The Formation of a Comfortable Habitat and the Economic Feasibility of Using Alternative Thermal Insulation Technologies

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Abstract. The pace of construction and renovation of buildings is increasing every year. This encourages the search and introduction of new materials and technologies to improve the comfort of housing. An important problem is also the need to ensure the energy efficiency of buildings. A peculiarity of the Russian natural conditions is a significant daily and annual difference in atmospheric temperatures. The use of various thermal insulation materials in the construction process will significantly reduce the cost of maintaining buildings and provide comfortable conditions for people, regardless of natural events. In addition, the use of certain facade treatments solves the aesthetic problem and can protect against precipitation and industrial emissions. Therefore, the purpose of this study is to find additional possibilities for thermal insulation of buildings using non-traditional technologies and materials. Modern approaches to the aesthetics of buildings involve the use of expensive mineral thermal insulation materials. Reducing the cost of their manufacture is possible through the use of industrial waste. Wastes from non-ferrous metallurgy are suitable for the production of slag wool or for the production of slag glass-ceramics. A wide range of possibilities allows the use of various wastes in the manufacture of bricks to increase porosity, strength and frost resistance. The use of a number of additives also provides an increase in economic efficiency and environmental friendliness of production. The use of special coatings for gypsum finishing materials could increase their strength and water resistance. The quality of facade paints is significantly increased when using aluminum silicate liquid sodium glass. Fine-dispersed waste of metallurgical enterprises will allow to lower the cost of production of liquid glass and aluminosilicate glue. The use, obtained from waste, astringent, provides for the production of heat-insulating materials the production of bright colors without the use of pigments. High strength and water resistance of materials can ensure the use of magnesian waste. Keywords: thermal insulation, energy efficiency, industrial waste, building materials, finishing materials, paints.

1. Introduction
In recent years, the Chelyabinsk region has begun to accelerate the pace of housing construction, which requires not only the development of raw materials, but also the use of progressive building materials. Among the effective building materials significantly reducing the material consumption and the cost of creating structures, are thermal insulation materials [1].
Thermally insulating materials with low thermal conductivity transmit the minimum amount of heat to the environment. Therefore, the most rational way to reduce heat losses during construction is to use strong thermal insulation materials with high porosity. These characteristics are achieved through the use of raw materials for their production that meet the necessary requirements [2].

In the Chelyabinsk region, much attention is paid to the aesthetics of city buildings and structures, facing them with protective plates made of marble, granite and other minerals. However, such slabs have a high cost, and the wastes obtained during their manufacture do not find effective application.

2. Statement of the research task
The raw materials for the manufacture of mineral thermal insulation materials are plastic clay, vermiculite, perlite, diatomite, asbestos, cement, agloporite, mineral and glass wool, etc. [2], [3]. These materials are expensive. Some of them are scarce or not suitable for the manufacture of thermal insulation material without special treatment. At the same time, various industrial wastes are formed in considerable volumes at the enterprises of the Chelyabinsk region, which are suitable after special treatment for the manufacture of heat-insulating materials. Such wastes are: metallurgical slag and dust, ash, slag and dust TPP, waste of natural ores (magnesite, dolomite, kaolin), wood, etc. These wastes are only partially used for the manufacture of building materials, despite the availability of efficient technologies for their processing.

Tasks of work: to investigate alternative technologies of use of the listed kinds of industrial wastes for manufacture of heat-insulating materials; to develop recommendations for implementation; to offer a scheme for the production of cast plates from magnesian concrete based on waste with the addition of sawdust.

Several studies in other countries have already been devoted to the development of alternative technologies for the production of thermal insulation materials. For example, using polyester fibers [4] and textile waste [5], sand and slag [6]. The authors propose methods of using waste, based on local specificity of the raw materials base. Metallurgical production prevails in the Chelyabinsk region, so the most urgent is to find ways to use the waste that has already been accumulated.

3. Coating of materials from gypsum with facade paint with the addition of zinc phosphate
A large number of finishing materials are obtained from gypsum, but such materials have insufficient strength and weather resistance, and therefore they are used most often for interior finishing of buildings and structures. To improve the strength and water resistance of such boards, a test was carried out in industrial conditions - the plates instead of latex were coated with silicate paint with 5% zinc phosphate added (relative to the amount of liquid glass). Plates covered with such a silicate paint had water resistance and increased strength and were used for the construction of small houses in the recreation center. The use of such a composition of silicate paint for painting the facades of two buildings also showed an increase in their weather resistance.

The quality of facade paints is significantly increased when using aluminum silicate liquid sodium glass for their production. The economical technology of obtaining such a liquid glass on the basis of waste production is developed and recommended for implementation [4]. In the meantime, the painting of the facades of buildings and structures of cities is produced by low-quality protective materials of the same color.

In this regard, to improve the quality of housing stock and reduce heat losses by buildings and structures it is necessary to provide them with high-quality thermal insulation materials. Including an increase in the aesthetics of cities, for example, by applying the finishing of facades high-quality facing plates of different colors.

The production of pigments of various colors (yellow, red, green) can be organized from sewage sludge and galvanic production sludge according to the technologies developed and proposed for implementation [7].

4. Application of slags of ferrous metallurgy in cement
Among the wastes of metallurgy, the most numerous are slags of ferrous metallurgy, which have high astringent properties [1, 3]. For example, blast-furnace granulated slag containing 39.5-40.7% CaO; 36.9-40.5% SiO2; 11-11.8% Al2O3, is used in an amount up to 20% as an additive to the raw mix of Portland cement. 20-60% of such slag is used in a mixture with cement for the production of slag Portland cement. A significant amount of blast-furnace slag is used to produce slag-alcohols, which in turn are used in floor coverings and facing slabs of the basement of buildings and structures.

A small amount of metallurgical slag is used by hot spraying to produce slag wool and pumice, used for thermal insulation of various purposes. Fibrous waste is imparted to the porosity and strength of the insulation materials, especially with the addition of finely ground talc, alumina cement or liquid glass.

5. The use of slags of ferrous metallurgy for the production of slag and slag-sitalls
Most of the slags of non-ferrous metallurgy do not have astringent properties because of the low content of calcium oxide in them, so they do not find wide application for the manufacture of heat-insulating materials [3]. However, such slags with a calcium oxide content of 32-39% are suitable for the production of slag wool, and slags with a calcium oxide content of 15-21% - for the production of cast products - slagstone. Nickel granulated slag in an amount of 2-5% is an active fluxing additive in the batch of clay bricks.

6. The use of ferrochrome slag in brick production
The rational application of ferrochrome slag is the production of silicate bricks on its basis with high economic efficiency. Silicate brick grade 250 has a lower (almost two times) coefficient of thermal conductivity (0.43 and 0.79 W/(m · ºC)), respectively, compared to calcareous siliceous bricks). In addition, in this process, the lime consumption in the binder is reduced by a factor of 1.5-6 [3].

7. Addition of ash from thermal power plants and waste kaolin in the production of bricks
Building bricks are used in large volumes for the construction of buildings and structures in the Chelyabinsk region. They are obtained from local clays with low ductility (with the addition of wood chips to increase porosity). The addition of sawdust does not increase its strength, frost resistance and aesthetic appearance. In this regard, the replacement of sawdust with granular slag or dust of magnesium or calcium carbonate will increase not only the porosity of the brick, but also increase its strength and frost resistance. Implementation of ash additives from TPP, burned rock, kaolin waste for the production of bricks increases all these indicators.

8. Cementing substances from metallurgical dust and waste etching solutions
No less important factor affecting the quality of thermal insulation materials are organic binders (resins, varnishes, adhesives, latexes) and mineral substances (liquid glass, aluminosilicate adhesives, phosphate binders, bischofite). Organic binders used for the manufacture of thermal insulation materials are uneconomical because of the high cost. Mineral binders are obtained from raw materials of lower cost (quartz sand, aluminum hydroxide, acids, magnesite and dolomite). Such mineral raw materials also have a significant cost, so it is unprofitable to receive such binders.

Prospective raw materials for the production of mineral binders are finely dispersed waste (dust and sludge) of metallurgical enterprises, whose chemical composition is given in Table. 1

| Name of waste          | SiO2   | CaO    | Al2O3  | MgO    | Fe2O3  | Other          |
|------------------------|--------|--------|--------|--------|--------|----------------|
| Dinas dust and sludge  | 85.89  | 0.2-3.0| 0.1-2.5| 0.1-0.2| 0.3-2.5| R2O-0.1-0.4    |
| Dust of carbon ferrochrome | 18-22 | 1.0    | 2-5    | 20-32  | 5-10   | Cr2O3-13-22    |
| Ferrosilicochrome dust | 83-93  | 0.5    | 0.3-1.5| 0.8    | 0.5-1.5| Cr2O3-0,8-1.4  |
| Silicocalcium dust     | 24-30  | 49-55  | 1.0-2.5| 0.8-3.2| 2.4-3.0| -              |
| Dust ferrosilicon      | 83-96  | 0.3-4.0| 0.7-1.5| 1.0-4.1| 3-13   | -              |
The dust of the dinasic production and dust of ferrosilicochrome and ferrosilicon the most suitable for the production of liquid glass and aluminosilicate glue. For the production of aluminosilicate bonding adhesive, the same dusts and spent solutions of pickling of non-ferrous metals are suitable for alkali. Phosphate binders are most economically available from spent orthophosphoric acid, and bischofite from dolomite waste and waste hydrochloric acid etching solution [9], [10].

The resulting binders from these waste products are of high quality, and their use makes it possible to obtain heat-insulating materials (yellow, red, green lining plates) without adding pigment to the reaction mixture. Liquid sodium glass and aluminosilicate adhesive of ferroalloy dust with the addition of spent etching solution of aluminum alloys are suitable for obtaining weatherproof façade paints and facing plates [7]. Facing plates from dust and sludge of marble, the specified liquid glass, aluminosilicates or bischofite from waste are also of high quality.

It is most rational to use an aluminosilicate or aluminophosphate binder for the production of facing slabs for the basement part of buildings and structures.

High strength and water resistance are also possessed by heat-insulating products obtained on the basis of magnesia waste (magnesite, dolomite). Such wastes are accumulated in the Chelyabinsk region in large volumes and they are practically not used.

Waste solutions of metal etching with acids and alkalis are also formed at the enterprises of the metallurgical and chemical industry in large volumes, which also do not find effective industrial application. At the same time, such wastes are valuable raw materials and are suitable for obtaining a variety of thermal insulation materials.

Low apparent density and water absorption impart heat-insulating materials to mixtures obtained with the use of phosphate binders. Phosphates, depending on the properties of the metal and the conditions of production, have high astringent properties. This allows them to be used for manufacturing both low- and high-temperature heat-insulating and refractory materials and products [7], [9].

9. Manufacture of cast plates from magnesian concrete based on waste and sawdust

There is a particularly great need for housing construction area in raw materials, used for the manufacture of heat-insulating floors and facing slabs facades of public and management buildings. A mixture of bischofite and gypsum with the addition of pigment is most often used for the production of such materials. However, there is no natural bischofite in the region, which hampers the fulfillment of these and other equally important construction works. In this connection, the technology of obtaining a mixture of bischofite, gypsum and pigment from dolomite dust and waste solutions of metals etching with acids and alkalis has been developed and recommended for introduction.

A wide application in house building finds wood and cement, as well as products made on the basis of woodworking waste (shavings, sawdust) and bischofite. In this regard, it is most rational to use such wood waste to produce wood beams using sawdust and bischofite. The peculiarity of this method is the processing of sawdust with bischofite solution and subsequent pressing of products. In this case, the following magnesian concretes are formed [11]:

$$\text{MgCl}_2\cdot6\text{H}_2\text{O} + 3\text{MgO} + 5\text{H}_2\text{O} = \text{MgCl}_2\cdot3\text{Mg(OH)}_2\cdot8\text{H}_2\text{O} \quad (1)$$

$$\text{MgCl}_2\cdot6\text{H}_2\text{O} + 5\text{MgO} + \text{H}_2\text{O} = \text{MgCl}_2\cdot5\text{Mg(OH)}_2\cdot2\text{H}_2\text{O} \quad (2)$$

The technological scheme for obtaining the bars is shown in Fig. 1. The technology of preparation of raw materials consists of packing in a bunker of a given composition of raw materials in the following ratio: 15-20 to 45-60 to 20-40. The raw material is transferred to the mixer (4, Fig. 1), where it is stirred for 15-20 minutes and transferred to the storage tank (5). As the accumulator is filled, the finished mixture by the distributor (6) under pressure is transferred to the press (7), where it is compressed. The bars at the exit from the press are cut with a knife (8) and fed into the dryer (9). The drying of the products is carried out with flue gases at a temperature of 80-90°C for 24 hours.
10. Conclusions

Thus, based on the results of the study of the production of thermal insulation materials from raw materials and industrial waste, it is proposed to increase efficiency:

1. Instead of natural and synthetic raw materials for obtaining heat-insulating materials, it is most rational to use ferroalloys, dolomite waste, and spent solutions of metals etching with acid and alkali to make binders of siliceous dust.

2. To increase porosity of heat-insulating materials, use dispersed waste of magnesium and calcium carbonate (marble, magnesite, dolomite).

3. To obtain flooding floors and facing slabs, use a mixture of bischofite, gypsum and pigment, obtained by treating dolomite dust with spent hydrochloric acid and phosphoric acid etching solutions.

4. For manufacturing construction beams, it is most rational to use a mixture of bischofite and wood sawdust by mixing the mixture, molding, cutting and drying according to the proposed technology.

The introduction of the above methods of obtaining raw materials from wastes suitable for the production of high quality insulating materials will make our cities environmentally friendly and aesthetically beautiful, and the life of the population safe and comfortable.

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