Determination of scale coefficients for samples of autoclave structurally heat-insulating aerated concrete based on fly ash

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Abstract. The article presents the results of determining the scale coefficients for autoclave structurally heat-insulating aerated concrete based on fly ash. In the course of research, the dependences of the compression strength values on the size and area of the working section of samples of autoclave aerated concrete of the grades D500 and D600 are derived. The dependences of mechanical characteristics on its average density in the range from 500 to 600 kg/m³ are established. For samples of autoclave structurally heat-insulating aerated concrete based on fly ash, the values of scale coefficients were experimentally determined, which in relation to the base sample of 150x150x150 mm are: for prisms of 40x40x160 mm – 1.45, for cubes of 70,7x70,7x70,7 mm and 100x100x100 mm – 1.2 and 0.95, respectively.

Aerated concrete based on fly ash is a type of cellular concrete and is an artificial stone material with evenly distributed pores throughout the volume, obtained as a result of solidification of a rationally selected mixture of a binder, ash, water, additives (if necessary) and a gas-forming agent. Autoclave aerated concrete gains strength under conditions of saturated steam in autoclaves at high temperature (175÷195 °C) and high pressure (0.8÷1.2 MPa) for a certain time (10÷12 hours).

From previously published works [1÷15], it is known that when testing materials for compressive strength, the dimensions of the tested samples have a significant impact.

According to GOST 10180-2012, the compressive strength of concrete that is not determined on basic samples is adjusted using scale coefficients K, which are set experimentally for each type and class of concrete, as well as for each test equipment [16].

Since there is no large aggregate in aerated concrete, its strength characteristics can be determined on small samples, for example, on prisms with a size of 40x40x160 mm.

The purpose of the work was to determine the scale coefficients for samples made of autoclave structurally heat-insulating aerated concrete based on fly ash.

The research was carried out on samples of autoclave aerated concrete based on fly ash produced by CJSC «Stroikompleks».

The research methodology was as follows. Samples with dimensions of 40x40x160 mm, 70,7x70,7x70,7 mm, 100x100x100 mm and 150x150x150 mm were cut from blocks of autoclave aerated concrete of grades D500 and D600. Then they were dried to a constant mass at a temperature of 105±5 °C and tested for strength in accordance with GOST 10180-2012 Concretes. Methods for strength determination using reference specimens.

The scale coefficients, standard deviations and variation coefficients were determined using the method set out in application L of GOST 10180.
The test results are presented in tables 1÷3 and shown in figures 1÷4.

Table 1. Mechanical characteristics of autoclave structurally heat-insulating aerated concrete based on fly ash.

| Grade of aerated concrete | Size of the sample, mm | Area of the working section of sample, sm² | Compressive strength, R_com, MPa | Flexural strength, R_fl, MPa |
|--------------------------|------------------------|------------------------------------------|-------------------------------|-----------------------------|
| D500                     | 40x40x160              | 25                                       | 2,39                          | 1,29                        |
|                          | 70,7x70,7x70,7         | 50                                       | 3,08                          | -                           |
|                          | 100x100x100            | 100                                      | 3,8                           | -                           |
|                          | 150x150x150            | 225                                      | 3,63                          | -                           |
| D600                     | 40x40x160              | 25                                       | 2,95                          | 1,47                        |
|                          | 70,7x70,7x70,7         | 50                                       | 3,36                          | -                           |
|                          | 100x100x100            | 100                                      | 4,43                          | -                           |
|                          | 150x150x150            | 225                                      | 4,13                          | -                           |

The results presented in table 1 show that as the samples size increases from 40x40x160 mm to 100x100x100 mm, the values of the compressive strength of autoclave aerated concrete based on fly ash increase. Further increase in size to 150x150x150 mm leads to a decrease in the values of the compression strength.

Figure 1. Values of the compressive strength of autoclave aerated concrete based on fly ash, depending on the size of the samples.

The difference in compressive strength between the grades D500 and D600 (figure 1) ranges from 9.1 to 23.4% depending on the size of the samples, while the average value is 15.7 %.

The dependence of the values of the compressive strength of autoclave aerated concrete based on fly ash on the area of the working section of the samples (figure 2) is described by the following equations.

For autoclave aerated concrete of the grade D500, the equation has the form:

\[ R_{com} = -0.0001 \cdot x^2 + 0.0314 \cdot x + 1.7035 \] (1)

For autoclave aerated concrete of the grade D600:

\[ R_{fl} = -0.0001 \cdot x^2 + 0.0336 \cdot x + 2.0962 \] (2)

where \( x \) is the area of the working section of sample of the autoclave aerated concrete based on fly ash, cm².
Figure 2. Values of compressive strength of autoclave aerated concrete based on fly ash, depending on the area of the working section of the samples.

According to the graph shown in figure 2, it can be determined that the maximum values of the compression strength of the studied grades of aerated concrete will be obtained on samples with an area of the working section of 150 cm$^2$.

Figure 3. Dependence of the compressive strength of samples of autoclave aerated concrete based on fly ash on the average density.

According to the graph shown in figure 3, it can be seen that the change in the compressive strength of samples of autoclave aerated concrete in the range of average densities from 500 to 600 kg/m$^3$ for a base sample of 150x150x150 mm is linear and is described by the equation:

$$R_{com} = 0.0038 \cdot x + 1.8132,$$

where $x$ – is the average density of autoclave aerated concrete based on fly ash, kg/m$^3$.

Figure 4 shows that the change in the flexural strength of samples of autoclave aerated concrete based on fly ash in the range of average densities from 500 to 600 kg/m$^3$ for prisms with a size of 40x40x160 mm is linear and is described by the equation:

$$R_{fl} = 0.0014 \cdot x + 0.636,$$

where $x$ – is the average density of autoclave aerated concrete based on fly ash, kg/m$^3$. 

$$R_{com} = 0.0038 \cdot x + 1.8132.$$
Figure 4. Dependence of the flexural strength of samples of autoclave aerated concrete based on fly ash on the average density.

Values of scale coefficients for samples of autoclave structurally heat-insulating aerated concrete based on fly ash are given in table 2.

Table 2. Experimentally established values of scale coefficients for samples of autoclave structurally heat-insulating aerated concrete based on fly ash.

| Grade of aerated concrete | Size of the sample, mm | Scale coefficient, $K$ |
|--------------------------|------------------------|-----------------------|
| D500                     | 40x40x160              | 1,52                  |
|                          | 70,7x70,7x70,7         | 1,18                  |
|                          | 100x100x100            | 0,96                  |
|                          | 150x150x150            | 1                     |
| D600                     | 40x40x160              | 1,4                   |
|                          | 70,7x70,7x70,7         | 1,23                  |
|                          | 100x100x100            | 0,93                  |
|                          | 150x150x150            | 1                     |

For samples of aerated concrete of the studied grades, general values of scale coefficients were derived, as well as standard deviations and variation coefficients were determined (table 3).

Table 3. Scale coefficients, standard deviations and variation coefficients for samples of autoclave aerated concrete based on fly ash.

| Grade of aerated concrete | Size of the sample, mm | Scale coefficient, $K$ | Standard deviation, $S_d$ | Variation coefficient, $V$, % |
|--------------------------|------------------------|-----------------------|---------------------------|-------------------------------|
| D500                     | 40x40x160              | 1,45                  | 0,0688                    | 4,75                          |
|                          | 70,7x70,7x70,7         | 1,2                   | 0,0214                    | 1,78                          |
|                          | 100x100x100            | 0,95                  | 0,0053                    | 0,56                          |
|                          | 150x150x150            | 1                     | 0                         | 0                             |
| D600                     | 40x40x160              | 1,45                  | 0,05                      | 3,45                          |
|                          | 70,7x70,7x70,7         | 1,2                   | 0,0292                    | 2,43                          |
|                          | 100x100x100            | 0,95                  | 0,0177                    | 1,86                          |
|                          | 150x150x150            | 1                     | 0                         | 0                             |

The variation coefficients (table 3) of the studied grades of aerated concrete do not exceed 15%, accordingly, the obtained values of scale coefficients can be used for calculating the strength characteristics of autoclave structurally heat-insulating aerated concrete based on fly ash in the range of average densities from 500 to 600 kg/m$^3$. 
Thus, in the process of research, the dependence of the values of the compression strength of autoclaved aerated concrete of the grades D500 and D600 on the size and area of the working section of the samples is derived. The dependences of mechanical characteristics on the average density of autoclave aerated concrete based on fly ash in the range from 500 to 600 kg/m³ have been experimentally established.

For samples of autoclave structurally heat-insulating aerated concrete based on fly ash, the values of scale coefficients were experimentally determined, which in relation to the base sample with size 150x150x150 mm are: for prisms of 40x40x160 mm – 1.45, for cubes of 70,7x70,7x70,7 mm and 100x100x100 mm – 1.2 and 0.95, respectively.

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