

The Reliability of Building Structures Against Power and Environmental Degradation Effects

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Abstract. In recent years, both Russian and foreign researchers have paid considerable attention to the problem of ensuring the reliability of building structures at all stages of their erection and operation, reconstruction, repair and reorganization. This is due to the growing need to ensure reliable operation of unique, expensive, historically significant structures, which dismantling and replacement are much more expensive than repair or it is impossible generally. Damage to reinforced concrete structures, as a rule, is associated with corrosion, overloading of individual elements and improper operation, design and production errors. In this article, the process of examining the reinforced concrete bearing structure of the building overlap for the possibility of its reconstruction and reorganization is considered in detail, as well as the design calculation based on computer modelling in the LIRA-CAD program.

1. Introduction

The practicability of buildings and structures reconstruction and reorganization is determined by many factors, including: the architectural and historical significance of the object, urban planning problems, architectural and planning and organizational and technological solutions, environmental, social and economic issues, remoteness from urban vehicles and communications, availability of infrastructure. Each object of reconstruction is individual; it has operational characteristics differing from other buildings, as well as physical and moral wear. Therefore, before reconstruction, it is necessary to conduct a thorough organizational and technical training based on the data of technical diagnostics and examination of the actual state of the building structures using modern design calculation techniques based on computer modeling. In this article, the process of examining the reinforced concrete bearing structure of the building overlap for the possibility of its reconstruction and reorganization is considered in detail, as well as the design calculation based on computer modeling in the LIRA-CAD program.



2. Surveying of reinforcement and concrete.

Before researches, the reinforcement position is determined in order to exclude the effect of metallic elements in the body of concrete on the instrument's reading. Reinforcement of load-bearing structures was determined by a non-destructive, electromagnetic method with the HILTI Ferroskan PS 200S device, and using pcontrol completions, to determine the reinforcement class (type of profile) and calibration of the device. According to the data, a statement is made with actual reinforcement compared with the project data. Control taps were made in the BB / 12 and C / 12 axes in order to clarify the reinforcement class and its diameter. According to the results of the survey, it is established that the reinforcement class A400 corresponds to the project, the diameter of reinforcing bars in the direction X in the upper support zone is 28 mm, which corresponds to the project for additional reinforcement. The strength of concrete monolithic reinforced structures is determined by nondestructive methods. The measurements were performed by the ultrasonic method (the surface sounding method), using the "UK-1401" device. The principle of determining the concrete strength by ultrasonic method is based on the existence of a functional connection between the speed of propagation of ultrasonic vibrations and the strength of concrete. The ultrasonic method is used to determine the strength of concrete classes B7.5 - B40 (grades M100 - M450) for compression. The strength of concrete structures is determined experimentally using the calibration dependences of the "ultrasound propagation speed: concrete strength: $V = f(R)$ " or "propagation time of ultrasound t - concrete strength: $t = f(R)$ ". Statistical evaluation of the concrete strength using universal calibration dependencies is not allowed. The approximate value of the conventional class of concrete is determined without statistical processing, taking it equal to 80% of the average strength of the concrete structure, site or group of structures, but not more than the minimum specific value of concrete strength. The work includes cleaning the surface of structures, including removal of finishing layers, performing at least six measurements in each section in two directions, obtaining an average value and processing the results. According to the results of the ultrasonic measurement, it was found that the strength of the concrete slab in the surveyed areas varies from 32.1 to 41.5 MPa that corresponds to the concrete strength class for compressive strength B30 (the strength of the concrete overlapping in the project is B35). The strength of concrete columns in the surveyed areas varies from 34.2 to 40.0 MPa that corresponds to the class of concrete for compressive strength B30. According to the results of a visual inspection of the slab at -0.420 m (bottom of the slab) and at -0.120 m (the top of the slab), it is established that there are no distributed loads at -0.120 m, except for the weight of the slab and the weight of the partitions; at a mark -0.420 m to the slab cover fixes ventilation, pipelines of the sprinkler fire-extinguishing system, sewerage and other utilities, as well as sectional gates; on the upper surface of the plate near the column in the BB / 12 axes there is a single crack, with an opening 0.2-0.3 mm, a length of about 600 mm, parallel to the face of the column. The lower surface of the floor slab at -0.420 m is finished with textured plaster. There is no damage in the form of cracks in the plaster layer along the lower surface of the overlap in the axes C-BB / 11-13. According to the results of the geodetic survey it was found that the maximum vertical deflection along the bottom surface of the slab in the span is 46 mm (relative to the mark in the support zone in the C / 13 axes -14).. A special feature of the computer modeling is the static calculation performed in the LIRA-SAPR software package 2015. As a result of preliminary estimation and verification of the variants in the project schemes, the element model consisting of rod elements and plates is adopted as the basic design model. The calculation was carried out in linear and nonlinear formulations.

3. Initial data for calculation.

Load summary in the calculation zone and the load from the partitions are presented in Table 1.

Table 1. Loads on the overlap at a mark -0.120

№	Loading name	Normative values (t / m ²)	The load reliability index γ_f	Rated loads (t / m ²)
1	Dead load (g)			
1.1	Dead load of reinforced concrete slab ($\delta=300$ mm; $\gamma=2.5$ t / m ²)	0.75	1.1	0.825
	Total dead load (g)	0.75	1.1	0.825
2	Constant load (q)			
2.1	Floor construction with screed	0.200	1.1	0.220
3.1	Loading from the premises	0.900	1.1	0.990
4.1	Suspended load	0.060	1.2	0.072
	Total constant load (q)	1.910	1.10	2.107
	Total full load (g+q+v_{sh})-	1.91	1.10	2.11
	Total full sustained load (g+q+vl)	1.91	1.10	2.11
3	Partitions			
5.1	Foam block partitions t=200 mm	0.50	1.20	0.60

Load from the partitions is applied linearly due to the calculation scheme. The scheme of the calculation area is presented in Figure 1.

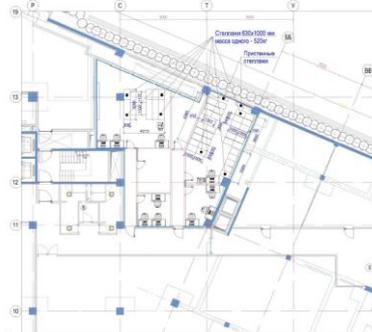


Figure 1. The scheme of the calculation area.

The schemes of the bottom and the upper reinforcement along the digital axes (in X and Y) are shown in Figure 2. The reinforcement class is A400.

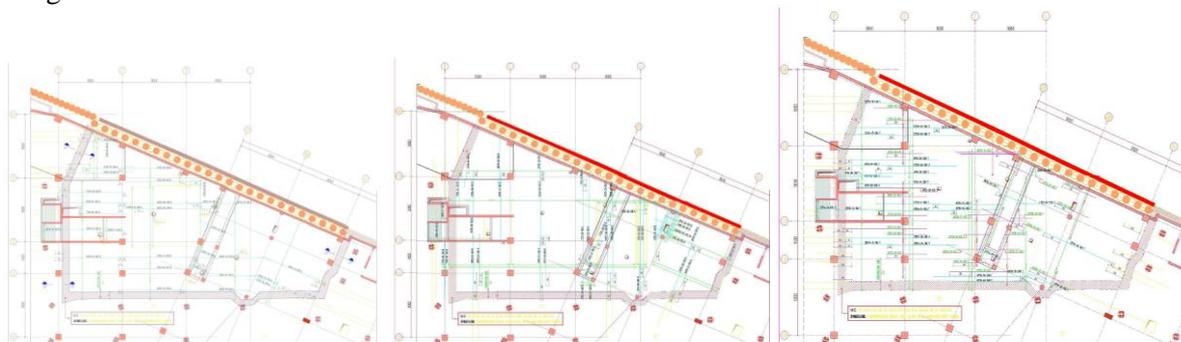


Figure 2. The schemes of the bottom and the upper reinforcement along the digital axes (in X and Y).

The scheme of the web reinforcement is shown in Figure 2. General view of the calculation model is shown in Figure 3. The reinforcement class is A400.

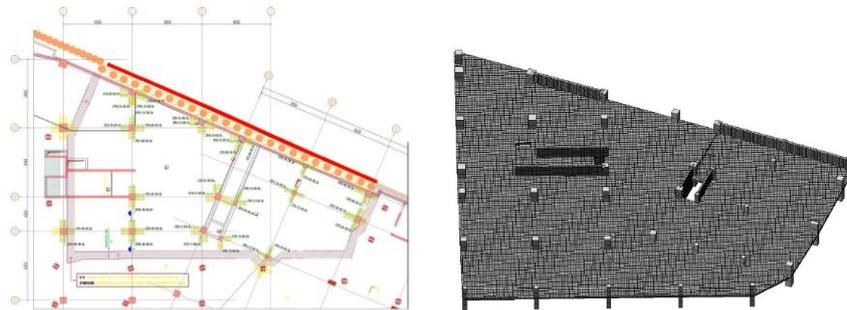


Figure 3. The scheme of the web reinforcement and the general form of calculation scheme.

The thickness of the slab is 300 mm, in the axes P-C / 13-14 the thickness is 350 mm without beams and capitals. The size of the columns section is 800x800.

4. Calculation results

The cross-sectional areas of the bottom and the upper reinforcement along the digital axes (in X and Y) per linear meter of the slab at -0.120 are shown in Figure 4. The reinforcement class is A400.

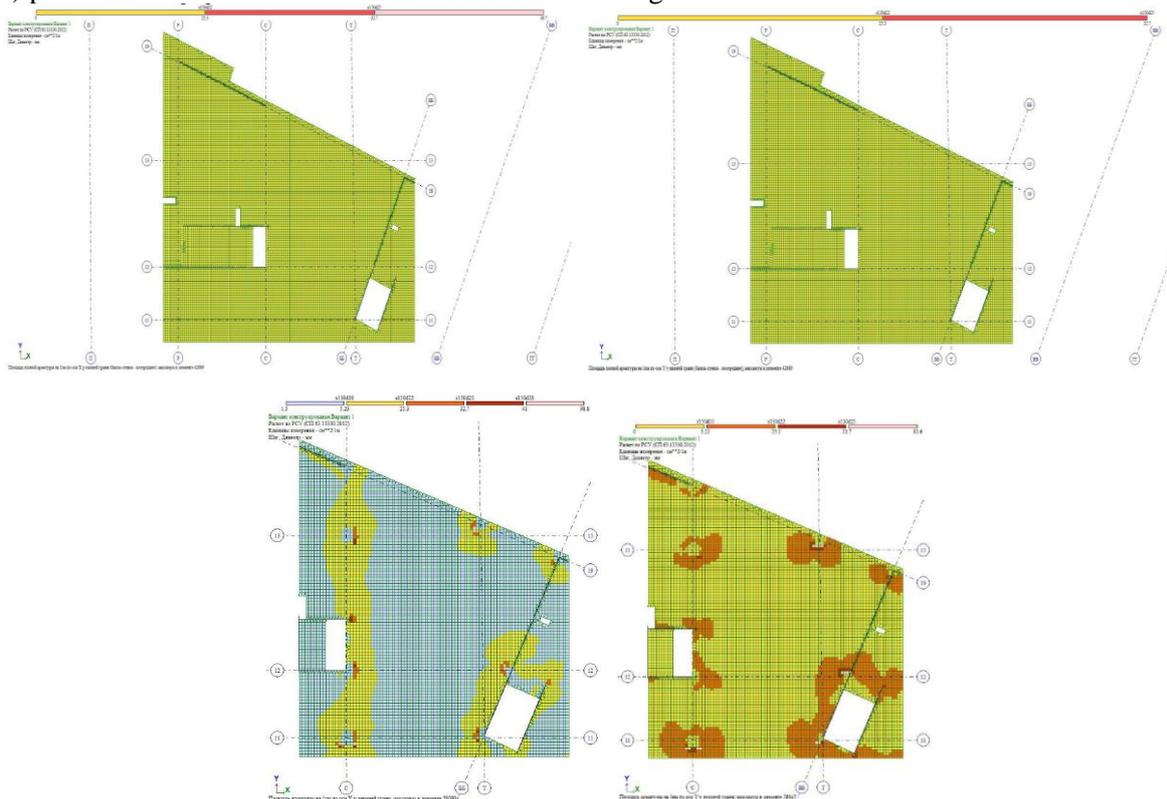


Figure 4. The cross-sectional areas of the bottom and the upper reinforcement along the digital axes (in X and Y).

The cross-sectional area of the bottom reinforcement according to X per linear meter of reinforced concrete slab is according to the documentation data is 32.70 cm². The maximum required area is 14.2 cm². Based on the data obtained, it can be concluded that the bearing capacity of the slab in the direction of X is sufficient. The cross-sectional area of the bottom reinforcement according to Y per

linear meter of reinforced concrete slab is according to the documentation data is 32.70 cm^2 . The maximum required area is 13.8 cm^2 . The bearing capacity of the slab in the direction of Y is sufficient. The cross-sectional area of the upper reinforcement according to X per linear meter of reinforced concrete slab is according to the documentation data is 32.70 cm^2 . The maximum required area is 47.0 cm^2 . Based on the data obtained, it can be concluded that the bearing capacity of the slab in the direction of X is not sufficient. The cross-sectional area of the upper reinforcement in Y per linear meter of the reinforced concrete slab in the allocated zone, according to the documentation data, is 35.85 cm^2 . The actual cross-sectional area of the upper reinforcement in Y per linear meter of reinforced concrete slab in the allocated zone is 24.50 cm^2 . The required area is 36.00 cm^2 . The bearing capacity of the slab in the direction of Y is not sufficient. The maximum deflection at full load is 30 mm with a span of 10 m, which is less than the limiting limit of 40 mm.

5. Conclusions

The strength of the slab is not provided for pressing in the slab in the column area in the T/ 13 and C/11 axes and in normal sections in the support zone of the slab on the column in the axes T/13, C/12, T/11, C/12-13, T/11, BB/12. Carrying out of works on reconstruction and adaptation requires measures to ensure the strength of bearing structures. Structures rigidity is ensured. For joints in the C/12, T/11, C/12-13 axes, there are two possible ways to provide load-bearing capacity. The first way is reducing the load by replacing the concrete screed with light adjustable floors (up to $50 \text{ kg} / \text{m}^2$ in weight) in the axes 11-13 / C-U, and also limit the time load in these axes to $200 \text{ kg} / \text{m}^2$ ($200 \text{ kg} / \text{m}^2$) - the normative temporary load on the floor according to SP 20.13330.2011 "Loads and impacts", perform the strengthening, for example, using composite materials. For column joints in the C/11, T/13, BB/12 axes, adjusting loads up to a weight reduction and a temporary load of 50% does not lead the joints to a safe state, it is necessary to perform the strengthening. Due to calculations it is turned out that some of the columns joints that are outside the influence zone (for example, P/10, P/11, C/10 at -0,120), the forces from the design loads significantly exceed the forces that cause overvoltage in the joints in the calculated zone, while there is no provision for any additional reinforcements for punching (reinforcement, capitals) for these joints. In this regard, it is recommended to conduct sample surveys and verification calculations in other areas of the building in order to determine the sufficiency of the decisions taken to ensure the mechanical safety of the building or measures to ensure it.

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