY SLAG ADDITIVES

Now at building of highways of general use design of road clothes from the strengthened materials allows increasing terms of their service and provides the increase of transport-operational indicators. At designing road clothes of wood roads it is necessary to consider specificity of their work taking into account increase in weight of lorry convoys and experience of improvement of road soils properties.

Introduction. One of the directions of increase in durability of road clothes should consider improvement of properties of initial road-building materials. It can be carried out on the basis of use of a waste of industrial productions. In the republic of Belarus there are ferrous metallurgy enterprises which produce metal in considerable quantities. When a waste product is formed, there are slags of various properties and structure. When melting different marks of steel at the Belarusian metallurgic plant (BMP) the following kinds of slags are formed: top, granulated, long, domain, carbide, converted, and short. Slag, as a rule, is a by-product, used as secondary raw material for obtaining building materials (for example slag glass ceramics), lime and phosphoric fertilizers, and also it is a reverse product in a number of metallurgical processes.

Steel-smelting slag is used to make large gravel for road building. Besides, it is used in cupola manufacture for Fe, Mn and SaO extraction.

Main provisions. Metallurgical slags and products of their processing are used in road and hydraulic engineering building, manufacture of building materials, facing plates, in agriculture, chemical industry, medicine and other industries.

Slags are by-products obtained at fusion black and nonferrous metals, when hard fuel is burned, and also at electrothermal sublimation of phosphorus.

Slag represents an oxide alloy of variable structure. The main components of slag are: acid oxide SiO_2 and the basic oxides CaO, FeO, MgO, and also - neutral oxide $A1_2O_3$ and (less often) ZnO. Depending on prevalence of the oxide slag can be acidic or basic.

Properties of domain slags are investigated full enough; they are widely used in building, including highways. However a group of enterprises, such as BMP, when manufacture basic production form the electrosteel-smelting slags, their properties sharply differ from those of domain manufacture. Being uninvestigated, such slags do not find wide application in road building, therefore huge stocks of non-granulated self-scattered slags have been accumulated at these enterprises .

Metallurgical slags are effective substitutes of natural stone materials, they are recommended for building and repairing of highways. The properties of large gravel from slag are not inferior to those of a product received from hard kinds, and sometimes they surpass them.

Taking into account their physical and mechanical properties, sand, large gravel and their mixtures apply to construct constructive layers of road of all kinds – coverings, bases, additional layers of bases etc. [2, 3].

Powdered, steel-smelting and domain slags are low marked binders, they are intended to create monolithic bases of roads; their durability is considerably raised when small amount of cement and lime is added as an activator (up to 10% of weight).

Strong bases of highways are obtained from a mixture of large gravel from active slag and weak limestones. –Large gravel from open-hearth furnace slags is successfully used to plug road basis made of large gravel. A peculiar feature of asphalt-concrete coverings received with application of steel-smelting slags is absence of deformations of shift even at heavy traffic of heavy transport. Slag large gravel contains some amount of chips which is considerably increased with rolling during a construction of a road bed.

At storage of waste there are processes which change properties of initial wastedump, its chemical, mineral and granulometric structures, durability, density, etc.

Metallurgical slags and products of their processing are used in metallurgy, building road, hydraulic engineering, manufacture of building materials, including facing plates and tubing at underground building, agriculture, shipbuilding, municipal and gas economy, atomic engineering, chemical industry, medicine and other industries. Taking into account the today's prices for stone building materials which are not common in most of the territories of Belarus or lack, it is necessary to solve questions of effective replacement of expensive stone building materials by industrial production waste. Replacement of gravel and crushed stone materials by BMP slag is offered in this case.

Research concerning definition of strength characteristics of a mixture containing various percentage of slag is conducted to ground the utility of gravel materials properties improvement.

The granulometric structure of slag and sand-gravel mixtures is defined by sieve method [1, 2, 3]. The examined slag has been preliminary powered in vitro in a special cylinder. As extracted particles posses the size 0, 14–20 mm, the analysis is conducted without washing by water [4, 5].

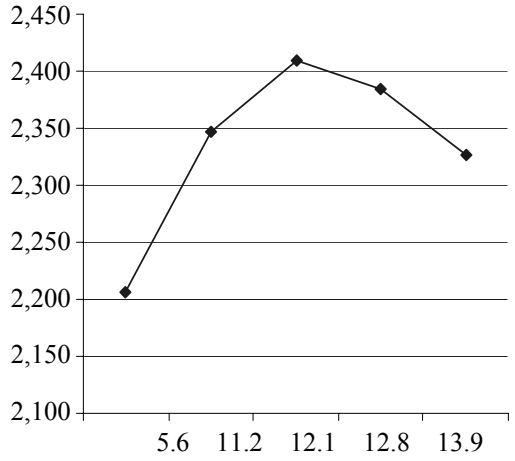

Fig. 1. The dependence diagram $\gamma_{ck} = f(W)$

The most important indicator of durability of road beds is the elasticity module. To define the module of elasticity it is necessary to consider such parameters, as the maximum density and optimum moisture of a mixture. According to the diagram: optimum moisture W_{op} = 12.1%; the maximum density of a ground γ_{max} = 2,409 kg/m^3. Using the received data, calculation of road beds based on a method of an elastic deflection by means of the computer program Radon [6] has been carried out.

The maximal density and optimal moisture of a ground are established according to the diagram of dependence of density from moisture (Fig. 1). The diagram is constructed based on the experimental data resulted in the Table.

Fig. 2 presents the calculations of a road construction. Its analysis allows to prove the worthwhileness of exchange gravel materials for 25% BMP slag sand-gravel mixture.

Conclusions. For the road building purposes slag is suitable mainly of the second discharge, its crystal structure does not contain a considerable amount of burning lime grains. Crystalline solid open-hearth furnace slag possesses durability of more than 100 MPa, small water absorption capacity, cold-resisting property. Physical and mechanical properties of slag are characterized by volume weight 3100–3300 kg/m^3, water absorption of 0.5–2%; cold resistance from above 100, durability at compression 80–120 MPa.

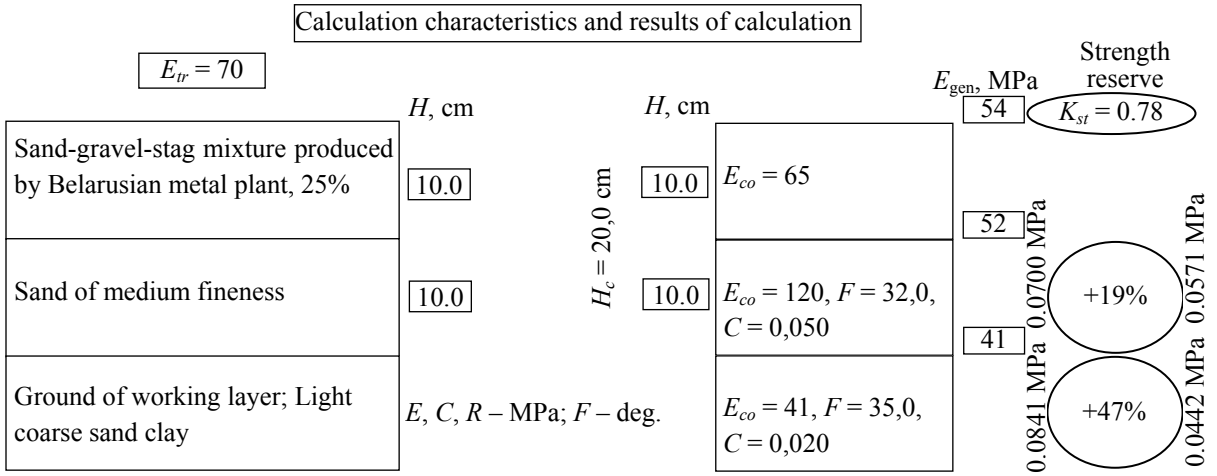

Fig. 2. Calculation characteristics and results of calculation of road beds on the basis of use of slags of the Belarus metal plant

Results of researches

Indicators	Definitions				
	1	2	3	4	5
Weight of the empty cylinder P_2 , kg	5.05	5.05	5.05	5.05	5.05
Weight of the cylinder with the condensed ground P_1 , kg	7.38	7.66	7.70	7.75	7.74
Volume of the cylinder V, m^3	0.001	0.001	0.001	0.001	0.001
Volume weight of a damp ground γ_0, kg/m^3	2,330	2,610	2,700	2,690	2,700
Moisture of ground W, %	5.6	11.2	12.1	12.8	13.9
Weight of a sample bottle $q_б$, g	14.40	14.35	13.39	14.40	13.39
Weight of a sample bottle with a damp ground $q_в$, g	24.52	28.45	28.21	27.34	28.69
Weight of a sample bottle with a dry ground $q_с$, g	23.98	27.03	27.42	25.94	26.82
Volume weight of a skeleton of a ground $\gamma_{ск}$, kg/m^3	2,206	2,347	2,409	2,385	2,327

The mixture of strong large gravel with a slag powder is used for the construction of bases of road beds depending on slag concrete type.

The bulk density of granulated slag ranges from 600 till 1,200 kg/m^3. It depends on the properties of molten slag and technologies of granulation. The grains of granulated slag can be dense or porous. Porosity of the granulated slag can reach up to 60...70%.

The granulated domain slags are used mainly in slag Portland cement production, but they are also used as a filler for concrete.

When two variants of road beds based on the use of metallurgical slag and sand-gravel are compared, it is clear that a slag mixture is not inferior to a sand-gravel covering in strength characteristics, and from the economic point of view it is the most efficient and practical, as cost of slag is much less, than gravel cost. The material expense will also be smaller because of the thickness of a top layer (Fig. 2).

Nowadays, a new composition of binder materials on the basis of the Belarus metal plant has been worked out. Slags should be used more widely instead of natural sand and gravel. A layer of 20–30 cm slag is sufficient for hardening 1 km of road and for its width of 3.5 m 600–900 tons of slag is required (depending on a filling thickness). When slags are applied as the bases of road – coverings it is possible to choose optimum grading which will provide durability increase by 7% and saving of applied materials up to 10–12%.

Besides, by results of samples tests it is necessary to state a quick increase of durability of a strengthened material. So, on the seventh day of hydration of the material, its durability has made - 70%. The given indicator is especially important at building of forest roads as it allows to reduce time between the beginning and the termination of road-building works and commissioning of new road constructions.

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