HEAT INSULATING COMPOSITE MIXTURES WITH
TECHNOGENIC MATERIALS

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Abstract. Rational use of techno genic materials with various physical and mechanical characteristics is one of the effective direction of resource-saving and the production of heat-insulating materials. The paper presents the results of experimental research and design development on the creation of a technological line for the production of heat insulation mixtures using techno genic porous aggregates.

At present, in Russia and abroad, the heat insulation of the exterior surfaces of buildings and structures is one of the most important tasks of resource-saving. Abroad, the greatest extension was obtained by heat insulation mixtures with porous fillers: fine-grained expanded clay, bloating glass granulate, perlite, vermiculite, spherical foam polystyrene, etc. [1].

The analysis shows that in Russia during the operation of the communal facilities, up to 20% of all energy resources of the country are consumed, which is 2-3 times more than the energy consumed per unit area than in the European countries. In Europe during operation of multi-storey residential buildings, 350-550 kW / h of energy are consumed but cottages consumption is 600-800 kW / h. At the same time, in the economically developed countries of Europe, residential buildings consume 90-120 kW / h of energy.

In this regard, the more active development of heat-shielding materials, along with the use of techno genic porous components (dust loss of burning aggregates of perlitic, vermiculite, ash components of TPP, etc.) in composite mixtures, as well as organic-mineral fiber-reinforced fillers, which have a reinforcing effect, is a very promising direction for science and practice.

At the same time, not only the urgent tasks of resource-saving are being solved, but also the rational use of techno genic materials, as well as the protection of the environment from pollution.

Heat insulation composite mixtures include a mixture of astringents, aggregates and various additives. Table. 1 presents the main components of dry construction mixtures.

Table 1. Components of dry building mixtures

| Astringents                  | Aggregates and fillers | Chemical additives                |
|-----------------------------|------------------------|-----------------------------------|
| Portland cement, white cement, gypsum, anhydrite, lime, alumina cement, dispersible polymer powders | Quartz sand, limestone, chalk, dolomite, perlite, kaolin, microsilica, ash loss, fibers, pigments, lightweight aggregates (expanded clay, bloating vermiculite and perlite, pumice, etc.) | Plasticizers, stabilizing and water-retaining additives dispersible polymer powders, retarders, accelerators, thickeners, pore-forming and antifoaming additives. |

Porous fillers have a special place in heat-insulating composite mixtures (HIM).
In the studies carried out [2], the bloatingpearlitic sand produced by JSCOskolsnab (StaryOskol, Belgorod region) was used as a porous aggregate. The granulometric composition of the bloating perlitic sand is shown in Table. 2.

The chemical composition of perlite is represented by the following oxides, wt.%: SiO2 - 75.8; Al2O3 = 12.73; Fe2O3 - 1.47; CaO = 2.46.

X-ray phase analysis (XRA) showed that perlite sandis represented by such minerals as cristobalite, tridymite and feldspar.

**Table 2.** Granular composition of perlite sand

| Title of residue | Residues on sieves, wt% | Passage through a sieve 0.14 wt% |
|------------------|-------------------------|---------------------------------|
| Particulate      | 2.5 1.25 0.63 0.315 0.14 | 7.2 19.4 18.2 29.6 25.2 0.4    |
| Full             | 7.2 26.6 44.8 74.4 99.6 100 |                                  |

When carrying out the experimental studies, the following HIM compositions were used in table 3.

**Table 3.** Blend composition of heat-insulating mixtures

| Composition number | Ratio cement: bloating perlite sand by volume | Cone slump, cm | Average density, kg/m³ (28 days) | Average compressive strength, MPa (28 days) |
|--------------------|----------------------------------------------|----------------|-----------------------------------|---------------------------------------------|
| 1                  | 1:5                                          | 1.34 10.3      | 952                               | 1.9                                         |
| 2                  | 1:7                                          | 1.38 11        | 555                               | 1.5                                         |
| 3                  | 1:9                                          | 1.59 10.5      | 490                               | 1.1                                         |
| 4                  | 1:11                                         | 1.78 10.2      | 443                               | 0.8                                         |
| 5                  | 1:15                                         | 213 10.3       | 381                               | 0.3                                         |

As a astrigent, portland cement CEM (PC 500 D0) was used. The water-hard ratio was determined according to the existing technical requirements for plaster solutions (mobility of the mixture OK = 10 ... 11 cm). The results of experimental studies (tests of cubes measuring 7.07 * 7.07 * 7.07 cm on compression when reaching the age of 28 days) are presented in the form of graphical dependence (Fig. 1). The ratio of cement-pearlite (C / P) varied in the range 1: 5 ... 1:15.

![Figure 1. Dependence of the strength and density of samples on the ratio"Cement: pearlitic sand" of the composite mixture: —— - density curve; - - - - strength curve](image-url)
The analysis shows that at a ratio of $C / P = 1: 7$, the following values are achieved: sample density $\rho = 550 \, \text{kg} / \text{m}^3$, compressive strength $\sigma = 1.5 \, \text{MPa}$ (with the minimum permissible strength of plaster solutions $\sigma = 1.0 \, \text{MPa}$).

The study of the influence of the granulometric composition of perlite sand on the physicomechanical characteristics of the samples showed that its selection is determined by the ultimate goal-reaching the maximum strength of the samples (at a higher density) or obtaining samples with increased heat-shielding properties.

Samples with grain sizes of $140 \ldots 630 \, \mu \text{m}$ (at $50\%$ content, by weight) possess the lowest thermal conductivity. Under increasing the content of large fractions, the density rise is observed and consequently, the mechanical strength with a higher heat conductivity.

In connection with the above said, we studied the possibility of using percolate dust in percolate production, pearlite dust trapped in cyclones and bag filters. Perlite dust is characterized by a high silica content ($\text{SiO}_2 = 75.7\%$) and alumina ($\text{Al}_2\text{O}_3 = 12.8\%$), as well as a greater absorption of Ca$^2+$ ions from the saturated lime solution compared to the composite perlite.

Under the ratio $C/P = 1: 9$ with the addition of $20\%$ perlite dust and the use of modified additives (Tylose, Tylovise SE, Hostapur OSB, etc.), the density of the plaster solution reached $490 \, \text{kg} / \text{m}^3$, and the compressive strength $\sigma = 2.2 \, \text{MPa}$. The coefficient of heat conductivity of the HIM corresponds to SNiP 11-3-79 $\lambda \leq 0.3 \, \text{W} / (\text{m} \cdot \text{K})$ or the European standard for plaster solutions EN 998-1 for grades T1 - $\lambda = 0.1 \, \text{W} / (\text{m} \cdot \text{K})$ and T2 - $\lambda = 0.2 \, \text{W} / (\text{m} \cdot \text{K})$.

It is useful to use vermiculite and vermiculite dust caught in the system to ensure the heat-insulating properties (with the necessary strength characteristics) to the plaster mixtures, in addition to, artistic-decorative form Fig.2 system [3].

![Figure 2. Microphotograph of vermiculite](image)

To obtain heat-insulating compositional mixtures of different compositions using techno genic materials, the technological complex developed by us can be used (Fig. 3) [4, 5]. The complex makes it possible to implement various technological operations: storage, preparation of various components of the thermal insulation mix (astringent, porous aggregate, techno genic fibrous fillers, organic additives); their qualitative homogenization in a recirculation mixer; packing and storage of finished products. If necessary, mechanical activation of astringent and fibrous fillers to a microdispersed state in a centrifugal grinding mixer of selective grinding is provided.
**Figure 3.** Diagram of heat-insulating composite mixtures:

1 - motor transport; 2 - pneumatic transport; 3 - bunker of astringents; 4 - auger conveyor; 5 - centrifugal grinding and mixing unit; 6 - auger feeder; 7 - bunker of porous aggregates; 8 - bunker of techno genic fiber-fillers; 9 - additive bunker; 10 - rotary-recirculating mixer; 15, 18 - belt conveyor; 16 - weighing batcher; 17 - warehouse of heat-insulating composite mixtures of combined action; 19 - cell feeder; 20 - motor transport of finished products.

To conclude:
1. Investigations of physic and mechanical characteristics and the chemical compositions of the porous aggregates (perlite, vermiculite) and the dust collector caught during their production were carried out.
2. The kinetics of the process of gain in strength of perlite-containing compositional mixtures at different ratios of "cement-perlite" - 1: 5 ... 1: 15 was found out.
3. Under the ratio C/ P = 1: 7, the density of the experimental samples reaches $\rho = 550$ kg / m$^3$, and the compressive strength $\sigma = 1.0$ MPa.
4. Samples with size grains of perlite 140 ... 630 $\mu$m (at 50% of their content, by mass) possess the smallest heat conductivity. Under the ratio C/ P = 1: 9 and adding 20% perlite dust and modified additives (Tylose, Tylovise SE, Hostapur OSB, etc.) to the composition the density of the plaster solution reached 490 kg / m$^3$, and the compressive strength $\sigma = 2.2$ MPa.
5. To expand the technological and architectural-building capabilities of HIM it is rational to use vermiculite and its derivatives.
6. A technological complex for the production of heat-insulating composite mixtures and special equipment for mechanical activation and homogenization of the mixture is developed.

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