UDC 624.012.44/.45

BUILDINGS WITH PRECAST AND CAST-IN-SITU DECK

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Actuality. There is a significant need for new flats for the population in Ukraine. However, due to the current crisis, both in the world and in Ukraine housing has decreased greatly. The lack of funds from the general population and the state does not allow to deploy a large-scale residential development. One possible solution to this problem is to reduce capital investments for the construction of residential buildings. It is needed to make better use of resources, including through the reduction of material production, the use of cheaper and more cost-effective structural systems, the economic use of raw materials and the introduction of new technologies for construction and, as a consequence, the reduce of the construction cost.

The purpose of the research. Based on experience of building construction using precast and cast-in-situ deck to determine the advantages and disadvantages of this overlapping, to develop key recommendations for its further use in Ukraine.

Presentation of the basic material.

In recent years cast-in-situ construction has been greatly developed in Ukraine. Technology of cast-in-situ building and applied for it architectural and design solutions, have significant advantages over precast concrete buildings that were widely built in the last century. The main advantage is the flexible design solutions and architectural and expressive appearance of buildings. The use of frame technology allows you to split bearing and partition walls of these buildings. Therefore, for the walls of these buildings the new more energy-efficient materials can be used. This will reduce energy consumption for buildings.

However, current methods of cast-in-situ construction can be achieved mainly by effective concrete form, centralized production and use of concrete mixes with good properties. Therefore, cast-in-situ building has a number of drawbacks. The main among them are the limited construction season (problems with concreting in winter), the increased weight of deck, high reinforcement consumption, up to 40 kg per 1m2 of deck.

Therefore, one of the most economical decks is flat precast and cast-in-situ deck PGASA [2]. The main advantage of this type of deck is the possibility of a free space planning, a high degree of reliability of the frame at a significantly reduced amount of labor and material, especially the reinforcement consumption.

The system under consideration involves precast and cast-in-situ frame with flat discs deck, each floor supported walls and exterior walls.

Discs deck in the frame (Figure 1) is formed by prefabricated hollow-core slabs and cast-in-situ bearing and braced crossbars, which are performed through the entire length and width of the building.

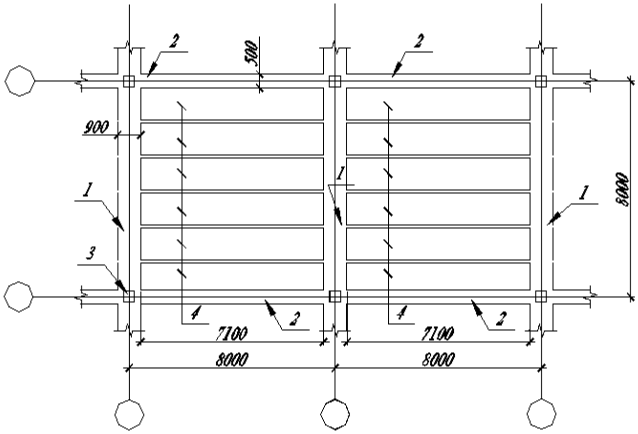

Fig. 1. Construction of precast and cast-in-situ frame of the building with a flat precast and cast-in-situ slabs PGASA: 1 – bearing crossbars, 2 – braced crossbars, 3 - concrete columns; 4 - hollow-core slabs;

Prefabricated hollow-core slabs in deck cells are placed in groups and each slab is supported at the ends on the supporting crossbars with the help of concrete dowels. For construction of buildings the slabs can be used, which are traditionally produced in the region at the existing old production lines. But in their manufacture punch is passed through the entire length of the slabs in order that in every side of the slab there were the same holes. It is a construction of the same holes in the slabs that allows during concrete casting f the crossbars to form concrete dowels by filling these holes with concrete to a depth of 150 ± 10 mm. Previously conducted tests proved the safe bearing capacity of the joint, which in several times is bigger than the required one [3].

It is also possible to use hollow-core slabs produced by continuous process with their cutting to the desired length. These slabs are notable for high quality concrete, lower consumption of stressed reinforcement (compared to traditional manufacturing techniques), accurate sizes, smooth surface.

Along the outer side of the last slabs there are braced crossbars adjoined to them. Bearing and braced crossbars, combined with each other in the plane of the deck in a single cross-frame, are jammed in the columns. Slabs which are installed in the permanent position form side boxing for bearing and braced crossbars, in which the reinforcement is installed in accordance with the project (Figure 2). Column spacing for flat deck can be of any desired size up to 8.0 m, both along and across the building. Column grid can have an unstable structure with spans of varying lengths. Depending on the availability of the production base of the contracting agency in the frame cast-in-situ or precast columns can be applied. Vertical diaphragms can be precast, cast-in-situ or precast-cast-in-situ.

Disks of deck are flat slabs with smooth ceilings. Dimensions of hollow-core slabs in each cell are made shortened, and cast-in-situ part of the bearing crossbars, therefore, - broadened. This can significantly increase the rigidity of the slab deck with a thickness of 22 cm under the influence of the vertical load, and the upper and lower working reinforcement of bearing crossbars can be relatively easily placed in a single layer.

Fig.2. Reinforcement crossbars

With the slab thickness of 22 cm bearing and braced crossbars are made with the height of 27 cm to increase their carrying capacity. Thus, crossbars project at 5 cm above the surface of the slabs. This projection in the future is hidden in the floor construction. The bottom of the crossbars to the lower plane of the slab is placed at the same level, which ensures smooth and even ceiling. Joint concreting of all the elements of deck provides hard disc from hollow-core slabs, cast-in-situ areas, bearing and braced crossbars.

After the construction of the experimental precast cast-in-situ slabs, field tests of fragment deck were conducted.

The purpose of the tests is the assessment of the carrying capacity of flat precast cast-in-situ slabs while their vertical static loads on the deck according to the calculated operation load.

The main method of experimental research method is the method of verification nature test of loading by slab system circuit with bringing loads to control the deformations according to the State standard of Ukraine Б В.2.6-7-95.

Verification nature tests of deck were provided directly in a building under construction of the trade and demonstration center near the street Tverskaya and street Kalinovaya,9 in Dnipropetrovsk, where as the support system the frame with flat precast cast-in-situ deck is applied, which was developed in PSACEA.

A fragment of a flat precast cast-in-situ deck, which was used for testing, was chosen two adjacent cells of deck disc with the size of 8x8 m.

This fragment has the following options: along the columns axis in one direction cast-in-situ bearing crossbars with the width of 900 mm and the thickness of 270 mm are placed; in the other direction there are braced beams with the width of 500 mm and the thickness of 220 mm.

The deck disc was subjected to the test above the first floor of the frame. In this case, the vertical loading was held on two cells of deck.

In the course of experimental investigations of the as-build deck slabs:

- the deflection plates were measured;
- the cracking was identified.

The fragment test was provided on the two-span scheme (Fig. 3). As the test load unit-load and sand were applied.

The load was increased in stages in accordance to the loading table: table 1. Exposed contour foundation blocks ensured even distribution of the load (supply sand) on the deck cells and prevented the formation of domes. The loading was performed in stages periodically loading one or the other cell of the building.

Interval between loading steps was 15 min. During the holding of deck under the load the metering and thorough examination of the deck surfaces were performed. During the testing the control load according to fracture strength and deformation was achieved.

During the test there were recorded:

- the value of the load and the corresponding deflection;
- the value of deflection while control test load;

During testing it was provided to establish:

- the value of the control load - assumed load;
- the control value of deflection while rigidity testing.

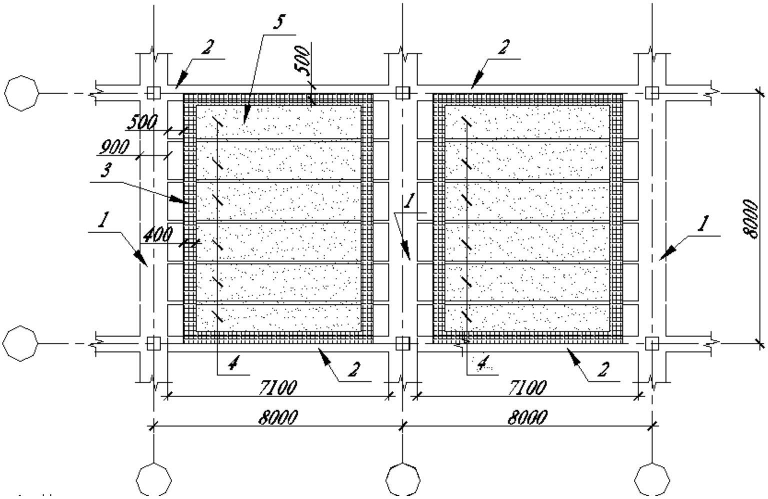

Fig.3. The scheme of precast cast-in-situ deck testing
1-bearing cast-in-situ crossbar, 2-braced beam, 3-unit-loads (foundation blocks), 4-precast hollow-core slabs of deck; 5-sand.

Table 1

The load on the deck on the steps of the testing

№ step of loading	The value of loading on one cell g, kH/m2	Comment
1	390	Placing of unit-loads evenly on the area
2	520	Sand covering till the level of 10cm.
3	650	Sand covering till the level of 20cm.
4	780	Sand covering till the level of 30cm.
5	910	Sand covering till the level of 40cm.
6	1040	Sand covering till the level of 50cm.
7	1170	Sand covering till the level of 60cm.

The registration of deformations and displacements of the elements along all characteristic sections and joints was performed at each stage of loading through dial indicators with scale 0.01 and 0.001 mm and a base of varying lengths, and flexometer Maximov.

During the tests, the results were recorded in the inspection records (readings, layouts), and the slabs were photographed at various stages of the preparation and testing of disk deck.

The cracks at the conjunction places of precast and cast-in-situ elements, as well as at the length of each of the elements, which were tested under full assumed load, were not found.

Fig.5. The loading of a flat precast cast-in-situ deck during the test

According to the results of static tests of as-built frame buildings on the vertical loads, the corresponding calculation for the first group of limit states, it can be concluded that the load did not cause to the frame, as well as its elements an joints, permanent damage, excessive deformations, exceeding acceptable according to the regulations document values. The formation of cracks and opening of joints were not observed.

The lack of reciprocal horizontal displacements of butts, relative to the side edges of cast-in-situ crossbars, indicates that in the horizontal plane overlapping disc works under the load as a single cast-in-situ construction.

The resulting deformations of deck (18.65 mm and 14.64 mm) are within the existing rules (limiting deflection for these elements is 40 mm.)

Table 2.

stage	Load Н/м2	Plates deflection, мм	Beam deflection мм
0	*0*	*0*	*0*
1	*3900*	*0,44*	*1,86*
2	*5200*	*5,32*	*5,93*
3	*6500*	*7,38*	*8,16*
4	*7800*	*9,57*	*8,57*
5	*9100*	*12,41*	*11,99*
6	*10400*	*15,35*	*14,30*
7	*11700*	*18,55*	*14,64*

The main advantage of this type of deck over the traditionally used cast-in-situ material is significantly reduced material consumption. While the thickness of the deck slab is 22 cm, the proposed thickness of concrete is 13 cm. The consumption of reinforcement in such slabs is less than 2 kg per square meter of deck, and with the reinforcement girders it does not exceed 15 kg.

In such deck the important advantage of stressed concrete deck slabs is realized, which by efficient deck can fill more than 80% of the deck area.

Using this precast cast-in-situ deck any spans up to 8 m at rated load up to 12 kH per square meter can be overridden. If it is necessary to override long spans, the hollow-core slabs with greater thickness should be used, and also with greater bearing capacity, which is easily controlled by the amount of set stressed reinforcement.

The use of a flat precast cast-in-situ deck allows reducing the complexity of the frame construction and material consumption up to 20%.

CONCLUSION

1. Flat precast cast-in-situ deck can be successfully applied in Ukraine, using hollow-core flooring slabs, produced using existing traditional factory production lines, as well as building new lines of continuous forming.

2. The tests of cast-in-situ deck demonstrated reliable work as the joint, and the normal section of the slab;

3. Shift and shear of the plate according to the cast-in-situ crossbar during tests were not identified;

4. The results of the test fragment of precast cast-in-situ deck of full assumed load demonstrate its strength and fracture rigidity.

5. The resulting deformation of deck (18.65 mm and 14.64 mm) are within the existing rules (limiting deflection for these points is 40 mm.)

6. As a result of tests of precast cast-in-situ deck fragment to test load 11.7 kH/m2 it was found that the deck construction meets the requirements of the project and normative documents on strength, deformation and fracture strength.

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