Features of monolithic house building

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Abstract. The article considers the problems of monolithic house building in Russia. The version of design of cellular concrete compositions based on assessment of water-solid ratio (W/S) and determination of optimal content of plasticizers of the new generation is proposed. It has been found that in order to obtain heat-insulating cellular concrete, the range of W/S is in the range from 0.35 to 0.5, and the percentage of plasticizer is up to 0.5 of the weight of binder.

A significant increase in real estate prices has led to a crisis in the housing market - the bulk of the population in need of improving housing conditions does not actually have the material opportunity to acquire in this market. The quality of supply in the secondary market is deteriorating due to the rapid aging of the housing stock. In particular, at least 90% of the housing stock of the Russian Federation does not meet modern standards of quality of life, while 62% of houses were built more than 30 years ago, and the average depreciation of the housing stock is 60% [1-3].

A combination of these factors is a prerequisite for a cultural and technological revolution in mass housing construction. In other words, housing can no longer exist in the current state, and the population no longer wants to live in these conditions.

In order not to increase social tensions, it is necessary to strive for the average European level of housing, which is 40 m² of living space per capita. In this case, in Russia it is necessary to put into operation by 2020 at least 200 million m² of housing, and by 2030 - at least 300 million m².

It should be emphasized that the basic principles of housing policy-making and standards of housing conditions need to be reviewed today. According to social surveys, the absolute majority of Russians would like to live in a separate landscaped country cottage. In other words, the consumer preferences of the middle class citizens of today's Russia suggest a new quality of housing at the level of the 21st century and with the prospect of living in it in the XXII century, while most of the population of our country lives in the conditions of the past century. This can include both "Khrushchev" and houses of pre-revolutionary construction.

There are several possible solutions:

Technology «Isode» or «Sopos». This house is made of foam blocks with monolithic cores made of heavy concrete as a frame.

«Canadian houses». In Soviet times, such houses were called prefabricated shield houses. The advantage is the very high speed of construction, assembly on site from finished factory elements. Insulation - most often mineral wool slabs. In the Leningrad region, the construction of houses of this
type is now actively underway, house-building plants for the production of prefabricated panels are operating and entire villages have already been built. In houses of this design, the thermal inertia of the wall fence is close to zero and when the heat supply is delayed or interrupted, cooling out occurs very quickly. And another interesting detail: the impregnation of mineral wool plates of the insulation is phenol-formaldehyde resin, and at temperatures above 40 degrees, the impregnation evaporates, which does not improve the atmosphere of the dwelling at all [4-6].

Bars and log houses. These are traditional Russian buildings and construction methods.

Low-rise buildings made of cellular concrete. Such buildings and construction methods best meet the conflicting requirements for modern and future housing.

Cellular concrete is divided into gas and foam concrete. Aerated concrete is obtained by mixing binder, water, aggregate and gasifier, for example, aluminum powder. In construction, gas concrete is used in the form of large blocks and wall panels manufactured in factory conditions. Foam concrete is an artificial stone material obtained as a result of hardening of a cement-sand mixture and a foaming agent. Concrete of light grades is used on floors and floors as heat and sound insulation, for the manufacture of prefabricated blocks covering slabs of suspended ceilings, it is also ideal for bulk filling (that is, it is not a structural material in itself). Monolithic foam concrete of natural hardening is a heat-and-insulation material produced directly on the construction site.

In the European part of Russia, Belarus and the Baltic countries, the construction of civilian buildings with a metal or wooden frame combined with a wall fence made of foam concrete is being developed. The technology is based on the method of monolithic construction in a permanent formwork. Simply put, this is a long-known technology of «embankments», only monolithic foam concrete fits into the wall instead of heat-insulating backfilling.

External formwork can be cement-chip slabs (CCS), brickwork in half of brick, sheets of flat slate, thin foam concrete slabs with textured layer, porcelain, etc. Depending on the customer's requirements, plastic or metal siding can be used for architectural design.

The building frame is made up of light steel thin-walled structures made of bent profiles, or a bar frame, widely used in construction for the construction of residential low-rise buildings, cottages and mansards. In seismic areas, such a framework replaces reinforced concrete cores and seismic belts, which are mandatory for the construction of walls from easily concrete blocks.

For internal lining of walls, partitions and floors, DSP or water-resistant gypsum board is usually used. It also makes all the internal elements of the permanent formwork, including internal walls, columns, girders, floor boxes, stairs, windows, jumpers, slopes. It is possible to arrange different channels for internal communications.

The mounted formwork is filled with monolithic foam concrete, and subsequently is not removed. Foamed concrete mixture is supplied by pumps. The construction rate of walls made of cast-in-situ foam concrete is higher than when performing works from blocks, thanks to functional permanent formwork and the technology of preparing and laying foam concrete mixture on the basis of a mobile complex on the construction site. Thus, in one operation, the installation of the insulation, the protection of the frame from corrosion and fire and the preparation for finishing are combined. The thermal resistance of the outer walls with a thickness of 200-350 mm varies from 3.2 to 5.4 m² • °C/W.

However, when performing work on laying foam concrete mixture in a non-removable formwork, a number of technological problems arise that affect the quality of work.

Foamed concrete pouring is a wet process, and if there are loopholes in the outer or inner layer of the formwork, leakage of the foamed concrete mixture is inevitable. On the outside of the finishing layer, seedlings and drifts can be formed. Sometimes the mixture has insufficient adhesion to the formwork and in some places local "claps" are formed, that is, when piercing, an alleged emptiness is "withdrawn." The reason for this is a poor-quality gypsum tone, which is deformed from moisture.

Low density foam concrete used for wall filling has a large water-solid ratio (W/S), in other words, the mixture is very liquid. After laying such a mixture, the water present in the structure goes into the loose joints of the formwork, and if the formwork is hygroscopic, then the water impregnates it, which leads to warping. In turn, the mixture, losing water, decreases in volume and "settles."


In addition, when the foam concrete mixture is pumped by the pump, it is compacted, and at the place of laying it has a density different from that in the mixer. The density difference depends on the pumping distance, and especially on the lifting height of the mixture. When compacting the mixture, the volume decreases accordingly.

A decrease in W/S and a simultaneous increase in strength are possible with the introduction of plasticizers, the most common of which is the melamine-formaldehyde plasticizer S-3, intended for use in heavy structural concretes. When introduced S-3, the foam concrete mixture settles, since protein and some synthetic foam users enter into chemical interaction with this plasticizer. Therefore, finding the optimal foaming-plasticizer pair is a serious research task.

To solve these problems, the department of industrial and civil engineering of Angara state technical university conducted studies on the properties of common foaming agents and foam cement systems.

At the initial stage, the hydrogen index (pH) of the solution of foaming agents was determined, as well as the stability and multiplicity of foams at various water temperatures. Hydrogen index of foaming agent solutions is related to steric repulsion effect, which consists in the fact that surfactant molecules enclose cement particles with formed gel shells. Thus, charges of one sign are formed around the particles. On the one hand, this increases the mobility of the mixture, but on the other hand, further makes it difficult to combine crystalline splices in the third hardening step and significantly reduces the strength of the cement stone. With the increase in the difference between the hydrogen values of the foaming agent and the cement system, the effect of the steric effect increases, which leads to a deterioration in the quality of foam concrete. Therefore, the pH of the foaming agent should be close to the background pH of the cement slurry, which, depending on the cement used, is 11-12. Foam stability and multiplicity also have a significant impact on foam concrete quality [7-11].

As a result of the studies, a plasticizer-neutral S-3 synthetic foaming agent was revealed, having the closest hydrogen value to the background (pH = 10.5), foam stability (at 20 °C) 12 minutes and foam multiplicity 7. Compositions have been developed and optimized, which are used in the city of Angarsk for the production of foamed concrete of thermal insulation grades with a strength of up to 3.5 MPa according to classical technology.

At the next stage, the influence of new generation additives – hyper plasticizers on the mobility of the mixture was studied. The use of such additives allows, at low W/S values, to achieve the necessary mobility of the mixture at a lower rate than the plasticizer S-3. In the experiments, a German-made hyper plasticizer was used. The mobility of the mixture was also determined using a Suttard viscometer.

The work was performed in the following sequence. Of the materials selected directly at the construction site, a series of nine mixes was carried out with the smallest, largest and average values of variable factors: W/S, which varied in the range of 0.3 sound0.65, and the content of the hyperplasticizer (0 sound 0.5% of the weight of the binder). For each composition, the melt diameter of the starting mixture Ds was measured. The obtained values were entered into a program developed by the authors for mathematical processing. As a result, an equation and graphs were obtained to determine the W/S required to prepare foam concrete of a given density and, accordingly, strength.

Figure 1 shows the dependence of the diameter of the foamed concrete mixture melt on the water-solid ratio at different contents of the hyperplasticizer. It can be seen that as the amount of plasticizing agent increases, the mobility of the mixture increases significantly.

Given the value of Ds corresponding to the foam concrete grade by density and the percentage of hyperplasticizer, from the equation or graph is the value of W/S, which can be used to calculate the composition of cellular concrete of this grade by density, according to the procedure set forth in SN 277-80.

The proposed approach also allows adjusting the composition according to the density difference of the mixture in the foam concrete mixer and at the place of laying to ensure the required density grade. At the same time, it is necessary to recalculate the number of kneads taking into account the compaction during pumping of the mixture.
Analysis of the results made it possible to determine the most advantageous content of hyperplastici-
cizer - from 0.35 to 0.5% of the weight of the binder. A further increase in the content of the plasticizing additive will affect the mobility of the mixture to a lesser extent, but it will seriously affect the cost of foam concrete "in business," and this is important for construction companies.

![Graph](image.png)

**Figure 1.** Dependence of melt diameter (Ds) of foam concrete mixture on water-solid ratio (W/S) and content of hyperplasticizer (wt% of binder).

Unfortunately, hyperplasticizers are not produced in Russia. Imported additives are offered on the market - German, Polish and others. Some manufacturers of additives introduce them as components of their complex preparations, the composition of which is often the secret of the company. Therefore, manufacturers who try to use them deal, as they say, with a "cat in a bag." Large construction organizations have their own laboratories, and, accordingly, the ability to select and adjust the composition of foam concrete on their own. And for small enterprises engaged in the production of foam concrete, the problem of product quality can be solved using the proposed or similar methods of optimizing the composition [12-15].

Recently, in the press, and especially on the Internet, there has been an active debate on the quality of foam concrete and the feasibility of its use in the construction industry. In our opinion, entrepreneurs engaged in the production of foam concrete are people far from the construction specifics, victims of active equipment advertising. They fill the construction materials market with poor-quality products, and construction companies, for lack of the best, are forced to buy it and use it on construction sites. This circumstance very restrains the spread of the advanced method of construction in Siberia.

For the construction complex of Eastern Siberia, this is a problem whose solution requires a systematic approach. The situation can be further aggravated if the licensing of construction organizations is abolished under the current approach. In our opinion, the way out of this situation lies in the training of qualified personnel and proper control of the quality of products.

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