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THE USE OF CHEMICAL ADDITIVES FOR THE PRODUCTION OF STRUCTURAL AND HEAT – INSULATING POLYSTYRENE CONCRETE

ИСПОЛЬЗОВАНИЕ ХИМИЧЕСКИХ ДОБАВОК ДЛЯ ПОЛУЧЕНИЯ КОНСТРУКЦИОННО-ТЕПЛОИЗОЛЯЦИОННОГО ПЕНОПОЛИСТИРОЛБЕТОНА

Макалада химиялык кошулманы колдонуу менен конструкциялык-жылуулукту обочолоочу кобуктуу полистирол бетонун алуу жана аны темир-бетон конструкцияларынын курамына колдонуу жөнүндөгү изилдөөнүн жыйынтыгы келтирилген.

Өзөк сөздөр: *көбүктүү полистиролбетон, полистирол, жылуулукту обочолоо, конструкция, сууну синирип алуу, суукка туруктуулук, женил бетон, микроармировкалоо.*

В статье даются результаты исследований получения конструкционно-теплоизоляционного пенополистиролбетона с использованием химического добавки и его применение в составе железобетонных конструкций.

Ключевые слова: *пенополистиролбетон, полистирол, теплоизоляция, конструкция, водопоглощение, морозостойкость, легкий бетон, микроармирование.*

This article presents the results of research on the production of structural and heat-insulating polystyrene concrete using a chemical additive and its use in the composition of reinforced concrete structures.

Key words: *Polystyrene concrete, polystyrene, heat insulation, construction, water absorption, frost resistance, lightweight concrete, micro reinforcemen.*

Styrofoam concrete is a modern type of lightweight concrete in which styrofoam pellets are used as a large aggregate. Polystyrene is an extremely light material (density 5-25 kg / m^3); such a filler gives low-density polystyrene concrete (from 150 kg/m^3). On its basis, it is possible to obtain various building materials and structures from the point of view of terminology (from thermal insulation to structural purpose). This material was invented in Germany in the mid-20th century, but it has gained popularity in the Kyrgyz Republic only in recent years. [1-4].

According to GOST 33929-2016 " Polystyrene concrete. Technical specifications " subdivide:

• by purpose and application:

for prefabricated products used in construction production; monolithic structures produced and used in construction.

• according to the degree of thermal protection and design features:

for thermal insulation (medium density D150-D225), thermal insulation and construction (medium density D250-D350), structural and thermal insulation (medium density D400-D600).

Numerous studies have proven that polystyrene concrete has a great advantage over other types of lightweight concrete. The main ones are:

- water absorption of 8-12 %, 3-4 times less than aerated concrete and does not require waterproofing;

- for frost resistance, it passes through a group of heavy concrete, i.e. it is completely soaked in water and then placed in the freezer, while maintaining 75 or more cycles;

- polystyrene concrete does not actually shrink;

- coefficient of thermal conductivity (from 0.055 W/(m ° C) at an average density of D150 to 0.145 W/(m ° C) at an average density of D600; - the construction index of polystyrene concrete with an average density of D450 allows you to build a frameless house up to 3 floors (with a load margin). This significantly reduces the load on the foundation and significantly reduces the cost of construction;

The raw materials that make up polystyrene concrete, as well as pellets, are environmentally friendly, absolutely safe for human health.

It should be borne in mind that the main disadvantage of polystyrene concrete is the delamination of the mixture during preparation due to the hydrophobicity of the expanded polystyrene aggregate compared to the cement dough. The solution to this problem was covered in the works of N. V. Archincheeva, O. V. Zhurb, where various chemical additives were used to increase the hydrophilicity of polystyrene [8]. These authors solved the problem of finding new effective chemical additives that increase the adhesion of expanded polystyrene to cement. Given that the main condition for the formation of adhesive contacts in the polystyrene concrete system is to reduce the surface potential of the polystyrene granules, it is necessary to use chemical additives that increase the hydrophilicity of the porous filler.

The purpose of this work is to study and develop the composition and properties of structural and heat-insulating expanded polystyrene concrete, as well as its application in the production of light reinforced concrete structures.

The aim of the study is to provide the regions of the Kyrgyz Republic with new efficient energy-saving materials and to develop the production of light reinforced concrete products based on them.

During the main experiment, the following materials were used for the selection of structural and thermal insulation compositions of expanded polystyrene concrete: Portland cement of the Kant Cement Plant (KCZ) brand M400 D20 GOST 10178-85. As a filler,expanded polystyrene granules (PPG) with fractions of 0-2. 5 mm, 2.5-5.0 mm, 5.0-10 mm were used. Styrofoam pellets are produced by grinding waste from styrofoam slabs.

Synthetic polypropylene fibers GOST 33370-2015 were used as micro-reinforcement. Calcium chloride (CaCl2) GOST 450-77 was used as a concrete hardening accelerator. To increase the hydrophilicity of expanded polystyrene, the adhesive additive SDO-L (SDO – saponified wood resin) TU 2453-013-10644738-2000 was used. As a plasticizer (improvement of hydrophobizing properties and frost resistance), the foaming agent PB-2000 according to TU2484 was used-185-05744685-01.

For the production of expanded polystyrene concrete mixture and for the preparation of expanded polystyrene concrete, water with a pH of ≥ 4 was used, containing no more than 2700 mg / l of sulfate (SO4) and no more than 5000 mg / l of mineral salts, corresponding to the requirements of GOST 23732-79.

SDO was added in the amount of 0.05; 0.1; 0.15 % and 0.20 % by weight of cement based on dry matter. The amount of water was chosen taking into account the required workability of the concrete mix. Composition of structural and heat-insulating polystyrene concrete-consumption of

cement, sand, expanded polystyrene, etc. - remained unchanged in all experiments. The results of the work of expanded polystyrene concrete with chemical additives are presented in Table. 1.

Table 1 - Effect of adhesive additives on the strength characteristics of polystyrene concrete

Type of additive	Compressive strength (MPa), depending on the amount and type of additive (in % of cement weight), 28 and day			
	0,05	0,1	0,15	0,2
SDO	2,54	2,71	2,92	5,01

Analysis of the research results showed that the styrofoam-concrete mixture with the addition of SDO was more plastic, and no delamination of the mixture was observed. The polystyrene filler is completely enveloped in the cement dough, thus creating a homogeneous frame with a uniform distribution of the polystyrene filler in the cement matrix.

When forming samples from a styrofoam-concrete mixture without adding additives to the mixture, delamination and uneven distribution of the aggregate by volume were observed. The compressive strength for 28 days for pure expanded polystyrene concrete is 4.45 MPa. The addition of SDO in an amount of 0.2 % by weight of cement made it possible to obtain expanded polystyrene concrete with a compressive strength of 5.01 MPa, respectively, at the age of 28 days. Thus, the addition of SDO allows you to obtain expanded polystyrene concrete with better strength characteristics compared to concrete without additives; Due to the good manufacturability of the expanded polystyrene concrete mixture, the technology of production of expanded polystyrene concrete on an industrial scale is simplified.

It is experimentally established that the use of adhesive additives is effective for the production of expanded polystyrene concrete with improved physical and mechanical properties. The addition of adhesive additives increased the hydrophilicity of the expanded polystyrene with respect to the cement by reducing the surface tension at the interface between the surfaces of the granules with the cement. Good rollability of the expanded polystyrene granules allowed us to obtain a mixture with a uniform structure, a uniform distribution of the aggregate in the concrete frame.

As a result of the research, styrofoam concrete with a density of 550-600 kg / m^3 and a strength of 3.5-5.1 MPa was obtained, which makes it possible to use this material not only for thermal insulation of buildings. as a structural and thermal insulation material in low-rise buildings.

The strength of the expanded polystyrene concrete samples was determined according to GOST 18105.1-80, the average density-GOST 12730-87. Frost resistance of concrete - according to GOST 10060-2012.

The thermal conductivity was determined on the IT-1 device.

Production of sample cubes from expanded polystyrene concrete of standard forms 150x150x150mm and 100x100x100mm. The technology of production of polystyrene concrete was carried out in the following order. First, the polystyrene pellets are loaded into a concrete mixer with the addition of a plasticizer or foaming agent for about 10 % of the total volume of water. It must be thoroughly mixed for at least 30 seconds, so that all the polystyrene is soaked and the necessary adhesive properties are achieved. Then, SDO (saponified wood resin) and other additives are slowly added to the entire volume of cement and the remaining water, and the mixture is mixed for 5 minutes. Then the styrofoam is ready for molding.

When testing expanded polystyrene concrete for compression GOST 10180-2012 " Concrete. Methods for determining compressive and tensile strength". The compressive strength of the expanded polystyrene concrete Rm was determined in cubic samples with a size of 150x150x150 mm, as in all types of light concrete, except aerated concrete. In this case, the conversion factor is equal to one.

In the course of conducting compressive strength testing experiments, we obtained styrofoam samples made using the main fraction of granules from PPG aggregate 0-2. 5 mm,2.5-5.0 mm, 5.0-10 mm. The content of the expanded polystyrene filler per 1.0 m^3 of the mixture was assumed to be the same and was 1.0 m^3. The test results show that the best strength indicators were obtained when using the main fraction of granules of expanded polystyrene aggregate in 2.5-5.0 mm.

It was found that the use of large fractions of the polystyrene aggregate makes the expanded polystyrene concrete less durable, partly due to the low strength of the aggregate itself, and partly due to the fact that part of the mortar matrix is strongly weakened by standard holes. Fine fractions increase the average density, and also increase the consumption of the cement component.

The results of the experiment (compositions, properties and brand) of the resulting expanded polystyrene concrete are presented in Table. 2 and 3.

Table 2 - Composition of expanded polystyrene concrete per 1m^3

№ in/or.	Name of materials	Units rev.	Material consumption per 1m^3 of polystyrene concrete		
1	Expanded polystyrene pellets PPG	m^3 / kg (fraction)	1,0/9 (0-2,5)	1,0/6 (2,5-5,0)	1,0/3 (5,0-10,0)
2	Cement	kg	330	330	330
3	Foaming agent PB 2000	l	1,0	1,0	1,0
4	Setting accelerator, CaCl	kg	6,6	6,6	6,6
5	Saponified wood resin (SDO)	kg	0,66	0,66	0,66
6	Polypropylene Fiber	kg	0,6	0,6	0,6
	Water	l	168	150	130

Table 3 - Basic properties and brand of polystyrene concrete

№ in/or	Main properties of materials	Units rev.	Indicators		
			PPG Fraction (0-2,5)	PPG fraction (2,5-5,0)	PPG fraction (5,0-10,0)
1	Average density, p	kg / m^3	550-600	450-500	300-350
2	Average strength, Rm	MPa	3,5-5,1	2,2-3,8	0,6-1,9
3	Coefficient of thermal conductivity,	W/m ^{0}S	0,15-0,16	0,11-0,12	0,08-0,09
4	Frost resistance, F	cycles	75-100	75-100	50-75
5	Grade by average density, D	kg/m^3	550	450	300
6	Compressive strength class, B	MPa	5,0	3,0	1,0

On the production line of LLC "Domostroitelny Service "Azat", an experimental batch obtained from the composition of the medium-density D450 brand was used in the manufacture of a reinforced concrete ventilation unit (VBS).

Conclusions:

1. It is known that styrofoam is an environmentally friendly and durable material;

2. The analysis of the research results showed that the expanded polystyrene concrete mixture with the addition of SDO was more plastic and there were no delaminations in the mixture. The polystyrene filler is completely enveloped in the cement dough, thus creating a homogeneous frame with a uniform distribution of the polystyrene filler in the cement matrix.

3. It is established that the quality indicators of the use of polystyrene granules, which is equal to 2.5-5.0 mm.

4. The use of polystyrene as a filler in the composition of concrete can replace light expanded clay, which is currently considered scarce and expensive.

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