

# ELASTIC-PLASTIC DEFORMATIONS OF ARBOLITE CONCRETE BASED ON RICE HUSK

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**Abstract:** The paper presents the results of the experimental studies of deformative characteristics of wood concrete (arbolite concrete) of different classes. The article is devoted to the question of estimation of the values of secant and tangent modulus of elasticity (E-Modulus) and the coefficient of transverse deformations (Poisson's ratio). It will be possible, from the analysis of the obtained results, to assess the adequacy of the Eurocode 2 provisions with respect to arbolite concrete manufactured with the use of rice husk fillers.

**Keywords:** Elastic-plastic deformation; strength and strain characteristics; short-term tests: ultimate compressibility arbolite concrete.

## **Intriduction**

Concrete is inherently a very heterogeneous material; in addition to its elastic properties, it possesses essential plastic properties which consist of irreversible and partially reversible components. Normal and tangential stresses act under all loading conditions in the material. Their development leads to different consequences.

Today, the use of insulating lightweight concrete is becoming more and more relevant, as it allows to significantly reduce the own weight of reinforced concrete structures and to ensure low thermal conductivity of load-bearing structures, minimizing the need for their insulation.

Currently, in Europe and the U.S. sufficient experience in the use of insulating lightweight concrete has been accumulated [1, 2], but in Uzbekistan, insulating lightweight concrete is used mainly for building envelopes and insulation of coatings.

In the light of current harmonization of design methods adopted in Uzbekistan with European norms, it is relevant to carry out experimental investigations of insulating lightweight concretes based on agricultural raw materials and determine strength and deformative characteristics of such concretes.

In particular, parameters such as longitudinal and transverse strain moduli and the transverse strain coefficient (Poisson's ratio), which characterise the deformation properties of the material, are important in design.

Increasing normal stresses cause brittle failure. Plastic deformation is caused by tangential stresses. It is necessary to find out how these deformations manifest themselves; this is most clearly seen in the diagram of deformation in concrete under compression and tension, which shows how the strain  $\varepsilon$  changes as the effective stress,  $\sigma$ , increases (Fig. 1). In the case of a single-loaded and low-strength concrete prism with a briefly applied load, the deformation of concrete is composed of elastic and inelastic plastic deformation.

The inelastic plastic deformation of the concrete is due to a reduction in the loading rate or an increase in the dwell time of the specimen under load. In this case, creep deformation increases in the concrete, hence the total deformation of the specimen  $\varepsilon_b$  also increases. A small fraction of the inelastic deformation (approximately 10%) recovers with time after unloading, which is called elastic consequence deformation. The elastic deformation of concrete corresponds only to the instantaneous loading rate of the specimen and naturally has a rectilinear character. With increasing loading rate at the same stress of a low-strength concrete specimen, the deformation also results from the elastic  $\varepsilon_{et}$  and the plastic  $\varepsilon_{pl,t}$  deformations.

Philosophical Readings XIII.4 (2022), pp. 465-470. 465

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10.5281/zenodo.6321505

$$\varepsilon_{bt} = \varepsilon_{et} + \varepsilon_{pl,t} \quad (1)$$

**Materials and test methods.**

The study was conducted on research work No. OT-Atesr-2018-178 in JV "Aysel Inshaat" Ltd. and researchers of the Tashkent Architecture and Construction Institute.

Portland cement with activity 32.5 MPa and normal dough density 27% was used for concrete mixture preparation. Rice husk with maximum particle size 10 mm, bulk density 100-150 kg/m<sup>3</sup> and compressive strength 2-1 MPa, which meet the requirements of regulatory documents, acting in the Republic, were used as an argon filler. The compositions of arbolite concrete adopted in the experimental studies are given in Table 1

For studying strength and deformation characteristics of arbolite concrete under short-term loads specimens - cubes with edge size 15 cm and specimens - prisms with size 15x15x60 cm which were cured in the open air till the moment of testing have been made.

Compression test of specimens was conducted on 100 ton hydraulic press PG-100. Samples cubes with rib size 15cm were tested at concrete age 7, 14, 28.

Processing of results of short-term tests was conducted mainly according to GOST 24452-80 "Concretes. Methods of determination of prism strength, modulus of elasticity and Poisson's coefficient". Parametric levels of micro-cracking.

Table 1.

Arbolite concrete composition.

№	Class of arbolite concrete	Consume of materials to 1 m <sup>3</sup>			w/c	Density kg/m <sup>3</sup>
		Cement kg	Rice huck kg	Water l,		
1	2	400	180	280	0.7	600
2	1.5	350	160	250	0.715	550
3	1	300	140	220	0.73	450

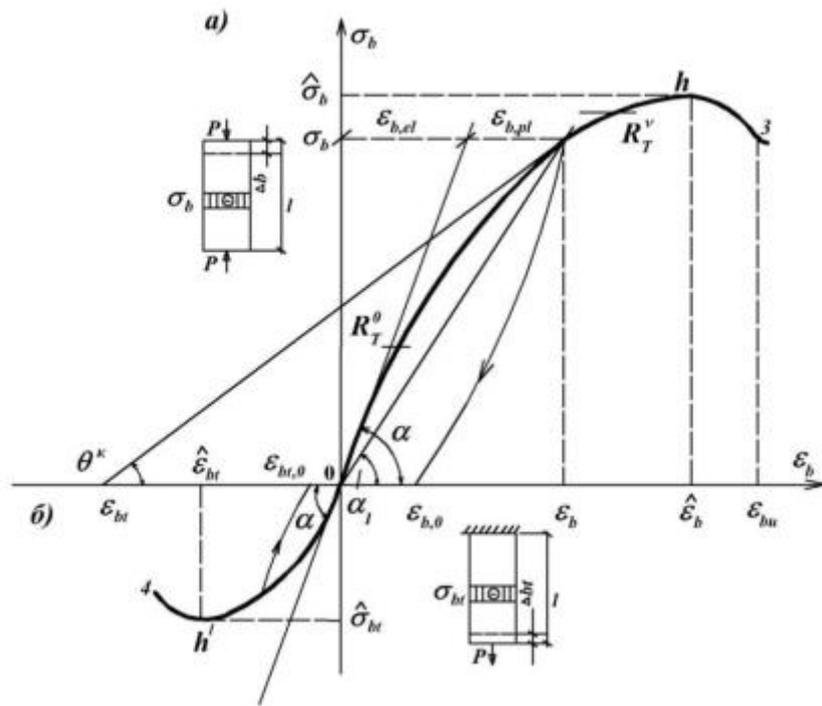


Figure 1. Stress-strain diagram for concrete in compression and tension.  $\epsilon_b$  - ultimate compressibility of concrete;  $\hat{\sigma}_b$  - ultimate tensile strength of concrete;

$R_b$  was determined by calculating the differential coefficient of transverse strain  $\Delta v$ , the change of the total relative volume. It is noted in the work that the strength and strain characteristics of the laboratory-cured arbolite concrete depend on the composition of the arbolite concrete, which leads to a significant change in the specified characteristics. The dependence of concrete deformations on stresses is also related to the composition of concrete. The data in Table 2 shows that the ultimate deformations of reinforced concrete, in compression, tend to increase with the growth of its strength.



Fig.2. Samples to be tested.

### Analysis of results.

Table 2 shows the results of experimental studies illustrating the effect of age of concrete on the strength and strain characteristics of expanded clay aggregate concrete in short-term

compression. As a result of processing and analysis of experimental data correlation dependence was obtained [4], according to which the average value of  $K_{pp} = 0.83$ .

$$R_b = 0.83R \quad (2)$$

The increased value of prism strength coefficient for reinforced concrete as compared to heavy concrete, can be explained on the basis of analysis of structural features of this material.

Table 2.

Strength and deformation characteristics of arbolite concrete.

№	Class of arbolite concrete	Characteristics of reinforced concrete			
		R, MPa	R <sub>b</sub> , MPa	K <sub>pp</sub>	E <sub>b</sub> , MPa
1	2	2,3	0,18	0,08	1900
2	1.5	1,45	0,11	0,075	1715
3	1	1,08	0,072	0,066	730

The results of numerous studies indicate a different fracture pattern in lightweight and extra lightweight concrete. It has been found that the total length of cracks in the mortar part of heavy concrete is much less than the length of the contact zones.

Taking into account that the strength of coarse aggregate in light concrete is almost one order of magnitude higher than the strength of concrete, one can conclude that its strength and deformation characteristics are mainly determined by the properties of mortar component of the contact zone.

The formation of the contact zone and the mortar component in especially light concretes (in comparison with light concretes) takes place, as already mentioned, in more favorable conditions. This explains the increased values of  $K_{pp}$  in comparison with light concretes. When analyzing the experimental data on the modulus of elasticity of arbolite concrete one can find significant variation, which indicates the existence of a more general dependence [8]. According to these data, the modulus of elasticity, as other deformation characteristics of an inhomogeneous material like concrete, cannot be uniquely related only to its strength

As the analysis of empirical data has shown, high accuracy of prediction can be achieved if the effect of other factors is taken into account along with the strength in the form of a model suggested in the paper and comprehensively tested for heavy concretes. According to the methodology of the work, the total value of the limit compressibility of concrete reinforced concrete was divided in the analysis into two components -  $\epsilon_e$  and inelastic  $\epsilon_{ie}$ . The second component reflects the effect on the deformation in the process of microfractures in the concrete structure (pseudo-plastic deformation). The elastic component of the ultimate compressibility  $\epsilon_e$  is determined by the relation

$$\epsilon_e = R_b / E_b \quad (3)$$

The inelastic component is the difference between the measured total strain and the elastic component (6). The dependences of pseudo-plastic deformations of expanded clay aggregate concrete under compression on the elastic component are given. It can be seen from the figure that the ratio of the above deformation components is generally less than unity, which is characteristic of lightweight concrete. As the strength of concrete increases, this peculiarity becomes more evident. Changes in the cross-sectional dimension of the specimens also influence this relationship, which was taken into account in the statistical analysis.

Comparison of static distribution parameters according to the analyzed methods shows high reliability of the proposed method. The prediction accuracy according to model (6) is characterized by extremely low value of variation coefficient and practically complete absence of average bias. It should be noted that the obtained model is highly versatile and convenient for practical application.

As a whole, the results of the present study confirm the conclusions of [7], to construct reliable methods for predicting short-term deformations of light concretes on porous aggregates.

**Conclusions.** Results of obtained data analysis show that there is rather close correlation relation between prismatic  $R_b$  and cubic  $R$  strength, expressed by the relation  $R_b=0,071R$ . Thus, the value of  $K=0.081$  for expanded clay aggregate concrete, hardening in natural conditions, is also higher than the value regulated by national standart of Uzbekistan CMK 2.03.01-96. "Concrete and reinforced concrete constructions. Design norms". According to the standard, estimation of influence of initial modulus of elasticity regardless of concrete type is made with the use of step-down coefficient 0.085. The static processing of experimental data shows that for arboit concrete the reduction factor is 0.072; for practical purposes one can take it as a first approximation equal to 0.07 instead of 0.085.

The results of the present experimental studies and their statistical processing allowed to formulate practical recommendations for prediction of the considered properties of structural reinforced concrete under short-term loading for use in calculations of reinforced concrete structures intended for operation.

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