VOL. 18, NO. 7, APRIL 2023 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences


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# APPLICATION OF ELECTROTHERMAL PHOSPHORIC SLAG AS A BINDER FOR FOAM CONCRETE PRODUCTION

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## ABSTRACT

The high pace of urban construction leads to a constant search for practical and inexpensive materials with the necessary thermal properties. Such materials that meet the requirements of energy saving are foam concrete of non-autoclave hardening. An urgent problem of the modern construction industry is the acute shortage and high cost of Portland cement used for the production of foam concrete as a binder. The study aimed to determine the most effective way of processing materials to activate the binder. The article provides information on the greater efficiency of applying impact grinders to activate the binder as compared to shock-abrasion units (ball mills). It is proved that when activating the binder in ball mills, cement particles have a rounded spherical shape, while in impact grinders, the binder particles acquire a crushed stone shape, i.e., such particles are more chemically reactive. Using granulated electrothermal phosphoric slag with the addition of cement in the amount of 10% and grinding the obtained mixture in an impact grinder allows producing a binder with an activity of 500-550 kgf/cm$^2$. Introducing the MB-01 and Aquatron-8 curing modifiers into this binder allows for obtaining a high-strength binder with an activity of 600-700 kgf/cm$^2$. The beginning and end times of the binder setting ranged from 55 minutes to 6.5 hours, respectively, which meets the requirements for preparing foam concretes using non-autoclave technology.

**Keywords:** foam concrete, granulated electrothermal phosphoric slag, foaming agent, technological parameters, physicochemical characteristics of a foaming agent, foam concrete mixture.

Manuscript Received 29 March 2023; Revised 9 May 2023; Published 30 May 2023

## 1. INTRODUCTION

The problem of energy saving in construction, given in the state standards of construction thermal engineering, has determined the intensive development of the research aimed at creating and producing efficient cheap materials with high thermal properties [9, 10].

Current fast paces of urban construction need to increase the production of cellular concrete products [11-13]. At present, scientific and production bases have been developed for manufacturing cellular concrete products, in particular non-autoclaved foam concrete, meeting the energy-saving requirements [14-16].

Indian scientists investigated the compatibility of the foaming agent with chemical additives in foam concrete. A coarse aggregate and reinforcement, including light fibers, were used as part of the foam concrete. Studies of the durability of foam concrete and the effect of various factors on the properties of foam concrete are given in [1].

Study of foam concrete, based on three mixtures, their structure, as well as foam structure in a solidified state allowed obtaining foam concrete characterized by compressive strength of 0.74 MPa and thermal conductivity of 0.054 W/m [2].

The authors [3] established that the use of foam concrete reduces the load on the foundation and construction costs and contributes to energy conservation. Besides, using foam concrete allows for reducing the estimated cost due to low transportation costs compared to costs for transportation of regular concrete.

Recommendations given by O. V. Korotyshevsky, which the author formulated during the development of resource-saving technology for the production of highly efficient foam concrete, can also be considered as a criticism of the work [4], in which the authors unequivocally state that the preparation of foam concrete by the method of dry mineralization of foam is possible only if using low-expansion foams [5]. This article presents an original technology for producing foam concrete with fine porosity (with a pore diameter of less than 0.8 mm) in a turbulent cavitation mixer.

At first glance, this technology can be widely implemented in production [5]. However, an in-depth study of this technology revealed a range of shortcomings, in particular, the need to use complex mixing and dosing equipment. Pore-forming of the concrete mixture in the mixer, into which all the components of the concrete mixture, including the foaming agent, are simultaneously loaded, does not allow controlling the technological process of preparing foam concrete. Foam concrete mixtures and foam concrete, obtained by this technology, do not have stable properties, since the foam under pressure in the pressure mixer, when moving out, sharply increases in volume and the structure of foam concrete becomes coarse-pored. Besides, foam concrete, obtained by this technology, is not always reproducible in terms of structural characteristics. Therefore, when implementing

foam concrete production technology, we abandoned the pressure-based technology of foam concrete preparation.
One of the most effective materials, currently used in enclosing structures, is foam concretes made using Portland cement of grades 400-500 as a binder, and natural sand as a silica component.

Now that construction is booming, the shortage of Portland cement is felt especially acutely. In the current situation, requiring increasing production to 80-90 million tons just to meet superficially the constantly growing demand, even large consumers have to put up with the often extremely low initial activity of Portland cement, and purchase material whose only advantage is its availability in stock.

The acute shortage of Portland cement, which has become a real problem of modern construction, leads to the fact that large cement plants are not at all concerned with improving the quality of their products, because high demand provides excellent sales of materials of dubious merits and poor quality.

Granulated electrothermal phosphoric slags, which contain in their chemical and mineralogical composition all the elements inherent in Portland cement, can serve as an alternative to expensive and scarce cement. However, it is known that finely ground granular slags do not exhibit binding properties without adding slag hydration activating agents [17-19].

An increase in the activity of granular slag can be achieved by an integrated approach, i.e. using slag activators and carrying out grinding in special grinding units, which allows using the capabilities of the binder more fully and opens up wide horizons for reducing the consumption of Portland cement in manufacturing products with normalized strength, frost resistance, etc. This study hypothesized that reducing the shortage of Portland cement should be achieved by using cement as a slag activator, where the cement content does not exceed 5-10% of the produced slag binder. In our opinion, today, such a solution should be recognized as the only true one for small enterprises engaged in the production of foam concrete.

The goal of the study was to determine the technology of increasing the activation of granulated electrothermal phosphoric slag with the addition of 10% cement by grinding it in various grinding units.

## 2. METHODS

At the first stage of the study of material processing, a grinder-disintegrator of the Horizont series with a central loading of the source material was used. A schematic diagram of the grinder-disintegrator is shown in Figure-1.

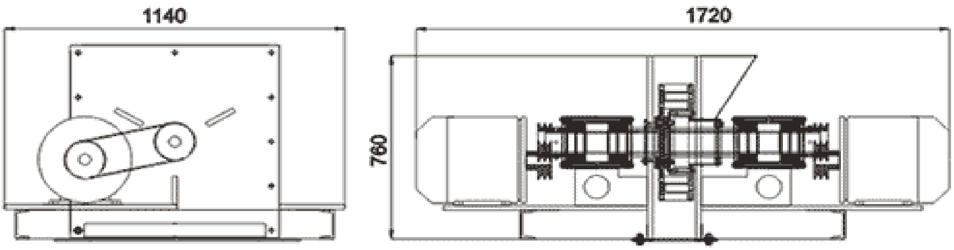


**Figure-1.** Schematic diagram of the grinder-disintegrator of the Horizont series.

The next stage of our research was to determine the setting time, normal density, and activity of the binder that had undergone disintegration treatment. Cements from the Novotroitsk and Shymkent cement plants were tested. The tests were carried out according to the methods described in GOSTs 310.1 - 310.4.

Keratin foaming agent significantly lengthens the start and end of the cement setting (by 60 minutes or more). This circumstance has a significant impact on the properties of foam concrete mixtures, i.e. can cause it to settle in the forms and, as a result, increase the specified (calculated) density of foam concrete. To reduce the time for the start of setting and hardening of foam concrete in the early stages, accelerator additives for hardening of foam concrete were introduced. As such additives, the Aquatron-6, Lignopan B-2, and Biotech-NM mineral-chemical additives were tested [4]. With the use of this additive, the main physical and mechanical properties of activated cements were determined.

By processing (Figure-1) experimental data, it was found that the dependence of the compressive strength of cement stone on the content of the additive can be approximated based on an equation of the following form:

$$Y=a+bx+cx2 \quad (1)$$

where x is the content of the additive.

For Novotroitsky 1 cement, the equation has the following form:

$$Y=65.5+5.5x-1.6x2 \quad (2)$$

For Novotroitsky 2 cement:

$$Y=64.8+4.2x-0.8x2 \quad (3)$$

For Shymkent cement:

$$Y=65.1+6.7x-2.6x2 \quad (4)$$

The correlation coefficient is 1.0.

## 3. RESULTS

VOL. 18, NO. 7, APRIL 2023 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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The results of tests to determine the main characteristics of the cements activated in the disintegrator of the Horizont series are shown in Table-1.

**Table-1.** The main characteristics of the cements activated in the disintegrator of the Horizon series

| Cements | Specific surface area, $cm^2/g$ | Normal density of cement paste, % | Water cement ratio of the solution 1:3 | Setting time, h-min | | Tensile strength after 28 days, MPa | |
|---|---|---|---|---|---|---|---|
| | | | | beginning | end | bending | compression |
| Before | | | | | | | |
| Novotroitsky 1 | 4,220 | 25.7 | 0.41 | 3-00 | 5-00 | 6.2 | 48 |
| After | | | | | | | |
| Novotroitsky 2 | 4,220 | 25.7 | 0.41 | 1-20 | 2-45 | 7.7 | 56.1 |
| Shymkentsky | 4,180 | 25.5 | 0.42 | 0-55 | 2-50 | 7.9 | 55.7 |

From the data presented in Table-1, it can be seen that the beginning and end times of the setting of the disintegrated cements are reduced by approximately 1 hour 10 minutes and 2 hours 10-15 minutes, respectively. The activity (grade) of the cements increased by one or more steps. With the use of Aquatron-6, Lignopan B-2, and Biotech-NM, the main physical and mechanical properties of the activated cements were determined. The test results are shown in Table-2.

**Table-2.** Basic physical and mechanical properties of the activated cements with hardening accelerator additives.

| Cements | Type and concentration of additives, % | Normal density of cement paste, % | Water cement ratio of the solution 1:3 | Setting time, h-min | | Tensile strength after 28 days, MPa | |
|---|---|---|---|---|---|---|---|
| | | | | beginning | end | bending | compression |
| Novotroitsky 1 | Aquatron-6 - 0.5 | 25.6 | 0.40 | 0-45 | 2-20 | 9.2 | 67.9 |
| | Aquatron-6 - 1.0 | 25.5 | 0.38 | 0-40 | 2-15 | 9.4 | 69.5 |
| | Aquatron-6 - 1.5 | 25.3 | 0.36 | 0-35 | 2-05 | 9.7 | 70.3 |
| Novotroitsky 2 | Lignopan B-2-0.5 | 25.7 | 0.40 | 0-40 | 2-25 | 8.8 | 66.7 |
| | Lignopan B-2-1.0 | 25.6 | 0.39 | 0-35 | 2-20 | 9.2 | 68.2 |
| | Lignopan B-2-1.5 | 25.5 | 0.37 | 0-30 | 2-15 | 9.4 | 69.3 |
| Shymkentsky | Biotech-NM-0.5 | 25.4 | 0.41 | 0-35 | 2-20 | 8.9 | 67.8 |
| | Biotech-NM-1.0 | 25.3 | 0.40 | 0-30 | 2-15 | 9.3 | 69.2 |
| | Biotech-NM-1.5 | 25.2 | 0.39 | 0-25 | 2-10 | 9.5 | 70.3 |

From the data presented in Table-2, it can be seen that Aquatron-6 reduces the time of the beginning and end of the cement setting. The onset of the setting of the cements with the addition of Aquatron-6 0.5% by weight of cement is in the range from 35 to 45 minutes and with 1.5% – from 25 to 35 minutes. The strength of the samples with the addition of Aquatron-6 increased by almost two steps (Figure-2).

VOL. 18, NO. 7, APRIL 2023 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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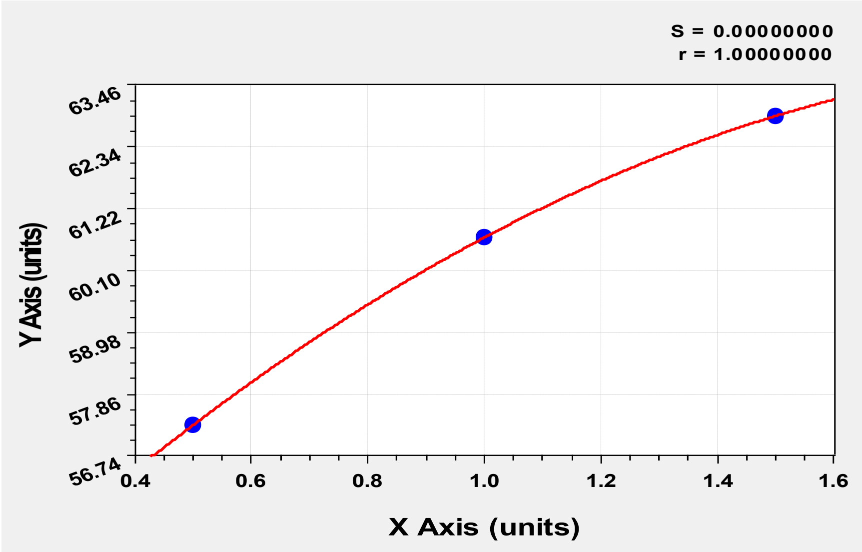


**Figure-2.** Mathematical processing of experimental data (in this case, the model of the strength of cement stone depending on the content of the additive) (Y=52.7+10.4x-2.4x2).

Table-2 shows that the use of the additive increases the strength of the activated cement specimens by more than one step. This allows us to reduce the consumption of cement by replacing part of it with activated (ground) sand in the disintegrator. To test this assumption, we conducted special experiments to replace part of the cement with disintegrated sand. The mixing of activated cement and sand was carried out directly in the disintegrator since it is impossible to evenly distribute the sand in the activated binder with manual mixing. For this, a dosed amount of binder and sand was passed through a disintegrator at a linear speed of the grinding bodies of 160 m/s.

As can be seen from the presented histograms, the main difference between powders, obtained using different grinding units, is the percentage ratio of their main fractions. The material, which was ground in a ball mill, is characterized by a relatively large number of fine particles smaller than 5 µm, and a high content of large grains larger than 40 µm.

The slag binder, activated in the impact grinder is characterized by a high particle content of fewer than 5 µm, occupying the largest area, and a sufficiently high, evenly distributed content of the commercial fraction of particles with sizes ranging from 15 to 40 µm, i.e. its fractional composition is narrower in comparison with the particles of the binder activated in a ball mill.

Based on the conducted research, we conclude that only employing impact grinders allows for increasing the activity of the slag binder most cheaply and rationally.

As a result of impact grinding, the particles of the slag binder acquire a fragmented or crushed stone shape with sharp ribs and a highly developed configuration, which contributes to their more intense interaction with water, which in turn allows increasing the physicochemical activity of the slag binder (Figure-3).

Cement grains, obtained during activation in a ball mill, have a rounded (spherical) shape, so their activity (with the same grain composition) is lower than the activity of the binder processed in the impact grinder.

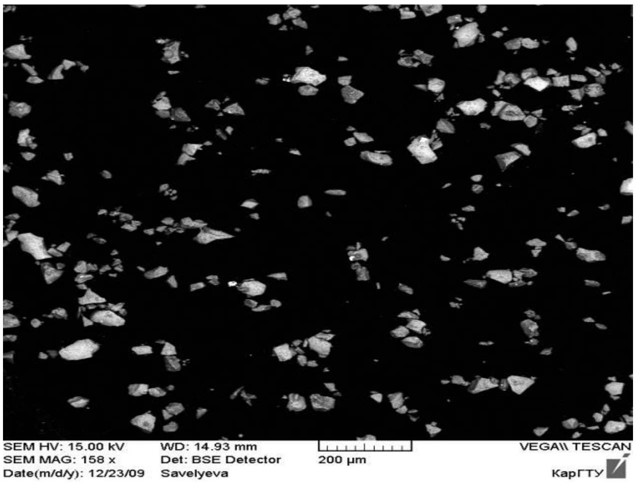


**Figure-3.** Micrograph of a slag binder, taken from a randomly selected area of a sample with an area of 462.4 $mm^2$

Figure-3 shows that the slag binder particles have the shape of crushed stone with particle sizes of about 20 µm. The data presented in the micrograph confirm the data given in the histograms, where the particle sizes were studied by fractions and the area occupied in randomly selected samples of slag binder.

To clarify the binding properties of the produced slag binder, studies of its basic physical and mechanical properties were carried out, which are presented in Table-3. Table-3 shows slag binders activated by adding 10% of Portland cements, produced at various cement plants.

**Table-3.** Basic physical and mechanical properties of slag binder.

| Cements added to slag during grinding (10% by slag weight) | Specific surface area, $cm^2/g$ | Normal density of cement-water paste, % | Cement water ratio, 1:3 | Setting time, hour-min | | Tensile strength after 28 days, MPa | |
|---|---|---|---|---|---|---|---|
| | | | | beginning | end | bending | compression |
| Novotroitsky | 5,520 | 25.7 | 0.41 | 2-20 | 7-15 | 7.7 | 56.1 |
| Shymkent | 5,480 | 25.5 | 0.42 | 2-35 | 7-50 | 7.9 | 55.7 |

From the data presented in Table-1, it can be seen that the beginning and end times of the slag binder setting have almost the same indicators as those of conventional cements. The activity of slag binders corresponds to the grade of 500-550.

It is proved that the keratin foaming agent significantly lengthens the beginning and end times of the cement setting (by 60 minutes or more) [7, 8]. This circumstance has a significant effect on the properties of foam concrete mixtures, i.e. it can cause precipitation in the molds and consequently increase the specified (designed) density of foam concrete. To shorten the setting and curing start time of foam concrete, we introduced additives, accelerating the curing of foam concrete. Chemical additives MB-01 and Aquatron-8 were tested as such additives. MB-01 and Aquatron-8 were pre-mixed with cement in a ball mill, which ensured their uniform distribution in the cement mass, and then were mixed with granulated electrothermal phosphoric slag, and undergone through an impact grinder.

It was established that these additives had a plasticizing effect on cement-water paste. Thus, when using MB-01, water intake was reduced by 30-35%. When using these additives, the main physical and mechanical properties of activated slag cements were determined. The test results are shown in Table-4.

From the data presented in Table-4, it can be seen that the chemical additive MB-01 plasticizes the cement-water paste and reduces the beginning time of the sample's setting by about an hour. The end of the setting is also reduced by an hour or more. The strength of samples with the addition of MB-01 increased by more than one step in comparison with the strength of samples without additives. The introduction of Aquatron-8 reduced the beginning and end time of the slag binder setting significantly more effectively than MB-01. The beginning time of slag cements' setting with the addition of Aquatron-8 at a dosage of 0.5% by weight of cement was within the range from 55 minutes to one hour and 45 minutes and at a dosage of 1.5% – from 35 to 65 minutes. The strength of samples with the addition of Aquatron-8 increased by almost two steps in comparison with samples without additives, and by one step in comparison with the samples containing MB-01.

**Table-4.** Basic physical and mechanical properties of activated slag binders with curing accelerator additives.

| Cements added to slag during grinding (10% by slag weight) | Type and concentration of additives, % | Normal density of cement-water paste, % | Cement water ratio, 1:3 | Setting time, hour-min | | Tensile strength after 28 days, MPa | |
|---|---|---|---|---|---|---|---|
| | | | | beginning | end | bending | compression |
| Novotroitsky | MB-01 - 0.5 | 20.4 | 0.32 | 1-56 | 7-0.5 | 8.9 | 66.2 |
| | MB-01 - 1.0 | 20.2 | 0.30 | 1-35 | 6-45 | 9.1 | 66.8 |
| | MB-01 - 1.5 | 20.1 | 0.29 | 1-15 | 6-10 | 9.4 | 69.5 |
| | Aquatron-8 - 0.5 | 25.6 | 0.40 | 1-15 | 6-20 | 9.2 | 67.9 |
| | Aquatron-8 - 1.0 | 25.5 | 0.38 | 1-05 | 5-55 | 9.4 | 69.5 |
| | Aquatron-8 - 1.5 | 25.3 | 0.36 | 0-55 | 5-15 | 9.7 | 70.3 |
| Shymkent | MB-01- 0.5 | 22.5 | 0.33 | 1-45 | 7-05 | 8.2 | 63.5 |
| | MB-01 - 1.0 | 21.3 | 0.32 | 1-35 | 6-35 | 8.5 | 66.7 |
| | MB-01 - 1.5 | 20.5 | 0.31 | 1-15 | 6-15 | 9.1 | 68.9 |
| | Aquatron-8 - 0.5 | 25.4 | 0.41 | 1-35 | 6-30 | 8.9 | 67.8 |
| | Aquatron-8 - 1.0 | 25.3 | 0.40 | 1-10 | 5-55 | 9.3 | 69.2 |
| | Aquatron-8 - 1.5 | 25.2 | 0.39 | 0-55 | 5-20 | 9.5 | 70.3 |
| | Lignopan B-2- 0.5 | 24.7 | 0.40 | 0-50 | 4-45 | 8.5 | 58.4 |
| | Lignopan B-2- 1.0 | 24.2 | 0.38 | 0-47 | 4-35 | 8.7 | 59.9 |
| | Lignopan B-2- 2.0 | 23.9 | 0.35 | 0-45 | 4-10 | 9.0 | 61.5 |
| | Biotech-NM-0.50.5 | 22.5 | 0.33 | 1-00 | 4-40 | 8.2 | 63.5 |
| | Biotech-NM-0.51.0 | 21.3 | 0.32 | 0-55 | 4-10 | 8.5 | 66.7 |
| | Biotech-NM-0.51.5 | 20.5 | 0.31 | 0-50 | 3-35 | 9.1 | 68.9 |

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**4. DISCUSSIONS**

Many properties of the binder, including its activity, curing rate, etc., are determined not only by the chemical and mineralogical composition of clinker and slag, but also to a large extent, by the fineness of the product grinding, granulometric composition, and the shape of powder particles.

The binder powder consists mainly of grains ranging in size from 5-10 to 30-40 μm. Usually, the fineness of grinding of Portland cement is characterized by residues on sieves equal to 0.08, and sometimes 0.06 mm, as well as the specific surface area of the powder. Portland cement of regular quality is crushed to a residue on a sieve No. 008 equal to 5-8% (by weight), while quickly harden cements are crushed to a residue of 2-4% or less. The specific surface area reaches 2,500-3,000 and 3,500-4,500 $cm^2/g$ and more, respectively. However, the relationship between the residue on the sieve and the specific surface area is rather conditional. Moreover, if the grinding of the material was carried out, for example, using an impact grinder, rather than an abrasive mill, such as in particular, a drum ball mill or a vibrating mill, the residue on the sieve, in this case, has nothing to do with the specific surface area of the resulting material. Accordingly, the residue on the sieve, as well as, strictly speaking, the specific surface area of cement powder cannot be considered as quantities capable of giving a real picture of cement activity.

The dispersion of cement powder, its grain composition, and grain shape, mainly depend on the type of grinding unit, using an open or closed grinding cycle, the shape, and size of grinding bodies, as well as the speed of free kick.

Considering the basic models of solids destruction, including cement grains, two types of destructive deformation can be distinguished, which cause the separation of the object into separate elements. Both during crushing and fine grinding, pieces or grains of materials in various destruction mechanisms are mainly exposed to compressive forces from two sides (for example, in the jaw, cone, and other types of crushers, drum balls, and vibration mills) or from just one side (for example, in disintegrators). Objectively, for the destruction of solids, shear deformation with displacement (as it happens when applying the impact breakage method) is preferable to compression deformation carried out as a result of the action of compressive forces on both sides. This is primarily because most of the materials used in the production of binders are characterized by compressive strength, 6-12 times higher than tensile strength. Therefore, crushing using grinding units implementing a destruction model based on compression deformation requires energy input, much more than is predicted preliminary based on calculations. Thus, in ball mills, no more than 1.5-10% of the total energy input is consumed for the useful work of grinding. The rest of the energy is transformed into irretrievably lost heat or, in other words, is simply wasted [6].

However, ball mills are widely used in the production of cement, both at the stage of preparation of raw materials and in the final grinding of clinker. This can be explained by the special specifics of cement production associated with large volumes of processed materials. In this case, the choice of grinding unit is determined to a greater extent by the required fineness of the product, as well as the reliability and ease of maintenance of the equipment, and not because of the outstanding grinding efficiency or optimal consumption of the input energy.

If the preparation and activation of the slag binder are carried out at the places of its direct use, for example at an enterprise manufacturing foam concrete products, it is the correct choice of the grinding unit type that will determine the economic feasibility of the efforts aimed at activating the slag binder. In other words, drum ball mills, traditionally employed in production, cannot be used in manufacturing slag binders at small and medium-sized enterprises. In works on the activation of Portland cement performed at the places of its use, when the volumes of processed material are relatively small (by the standards of cement plants), the impact destruction method, or as it is also called the disintegrator method, is economically feasible.

Cement powder is very heterogeneous in terms of its granulometric composition. In this regard, some researchers recommend characterizing the activity of cement not only by the specific surface area of the powder but also by the grain composition. Thus, A.N. Ivanov-Gorodov believes that uniform and rapid curing of cement can be achieved at the following grain compositions: grains smaller than 5 μm - no more than 20%, grains of 5-20 μm - about 40-45%, grains of 20-40 μm - 20-25%, and grains larger than 40 μm - 15-20%.

Numerous studies describe the relationship between the number of grains of a certain size and the rate of hardening. Thus, particles with sizes of 0-5 have a decisive influence on the growth of the strength of the cement stone in the first hours of hardening. Particles with a size of 5-10 μm affect the strength of the cement stone at 3-7 days of age, and fractions of 10-20 μm determine the strength at 28 days of age and later.

The product, crushed in ball mills is characterized by a very diverse granulometric composition, which is represented by small particles (<5 μm), particles of the main commercial fraction (5-40 μm), and large particles, whose size is ten times larger than the size of the commercial fraction. The percentage of particles of each fraction varies depending on the type of mill, the size of grinding bodies, the shape of armor plates in ball mills, as well as the ratio between the length and diameter of the mills. In other words, ball mills are characterized by low selectivity of grinding, which is manifested in the inability of regulating the granulometric composition of the resulting product in terms of reducing the particle size of the average most important fraction of cement powder.

Trying to reduce the particle size of the average fraction, say from 40 to 20 μm (reduce exactly the average particle size rather than increasing the specific surface area) caused the crushing of the entire size range of cement grains as a result of indiscriminate crushing and grinding. The upper part of the middle fraction passes into a thin over-ground class of cement particles, while the crushed large grains do not have time to compensate for the loss of the middle fraction. As a result, against the background of an increase in the specific surface area of cement powder, the proportion of the most important grain sizes of 10-20 μm is reduced. The inability to influence the granulometric composition of cement powder when grinding in ball mills leaves virtually no hope of obtaining a material whose increased activity in the initial curing period would not further result in a decrease in strength and frost resistance in the long term.

On the contrary, the method of impact grinding of cement-slag grain is characterized by a rather narrow granulometry. The percentage of medium fraction particles in the powder, when grinding the material using the free kick method is much higher than that using other grinding methods. Therefore, the main increase in the strength of cement crushed by the impact method is observed not in the first hours of hardening, but after 3-7 days. This is explained, first of all, by the high selectivity of the grinding process using a free kick mechanism.

## 5. CONCLUSIONS

The practice of foam concrete preparation has shown that the mixing time of the foam concrete mixture in the mixing batch is approximately 7-10 minutes, and the time of unloading the mixture from the froth-generating concrete mixer and distributing it in molds is within 15-20 minutes. Based on this, we consider it expedient to introduce Aquatron-8 in a concentration of 1.5% of the cement weight, since in some cases this time may not be enough to place the foam concrete mixture into molds and the mixture may harden in the concrete mixer or the gerotor pump hoses. Therefore, we consider the optimal dosage of Aquatron-8 to be 0.5% by weight of disintegrated cement.

Thus, the experiments showed that the disintegrator activation of cement and sand increases the activity of the binder by one or two steps due to an increase in the commercial fraction of cement particles with grain sizes of 10-40 μm and the complete absence of inactive cement grains with particle sizes of more than 60 μm. Along with an increase in the activity of cement, the time of the beginning and end of their set is reduced by 1 and 2 hours, respectively, in comparison with their initial state. The use of mineral-chemical additives cement hardening accelerators, such as Lignopan B-2, Biotech-NM, and Aquatron-8, gives an even greater effect. The beginning of the cement setting is reduced to 1 hour or less, and the end of the setting is reduced to 2 hours or more. The cement grade rises to 550-700. Due to the activation of cement and sand in disintegrators and the use of hardening accelerator additives, it became possible to reduce the consumption of a binder and increase productivity by reducing the molding cycle.

## REFERENCES

[1] Ramamurthy K., Kunhanandan Nambiar E.K. and Gandhi I.S.R. 2006. A classification of studies on properties of foam concrete. Cement & Concrete Composites. 31(6): 388-396. https://doi.org/10.1016/j.cemconcomp.200904.006

[2] Jiang J., Lu Z., Niu Y., Li J. and Zhang Y. 2016. Investigation of the properties of high-porosity cement foams based on ternary Portland cement-metakaolin-silica fume blends. Construction and Building Materials, 107, 181-190. https://doi.org/10.1016/j.conbuildmat.2015.12.190

[3] Amran Y. H. M., Ali A. A. A, Rashid R. S. M., Hejazi F. and Safiee N.A. 2016. Structural behavior of axially loaded precast foamed concrete sandwich panels. Construction and Building Materials. 107, 307-320. https://doi.org/10.1016/j.conbuildmat.2016.01.020

[4] Shintemirov K. S., Montaev S. A., Ryskaliyev M. Zh., Bakushev A. A. and Narikov K. A. 2016. Investigation into the properties of foamed concrete modified by chemical additives. Research Journal of Pharmaceutical, Biological and Chemical Sciences. 7(3): 2065-2072.

[5] Korotyshevsky O. V. New resource-saving technology for the production of high-performance foam concretes. Building Materials,**2**, 32–33(1999).

[6] Ryskaliyev M. Z., Zharylgapov S. M., Zhapakhova A. U., Sarabekova U. Z. and Abdikerova U. B. 2021. Development of technological parameters for production of keratin foaming agent. International Journal of Mechanical Engineering. 6(3): 16-122.

[7] Ryskaliyev M. Z., Zharylgapov S. M., Zhekeyev S. O., Ryskulov B. K. and Konebayev Y. U. 2021. Disintegrator activation of cement and sand to obtain foam concrete of specified physical and mechanical properties. International Journal of Mechanical Engineering. 6(3): 109-115.

[8] Ryskaliyev M. Z., Zharylgapov S. M., Saktaganova N. A., Sarabekova U. Z. and Yerimbetov K. A. 2019. Physico-mechanical properties of foam concrete with a keratin-based foaming agent. International Journal of Engineering and Advanced Technology. 8(3): 80-82.

[9] Kagonbé B. P., Tsozué D., Nzeukou A. N., Ngos S. 2021. Mineralogical, physico-chemical and ceramic properties of clay materials from Sekandé and Gashiga (North, Cameroon) and their suitability in earthenware production. Heliyon, 7(7): e07608. https://doi.org/10.1016/j.heliyon.2021.e07608

[10] Xiong Y., Xu G., Wu D., Fang S., Tang Y. 2021. Investigation of using the ceramic polishing brick powder in engineered cementitious composites. Journal of Building Engineering, 43, 102489. https://doi.org/10.1016/j.jobe.2021.102489

[11] Alnahhal A. M., Alengaram U. J., Yusoff S., Singh R., Radwan M. K. H., Deboucha W. 2021. Synthesis of sustainable lightweight foamed concrete using palm oil fuel ash as a cement replacement material. Journal of Building Engineering, 35, 102047. https://doi.org/10.1016/j.jobe.2020.102047

[12] Liu, X., Ni, C., Meng, K., Zhang, L., Liu, D., Sun, L. Strengthening mechanism of lightweight cellular concrete filled with fly ash. Construction and Building Materials, 251: 118954.https://doi.org/10.1016/j.conbuildmat.2020.118954

[13] Athira V. S., Charitha V., Athira G., Bahurudeen A. 2020. Agro-waste ash based alkali-activated binder: Cleaner production of zero cement concrete for construction. Journal of Cleaner Production, 286, 125429. https://doi.org/10.1016/j.jclepro.2020.125429

[14] Font A., Soriano L., Tashima M. M., Monzo J., Borrachero M. V., Payá J. 2020. One-part eco-cellular concrete for the precast industry: Functional features and life cycle assessment. Journal of Cleaner Production, 269, 122203. https://doi.org/10.1016/j.jclepro.2020.122203

[15] Fomina E. V., Lesovik V. S., Kozhukhova M. I., Solovyova E. B. 2020. The raw materials genetic characteristics role in autoclave cellular concrete carbonation process. Materials Science Forum 974 MSF, 224-230. https://doi.org/10.4028/www.scientific.net/MSF.974.224

[16] Fabien A., Sebaibi N., Boutouil M. 2022. Effect of several parameters on non-autoclaved aerated concrete: use of recycling waste perlite. European Journal of Environmental and Civil Engineering, 26(1): c. 58-75.

[17] Yang X., Jia Y., Yang C., He X., Jia Y., Xu L. 2022. Research on formulation optimization and hydration mechanism of phosphogypsum-based filling cementitious materials, 10, 1012057. https://doi.org/10.3389/fenvs.2022.1012057

[18] Sun L., Zhao Z., Yang X., Sun Y., Li Q., Luo C., Zhao Q. 2022. Thermochemical decomposition of phosphogypsum with Fe-P slag via a solid-state reaction. Chinese Journal of Chemical Engineering, 47, 113-119. https://doi.org/10.1016/j.cjche.2021.06.025

[19] Ahmad J., Kontoleon K. J., Majdi A., Naqash M. T., Deifalla A. F., Ben Kahla N., Isleem H. F., Qaidi S. M. A. 2022. A Comprehensive Review on the Ground Granulated Blast Furnace Slag (GGBS) in Concrete Production. Sustainability, 14, 8783. https://doi.org/10.3390/su14148783