EXPERIMENTAL RESEARCH OF COMBINED JOINTS OF WALLBOARDS FROM NATURAL HARDENING FOAM CONCRETE

Anatoliy Kostyuk, Dariya Kovtunenko

Abstract: *The article is dedicated to investigation of fracture behavior of combined horizontal joints of wallboards from natural hardening foam concrete and influence of some factors on ultimate loads for joints. Two the most valuable factors that influences on ultimate loads for wallboard joints was allocated while planning experiment: load eccentricity and indirect reinforcement. The samples consisting of three elements (top wallboard, bottom wallboard and floor slab) was made for experiment. The typical scheme of destruction for combined joints of wallboards with and without indirect reinforcement was identified in result of testing. The table of comparison of analysis values of ultimate loads for combined joints by existing methods and obtained in result of analysis by SP "LIRA" with received experimental data is shown in the article. Also in paper are shown the diagrams of ultimate load relation with load eccentricity and indirect reinforcement.*

Keywords: *ultimate load, combined joint, indirect reinforcement, natural hardening foam concrete, wallboards.*

1. STATE OF MATTER

In contemporary civil engineering the important place is holden by a celurar concrete side by side with heavy aggregate concrete. The physical and thermal properties of foam concrete have the best usage in houses building. Basically, this material is presented as blocks for masonry which lead to a longer duration of building construction due to the need for additional work. The use of wall panels will reduce the construction time.

Existing methods of analysis of wall panels horizontal joints from cellular concrete [1] are empirical and do not fully reflect the physical side of the work of wall panels support zones.

Currently Laboratory of reinforced concrete and masonry structures of the Kazan State University of Architecture and Engineering is engaged in the study of stress-strain state of butt joints of large-panel buildings. The method of joints strength analysis, which is based on the theory of compression resistance of anisotropic materials and reflects the destruction mechanism of supporting zones of wall panels from heavy concrete, is developed by authors of [2, 3, 4]. The applicability of this theory for the determination of ultimate loads for horizontal joints of the wall panels from cellular concrete has not been studied.

The research of joints stress-strain state of wall panels from natural hardening foam concrete is provided in Odessa State Academy of Civil Engineering and Architecture. The method of numerical study of joints stress state, implemented in the SC „LIRA", is described in [5].

The purpose of experimental research is to study the destruction nature of the combined horizontal joints of the wall panels from natural hardening foam concrete and the influence of various factors on the ultimate load for the joints.

2. PLANNING OF EXPERIMENTAL RESEARCH

The two most significant factors: the eccentricity of load application and the amount of indirect reinforcment grids, that may affect on ultimate load for the joint, have been isolated. The coded and full-scale values of the factor are shown in Table 1. Scheme of tests is shown in Figure 1.

Table 1. Characteristics of experimental samples

Sample code	Values of factors			
	The amount of indirect reinforcement grids X_1		The eccentricity of load application X_2	
	Coded	Full-scale, pcs.	Coded	Full-scale, mm
JCP-0-0	-1	0	-1	0
JCP-2-0	0	2	-1	0
JCP-4-0	+1	4	-1	0
JCP-0-20	-1	0	0	20
JCP-2-20(1)	0	2	0	20
JCP-2-20(2)	0	2	0	20
JCP-2-20(3)	0	2	0	20
JCP-4-20	+1	4	0	20
JCP-0-40	-1	0	+1	40
JCP-2-40	0	2	+1	40
JCP-4-40	+1	4	+1	40

Samples, that consist of three parts: the overlying panel, the underlying panel and floor slab, were prepared for experiment. Dimensions of the test-samples elements were accepted by geometric similarity to full-scale parameters of panels and their joints. The thickness of wall panels is accepted 200 mm (100 mm contact part and 100 mm platform part). The thickness of floor slab is accepted 150 mm. The width of test samples is accepted 600 mm with consideration of dimensions of support platform of press.

Supporting areas in contact and platform parts of overlying panel are located close to each other, so we can assume that load on the sample is applied to its full width l_c = 200 mm. The height of overlying panel is accepted $3l_c$ = 600 mm. The maximum possible width of support in platform part of underlying panel is 100 mm. The required height of underlying panel is $3l_c$ = 300 mm. The ledge height of underlying panel is accepted 160 mm. Finally the height of underlying panel with ledge is accepted 600 mm with consideration of production conditions. The cantilevered ledge of floor slab fragment is 510 mm.

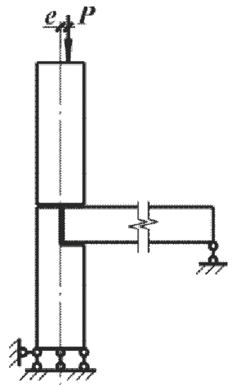

Figure 1. Scheme of tests

The wall panels of test samples are made of natural hardening foam concrete with density from 700 to 1000 kg/m^3. The floor slab is made of concrete class C20/25. The indirect reinforcement of wall panels is made of grids from reinforcement wires Ø3 mm class Bp-I with characteristic yield strength f_y = 608 MPa and modulus of elasticity E = 20.51 × 10^5 MPa.

The model of test sample with main dimensions and scheme of instrumentation layout is presented on Figure 2. The tensoresistors are installed on levels of first and fourth grids of indirect reinforcement. The general view of test samples is shown on Figure 3.

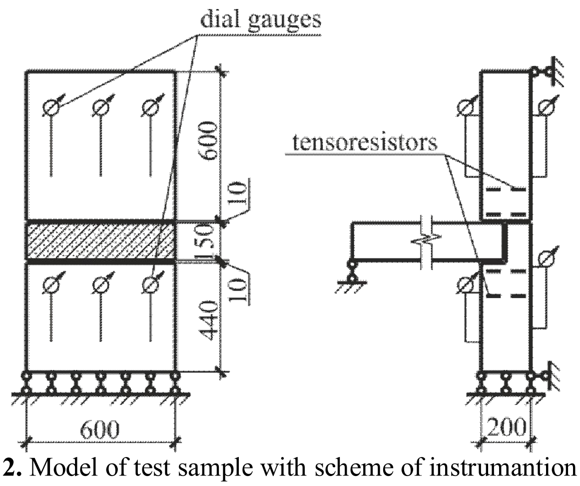

Figure 2. Model of test sample with scheme of instrumantion layout

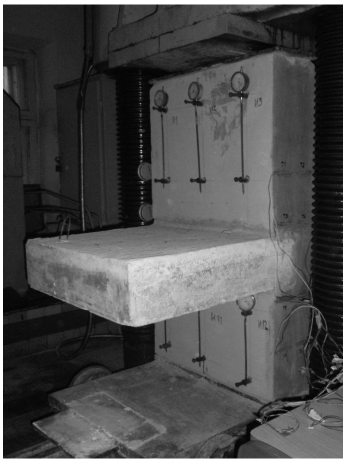

Figure 3. The general view of test sample, that is mounted on press platform

All samples were exposed to static load. On each stage the load on the sample of combined joint was applied by 0.1 of the expected destructive value.

3. MAIN RESULTS OF EXPERIMENT

The characteristic schemes of destruction are identified on the testing results of horizontal joints of the wall panels from natural hardening foam concrete are shown on Figure 4.

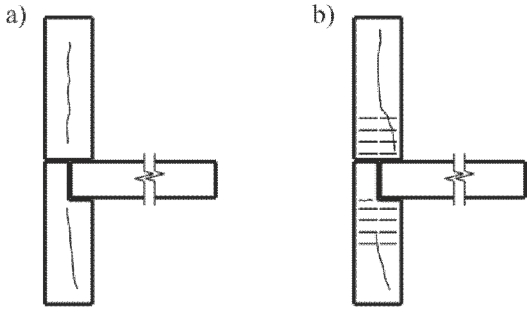

Figure 4. The characteristic scheme of destruction
a) samples without indirect reinforcement;
b) samples with indirect reinforcement.

The destruction of the test samples without indirect reinforcement occured in accordance with the diagram shown on Figure 4(a). The formation of the first vertical crack was observed near the cement mortar joint on the boundary between contact and platform parts of the wall panel. The development of vertical cracks in height of wall panels took place with the load increasing. The destruction of the samples occurred as a result of the split of panels on conditional boundary between contact and platform part.

The destruction of the test samples with indirect reinforcement occured in accordance with the diagram shown on Figure 4(b). The character of cracking on the visible surfaces of samples with indirect reinforcement is generally consistent with cracking of samples without indirect reinforcement. At the same time, the presence of grids had prevented the development of vertical cracks. The destruction of samples occurred as a result of crushing of foam concrete of wall panels in locations of resting on concrete floor slab and support platform of press. The spalling of underlying panel ledge was occurred in the samples to which load was applied with the eccentricity.

Also combines joint was modeled in the software complex „LIRA 9.4“ [5] which implements the finite elements method (Figure 5).

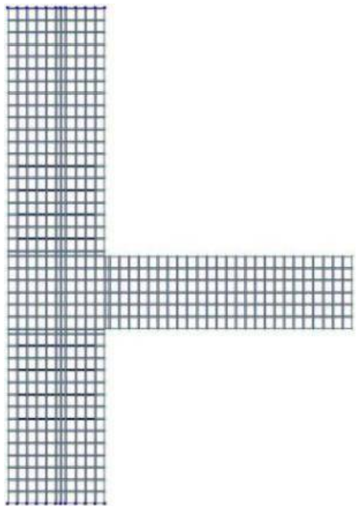

Figure 5. General view of joint that is built for analysis in SC "LIRA"

The finite elements, that allows to build the plane model, were used for modeling:

223 – physically non-linear universal rectangular finite element of plane problem (beam-wall), which simulates the body of foam concrete and mortar;

210 – physically non-linear universal spatial rod finite element, which simulates the indirect reinforcement of joint.

The analysis was performed in the nonlinear formulation with stepwise increment of the load. Physical and mechanical characteristics of the materials were set according to the results of cubes and prisms tests in compression and reinforcing bars in tension. A significant increment of nodes displacement of design scheme at the current stage of load was assumed as destruction criterion.

The values of the foam concrete cube strength, as well as the values of the joint ultimate load obtained from tests, analysis by the formulas given in the normative literature [1] and studies carried out under guidance of B.S. Sokolov [2, 3, 4], and numerical studies [5] are given in Table 2.

Charts of ultimate loads for the combined horizontal joints of the wall panels from natural hardening foam concrete depending on the factors studied are shown in Figure 6.

Table 2. Ultimate loads for the combined horizontal joints

Sample code	Cube strength $f_{cd,cube}$, MPa	Ultimate load, kN			
		by test results	by [1]	by [4]	by numerical study results
JCP-0-0	2,39	60,00	141,3	380,9	53,33
JCP-2-0	0,89	33,33	66,3	-	20,00
JCP-4-0	1,99	46,67	192,0	-	53,33
JCP-0-20	1,42	33,33	78,7	147,0	26,67
JCP-2-20(1)	2,95	73,33	198,1	-	66,67
JCP-2-20(2)	2,84	46,67	130,3	-	40,00
JCP-2-20(3)	4,16	86,67	372,3	-	80,00
JCP-4-20	3,26	46,67	163,6	-	53,33
JCP-0-40	2,14	33,33	93,9	427,4	46,67
JCP-2-40	1,66	53,33	89,3	-	40,00
JCP-4-40	4,61	73,33	216,9	-	80,00

Note: The method [4] does not allow to take into account the indirect reinforcement of the wall panels support zones

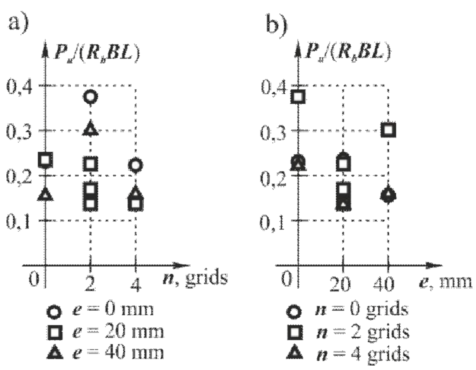

Figure 6. Ultimate load depending on:
a) quantity of indirect reinforcement grids;
b) eccentricity of loads application

4. CONCLUSIONS

The next conclusions could be made by analysis of gotten test results:

- the ultimate loads of gorizontal joints of the wall panels from natural hardening foam concrete, that is calculated according with normative literature [1] and propositions of authors [2, 3, 4], is significantly overtaken compared with the results of numerical and natural experiments;
- increasing of load application eccentricity leads to decreasing of the ultimate load for joint;
- indirect reinforcement of the wall panels ends by two grids leads to increasing of the joint bearing capacity; indirect reinforcement of the wall panels ends by four grids do not influence on the joint bearing capacity.

5. REFERENCES

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