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COMPOSITE MATERIALS USING METAL SLUDGE

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In the conditions of energy deficit of economy of Ukraine the question of development and introduction of new low-energy technologies for the enterprises of the industry of building materials sharply arises. Resource and energy saving for technological cycles of production of material resources at the enterprises of the production base of the construction industry is the main vector in the development of competitive economic activity. However, the introduction of modern scientific and engineering solutions at the stages of design and construction of buildings and structures will also reduce operating costs for real estate [1-4].

Traditionally, in building practice, hydraulic binders have been given the highest priority for the production of artificial composite materials, products and ready-mixed concrete and mortars. Cement is the most affordable in terms of manufacturability of production operations and logistics communications raw material component of construction mixtures, although in the structure of the total cost of raw materials, its cost is sometimes from 30 to 60% [5]. Thus, one of the reserves in the direction of resource-saving technologies of building materials is the search for alternative developments to create effective binders with minimized capital costs for their production.

It is known that the use of secondary resources in the technology of production of building materials, mortars and concretes is gaining popularity among the existing areas of construction research in materials science. Among the existing scientific developments, the complex resource-saving technology of processing of toxic wastes of the enterprises of the chemical industry (phosphogypsum) and ash-removal of thermal power plants for production of artificial building composite materials and products attracts considerable weight. Characteristic features of this technology are waste-free utilization of harmful chemicals in the process by neutralization of the mineral component of ash-removal in the technological process of complex mechano-chemical activation. The use of pre-treated fly ash in the electromagnetic field (microwave technology) leads to an increase in the dispersion of raw material particles, as a result of temperature deformation when heated, its glassy shell is destroyed and the active particles of silica and alumina are released. The result of the next technological operation of mechano-chemical activation during long-term homogenization of a mixture of phosphogypsum and fly ash is the intensification of physicochemical interactions of the components of the mixture that can affect the physico-mechanical properties of subsequent building materials [6-9].

One of the methods of obtaining a composite material for multifunctional purposes is the addition to the composition of the activated mixture of phosphogypsum and fly ash of fine metal powders (metal waste). Iron powders by their physical parameters can be attributed to the group of dispersed aggregates. The average particle size of the powders is 2×10^{-5} m, and the specific surface area of such aggregate varies within $(0.5 – 2.0) \times 10^3$ m^2/kg. Characteristic indicators of the chemical composition of powders are the high percentage of iron, which is 86.3 – 87.96%. In the process of metal processing and during long-term storage of waste in open dumps there is a deep oxidation of the surfaces of iron powder particles. The oxide layer consists of hematite (Fe_2O_3), magnetite (Fe_3O_4), justice (solution of Fe_2O_3 in FeO), lapidocrit (FeO (OH)). According to the classification of binders according to the results of research [10-13], the use of metal powders with a high content of oxides as a filler will encourage the intensification of physicochemical interactions in the mixture of multicomponent dispersed composite material.

For carrying out experimental researches we used phosphogypsum of Vinnytsia "Khimprom", fly ash of Ladyzhyn thermal power plant, fine iron powders - metal sludges of bearing productions accumulated in dumps. Complex resource-saving technology for the manufacture of composite material involves pre-electromagnetic activation of a mixture of silica and metal components in the field of microwave irradiation. The next stage of the technology is the addition of a mixture of phosphogypsum and water with subsequent mixing of the components, which will intensify the processes of physicochemical interactions in the system of iron-phosphate binder. The formed samples-models of construction products in the form of beams were kept in a steaming chamber. The results of physical and mechanical characteristics of the samples are shown in table 1.

Table 1 – Composition and physical and mechanical properties of samples

The composition of the mixture	ρ, kg / m^3	$R_{bending}$, MPa	$R_{ompression}$, MPa
(AR + IP): PG =2,0:2	2080	3,4	6,3
(AR + IP): PG =1,5:2	1980	4,4	7,6
(AR + IP): PG =1,0:2	1860	3,2	6,2
(AR + IP): PG =1,5:2 with the addition of "C-3"	2010	4,8	8,4

Note: AR - ash-removal; IP- iron powder; PG – phosphogypsum.

The obtained results of the study of physical and mechanical characteristics of the samples of dispersed-filled composite material indicate the possibility of using the proposed resource-saving technology for processing man-made waste to obtain construction products for multifunctional purposes. The presence of a metal filler in the structure of the composite material ensures the acquisition of conductive properties, so the manufactured samples can be further implemented as elements of low-temperature underfloor heating systems for non-residential premises. In addition, the presence of conductive properties for flooring elements will allow the installation of antistatic protection systems for industrial premises [13].

Studies of radiation protection properties of metal-saturated concrete products (betels-m) confirmed that the use of metal aggregate in the composite material is accompanied by the acquisition of increased shielding characteristics compared to other materials with the same average density of products [13-15].

Conclusions

Therefore, the use of iron powders in the composition of the dispersed-filled composite material and the formation of a conductive matrix in its structure, along with satisfactory physical and mechanical characteristics of the products will ensure the acquisition of radiation-protective properties.

References

1. Hnes, L., S. Kunytskyi, and S. Medvid. "Theoretical aspects of modern engineering." International Science Group: 356 p. (2020).
2. Березюк, О. В. Фосфогіпсозолоцементні та металофосфатні в'яжучі з використанням відходів виробництва. Київський національний університет будівництва і архітектури, 2011.
3. Лемешев, М. С. Комплексне використання промислових відходів в будівельні галузі. ВНТУ, 2019.
4. Сердюк, В. Р. "Технологічні особливості формування металонасичених бетонів для виготовлення радіозахисних екранів." Сучасні технології, матеріали і конструкції в будівництві 4 (2007): 58-65.
5. Khrystych, O. "Technological parameters of the radiationresistant concrete production." Scientific Works of Vinnytsia National Technical University 1 (2020).
6. Березюк, О. В. "Визначення параметрів машин для поводження з твердими відходами: монографія." Omni Scriptum (2020).
7. Сердюк, В. Р., et al. "Пути использования дисперсных металлических шламов." (2004).
8. Мироненко, Д. В. Композиционные материалы для переработки отходов АЭС. Тюменский индустриальный университ1ет, 2011.
9. Сердюк, В. Р., "Радіопоглинаючі покриття з бетелум." Ресурсоекономні матеріали, конструкції, будівлі та споруди.№ 12: 62- 68. (2005).
10. Христич О. В. "Покриття із бетелу-м для боротьби з зарядами статичної електрики." Сучасні технології, матеріали і конструкції в будівництві 6.1 (2009): 29-31.
11. Лемешев, М. С., О. В. Христич, and О. В. Березюк. "Комплексна переробка техногенних відходів хімічної промисловості та металообробних виробництв." Materiály XI Mezinárodní vědecko-praktická konference «Aktuální vymoženosti vědy–2015». Publishing House «Education and Science» sro, 2015., 2015.
12. Сердюк, В. Р. "Формування структури анодних заземлювачів з бетелу-м для систем катодного захисту." Будівельні матеріали, вироби та санітарна техніка. Вип. 35: 99-104. (2010).
13. Палагнюк, С. В. Композиционные материалы полифункционального назначения. Тюменский индустриальный университет, 2012.
14. Сердюк, В. Р. "Технологические приемы повышения радиопоглощающих свойств изделий из бетэлам." Строительные материалы и изделия.№ 5: 2-6. (2005).
15. Лемешев М. С. Ніздрюваті бетони з використанням промислових відходів / М. С. Лемешев, О. В. Березюк // Перспективные инновации в науке, образовании, производстве и транспорте '2017 : материалы международной научно-практической Интернет-конференции. – Москва : SWorld, 2017. – 7 с.