Lightweight concrete for frame-monolithic construction

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Abstract. The proposed article is devoted to the study of the properties (strength, impact strength, sound absorption) of lightweight concrete used for frame-monolithic construction. Characterized by the well-known advantages (reduced load on the foundation, reduced consumption of reinforcement, as well as improved heat and sound isolation), lightweight concrete requires additional technological methods to achieve the necessary mechanical characteristics - compressive strength and impact strength. An alternative to the traditional preparation of concrete mixtures is proposed a technology using a high-speed mixer-activator in the presence of ground chamot, superplasticizer C-3 with the introduction of hydrophobic expanded clay gravel up to 75\% of the amount of granite crushed stone. The use of mechanical activation leads to an increase in impact strength by 44\% compared to the control, and makes it possible to obtain concretes, the sound isolation level of which provides the maximum efficiency of impact noise isolation and is equal to 45.7 - 42.8 dB in three frequencies, and the sound absorption level is 39.8 - 49.7 dB.

1. Introduction

One of the promising directions in frame-monolithic construction is the use of lightweight concrete with an average density of 1850 ... 2100 kg / m\textsuperscript{3}, in which part of the dense aggregate is replaced by porous one, for example, expanded clay gravel. The use of lightweight concrete of classes C20/25...C25/30 is advisable in almost all building structures. By decreasing the average concrete density by 20-25\%, lightweight concretes will reduce the load on the foundations, decrease the consumption of reinforcement, reduce transport costs, and also provide better sound isolation of intermediate floors. At the same time, a decrease in the average density of concrete causes a decrease in its strength. It is possible to accelerate the process of structure formation of concrete, as well as to increase its compressive strength, using the mechanic activation of the binder.

The amplification of the quality of concrete, more intensive growth of strength, can be achieved through the purposeful change of the structure of the cement stone, as by activating the cement grains [1-4] and fillers [5, 6] under conditions of intense hydrodynamic influence on them, and due to the modification of their surface area by surfactants [7, 8].

Works by Y. M. Bazhenov [9], R. F. Runova [10] etc. found that the use of active mineral additives provides a real opportunity to obtain concrete with preset physical and mechanical characteristics, with significant savings Portland cement.

2. The purpose of the research

The goal is to improve the physical and mechanical characteristics of concrete by mechanical activation of Portland cement and partial replacement of crushed granite with expanded clay gravel. The objective of the research is to find out the effect of partial replacement of crushed granite with expanded clay gravel and the introduction of ground chamot into mechanically activated Portland cement on the compressive strength, sound absorption and impact strength of concrete.
3. Research method
The impact strength of concrete (T) was evaluated by testing cube specimens with an edge of 7.07 cm on a laboratory pile driver. The sound isolation of concrete was determined by testing specimens measuring 20.5×10×5 cm on a PI-6 measuring device and a GZ-112 low-frequency signal generator, by measuring the number of dB passing through the sample. To clarify the role of mechanical activation of Portland cement on the structural and mechanical characteristics of concrete, a high-speed mixer with an adjustable number of revolutions of the working body of the mixing chamber was used.

4. Research results
The study of the mechanical properties of concrete was carried out by testing two similar series of samples: the first - using mechanical activation of cement in a high-speed mixer and the other, control - using traditional technology. To plasticize the concrete mix, the C-3 thinner was used. The hydrophobization of expanded clay granules was carried out by dipping them into an organosilicon liquid GKZH-94 and subsequent drying at t = 90 ÷ 100 °C. Ground chamot was used as a mineral additive to Portland cement. Quartz sand with M<sub>cr</sub> = 2.5 was used as a fine aggregate. As a coarse aggregate in the experiments, we used:

a) crushed granite of 5-20 mm fractions (the bulk density of crushed stone was 1375 kg / m<sup>3</sup>);
b) expanded clay gravel of fraction 5-20 mm (bulk density of gravel - 540 kg / m<sup>3</sup>).

The activation time of the cement-containing slurry in the experiment was 60 sec.

The experimental design and the levels of variation of the recipe factors are shown in table 1:

| №  | Values of natural variables | Reaction |
|----|-----------------------------|----------|
|    | mixed          | technological          | Control       | Mechanoactivation |
|    | S, m<sup>2</sup>/kg | S, m<sup>2</sup>/kg | S, m<sup>2</sup>/kg | Clay gravel, % | Chamot, % | T, J | T, J |
| 1  | 250           | -                  | -            | 25          | 10        | 42.37 | 52.4 |
| 2  | -             | 350                | -            | 25          | 10        | 43.15 | 53.8 |
| 3  | -             | -                  | 450          | 25          | 10        | 40.95 | 51.1 |
| 4  | 250           | 350                | -            | 25          | 20        | 44.76 | 55.05 |
| 5  | -             | 350                | -            | 25          | 30        | 46.25 | 57.3 |
| 6  | 250           | -                  | 450          | 25          | 30        | 45.8  | 55.2 |
| 7  | 250           | -                  | -            | 50          | 30        | 53.35 | 60.5 |
| 8  | -             | -                  | 450          | 50          | 30        | 51.2  | 60.1 |
| 9  | 250           | 450                | -            | 50          | 20        | 51.1  | 59.8 |
| 10 | 250           | 350                | 450          | 50          | 10        | 50.75 | 59.2 |
| 11 | 250           | -                  | -            | 75          | 10        | 59.6  | 66.4 |
| 12 | -             | 350                | -            | 75          | 10        | 60.25 | 67.5 |
| 13 | -             | -                  | 450          | 75          | 10        | 59.15 | 66.2 |
| 14 | -             | 350                | 450          | 75          | 20        | 61.4  | 68.4 |
| 15 | 250           | 350                | -            | 75          | 10        | 62.1  | 68.95 |

As a result of research, it was found that the impact strength is influenced by the granulometric composition of the ground chamot. The maximum impact resistance with the same content of ground chamot and expanded clay gravel is observed at the maximum content of ground chamot with specific surfaces of 250 m<sup>2</sup> / kg and 350 m<sup>2</sup> / kg.

Mechanical activation of the binder sharply increases the impact strength of concrete at any content of expanded clay gravel and ground chamot. Thus, in concrete with 50% expanded clay gravel, activation of a binder containing 20% of ground chamot makes it possible to increase the impact strength of concrete from 50.8 to 59.4 J. At the same time, the tendency for an increase in the impact...
strength of concrete with an increase in the content of expanded clay gravel and ground chamot remains, Figure 1.

![Figure 1. Influence of the amount of expanded clay gravel and ground chamot on the impact strength and compressive strength of concrete](image1.png)

In Figure 2 shows the dependence of the change in impact strength depending on the strength of concrete in compression.

![Figure 2. Influence of the amount of ground chamot and expanded clay gravel on the impact strength of concrete](image2.png)

As mentioned above, with an increase in the amount of expanded clay gravel, there is an increase in the impact strength and a decrease in the strength of concrete in compression, and the intensity of the decrease in the strength in compression is higher than the intensity of the increase in the impact strength when the content in concrete is up to 50%.

The most important property of concrete, along with strength, is its sound isolation.

It is worth noting that with the introduction of 20% expanded clay gravel, the level of sound isolation sharply decreases by an average of 5 dB, another jump can be observed with the introduction of 60% expanded clay gravel. The sound isolation level is reduced by an average of 10 dB. The lower the level of sound isolation of concrete, the better it will soundproof the room from noises and sounds of a different nature (it absorbs more dB), Figure 3a.
Figure 3. Influence of the content of expanded clay gravel in the aggregate mixture "granite crushed stone - expanded clay gravel" on the sound isolation of concrete:

a) mechanically activated binder; b) on mechanically activated binder

- 100 % expanded clay gravel;
- 60 % expanded clay gravel;
- 0 % expanded clay gravel.

It is known that for maximum impact sound isolation efficiency, the sound absorption of the indoor material is 26-39 dB. It was experimentally established that the sound absorption of concrete on an unmechanically activated binder varied within the following limits: frequency 500 Hz - from 23.2 to 38.2 dB, i.e., by 39%; frequency 1000 Hz - from 26 to 41.3 dB, i.e., by 37%; frequency 3000 Hz - from 32.1 to 49.5 dB, i.e., by 35%.

The given figure 3 indicates that with the introduction of a porous aggregate in the amount of 60% of expanded clay gravel, the sound absorption of the material increased by an average of 10 dB.

5. Conclusions

It has been established that the introduction of hydrophobic expanded clay gravel into the composition of heavy concrete makes it possible to obtain lightweight concrete with an average density from 2000 kg/m³ to 1850 kg/m³ and strength from 25 MPa to 30 MPa, respectively. Mechanical activation of the binder allows one to obtain concretes of a similar average density with compressive strength from 34 MPa to 45 MPa. Impact strength is 44% higher than that of heavy concrete.

The conducted studies allowed us to conclude that the introduction of hydrophobic expanded clay gravel (in the amount of 60% of the basic composition of concrete) instead of granite crushed stone (in the amount of 60% of the basic composition of concrete) makes it possible to obtain concretes, the level of sound isolation of which ensures the maximum efficiency of isolation of impact noise and is equal to 45.7-42.8 dB in three frequencies. The sound absorption level is 39.8-49.7 dB.

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