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STUDY OF LOADING CAPACITY OF LIGHTWEIGHT AND ARBOLITE CONCRETE PANELS

Abstract: *Structural wall panels usually have significant flexibility, which in residential buildings is in the range $\frac{l_0}{h}$ = 18÷22, and in public and agricultural buildings it can be even higher. In this regard, the issues of stability of such structures, especially under a long-term load, are of great importance, since deformations significantly reduce their long-term strength.*

Key words: *hardwood concrete, deformation, deflection, long-term load.*
Language: *English*
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Introduction

When drawing up structural design standards (KMK 2.03.01-96 and 2.03.03-96), values of coefficients φ_l were established for the calculation of flexible structures, taking into account the influence of long-term load action [1,2]. The values of these coefficients were taken based on the results of a very limited number of tests conducted by the research work No. OT-Atex-2018-178 of OOO JV "Aysel Inshaat" and the Tashkent Institute of Architecture and Civil Engineering.

Flexible panels were studied mainly during bending. This type of work of panel walls is the main one in the conditions of their operation. Deflections of various sizes are created as a result of deviations in the centering of elements, due to uneven filling of mortar joints when supporting panels, their curvature obtained during manufacture at the factory, uneven density of concrete in cross section, etc.

Few results of studies on the long-term strength of concrete and reinforced concrete have been published in the foreign press. Extensive studies of the long-term strength of short concrete prisms were carried out by the laboratory of the Munich Higher Technical School. Based on these tests, the laboratory concludes that the limit of the long-term strength of heavy concrete in prisms does not exceed 80% of the strength limit obtained during conventional short-term tests [3].

We have no information about tests under prolonged load of flexible weakly reinforced concrete elements, such as wall panels. The conditions of their operation under a long-term operating off-center load in the absence of reinforcement or insufficient reinforcement are very unfavorable. All this forced us to start in 2018 studies of the strength and deformations of panels under prolonged load.

The article presents the results of tests of panels and prisms made of expanded clay and dense arbolite concrete, conducted in 2018-2020.

Experimental samples and methods of their manufacture: Panels made of monolithic concrete were made in a laboratory landfill. The molded products are kept indoors for 6 hours and then steamed in an autoclave according to the mode: temperature and pressure rise for 3 hours, steaming at 8 atm for 6 hours and lowering the temperature for 3 hours.

Young Samarkand lime was used for the manufacture of panels. According to the content of CaO + MgO = 81.6%, lime belongs to Grade II. Sand from the quarry of the Chinaz deposit was used as a filler

Concrete was compacted on a vibration platform that had 3000 vibrations per minute and an amplitude of 1 mm. The vibration lasted 1.5-2 minutes with a load of 0.07 kN/cm^2.

Tensile strength arbolitos concrete when tested in cubes 15x15x15 cm during periodic monitoring, which lasted for two years, ranged from 1.83-1.99 and the average was equal to 1.92 kN/cm^2.

Volume weight crossbow concrete when tested at the age of four days after the Park was equal to 2080 kg/m^3, and two years later dropped to 1980 kg/m^3.

Panels made of expanded clay concrete were made in 2018 in Tashkent in the open landfill of OOO JV "Aysel Inshaat". The panels were molded on platforms with dividing partitions, vibrated without overload and then subjected to heat treatment.

As a binder, Portland cement of the 500 brand was used, a fine aggregate quartz sand of medium size. A large aggregate is expanded clay gravel with a size of 10-20 mm, volume weight from 380 to 480 kg / m^3 and with a compressive strength when tested in a cylinder of 14-19 kN/ cm^2

The panels are reinforced with volumetric wire frames with a diameter of 4 mm for their safe lifting during installation (Fig. 1). Bending tests were carried out. The distance between the supports is 2400 mm.

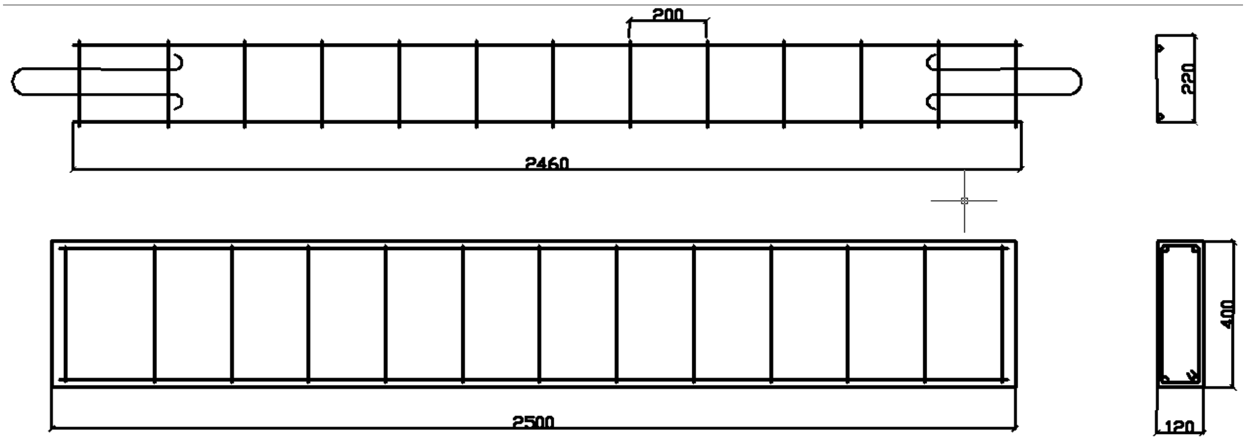

Fig. 1. Tested panels and their reinforcement

Results: Deformation and bearing capacity of panels

Before infecting the panels with a long-acting load, the reference panels were tested for off-center compression before destruction. During their testing, the values of the destructive load given in Table 1 were determined, as well as their deflections and vertical deformations of concrete on opposite sides.

When determining the flexibility of the panels, the distance between the hinges of the spring installations was taken as the calculated length l0.

Table 1. Test results of reference panels

Series	№ panels	Type of concrete	Age by immersion time n days	Flexibility $\frac{l_0}{h}$	Destructive load t	Deviations from the average value in %
AB	1 2 3	Arbolito concrete	42 42 71	21,6	27.6 24.7 31,6	+ 5 — 5 — 7
KB	4 5 6	ceramzito- concrete	72 86 89	25	24,5 37 43,2	— 28 + 8 +27

A significant variation was obtained in the values of destructive loads for expanded clay concrete, while no such variation was revealed in deformations and deflections (Fig. 2). Taking into account these results, the value of the long-acting load was assigned according to the average values of deformations and deflections of the reference panels of each series. This provided greater accuracy in determining the magnitude of the load.

To test panels made of monolithic concrete with a flexibility of $\frac{l_0}{h}$ = 21, 10 panels were loaded with a load. The load value for individual panels ranged from 46 to 87%. Of these, eight panels collapsed within two years under a load of 56 to 87%.

From expanded clay concrete in the KB series in 2018, seven panels with flexibility $\frac{l_0}{h}$ = 25 were loaded with a long-term load that ranged from 57 to 95% destructive; within 2 years, six panels collapsed under a load of 67% or more of destructive.

Expanded clay concrete panels with flexibility $\frac{l_0}{h}$ = 21 were loaded with a long load in 2020. 12 panels were loaded with a load ranging from 38 to 89% destructive. Of these, nine panels collapsed within 8 months under a load of 68 to 89% and three more panels were preserved without destruction, the load of which was from 38 to 71% destructive.

Measurements of vertical deformations and deflections of panels were carried out by portable indicators with a division price of 0.01 mm (Table 2).

As a result of the increase in deflections of the panels, the actual eccentricity of the load increased in the middle section, which eventually led to destruction. The destruction began with the appearance of horizontal cracks in the stretched zone. As the deflections increased, new cracks appeared and those that appeared earlier expanded. When the critical deflection values were reached, the stretched reinforcement ruptured and the concrete of the compressed zone collapsed. The destruction occurred in the section with the lowest strength of concrete, and it did not always coincide with the highest value of the bending moment. Deviations from the curve in the direction of decreasing load-bearing capacity for expanded clay concrete panels are no more than 9%, while for arbolite concrete panels, most of the experimental points were located below the curve and deviations from it reached 30%.

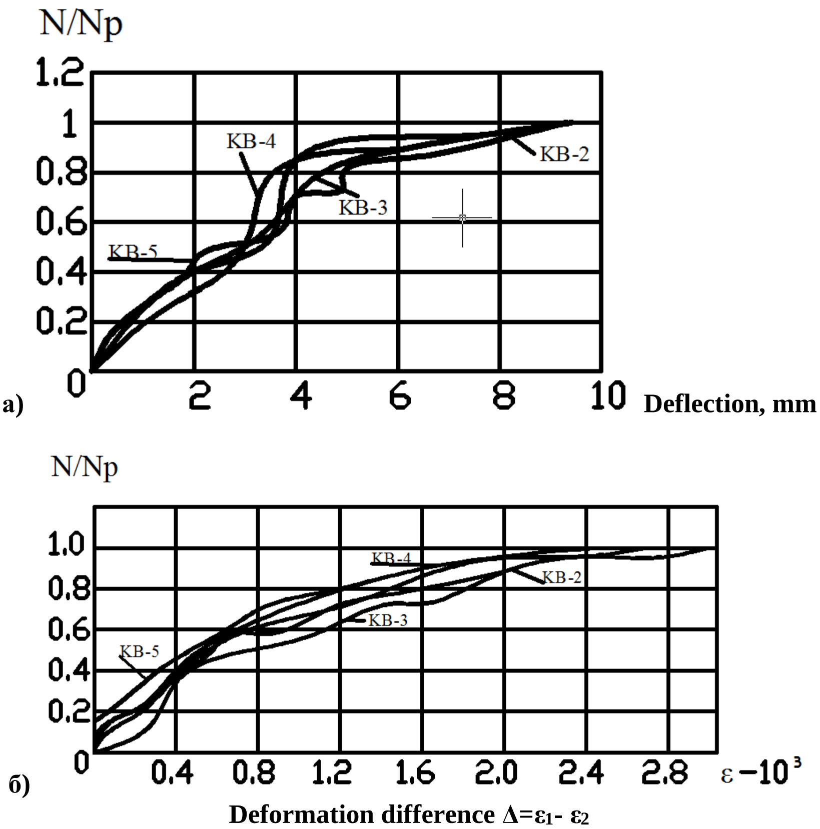

Fig. 2. Deflections and deformations of the reference panels made of expanded clay concrete of the KB series a — deflections; b - the difference of deformations on the compressed and stretched faces

Despite the significant spread of experimental points around the normative curve, it can be concluded that the deflections of the middle part of the panels under a long-term load have the same effect on their

Impact Factor:

ISRA (India) = **6.317**	**SIS** (USA) = **0.912**	**ICV** (Poland) = **6.630**
ISI (Dubai, UAE) = **1.582**	**РИНЦ** (Russia) = **3.939**	**PIF** (India) = **1.940**
GIF (Australia) = **0.564**	**ESJI** (KZ) = **9.035**	**IBI** (India) = **4.260**
JIF = **1.500**	**SJIF** (Morocco) = **7.184**	**OAJI** (USA) = **0.350**

bearing capacity as the initial eccentricities of the loads in the support sections.

The bearing capacity of the panels depends on the duration of the load. The complexity of the problem lies in the fact that when designing panels, it is necessary to know the possible maximum bearing capacity of them during the operation of buildings. The term of operation of capital buildings is usually estimated at 100 years, and in some cases even more. Due to the impossibility of testing panels under such a long load, it is necessary to judge the bearing capacity of the structure based on the results of their tests in a fairly short time, usually 1-2 years.

Table 2. Deformation and deflections of panels

№ panels	Strain load %	During loading			Under prolonged load			tests in days
		Deflection in mm	Deformations 10^{-3}		Deflection in mm	Deformations 10^{-3}		
			Compression ε_1	Stretching ε_2		Compression ε_1	Stretching ε_2	
Expanded clay concrete panels, KB series								
1	82	5.63	11.4	0.46	6.13	0.85	0.76	28
2	75	4.16	0.97	0.21	11.38	2.16	1.8	36
3	69	3.99	1.16	0.28	11.12	1.59	1.12	61
Arbolite concrete panels, SB series								
4	0.87	5.5	1.29	0.37	8.9	1.6	1.54	79
5	0.68	7.7	0.92	0.39	8.1	1.42	0.81	140
6	0.59	3.61	0.99	0.34	7.2	1.8	1.06	314

When evaluating the results obtained, it should be taken into account that the tests were carried out with the hinged support of the panels, while in the building, when the floors are supported on the walls, conditions are created equivalent to partial sealing of the upper and lower support sections of the panel. Partial sealing of the panels in the support sections increases the value of φl, compared with that obtained from the tests.

The tests were carried out on narrow sections of panels 40-50 cm wide, while the panels in the building are usually at least 2.5 m wide. Due to the small width of the tested segments, local weakening of the cross section could not but affect the bearing capacity. In panels of normal width, local attenuation is balanced by neighboring, stronger sections and there is no reduction in load-bearing capacity or it will be revealed to a lesser extent than in narrow segments. Consequently, with a larger width of panels in buildings, a higher value of the coefficient φl can be expected.

Conclusions: All this suggests that the resulting dependence cannot be expressed in one straight line. It will be curved; the curve can be replaced by a polyline consisting of a series of straight segments with a different slope to the abscissa axis.

Therefore, the shown dependence can be considered as setting the limit values below which the load-bearing capacity of the tested panels cannot fall. The actual load-bearing capacity of the panels will be slightly higher than the values expressed by a straight line.

When drawing up design standards for stone and reinforced stone structures (KMK 2.03.03-96), the effect of partial sealing of the support sections of panels was taken into account by increasing the experimental values of the coefficient φl for flexible elements by 10% [8]. If this correction is taken into account, the deviation of the experimental values from the calculated ones will be only 6-10%. Taking into account other factors influencing the results of testing the panels mentioned above, it can be concluded that the test results of panels made of expanded clay concrete are quite close to the calculated ones.

When testing the load-bearing capacity of panels made of arbolite concrete, the deviation of the coefficient from the calculated value was obtained equal to 33%, i.e. significantly greater than panels made of expanded clay concrete. For this type of panels, before obtaining the results of additional tests, it is advisable to calculate the values of the coefficient φ_l.

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