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Use of chrysotile cement waste as a filler for concrete compositions

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Abstract
This article substantiates the possibility of creating effective fine-grained concrete through the use of chrysotile cement waste, in particular, out-of-service roofing material (slate). The use of crushed particles of corrugated slate with partial replacement of the natural filler with an additive that ensures increased homogeneity and reduced capillary porosity, affecting strength properties fine-grained concrete.

Keywords: Fine-grained concrete, chrysotile cement waste, asbestos, filler grain

Introduction

Disposal of construction waste when dismantling old buildings is an important aspect from an environmental and sustainable development point of view. Many materials such as brick, concrete, glass, metal, etc. can be recycled and used again in new construction projects. This reduces the need to mine new materials and reduces waste. When repairing the roofs of apartment buildings, a large amount of spent chrysolite cement roofing material is formed. It should be noted that one of the important areas of resource saving in construction is the use of secondary resources in the production of building materials, of which a significant part is occupied by chrysotile cement waste - chrysotile cement dust, wet waste, broken sheets and pipes, and used chrysotile cement slates. Every year, about 1,260 thousand tons of chrysotile cement products are produced. The approximate total amount of waste generated at chrysotile cement enterprises is 8 - 10% of the mass of products, i.e. about 100 - 126 thousand tons per year. The composition of raw materials for production chrysotile cement products include cement in the amount of 80.85% and chrysotile 15.20% by weight. As studies have shown, the composition, structure and properties of chrysotile cement waste significantly depend on the method of their formation; two types can be distinguished: dry or wet. Dry waste includes substandard products, shavings from pipe turning, cuttings of products, etc. As a result, they contain non-hydrated clinker minerals, and their structure and properties differ in a more constant composition than that of wet waste generated in settling tanks and representing sewage sludge. Products (pipes, sheets, slate).

Recently, a negative attitude towards asbestos-cement products has developed primarily due to competition between roofing manufacturers. However, it has been proven that products based on chrysotile asbestos have no environmental burden. At the same time, a significant amount of unclaimed waste is accumulated during the overhaul of roofs made using corrugated asbestos-cement sheets. It is known that the composition of asbestos-cement products includes chrysotile asbestos as well as calcium hydrosilicates, which are part of the cement matrix and connect asbestos fibers to a dense and durable composite material. When crushing waste asbestos-cement products to a fraction close to the size of cement particles, it is possible to reuse the waste, which can simultaneously serve as a dispersed reinforcing filler and as an active component in the composition of hardening fine-grained concrete. The safety of chrysotile cement products has been confirmed by many years of research by Russian and foreign scientists. It is known that asbestos includes minerals of the serpentinite group (for example, chrysotile) and minerals of the amphibole group. The structure and properties of serpentinites and amphiboles differ significantly. Currently, asbestos of the amphibole group is recognized as group 1 carcinogens and is prohibited for use. In construction, chrysotile asbestos, which has less biological activity, is used exclusively. The works show that spontaneous emission of chrysotile fiber from the material is excluded. The fiber can leave the product only if it is mechanically damaged. In this case, all chrysotile fibers emitted from the surface of chrysotile cement are almost completely covered with the products of hydration and subsequent carbonization of clinker phases. It has Chrysotile fibers coated with cement hydration products have reduced biological activity been established that all chrysotile fibers located in the cement matrix enter into chemical interaction with cement hydration products, changing their composition and structure.The chemical composition of asbestos-cement waste from various industries is represented by the same components, the content and quantity of which depends on the type of raw material used and varies within insignificant limits.

Basic oxides and, the total content of which averages 69%. The composition also includes a small amount of aluminum and magnesium oxide. The mineral composition is represented by hydrosilicates, hydroaluminates, calcium hydroxide and carbonate, as well as chrysolite-asbestos. The content of chrysolite-asbestos in asbestos-cement waste depends on its dosage in the mine during the production of products and is 12.15%. Considering that chrysotile cement products, in particular slate, retain their chemical composition after use, one of the ways of its disposal is the possibility of using it to obtain building materials. Fine-grained concrete, due to the absence of coarse aggregate in its composition, has a more uniform structure than concrete with coarse and fine aggregate. However, the presence of only a fine fraction of filler in concrete causes a number of disadvantages, such as an increase in the specific surface of the filler and its voids. To obtain a uniform mixture compared to concrete with coarse aggregate it is required to increase the amount of water by 15.25%, which leads to an increase in shrinkage deformations and the manifestation of internal stresses during the hardening of concrete; in addition, an increased water content leads to an increase in the capillary porosity of concrete, which significantly reduces its frost resistance. To increase the efficiency of fine-grained concrete, there are several ways: introducing complex additives into the concrete mixture, improving methods for molding products, using modified technogenic waste, etc. Effective fine-grained concrete can be obtained by using waste from chrysotile cement production in the form of a fine-particle additive, which allows modifying fine-grained concrete and reducing the consumption of natural sand. To confirm the stated provisions, it is necessary to establish generalized dependencies for the formation of the structure and properties of fine-grained concrete mixtures using mechanochemically activated waste from chrysotile cement production.

Objective

The aim of the presented research is the development of concrete compositions using chrysotile cement products as a secondary filler.Crushed slate was used to produce concrete compositions using dry asbestos-cement waste.

Analysis and discussion

To produce concrete compositions using dry asbestos-cement waste, crushed slate was used.

Fig 1: A piece of waste chrysotile cement flat sheets (slate)

Table 1: The chemical composition of asbestos-cement waste - slate - chrysotile cement flat sheets is given in

Type of asbestos-cement waste	Content of components, %							
	SiO_2	Fe_2O_3	Al_2O_3	CaO	CaO_b	MgO	SO_3	RO_2
Fight sheets	20,1	4,2	4,1	50,1	5,5	6,2	1,3	0,5

M400 cement, which is a product of the Norm Cement plant in Azerbaijan, was used as a binder.

The water for mixing the concrete mixture during the manufacture of experimental samples complied with GOST 23732-79 Medium-sized quartz sand was used as a fine aggregate. The properties of sand were determined using standard methods. In terms of grain composition, the sand meets the requirements of GOST. Using mechanochemical activation, the hydraulic activity of waste can be increased. To identify the optimal mode of mechanochemical activation, studies were carried out on the effect of grinding time on the value of the specific grinding surface. In a ball mill, with a ratio of the mass of material to the mass of grinding media of 1:10, grinding was carried out for 160 minutes, and the resulting specific surface area was measured every 20 minutes using a Blaine device. Based on the grinding results, experimental dependences of the change in specific surface area on grinding time were obtained (Table 2).

Table 2: Indicators of the specific surface of slate particles

Grinding time, min	Specific surface area, m^2/kg
0	100
20	290
40	480
60	550
80	610
100	630
120	650
140	650
160	650

The properties of fine-grained concrete also depend on the particle size distribution.

Broken slate fractionated using a standard sieve set of 40, 20, 10, <5 mm was used to produce concrete using asbestos-cement waste.The filler was divided into four fractions, three of which were broken corrugated asbestos-cement layers with grain sizes:

– № 1 – ≤ 5 mm;
– № 2 – 10.20 mm;
– № 3 – 20.40 mm;

Sample production technology and testing methodology were carried out in accordance with existing standards. Next, a number of samples were prepared to determine the strength of fine-grained concrete, where sand was partially replaced by fractions of waste asbestos cement waste.

Sample № 1 (R1) was prepared with 0%, 30%, 60% and 100% partial replacement of sand in the concrete content using the broken fraction of corrugated slate sheets with grain sizes ≤ 5 mm.Next, sample № (R2) was made with a grain size of 10.20 mm for corrugated asbestos-cement sheets, sample №(R3) with a grain fraction of -20.40 mm.

The resulting samples passed strength tests according to existing standards. The results of studies of compressive strength for all concrete compositions are presented in Fig. 2.

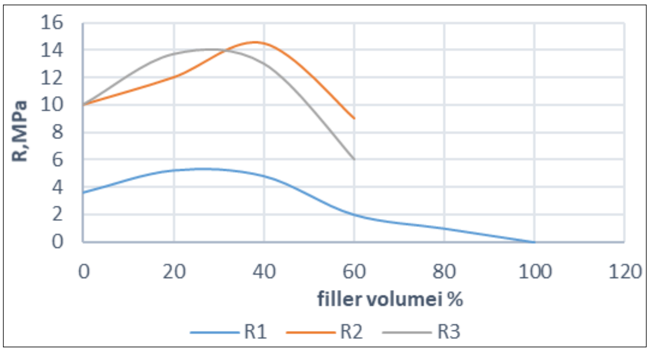

Fig 2: Indicators of concrete strength from the percentage of crushed particles of waste chrysotile cement flat sheets (slate) fraction

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Compressive strength reached its maximum value with the introduction of 30–40% filler. With an increase in the amount of asbestos-cement filler, the strength dropped sharply, apparently due to the fact that the cement binder did not provide complete adhesion of the filler grains.The use of chrysotile cement products as a filler for concrete completely eliminates the emission of fiber from concrete due to the double "protection" of the fiber in the concrete. Economic and environmental efficiency will be achieved by using recycled chrysotile cement aggregate.

Conclusion

Quality building material can be obtained by using asbestos cement waste.

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