Vital Annex: International Journal of Novel Research in Advanced Sciences (IJNRAS)
Volume: 01 Issue: 06 | 2022 ISSN: 2751-756X
http://innosci.org

# Selection of Aerated Concrete Compositions Using Local Raw Materials

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**Annotation:** The article provides materials and selection of the composition of non-autoclaved aerated concrete from raw materials of Uzbekistan. The physical and mechanical properties of cellular concrete of the studied compositions are shown. As well as technology for producing cellular concrete.

**Keywords:** Technology, aerated concrete, cement, aluminum powder, lime, soda ash, filler, mill, component, polymers, additives, concrete, binder, blowing agent, pore formation, structure formation, porization.

## Introduction

Experimental studies were aimed at obtaining the composition of non-autoclaved aerated concrete from the raw materials of Uzbekistan: sand from the Chinaz deposit, fly ash Novoangren TPP, Akhangaran portland cement PC400 D20 , aluminum powder PAP-1 and lime Kuterminskoy field (Jizzakh region) . BASF additives were used as additives. Glenium 111 (Germany) , C3 (Russia) and " POLIMIX " (Uzbekistan) .

The process of forming a cellular macrostructure of aerated concrete is the most important stage in its production. The nature of porosity determines to one degree or another most of the properties of concrete. The creation of a large-pore cellular structure of non-autoclaved aerated concrete occurs at the stage of porousization of the mortar mixture and subsequent hardening of the expanded aerated concrete mass. Pore formation is caused by PAP-1 aluminum powder. In the experimental compositions of aerated concrete containing lime, as a result of the interaction of the blowing agent (aluminum) with lime, hydrogen is released, which swells the mass and makes it porous. The gas formation reaction proceeds as way:

$$3Ca(OH)_2 + 2Al + 6H_2O \rightarrow 3H2\uparrow + 3CaO\ Al_2O_3\ 6H_2O + Q$$

In the experimental compositions of aerated concrete with caustic soda, the process of gas formation occurs as a result of the following chemical reaction:

$$2Al + 6NaOH + 6H_2O \rightarrow 3H2\uparrow + 3Na_2O\ Al_2O_3\ 6H_2O + Q$$

As a result of mixing the components of aerated concrete, the following chemical transformations begin: as mentioned above, aluminum powder begins to react with lime and caustic soda; Portland cement clinkers begin to interact with water, low-basic calcium hydrosilicates of various compositions.

The aerated concrete mixture first loses its mobility, seizes, and then gains strength.

After the mixing process is completed and the mold is filled, the mortar mixture contains a minimum amount of gas. After a certain amount of time (1-5 minutes), hydrogen evolution begins. As a result of pore formation, the mixture in the form "rises" - the processes of structure formation begin. The porousization process can be described as follows. The interaction of calcium hydroxide with aluminum leads to the formation of tiny gas bubbles, which further increase in diameter due to increasing pressure inside the bubble. The process of hydrogen formation continues. The increase in the volume of the bubble continues until the pressure in the pore is balanced by the pressure that prevents its growth. [one].

**Main part**

Search experiments were carried out on the basis of the calculation of the composition of aerated concrete, taking into account the required characteristics of aerated concrete and the properties of the materials used are given below.

Select aerated concrete grade 500 from local raw materials materials.

The blowing agent is PAP-1 aluminum powder.

We accept the ratio (by weight) 1 ÷ 1, then the material consumption of 1 m $^{3}$ of concrete will be:

$C = 500 \cdot 0,85/1+1 = 212,5$ kg

$Z = 212,5 \cdot 1 = 212,5$ kg

that the spread of the mass according to the Suttard viscometer is 20 - 21 cm, with W / T \u003d 0.48, then the pore volume of 1 m 3 $^{of}$ aerated concrete will be:

$V_p = 1000 - 500/1,85 – (212,5+ 212,5) \cdot 0,85 \cdot 0,48) = 556,4$

where, 1.85 is the density of the cement stone of the composition Theoretical consumption of aluminum powder

$A_t = 556,4/1,42 = 391,8$ gr

The actual flow rate of the blower

$A_d = 1,2 \cdot 391,8 = 470$ gr

Amount of water consumption

$V = (C + Z) \cdot V / T = (212,5 + 212,5) \cdot 0,48 = 204$

The mixture for aerated concrete was made in laboratory conditions. Additives were introduced with mixing water as a percentage of the cement content. Aluminum powder was mixed in water at 60°C. Ready concrete mixture was poured into molds 10×10×10 cm and 40×40×160 mm in size. Samples were tested after 28 days molding.

Table 3.1. physical and mechanical properties of cellular concrete of the investigated compositions are shown.

**Table 3. 1. Compositions of cellular aerated concrete compositions**

| No. p / p | The ratio of the components of the cellular concrete mixture,% by weight | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | aluminum powder | V/T | C | Ash | Pe - juice | Lime | P olimix ,% | C3 ( Russia ) | Glenium | ρ, kg / m 3 | Rszh , MPa |
| 1 | 0.00 2 | 0.7 | 0.5 | 0.5 | - | - | - | - | 0.8 | 96 5 | 0.8 5 |
| 2 | 0.00 2 | 0.6 | 0.5 | 0.5 | - | - | - | - | 0.8 | 10 30 | 1.5 0 |
| 3 | 0.00 2 | 0.4 _ | 0.5 | - | 0.5 | - | 2 | - | - | 11 70 | 2.9 0 |
| 4 | 0.00 2 | 0.4 _ | 0.5 | - | 0.45 | 5 | 0.8 | - | - | 1000 | 0.6 5 |
| 5 | 0.00 2 | 0.4 _ | 0.5 | - | 0.45 | 5 | 1.5 | - | - | 11 50 | 1.1 0 |
| 6 | 0.00 2 | 0.4 _ | 0.5 | - | 0.45 | 5 | 2 | - | - | 11 10 | 1.1 0 |
| 7 | 0.00 2 | 0.45 | 0.5 | 0.225 _ | 0.2 2 5 | 5 | 0.8 | - | - | 8 70 | 0.6 0 |
| 8 | 0.00 2 | 0.7 | 0.5 | 0.225 _ | 0.2 2 5 | 5 | 0.8 | - | - | 6 30 | 0.2 5 |
| 9 | 0.00 2 | 0.45 | 0.5 | 0.25 _ _ | 0.25 | - | 0.8 | - | - | 8 8 3 | 0.6 5 |
| 10 | 0.00 2 | 0.45 | 0.5 | 0.25 _ _ | 0.25 | - | - | 0.2 | - | 11 8 8 | 1.9 0 |
| 11 | 0.00 2 | 0.5 | 0.5 | 0.25 _ _ | 0.25 | - | - | 0.2 | - | 10 3 6 | 1.2 0 |
| 12 | 0.00 2 | 0.49 | 0.5 | - | 0.5 | - | - | - | - | 139 5 | 0.7 2 |
| 13 | 0.00 2 | 0.4 _ | 0.5 | 0.5 | - | - | - | - | - | 6 35 | 0.4 2 |

As a result of exploratory experiments, we obtained aerated concrete with density values ranging from 630 to 1395 kg/m $^3$. The lowest density of the samples was obtained in the range of up to 630 kg/m $^3$ in 8 composition (Table 3.1). This is due to the activity of the ash and its ability, when mixed in a finely divided form with air lime, to harden under various conditions when mixed with water. As can be seen from Table 3.1, samples without lime additives have higher density values. Experimental results have shown that the introduction of various additives affects on the change physical and mechanical indicators and properties aerated concrete.

Compounds without additives have low compressive strength (composition 12-13). The use of the Rolimix additive in 3 compositions leads to an increase in strength up to 2.90 MPa. The effect of the interaction of C3 additives gives an increase in strength up to 1.90 MPa in 10 composition, with a simultaneous increase in density equal to 1188 kg/m $^3$. The use of Glenium supplements also gives positive results. It allows you to reduce the amount of water, since Glenium is a highly effective water- reducing plasticizing additive, the concrete mixture becomes more plastic.

Table 3.2 shows the results of further selection of the composition of aerated concrete. In these compositions, in addition to the used additives, we use soda ash $Na_2CO_3$ and semi-aqueous gypsum.

**Table 3. 2. Compositions of cellular aerated concrete compositions**

| No. | The ratio of the components of the cellular concrete mixture,% by weight | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| seri | Alu Mini Powder a | C | W | Sand | Lime _ | Soda | gle-_ nium , % | P olimix ,% | gypsu m , _ % | V/T | ρ , kg / m $^3$ | R compres s , MPa |
| | 0.08 | 0.3 | 0.20 | 0.20 | 0.20 | 0.01 | - | - | - | 0.95 | 53 5 | 0.1 8 |
| | 0.08 | 0.3 | 0.20 | 0.20 | 0.20 | 0.085 | - | - | - | 0.7 | 6 60 | 0.5 5 |
| 1 | 0.08 | 0.40 | 0.20 | 0.20 | 0.025 | 0.085 | - | - | - | 0.65 | 570 | 0.31 |
| | 0.08 | 0.475 | 0.24 | 0.24 | 0.025 | 0.075 | - | 2 | - | 0.55 | 7 7 2 | 0.71 _ |
| | 0.08 | 0.475 | 0.243 | 0.243 | 0.025 | 0.075 | - | 0.8 | - | 0.55 | 6 55 | 0.41 _ |
| 2 | 0.08 | 0.3 | 0.242 | 0.242 | 0.20 | 0.075 | - | 1.4 | - | 0.7 | 7 30 | 0.4 5 |
| | 0.08 | 0.6 | 0.149 | 0.149 | 0.05 | 0.075 | 0.8 | - | - | 0.65 | 745 | 1.30 |
| | 0.08 | 0.6 | 0.149 | 0.149 | 0.05 | 0.075 | - | 0.8 | 2 | 0.65 | 6 8 5 | 1.7 4 |
| 3 | 0.08 | 0.6 | 0.104 | 0.104 | 0.05 | 0.075 | - | - | 2 | 0.65 | 537 | 0.62 |

In the first series, aluminum powder is used as a blowing agent. Lime and soda ash $Na_2CO_3$ were used as additives.

In this series of experiments, densities up to

=535 kg/m $^3$ due to the above additives. Lime and soda ash improve swollen dough by a chemical reaction that releases gas. The strength indicators are low, the highest compressive strength is 0.55 MPa in the composition with the addition of lime 20% and soda 0.87%. The density of the sample is 660 kg/m $^3$. To increase the compressive strength in subsequent series, we use a superplasticizer Polimix.

In the 2nd series of experiments, the samples were dried under normal conditions for 28 days, and as can be seen from Table 3.2, the best indicator in this experiment is composition No. 1, in which the density is 772 kg / m $^3$, and the compressive strength reaches 0.71 MPa had not very high strength indicators. In the third series of experiments, we also use superplasticizers - Rolimix, Glenium, and semi-aqueous gypsum to increase strength. In order to increase the strength, another type of hardening was used - heat and moisture treatment. The samples were steamed at 95C $^0$ according to the following regime: reaching the required temperature - 2 hours; steaming samples - 3 hours; temperature drop - 2 hours. The results of the strength indicators of the steamed samples turned out to be higher. The composition with the addition of Rolimix and semi-aqueous gypsum 2%. At a density of 685 kg/m $^3$ the samples showed a compressive strength of 1.74 MPa. This is due to the rapid setting and hardening of semi-aqueous gypsum. In this series of experiments, composition No. 1 with a superplasticizer also showed a good result. Glenium 111. In this composition, $R_{com}$ = 1.30 MPa at a density of 745 kg/m $^3$.

The results obtained showed that the introduction of various additives affects the change in the physical and mechanical properties of aerated concrete. Compounds without additives have a high density and low strength characteristics [2,3,6,7,8,9,10].

These were pilot experiments on the selection of the composition of non-autoclaved cellular concrete from local materials in Uzbekistan. Thus, using sand and ash as fillers, non-autoclaved aerated concrete compositions were obtained, presented in tables 3.1. and 3.2. Further experiments on the selection of compositions of non-autoclaved aerated concrete were continued using powdered waste from the production of facing slabs from limestone-shell rock.

Table 3.3 shows the physical and mechanical properties of cellular concrete of the studied compositions.

Experimental studies on the selection of compositions of aerated concrete with limestone-shell rock showed that the density of the samples ranges from ρ=510 to ρ=995 kg/m $^3$ (Table 3.3). The density values without the addition of gypsum (composition 5, 6 and 9) turned out to be relatively low, so we achieve a decrease in density in the range up to ρ= 510 kg/m $^3$ in composition 6. As can be seen from Table 3.3, the compressive strength of aerated concrete with limestone shell rock turned out to be higher compared to other fillers (sand and ash).

**Table 3. 3. Compositions of cellular aerated concrete compositions**

| No. p / p | The ratio of the components of the cellular concrete mixture,% by weight | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aluminum - nium powder | V/T | C | lime – | Soda | P olimix ,% | gypsum | Lime - nyak | sand | ash | ρ, g/cm $^3$ | Rszh , MPa |
| one | 0.08 | 0.65 | 0.55 | - | 0.75 | - | 0.05 | 0.372 | - | - | 0.989 | 1.2 |
| 2 | 0.08 | 0.4 | 0.55 | - | 0.75 | 0.8 | 0.05 | 0.392 | - | - | 0.995 | 2.9 |
| 3 | 0.08 | 0.65 | 0.45 | 0.1 | 0.75 | - | 0.05 | 0.372 | - | - | 0.960 | 0.4 |
| four | 0.08 | 0.4 | 0.45 | 0.1 | 0.75 | 0.8 | 0.05 | 0.392 | - | - | 0.915 | 1.4 |
| 5 | 0.08 | 0.38 | 0.5 | - | 0.75 | 0.8 | - | 0.492 | - | - | 0.887 | 2.1 |
| 6 | 0.08 | 0.6 | 0.6 | - | 0.75 | 0.8 | - | 0.4 | - | - | 0.510 | 0.78 |
| 7 | 0.08 | 0.6 | 0.5 | 0.15 | 0.75 | 0.8 | 0.04 | - | 0.31 | - | 0.751 | 1.2 |
| eight | 0.08 | 0.65 | 0.45 | 0.1 | 0.75 | - | 0.05 | - | 0.18 | 0.181 | 0.631 | 0.7 |
| 9 | 0.08 | 0.6 | 0.6 | - | 0.75 | - | - | 0.392 | - | - | 0.578 | 0.73 |

With a combination of Rolimix additives and gypsum in composition 2, the samples have the highest strength index equal to 2.9 MPa, at ρ = 995 kg/m $^3$. The Rolimix additive is a plasticizer and has a good effect on the rheological properties of concrete mixtures, which, with a certain combination, leads to an increase in strength. In composition 5 with the addition of Rolimix, at a density of 887 kg / m $^3$, the compressive strength index reaches the limits of 2.1 MPa. The content of 91% $CaCO_3$ in the composition of limestone-shell rock increases the compressive strength of cement compositions. This is due to their ability to adhere to the hydration products of Portland cement. [5].

Thus, it can be concluded that shell limestone is an effective filler for non-autoclaved aerated concrete. In the future, it is possible to improve the technology for the production of non-autoclaved aerated concrete with limestone-shell rock.

As previous experiments have shown, shell limestone is an effective raw material for aerated concrete. In further experiments, we decided to use it in combination with the ash from Novoangrenskaya TPP. Fly ash has a higher value of the modulus of elasticity, which corresponds to high hardness value. The main structural elements of fly ash are quartz, mullite, and glass.

the physical and mechanical properties of non- autoclaved aerated concrete with shell limestone and ash.

**Table 3. 4. Physical and mechanical properties of non-autoclaved aerated concrete with shell limestone and ash**

| No. | Cement | Ash | P olimix | Aluminum | soda | Rakushech Nick | Water | ρ , kg / m 3 | Rszh ( MPa ) |
|---|---|---|---|---|---|---|---|---|---|
| one | fifty | ten | 0.8 | 0.08 | 0.15 | 38.8 | 0.53 | 536 | 0.53 |
| 2 | fifty | ten | 0.8 | 0.08 | 0.15 | 38.8 | 0.53 | 520 | 0.53 |
| 3 | fifty | ten | 0.8 | 0.08 | 0.15 | 38.8 | 0.53 | 525 | 0.6 |
| four | fifty | twenty | 0.8 | 0.08 | 0.15 | 28.8 | 0.53 | 557 | 0.7 |
| 5 | fifty | twenty | 0.8 | 0.08 | 0.15 | 28.8 | 0.53 | 551 | 0.91 |
| 6 | fifty | twenty | 0.8 | 0.08 | 0.15 | 28.8 | 0.53 | 575 | 0.98 |
| 7 | fifty | thirty | 0.8 | 0.08 | 0.15 | 18.8 | 0.53 | 639 | 0.85 |
| eight | fifty | thirty | 0.8 | 0.08 | 0.15 | 18.8 | 0.53 | 643 | 0.93 |
| 9 | fifty | thirty | 0.8 | 0.08 | 0.15 | 18.8 | 0.53 | 642 | 0.79 |

As a result of experiments with ash and limestone-shell rock, aerated concretes with a density ranging from ρ=520 kg/m $^3$ to ρ=643 kg/m $^3$ were obtained. Samples with 10% ash content have minimum density values from

520 - 536 kg / m $^3$, with an increase in the ash content, the density indicators increase.

If we compare experiments with previous combinations of fillers in the latest compositions, we managed to obtain low density values for samples with higher strength values (Table 1). 3.5).

**Conclusion:**

Thus, experiments on the selection of the composition of non-autoclaved aerated concrete showed the best results using the ash of Novoangrenskaya TPP as a filler, powdered waste from the production of facing slabs from shell limestone. Ash has a chemical activity and in the presence of water interacts with calcium hydroxide, which is formed during the hydration of Portland cement. In this case, calcium hydrosilicates of various basicity are formed, which, over time, strengthen the cement stone. Used as filler limestone shell rock has a porous structure, and also has chemical activity due to the content of calcite. In a finely ground form, shell limestone contributes to the creation of centers for the formation of crystalline neoplasms during the course of physicochemical processes occurring during the hydration of Portland cement. The formation of crystalline compounds that contribute to strengthening the structure of aerated concrete will depend in each specific case on many factors such as: on the combination of components included in the composition of the aerated concrete mixture, on the chemical composition of the binder and fillers used, on the technological factors for preparing the aerated concrete mixture and other factors.

Limestone-shell rock and ash are effective fillers for aerated concrete. Ash does not require an energy-intensive grinding process, limestone-shell rock is a highly grindable raw material compared to sand [4].

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