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About the Shear Modulus of Non-Autoclaved Cellular Concrete

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ABSTRACT

The results and analysis of experimental data on testing of non-autoclaved aerated concrete in a biaxial stressed state of "tension-state" "state-compression" are presented. Also, according to the results of tests of prisms in axial position without eliminating friction, the shear modulus of non-autoclaved aerated concrete was determined. Appropriate conclusions are drawn from the test results.

Introduction. The low average density of non-autoclosing agglomerated concretes with sufficiently high strength and frost resistance, low thermal conductivity, as well as a simple technology for manufacturing products, ensures a reduction in the mass of panels by 45% less than the mass of the most effective expanded clay concrete panels, and their cost “in fact” is 18% lower. The energy intensity of the production of non-autoclaved cellular concrete is 75-80% less than the energy intensity of the production of expanded clay concrete and 60-80% less than that of brick. Non-autoclaved yagem concretes make it possible to widely use local industrial wastes, such as ash from thermal power plants, waste from the chemical industry and non-ferrous metallurgy, local natural materials (dune sands, and so on)

Non-autoclaved cellular concrete in construction is mainly used for the production of enclosing structures as a structural and heat-insulating material. The main types of products from non-autoclaved cellular concrete are as follows: small wall blocks, reinforced and non-reinforced large wall blocks, reinforced wall panels, reinforced roof and attic floor slabs, heat-insulating plates.

However, despite the existing experience in the production and use of non-autoclaved cellular concrete, their scope in construction remains limited. One of the reasons hindering wide application is the insufficiency of the conducted studies.

In this regard, the NIIZHB carried out complex experimental and theoretical studies of the operation of the based varieties of non-autoclaved cellular concrete, both under short-term and long-term compressive loads, as well as under a biaxial stress state.

Methods. The test was carried out according to the method and on the installation [1], consisting of a U-shaped vertical frame fixed to the power floor and a suspended horizontal frame with a reverse to create a tensile force, as well as two hydraulic jacks with a capacity of 50 kN connected to a pumping station by applying a load tension and compression steps, constituting 0.05-0.1 of the breaking load for axial tension. Uniform stretching was carried out using thick steel plates of self-centering grippers glued to the sample with epoxy glue through wooden bosses 60 mm thick with wood fibers located in them in the direction of the stretching force. When a load was applied, the bosses deformed across the fibers, which reduced the effect of friction on the stretched faces of the cubes.

The compression force was applied to the sample through polished steel plates. To eliminate the effect of friction between the plates and the sample, two celluloid plates 0.5 mm thick were placed, between which a thin layer of graphite lubricant was applied.

Efforts were controlled by the pressure gauge of the pumping station and a glass-type dynamometer installed between the frames and rigid support pads (or reverse). Glass-type dynamometers with paper-based strain gauges glued to their surface with a base of 20 mm made it possible, when determining the forces acting on the sample, to take into account the friction forces arising during loading in the jacks.

Tests of non-autoclaved aerated concrete samples with dimensions of 15x15x15 cm were carried out 162 days from the date of their manufacture under conditions of a biaxial stress state “compression-tension”, equivalent to pure shear

$$G_1=-G_2=\tau_{XY} \qquad (1)$$

According to [1, 2], when a “compression-tension” load is applied to the test sample, with the principal stresses G1 and G2 equal in magnitude and opposite in sign, the element isolated inside with sides located at an angle of 45° to the main axes of the sample will be in under conditions of pure shear, i.e., only tangential stresses τxy will act on the faces of this element.

The measure of deformation caused by shear stresses is characterized by the shear angle or simply shear deformation γ, which is related to the shear modulus GB and the magnitude of shear stresses τxy by the following relation

$$G_B = \tau_{xy}/\gamma \qquad (2)$$

where γ is the shear angle, which is defined as twice the elongation strains of the diagonals of the element, along the edges of which shear stresses act in the zone of elastic operation of non-autoclaved aerated concrete. In order to avoid the influence of the presence of shrinkage cracks in the cubes, shortening deformations were not taken into account.

When testing tensile and compressive strains, the readings were measured with wire strain gauges with a base of 50 mm using an AID-IM strain gauge. For the purpose of mutual control, strain gauges were glued symmetrically on opposite faces of the sample, free from loading, and their direction would coincide with the diagonals of the sample element, along the faces of which shear stresses act.

Results. Before testing in biaxial “tension-compression”, in order to identify the effect of friction on the strength in uniaxial compression and tension, some of the prototypes were tested on the same installation with the elimination of friction.

The results of these tests are shown in table 1 and in the figure. 1 a, b. Note: in the table, the value of ρ is given in a naturally humid state.

The results of comparison of experimental data obtained under uniaxial compression and tension with the elimination of friction with experimental data obtained under the same loads without elimination of friction (table 1) shows that the elimination of friction in the bearing surfaces led to a decrease in compressive strength by an average of 12% . And the tensile strength, determined using self-centering grippers, decreased by 6.5%. The results obtained are consistent with the previously obtained experimental data on other types of concrete, in [3,4].

Table 1. Results of tests in uniaxial compression and tension with the elimination of friction.

Series number (according to table 2.1; 2.2 and 2.3)	Type of test	ρ, kg/m3	R, MPa	Deformations at the time of feathering 10-5
IX	Under axial compression.	1191	3,55	177,5
	With axial tensi	1124	0,37	15,25

Discussion. The destruction of the samples tested with the elimination of friction in axial compression occurs due to longitudinal cracks parallel to the action of the compressive force. And with axial tension, their destruction occurs along a plane perpendicular to the action of tensile stresses.

In tests for biaxial “tension-compression” (in pure shear), it was found that redistribution stresses are 13.5% lower than in axial tension, i.e. is 0.32 MPa.

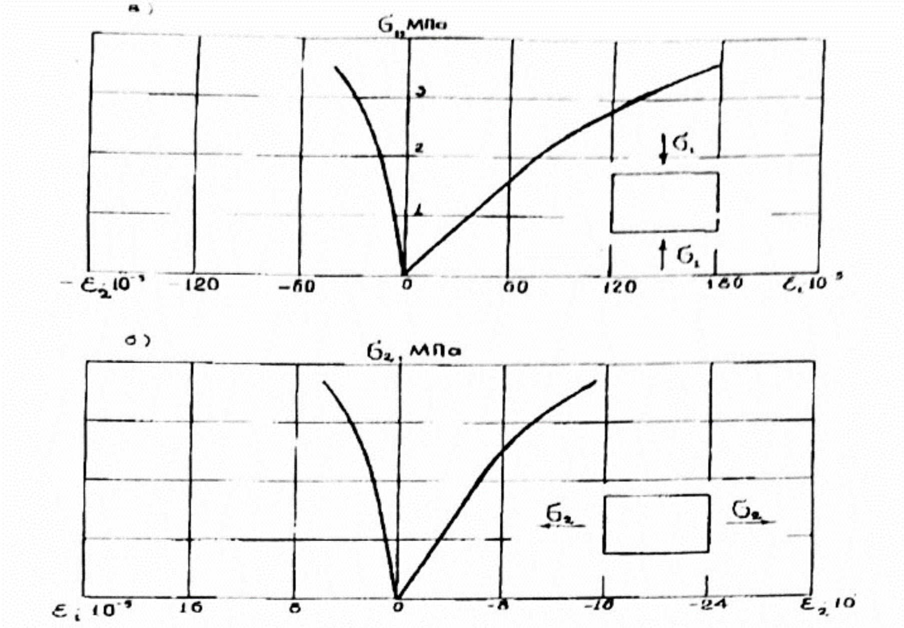

Fig.1. The nature of the change in the relative deformations of non-autoclaved aerated concrete (on non-ground sand, series IX) under central compression-a and tension-b) (with the elimination of the effect of friction).

Similar results were obtained in [7,8,17,18,19,20]. The results of measurement of relative deformations are presented in fig. 2. From fig. 2 it can be seen that the nature of the change in the relative deformations of shortening and elongation is almost the same. However, to calculate the shear modulus using formula (2), elongation deformations were taken into account. At the same time, it was determined that the values of the shear modulus of non-autoclaved aerated concrete are 1200 MPa, which is equal to 0.414 of its initial compressive modulus.

Also, according to the results of tests of 6 prisms with a size of 15x15x60 cm under axial compression without eliminating friction, the shear modulus of non-autoclaved aerated concrete was determined using the well-known formula:

$$G_B = E_{B/}2(1+\mu) \qquad (3)$$

where, E_B=2900 MPa, μ=0.21.

The value of the shear modulus according to formula (3) is 1198 MPa, i.e. $0.413 * E_B$.

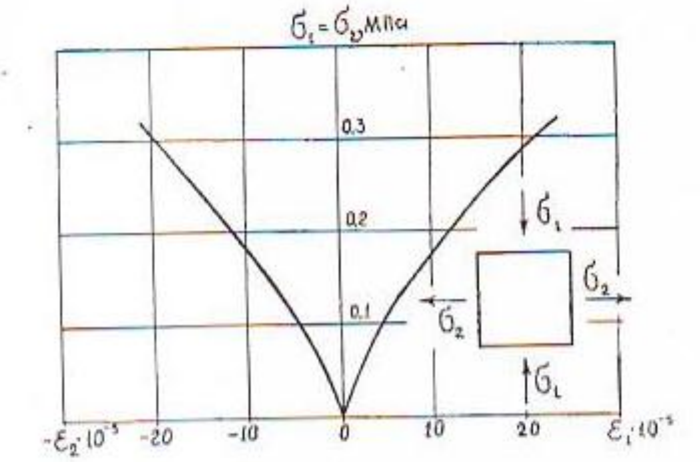

Figure 2. Changes in relative strains of non-autoclaved aerated concrete under pure shear conditions.

Conclusion

1. Thus, it was experimentally established that the shear modulus of non-autoclaved aerated concrete, established by experiments under pure shear conditions, is 1200 MPa, which is $G_B=0.41E_B$.
2. The strength of non-autoclaved aerated concrete with biaxial “compression-compression” increases. The greatest increase is 20% with the ratio of the main compressive stresses of 0.4-0.6, and with uniform compression this increase is 8-10%.
3. It was experimentally established that the strength of non-autoclaved aerated concrete in biaxial “compression-tension” is 13.5% lower than in axial tension.

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