

Dependence of foam concrete properties on technological factors

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Abstract. The dependences of foam concrete properties on various factors, which are divided into 4 groups, are considered. The dependence of physical and mechanical properties on the properties of materials, conditions for maintaining foam concrete, on the brand and mineralogical composition of cement was revealed. Joint and separate methods of preparing a foam concrete mixture using pressure-chamber turbulence-cavitation mixers and modernized standard forced-action mortar mixers are considered. The importance of technological influence of temperature in foam concrete technology is determined. Methods of transportation of foam concrete mix, which also affect the properties of the material, are considered.

1 Factors affecting the properties of foam concrete

Foam concrete is a light cellular concrete obtained by hardening a solution consisting of cement, sand, water, and foam. The foam provides the necessary content and even distribution of air in the concrete. The foam is obtained from a foam concentrate (foaming agent). As a foaming agent, various organic and inorganic compounds can be used: those obtained on the basis of natural protein, and synthetic ones obtained in the production of detergents.

The physical and mechanical properties of foam concrete depend on a number of factors, which can be divided into 4 groups: factors due to the properties of materials and their quantitative ratios; technological factors; structural and technological parameters of equipment; conditions for maintaining foam concrete. [1]

Varying the number of components makes it possible to obtain heat-insulating, heat-insulating and structural foam concrete: super light, light, medium density and heavy with a density, respectively, of 100 - 300 kg/m³, 300 - 600 kg/m³, 600 - 1000 kg/m³, 1000 - 1600 kg/m³. At the same time, a mixture of foam concrete with a density of 100 - 600 kg/m³ is prepared without sand.

The type of foaming agent has a significant impact on the quality of foam concrete. So, to obtain high-density foam concrete, synthetic foaming agents are usually used, which affect the strength of the foam concrete, but increase the time of setting and strength gain.

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Protein foaming agents are used in the production of low-and medium-density foam concrete.

In our country, widely used foaming agents PB-2000 according to TU 2481-185-05744685-01, protein-protein foaming agent Rospena according to TU 24.66.47.142-001-0139620869-2019, German-made zimpor foaming agent and others.

Foaming agents must have a high resistance of the foam closed microporous structure to prevent shrinkage of the mixture after pouring. The size of the sand is important for thermal insulation and structural foam concrete. The fraction (particle size) should not exceed 2 mm.various porous materials such as expanded polystyrene, expanded clay or perlite sand, and others can also be used as a filler. PC-500 D0 or PC-400 D0 cement is used as a binder.

Table 1. Factors affecting the properties of foam concrete.

FACTORS AFFECTING THE PROPERTIES OF FOAM CONCRETE	
Name of factors	Components of factors
1. Properties of materials and their quantitative correlations	→ cement (type, brand)
	→ water (w/c)
	→ foaming agent (type, consumption)
	→ sand (particle size)
2. Design and technological parameters of the equipment	→ Pressure chamber turbulence cavitation mixers: - geometric dimensions of the camera; - types of mixer blades
	→ The mixers forced mixing cavitation mixers: - rotation speed; - presence of excessive air pressure
3. Technological factor	→ Methods for preparing a foam concrete mix: - collaborative technology; - separate technology
	→ The temperature of the concrete mix
4. Conditions of production and maintenance	→ Outdoor temperature
	→ The thickness of the layer to be laid, the massiveness of the structure, the type of formwork

The main physico-mechanical properties of foam depend on the composition and properties of its components: brand and mineralogical composition of cement; the uniformity of distribution of pores; their nature (open, connected or closed); type of foaming agent; water quality; sand, above all, its granulometric composition, kind of additives; the condition of curing and other factors.

The properties of foam concrete are interrelated. Thus, the coefficient of thermal conductivity (λ) in the dry state depends mainly on the value of the average density. The type of binder, hardening conditions, and other factors have an insignificant effect on the value of λ . This is due to the fact that the material of the walls that form the pores consists of a cement stone or a hydrosilicate frame close to it. Therefore, the amount of porosity

and, accordingly, the average density mainly determines the thermal conductivity of foam concrete. [2]

A significant influence on the properties of foam concrete has a set of technological factors. The quality of foam is generated at all stages of the process: in the preparation of foam concrete mix; when filing (transporting) of the mixture to the place of installation; while keeping the concrete until it has cured completely and the final operation of drying the foam concrete.

2 Joint and separate methods for preparing a foam concrete mix

An important place in the technology of foam concrete is the method of preparing a foam concrete mixture. There is separate and joint technology.

For both methods, the structural and technological parameters of the mixing equipment used have a significant impact on the quality of foam concrete. The main ones are the shape and geometric volume of the chamber (drum), the type and number of blades (blades), the speed of rotation of the shaft (rotor), the amount of excess pressure (when cooking in pressure chamber mixers).

2.1 Joint technology of foam concrete mix preparation

Joint preparation provides simultaneous loading of components: water, cement, foaming agent and, for heat-insulating and structural concrete, sand. Mixing is carried out in various types of pressure chamber turbulence-cavitation mixers.

The rotor speed of pressure chamber mixers is proportional to their volume and ranges from 350 to 650 revolutions per minute depending on the geometric dimensions of the chamber. High-speed mixing provides mechanical activation of the binding materials and intensive foam generation, and the excess pressure in the chamber created by the compressor contributes to the greatest involvement of air in the mixture. [3]

2.2 Separate the technology of preparation of concrete mix

With a separate technology, a water-cement mixture is first prepared and sand is introduced, depending on the calculated density. Using a continuous foam generator, for example, the calculated amount of foam is prepared and then added. Subsequent mixing of the hydro mixture with foam allows you to get a ready-made foam concrete mix with the specified properties, suitable for its installation in forms or formwork.

With separate technology, modernized standard forced-action mortar mixers are used. The rotation speed of the mixer shaft is 35-45 rpm; the blades are plate or screw (involute). To improve the mixing of foam concrete mixtures, additional cavitation plates are installed on the spokes of the blades. [3]

3 Technological influence of temperature in foam concrete preparation technology

An important factor in foam concrete technology is temperature. First of all, this is the temperature of the outside air and the foam concrete mix at the time of laying. When the temperature drops below +15° C, the time of setting of cement, the set of plastic and final strength increases.

The heat can be added to the hydro mixture directly when it is prepared with hot mixing water, or by heating the hydro mixture in a mixer using electricity, steam, or others. With

separate technology, part of the heat can be added with foam. Due to the heat introduced into the foam concrete mix during its preparation, and the exothermy of the cement during the hardening of the foam concrete, an optimal temperature regime of its retention is provided. The production cycle time is reduced, the physical and mechanical properties of foam concrete are improved, and the technical and economic indicators of production are increased. High temperature at an early stage provides a more intensive formation of the cement matrix, which reduces shrinkage phenomena, allowing you to increase the thickness of the layer being laid when concreting structures.

The quality of foam concrete is also affected by the method of transporting the mixture to the installation site. A fairly simple and reliable method of feeding is pneumotransportation, based on the use of excess pressure created in barosmesiteli. Piston, diaphragm and gerotor pumps are also used for pumping the foam concrete mixture. The most effective in practice are recognized gerotornye pumps that allow you to feed the foam concrete mixture at 100 - 150 m horizontally and 50-70 m in height. The most favorable conditions for preserving the structure of the foam concrete mixture are provided when applying the crane-bucket scheme. The advantage of this method is the possibility of laying the mixture at any point of the object within the working area of the crane – hook departure. Disadvantages – additional overloads that increase the time of laying the mixture in the formwork, and the use of crane time. [4]

When constructing monolithic structures made of foam concrete, it is necessary to observe the temperature conditions of holding and drying, and the design features of formwork systems. The greatest problems arise at low positive and, especially, at negative outdoor temperatures. In the construction of massive and medium massive structures, use the methods of the thermos and pre-heating of the mixture. Significant consumption of high-quality cement from - 400 to 450 kg / m³ provides the release of 14000-18000 kJ/m³ of exothermic heat, sufficient to ensure optimal temperature and humidity conditions of aging. For small massive and thin-walled structures, the thermos and preheating methods must be combined with the use of thermoactive formwork, thermomats, a hothouse device, or others. it is Necessary that by the time the foam concrete mixture loses its survivability, a stable frame of the cement matrix is formed that can preserve the pore walls, excluding concrete sediment.

The cast consistency of the foam concrete mix, with a high water-cement ratio, has both positive and negative sides. A positive feature is high workability, the ability to fill all pores, niches and other structural elements. Lack of increased requirements for the tightness of the formwork or elements of enclosing structures that perform the functions of fixed formwork. The high content of free water in the hardening foam concrete requires the use of formwork materials that can provide a holding and drying mode.

References

1. S. Samborsky, I. Ivanov, V. Zhmikhov, L. Shakhova, *Foam Concrete-2007: Sat. report of the International Scientific and Practical Conference*, 107-117, St. Petersburg (2007)
2. S. Gusenkov, V. Smirnov, S. Galkin, at al., *Construction Materials, Equipment, and Technologies of the XXI Century*, № 3, 20-21 (2001)
3. V. Trambovetsky, *Technologies of Concrete*, 30-31 (2007)
4. S. Gusenkov, V. Udachikn, Russian foam concrete "Science and technology in industry" **1** (2000)