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# Experimental tests of the over-columned plates of the precast building frame

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**Abstract.** The construction of a precast flat plate frame of buildings is considered for its implementation during the restoration of the housing stock of Ukraine. The analysis of the precast flat plate floor system of the frame structural system by using the yield line method showed that in the ultimate state the floor is divided into separate discs along the joints of precast plates. This makes it possible to determine the load-bearing capacity of the floor by considering each plate taking into account their supporting and loading conditions. Based on this, experimental tests of three full-size over-columned plates of a precast flat plate floor system are carried out, according to the diagram closest to the actual scheme of their operation as part of the floor. The general deflections of the plates, moments of crack formation and width of their opening, as well as strains of concrete and reinforcement in characteristic cross-sections of the plates are determined. Based on the experimental tests, the accepted failure scheme of the over-columned plates of the precast flat plate floor system is confirmed and the feasibility of applying the yield line method to the calculation of their bearing capacity is proven.

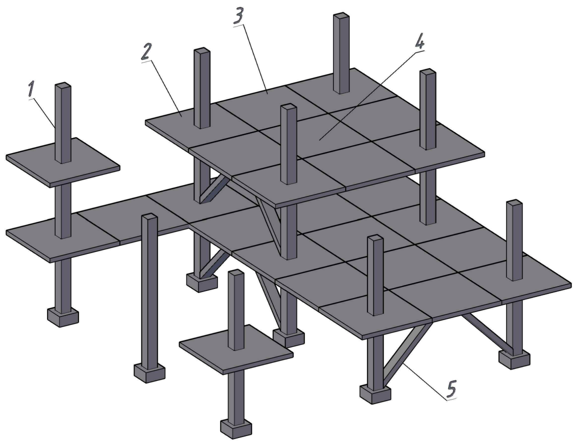
## 1. Introduction

To date, renewal of the housing stock of Ukraine has become one of the most urgent tasks in the field of construction. This task can be solved by introducing modern structural systems in the erection of buildings and structures. It is quite possible and expedient to apply the structural system of buildings based on a precast flat plate frame [1] to solve this problem.The benefits of using the named system are proven: construction speed increases by 50% due to the use of industrial precast reinforced concrete structures; installation of reinforced concrete members does not depend on weather conditions and can be carried out throughout the year; starting a production line for the manufacture of precast members is quite simple and can be done in the shortest possible time; the frame has features that allow each building to have unique architectural forms, which makes the urban landscape more attractive and diverse; architectural and planning solutions meet high aesthetic requirements, provide comfort and a high level of microclimate; the cost of 1 square meter of housing is reduced by almost 40% compared to buildings using traditional structural systems.

The precast flat plate frame structural system of buildings is being widely implemented in residential construction (figure 1). The flat plate of the structural system is arranged on columns and is a simple structure consisting of reinforced concrete plates of the same thickness and shape. This composition of floor components simplifies the process of formwork and production and significantly speeds up the construction of objects. The main structural members of the flat plate

**Figure 1.** One of the new buildings of precast flat plate frame structural system in Poltava.

(*a*)




(*b*)

**Figure 2.** Precast flat plate frame structural system of buildings: (*a*) a building under construction and (*b*) the general view of the structural system: 1 – column; 2 – over-columned plate; 3 – inter-columned plate; 4 – middle plate; 5 – linear brace.

frame structural system are columns and plates (figure 2). Flat floors are directly connected to columns without the use of protruding members, which provides the opportunity to freely adapt the architectural and planning solutions of buildings for any purpose.

The design of flat plate frame structural systems is usually carried out by dividing them into flat orthogonally located frames [2, 3]. At the same time, the frame is considered as a set of frames with rigid nodes. Over-columned and inter-columned floor plates in the range of each row of columns are considered as continuous crossbars of the frames, and therefore are designed as continuous beams at equalized moments based on consideration of the redistribution of forces in the ultimate limit state. The middle plate is designed as two-way slab according to the limit equilibrium method, taking into account the fastening way in the supporting circuit.

Meanwhile, as practice shows, the work of members in the framework of a precast flat plate structural system differs from that implemented in the mentioned design schemes. In particular,

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in the precast version of the structural system the destruction scheme of its members is formed depending on the design of the joints of the precast members. At the same time, the schemes of deformation of floor plates are accepted as for plates with special fastening conditions. As evidenced by works [1, 4], for the strength design of plates supported along the contour, it is quite expedient and convenient to use the yield line method, which allows taking into account the actual conditions of fastening, reinforcement and the nature of the destruction of members.

The application of the yield line method [5–9] to the calculation of the bearing capacity of reinforced concrete plates is considered for plates made of fiber concrete [10, 11], plates supported on two adjacent sides [12], plates with an irregular grid of columns [13], plates with the destruction of individual columns [14], as well as in many other cases [15–19]. Data of theoretical calculations in the mentioned works are supported by experimental results. Experimental data [20] for plates of the flat plate frame structural system are scarce today, so there is a need to experimentally investigate the members of this system in order to confirm the proposed fracture schemes [4].

## 2. Construction of experimental samples of over-columned plates

Three experimental full-scale samples of over-columned floor plates were used for conducting experimental tests. The plate samples had nominal dimensions of 2980×2980×160 mm. The specified geometric characteristics are adopted for the purpose of their compliance with the unified dimensions of precast reinforced concrete members of the flat plate floor system. The design of the test sample and its geometric dimensions are shown in figure 3. The reinforcement scheme of the experimental sample of the over-columned plate is displayed in figure 4. The characteristics of concrete and reinforcing steel used in the manufacture of the samples of the experimental over-columned plates are specified in table 1.

**Table 1.** Characteristics of materials used in the manufacture of experimental samples of over-columned plates.

| Physical and mechanical characteristics of materials | Plate PO-1 | sample PO-2 | code PO-3 |
|---|---|---|---|
| Reinforcement A500C | | | |
| Ø18, $\sigma_y$, MPa | 600 | 600 | 600 |
| Ø14, $\sigma_y$, MPa | 610 | 610 | 610 |
| Ø10, $\sigma_y$, MPa | 620 | 620 | 620 |
| Ø8, $\sigma_y$, MPa | 630 | 630 | 630 |
| Concrete C25/30 | | | |
| $f_{cd}$, MPa | 17 | 17 | 17 |

The production of the tested samples of the over-columned plates is divided into stages: at the first stage, reinforcement products are made for laying in the formwork, at the second stage, concreting is carried out A500C class bars are used as the principal reinforcement of the plates. The over-columned plates are reinforced with a spatial reinforcing cage (figure 4), which includes the upper and lower plane meshes and embedded support structure. The upper mesh was assembled by hand in conjunction with the support structure of the plate in the form of a steel clip and vertical cages welded to it.

The over-columned plates are made of heavy concrete, which has an average density ranging from 2200 kg/m$^3$ to 2500 kg/m$^3$. Strength class of concrete is C25/30 [3]. The over-columned

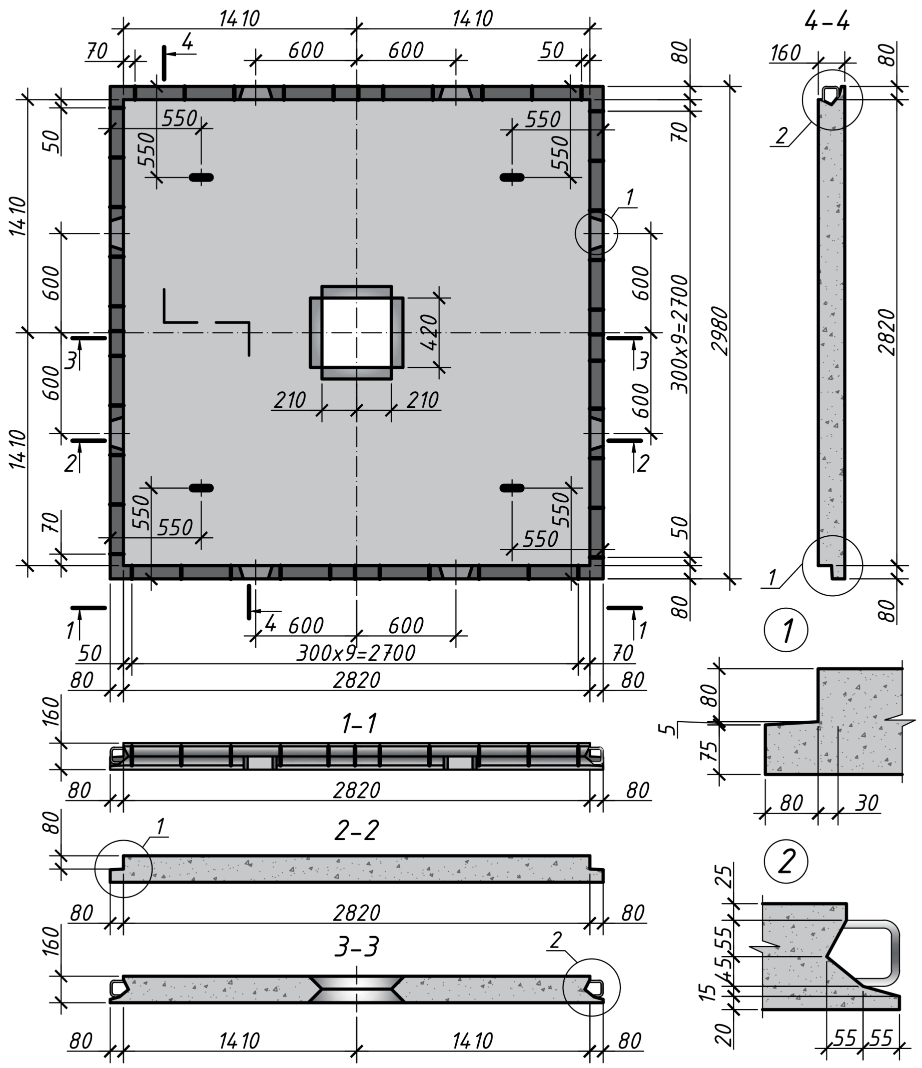



**Figure 3.** Design of experimental samples of over-columned plates.

plates are reinforced with reinforcing components made of of A500C steel, which included (positions on figure 4):

1 – the plane M-1 mesh made of steel bars of a diameter 14 mm, a length of 2800 mm, connected to an embedded support structure SSE-1, in which 3 outlets of reinforcement with a diameter of 18 mm are arranged on four sides (figure 5);

2 – the plane mesh M-2 made of steel bars with a diameter of 8 mm and a length of 2960 mm;

3 – bent bars B-1 with a diameter of 12 mm, a length of 800 mm, a bending angle of 90°;

4 – the spatial cage CS-1 made of steel bars with a diameter of 12 mm and a length of 850 mm and reinforcing bars with a diameter of 4 mm and a length of 300 mm;

5 – bent bars B-2 with a diameter of 12 mm and a length of 800 mm.

To determine the physical and mechanical characteristics of the reinforcing steel (table 1) the passport data provided by the manufacturer are used.

The production of reinforcing cages, meshes and embedded parts, as well as concreting of over-columned plates was carried out at the plant of reinforced concrete products of "Combinat of industrial enterprises" in the village of Tereshki of Poltava region.

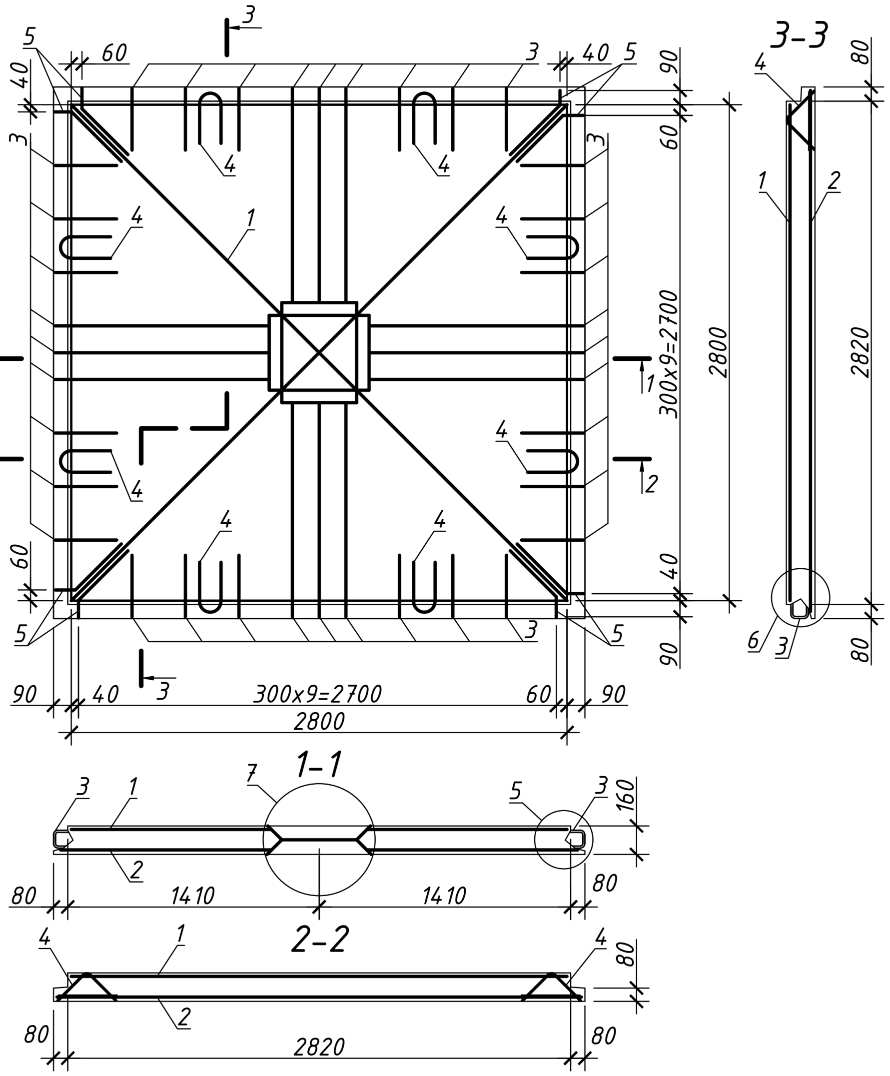



**Figure 4.** Reinforcing scheme of the experimental sample of the over-columned plate: 1 – mesh M-1; 2 – mesh M-2; 3 – bent bar B-1; 4 – spatial cage CS-1; 5 – bent bar B-2.

The concrete mixture was produced directly at the concrete unit of the enterprise. Dosing of components took place in automatic mode. Laying of the concrete mixture was carried out using a dosing device. After laying the concrete mixture in the metal formwork, it was compacted with deep vibrators. Hardening of the concreted samples took place under the conditions in the steaming chamber. After the concrete reached full strength, the elements were released from the formwork. After that, the tested samples of the over-columned plates were transported to the laboratory of the Department of Building Structures of the National University "Yuri Kondratyuk Poltava Polytechnic" for testing.

In the laboratory, strain gauges with a base of 50 mm and 20 mm, respectively, were pasted on the concrete and on the reinforcing bars of the experimental plate samples in the zones of their possible destruction. Gluing of strain gauges was carried out using BF-2 glue, following all recommendations for performing such works. Previously, the surface of concrete and reinforcing bars in the areas where strain gauges were installed was cleaned, polished, degreased with a solvent and primed with glue.

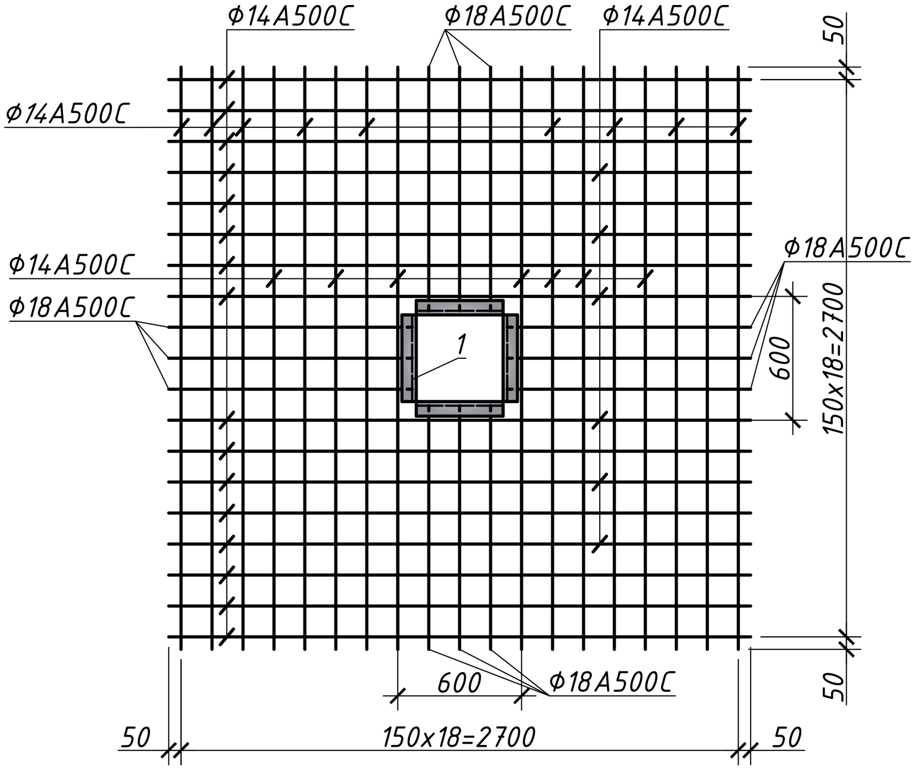



**Figure 5.** Structure of the reinforcing mesh M-1 of the over-columned plate: 1 – embedded support structure SSE-1.

## 3. Methodology of over-columned plates tests

Control tests of full-scale samples of over-columned plates is carried out on a specially designed stand according to the developed scheme (figure 6). It is impossible to simulate the supporting and loading scheme of the plate, which would absolutely correspond to the real work of the plate as a member of a precast flat plate floor system. That is why the testing scheme of over-columned plates is adopted in such a way that it allowed implementing the design fracture scheme accepted on the basis of the yield line method, which is realized in the composition of a flat plate floor system [4].

A stand with a hydraulic jack was used to load the experimental samples of the over-columned plates. The pressure in the system was increased using a mobile pumping station. A pressure gauge, which was previously tared, was used to measure the load. When conducting static load tests, the following measuring devices were used: watch-type deflection gauge 6PAO with a division value of 0.01 mm (figure 6) for measuring linear displacements; strain gauges for measuring concrete and reinforcement deformations (figure 7); MPB-2 microscope with a resolution of 0.05 mm for measuring the crack opening width.

The general appearance of the installation during the testing of the over-columned plate samples and the location of all measuring devices is presented in figure 8.

## 4. Over-columned plates tests results

The testing of the over-columned plates PO-1, PO-2, and PO-3 was carried out to an external load of 320 kN, 360 kN, and 400 kN, respectively. These values of load made up about $0.55F_{Rd}$, $0.6F_{Rd}$, and $0.7F_{Rd}$, respectively, where $F_{Rd}$ = 580 kN – the design value of the destructive load, calculated by the yield line method for the over-columned plate according to [4] taking

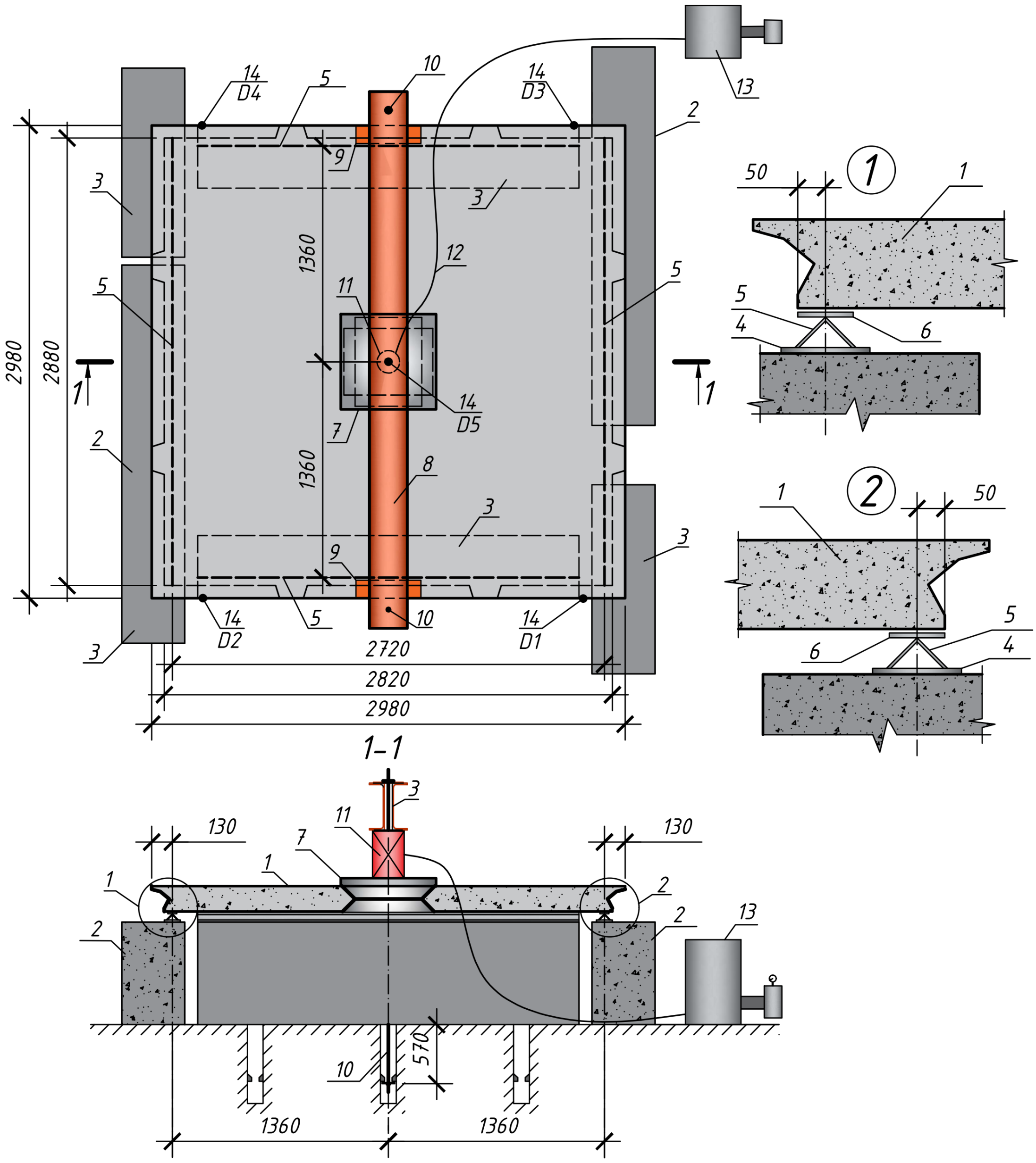
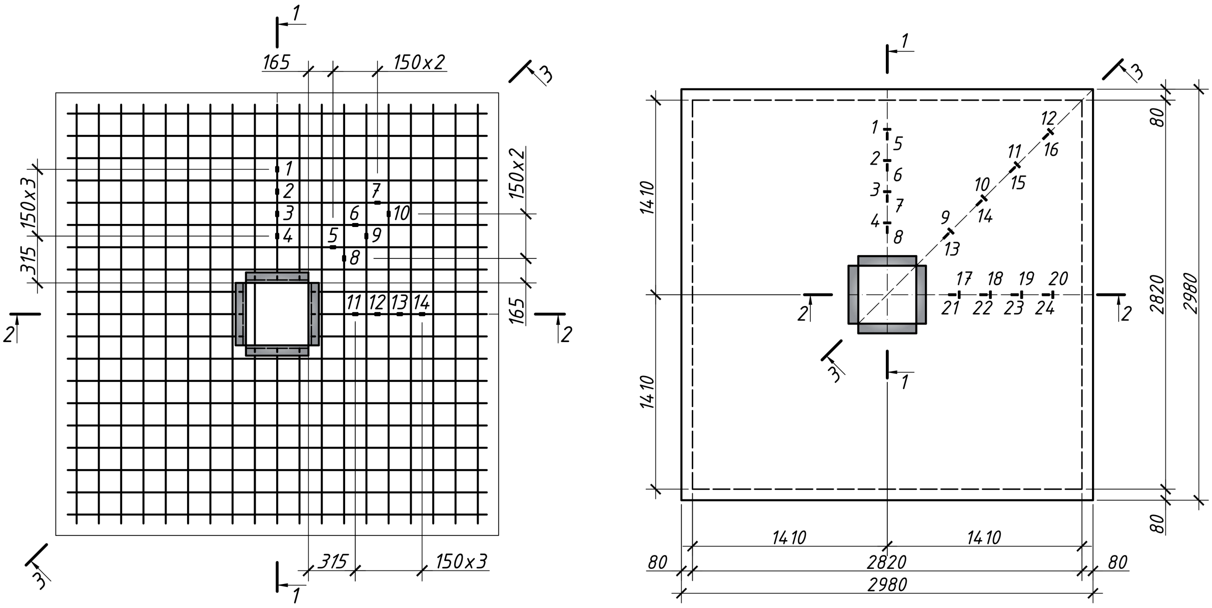



**Figure 6.** Test scheme of the over-columned plate: 1 – plate PO; 2 – supporting element (concrete block FB 24.6.5); 3 – supporting element (concrete block FB 12.6.5); 4 – steel plate (strip 150×10); 5 – unmovable hinged support (steel angle bar 75×5); 6 – steel plate (strip 100×8); 7 – steel plate (strip 600×5); 8 – traverse (2 channels No. 30); 9 – temporary support for the traverse; 10 – steel bar (Ø30A240); 11 – hydraulic jack F = 500 kN; 12 – oil pipeline; 13 – pumping station; 14 – 6PAO watch-type deflection gauge.

into account calculated values of ultimate strains of concrete in compression.

In the course of the tests, it was noted that the character of the formation of cracks and the deflections growth of various test samples of plates PO-1, PO-2 and PO-3 did not differ significantly, since all the test samples had the same geometric dimensions and were tested according to the same supporting and loading scheme (figure 6).

When testing the PO-1 plate, the first crack was formed near the supporting opening along




(*a*) (*b*)

**Figure 7.** Strain gauges arrangement diagram: (*a*) on the principal reinforcement of the over-columned plate: 1 ... 14 – gauges with a base of 20 mm and (*b*) on the concrete of the over-columned plate: 1 ... 24 – gauges with a base of 50 mm.

(*a*) (*b*)

**Figure 8.** General view of the over-columned plate PO-1 during the test: (*a*) top view and (*b*) side view.

one of the diagonals of the plate under a load of 120 kN ($0.2F_{Rd}$). When the load increased, it began to open, and then another crack was formed along the other diagonal of the plate. During loading, these cracks extended along the diagonals in the direction from the center of the plate to its edges. The opening width of the cracks in the plate under a load of 120 kN was 0.1 mm, under a load of 320 kN ($0.55F_{Rd}$) the width of the crack reached 2 mm.

During the experimental tests of the PO-1, PO-2, and PO-3 the dependence of the deflections on the magnitude of the external load was studied. The readings of the deflection gauges (D1 – D5), the location of which is shown in figure 6, were recorded for all slab samples up to a load value of 320 kN. Graphs of the dependence of deflections of full-scale over-columned plates on

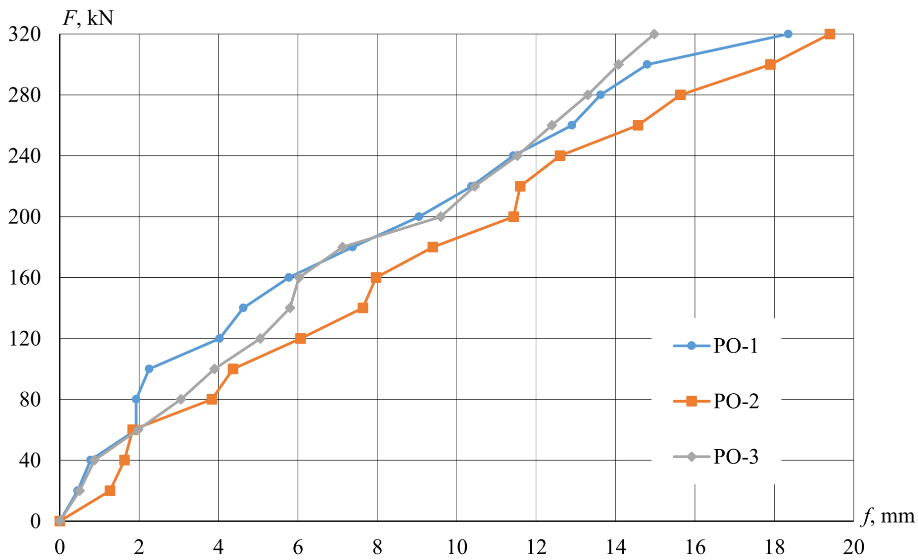



**Figure 9.** Growth of the total deflection of the over-columned plates during the test.

the value of the external load are shown in figure 9.

It can be seen from the graphs (figure 9), up to a load value of 40 kN ($0.07F_{Rd}$) in PO-1 and PO-3 slabs and 60 kN ($0.1F_{Rd}$) deflections in the plates grew much more slowly than after this level, which is explained by the influence concrete work in the tensile zone of the plate by the amount of its deflections. As long as the concrete in the tensile zone of the plate perceives the tensile forces, the deflections grow more slowly, but as soon as the tensile forces cease to be perceived by the concrete, due to the formation of cracks in it, the deflections begin to grow faster.

The specified load levels can serve as moments of crack formation in the tensile zone of the over-columned plate. In addition, by analyzing the graphs in figure 9, it can be concluded that the dependence of the deflections on the load level is directly proportional. That is, the dependence of the deflections on the load on the graphs is linear, when the principal reinforcement of the plate, located in its tensile zone, works elastically.

The graphs (figure 9) show that at the external load level of 280 kN ($0.5F_{Rd}$) the deflections of all test samples of the over-columned plates are the closest in terms of values. The deflection values for PO-1, PO-2 and PO-3 plates are 13.9 mm (l/209) and 14.9 mm (l/195) and 13.9 mm (l/209), respectively. The maximum measured deflections of plates PO-1, PO-2 and PO-3 under a load of 320 kN ($0.55F_{Rd}$) were 18.2 mm (l/159), 18.4 mm (l/158) and 15.6 mm (l/186) respectively.

When conducting experimental studies, the strains of concrete and reinforcement were measured on one of the four quarters of the plate (figure 7), since the plate is symmetrical with respect to two mutually perpendicular axes of symmetry passing through the center of gravity of the structure. This made it possible to study sufficiently the features of the stress-strain state of the test samples.

The regularity of the distribution of deformations can be traced on the graphs of the dependence of the strains $\epsilon_s$ of the tensile reinforcement on the value of the external loading F, constructed based on the results of experimental studies (figure 10, figure 11).

The graphs (figure 10, figure 11) show that the strains of the reinforcement depending on the load had different values in different areas. From the very beginning of loading, the maximum strains were observed in section 3-3, and with further loading, these strains in the diagonal direction (section 3-3) significantly increased and the difference between them and strains in the

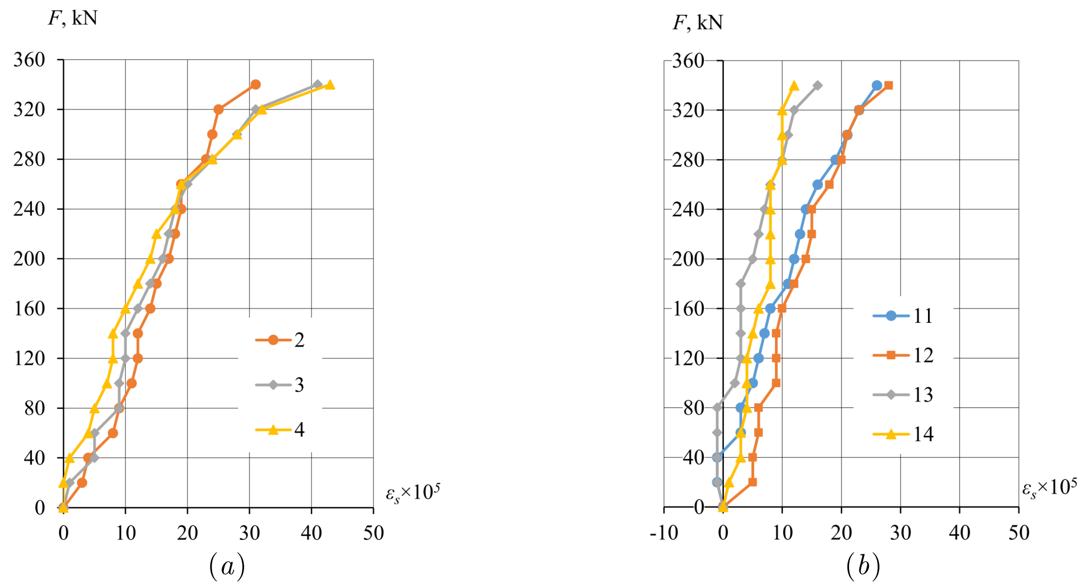



**Figure 10.** Strains of the principal reinforcement of the over-columned plate PO-1 during loading: ($a$) in section 1-1 and ($b$) in section 2-2.

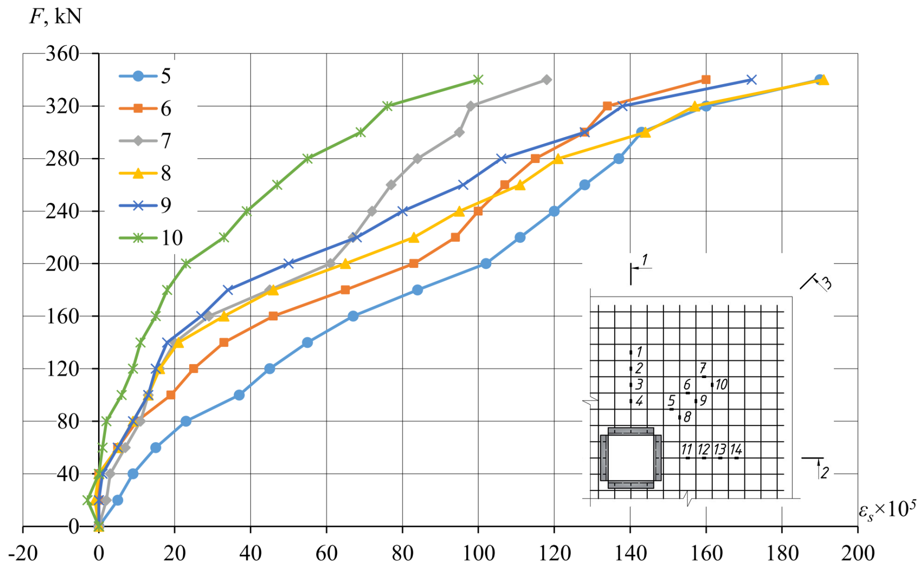



**Figure 11.** Strains of the principal reinforcement of the over-columned plate PO-1 during loading in section 3-3.

longitudinal and transverse directions (sections 1-1 and 2-2) enlarged considerably.

As it can be seen from graphs in figure 10, in sections 1-1 and 2-2 the bars work proportionally according to the perceived load. At the same time, the values of their strains in the PO-1 slab under a load of 320 kN ($0.55F_{Rd}$) are $10 \times 10^{-5}$ – $32 \times 10^{-5}$ ($0.03\epsilon_{s0}$ – $0.1\epsilon_{s0}$), in the PO-2 slab under a load of 360 kN ($0.6F_{Rd}$) – $9 \times 10^{-5}$ – $37 \times 10^{-5}$ ($0.03\epsilon_{s0}$ – $0.1\epsilon_{s0}$), in the PO-3 slab under a load of 400 kN ($0.7F_{Rd}$) – $3 \times 10^{-5}$ – $23 \times 10^{-5}$ ($0.03\epsilon_{s0}$ – $0.08\epsilon_{s0}$), where $\epsilon_{s0} = \sigma_y/E_s = 600/210000 = 286 \times 10^{-5}$ – strains of reinforcement at the yield point (table 1). Therefore, it is possible to draw a conclusion about the savings reserves of these bars.

Examining the graphs of reinforcement strains in cross-section 1-1 (figure 10, a) at the locations of gauges 1-4, it may be concluded that with the gradual approach to the supporting opening, the strains of the bars in the tensile zone of the plate increase slightly. At that time, in section 3-3 (figure 11), a significant increase in strains is observed as the reinforcing bars approach the opening.

The graphs of the strains of reinforcing bars in the diagonal section 3-3 (figure 11) up to the strain value of $20 \times 10^{-5}$ $(0.07\epsilon_{s0})$ have a significantly greater angle of inclination to the horizontal axis than after reaching this value. This indicates a more intensive reinforcement deformation in the further range, which is explained by the beginning of the formation of cracks in tensile concrete. At the same time, the reinforcing bars reach the mentioned strain values at different values of the external load from 70 kN to 170 kN. The bars closest to the supporting opening are the first to reach the indicated strain values. Therefore, it can be predicted that the failure of the slab will begin when the yield point is reached, first, in the reinforcing bars that pass around the plate's opening.

The maximum values of tensile strains of the principal reinforcement in the diagonal section 3-3 were $160 \times 10^{-5}$ $(0.6\epsilon_{s0})$ under a load of 320 kN $(0.55F_{Rd})$ in the plate PO-1, $181 \times 10^{-5}$ $(0.6\epsilon_{s0})$ at a load of 360 kN $(0.6F_{Rd})$ in the PO-2 slab, $178 \times 10^{-5}$ $(0.6\epsilon_{s0})$ with a load of 400 kN $(0.7F_{Rd})$ in the PO-3 plate and the minimum values were $76 \times 10^{-5}$ $(0.3\epsilon_{s0})$, $98 \times 10^{-5}$ $(0.3\epsilon_{s0})$, $111 \times 10^{-5}$ $(0.4\epsilon_{s0})$, respectively.

During the experimental studies of full-scale over-columned plates PO-1, PO-2 and PO-3, in addition to strains of reinforcement $\epsilon_s$ in the tensile zone of the plate, strains of concrete $\epsilon_c$ located in the compressed zone were also studied.

From the very beginning of the experimental research, during the loading of the test samples of the over-columned floor plates, the maximum values of the concrete compressive strains were observed at the locations of the gauges 1–4, 9–12, and 17–20 (figure 13, figure 14), respectively, in sections 1-1, 2-2, 3-3.

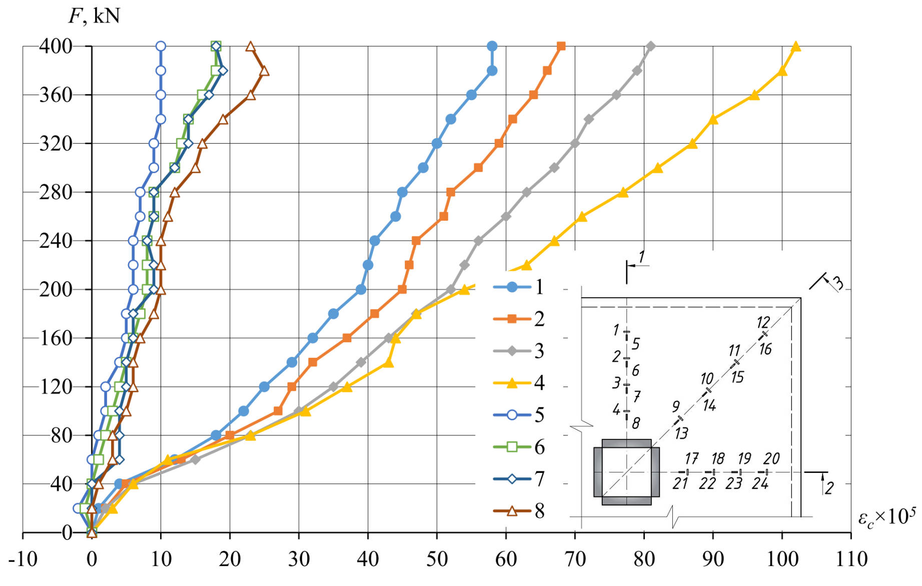



**Figure 12.** Compressed concrete strains of the PO-3 over-columned slab during loading in section 1-1.

By analyzing the nature of the graphs in figures 12–14, it can be noted that the strains of concrete across sections 1-1, 2-2 and 3-3 occurred more intensively than in the longitudinal direction. The specified difference is typical for all sections. The maximum values of compression strains of concrete in the transverse direction in sections 1-1, 2-2 and 3-3 were:

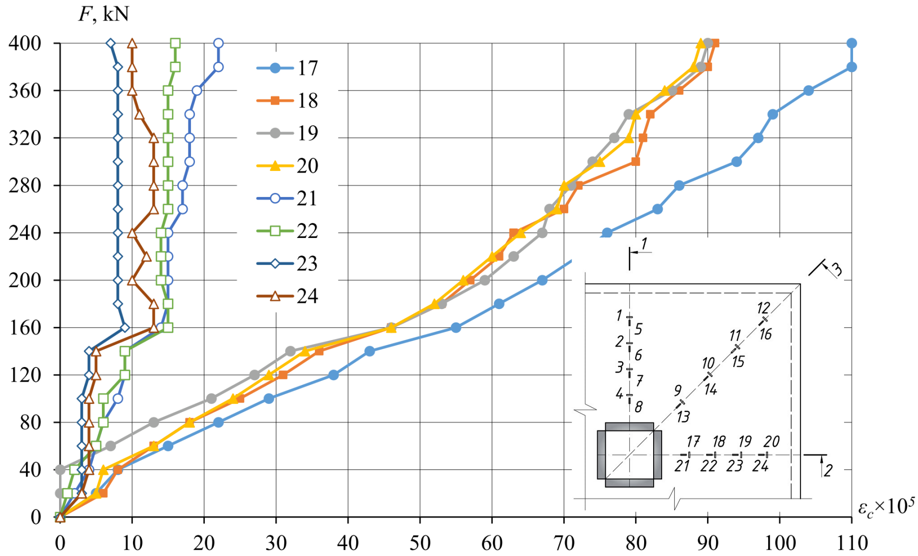



**Figure 13.** Compressed concrete strains of the PO-3 over-columned slab during loading in section 2-2.

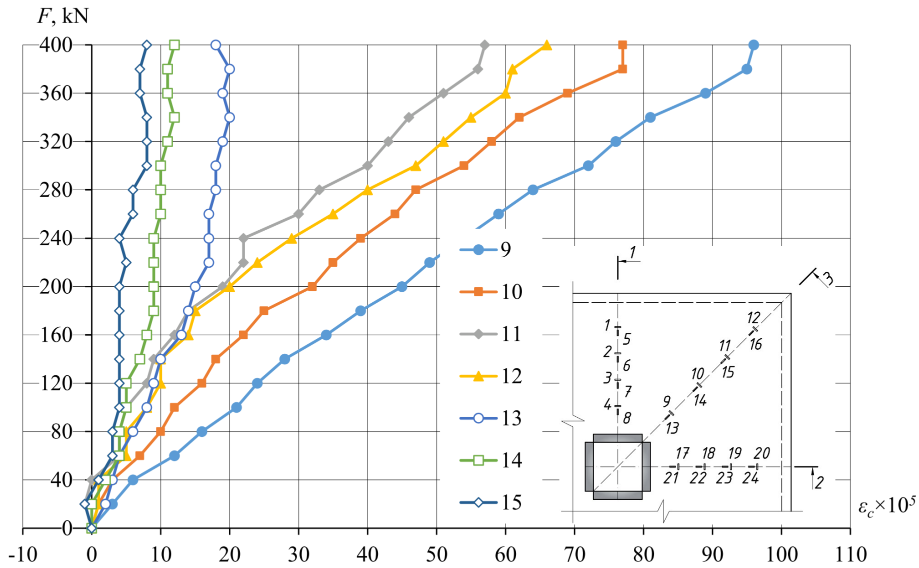



**Figure 14.** Compressed concrete strains of the PO-3 over-columned slab during loading in section 3-3.

- in the PO-1 plate under a load of 320 kN ($0.55F_{Rd}$), respectively $64 \times 10^{-5}(0.2\epsilon_{cu1})$, $110 \times 10^{-5}(0.3\epsilon_{cu1})$ and $70 \times 10^{-5}(0.2\epsilon_{cu1})$;
- in the PO-2 plate under a load of 360 kN ($0.6F_{Rd}$), respectively $52 \times 10^{-5}(0.1\epsilon_{cu1})$, $89 \times 10^{-5}(0.3\epsilon_{cu1})$ and $84 \times 10^{-5}(0.2\epsilon_{cu1})$;
- in the PO-3 plate under a load of 400 kN ($0.7F_{Rd}$), respectively $102 \times 10^{-5}(0.3\epsilon_{cu1})$, $110 \times 10^{-5}(0.3\epsilon_{cu1})$ and $96 \times 10^{-5}(0.3\epsilon_{cu1})$, where $\epsilon_{cu1} = 350 \times 10^{-5}$ – ultimate value of strains of concrete C25/30 according to [3].

The maximum values of compression strains of concrete in the longitudinal direction in sections 1-1, 2-2 and 3-3 were:

- in the PO-1 plate under a load of 320 kN $(0.55F_{Rd})$, respectively $29 \times 10^{-5}(0.08\epsilon_{cu1})$, $23 \times 10^{-5}(0.07\epsilon_{cu1})$ and $30 \times 10^{-5}(0.08\epsilon_{cu1})$,
- in the PO-2 plate under a load of 360 kN $(0.6F_{Rd})$, respectively $17 \times 10^{-5}(0.05\epsilon_{cu1})$, $10 \times 10^{-5}(0.03\epsilon_{cu1})$ and $9 \times 10^{-5}(0.03\epsilon_{cu1})$,
- in the PO-3 plate under a load of 400 kN $(0.7F_{Rd})$, respectively $23 \times 10^{-5}(0.07\epsilon_{cu1})$, $22 \times 10^{-5}(0.07\epsilon_{cu1})$ and $18 \times 10^{-5}(0.05\epsilon_{cu1})$.

Thus, the difference between strains in the transverse and longitudinal directions for all plates ranged in section 1-1 from 69% to 82%, in section 2-2 from 79% to 93%, in section 3-3 from 64% to 84%.

Examining the graphs of concrete strains by gauges perpendicular to the section, it can be concluded that with the gradual approach to the supporting opening, the values of strains of concrete in the compressed zone of the slab increase significantly. At the same time, in the longitudinal direction (according to the gauges located along the cross-sections), this tendency is much less pronounced. By comparing the graphs of strains of compressed concrete and tensile reinforcement, it should be noted that in concrete the distribution of strains in cross-sections 1-1, 2-2 and 3-3 does not have a considerable difference, in contrast to the reinforcement, in which the strains in cross-section 3-3 are significantly larger in comparison with strains in sections 1-1 and 2-2. The indicated trend is clearly demonstrated in the fields of strain distribution over the area of the experimental plates, built according to the results of experimental studies (figures 15, 16).

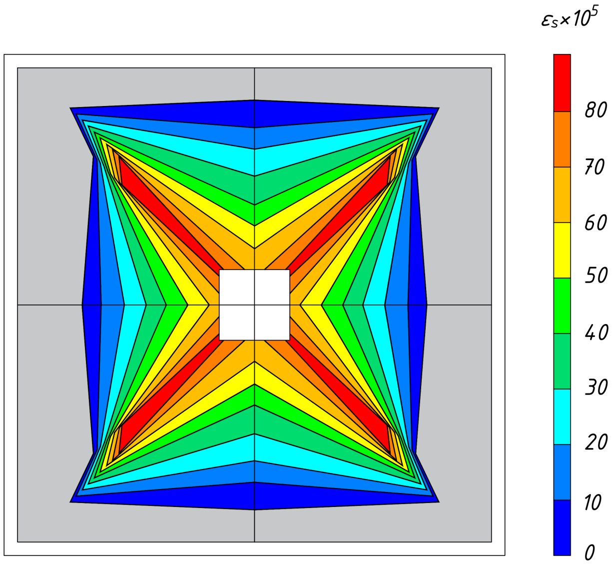



**Figure 15.** Fields of strains' distribution of the principal tensile reinforcement of the PO-1 plate at the moment of destruction.

Figures 15, 16 illustrate that the over-columned plate when working as part of the floor system has the largest values of strains of tensile reinforcement in diagonal directions. At the time of failure, yield lines will form along the diagonals of the plate, which are characterized by reaching the yield point in the tensile reinforcement.

The yield phenomenon, which begins in the most stressed places of the plate – around the supporting opening – with the load increasing will spread to the entire reinforcement along its diagonals, forming lines along which the bending moment reaches the ultimate value. At the same time, the plate will be divided into separate disks connected by diagonal yield lines, which

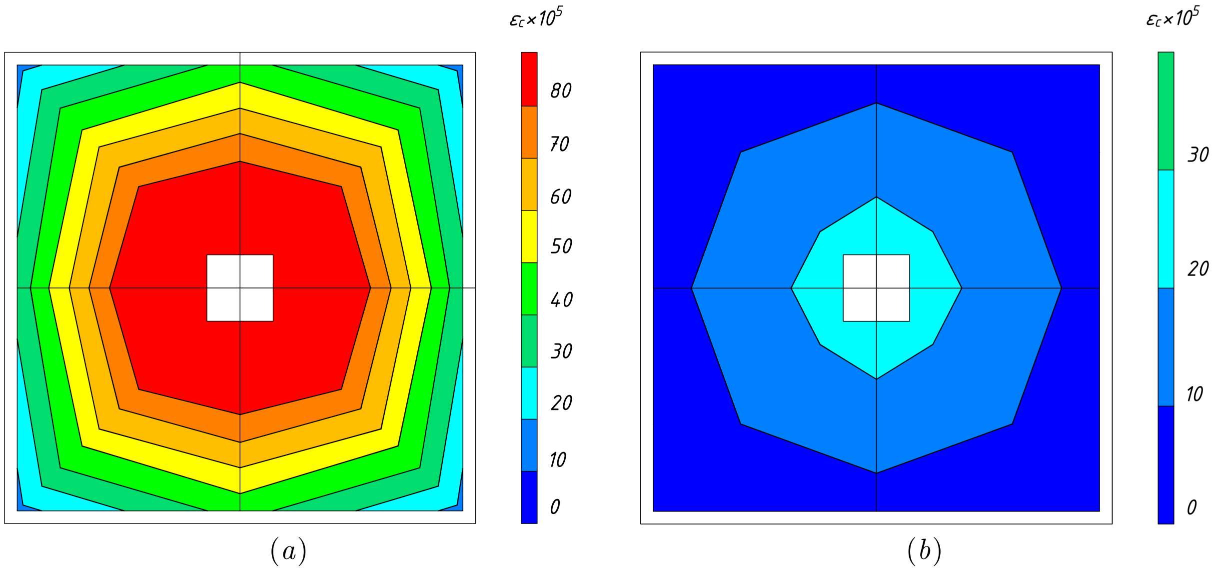



**Figure 16.** Fields of strains distribution of the compressed concrete of the PO-3 plate at the moment of destruction: $(a)$ in the direction transverse to sections 1-1, 2-2, 3-3 and $(b)$ in the direction longitudinal to sections 1-1, 2-2, 3-3.

corresponds to the accepted fracture scheme of the over-columned plate [4] when it is designed using the yield line method.

In addition, it should be noted that the plate works in two directions (figure 16), that is, the concrete of the compressed zone undergoes flat biaxial compression. This aspect is not fully taken into account in the calculations of its bearing capacity. Taking into account the actual stress-strain state of the over-columned plate of the precast flat plate floor system will make using principal reinforcement more economical to ensure the strength of the floor structure.

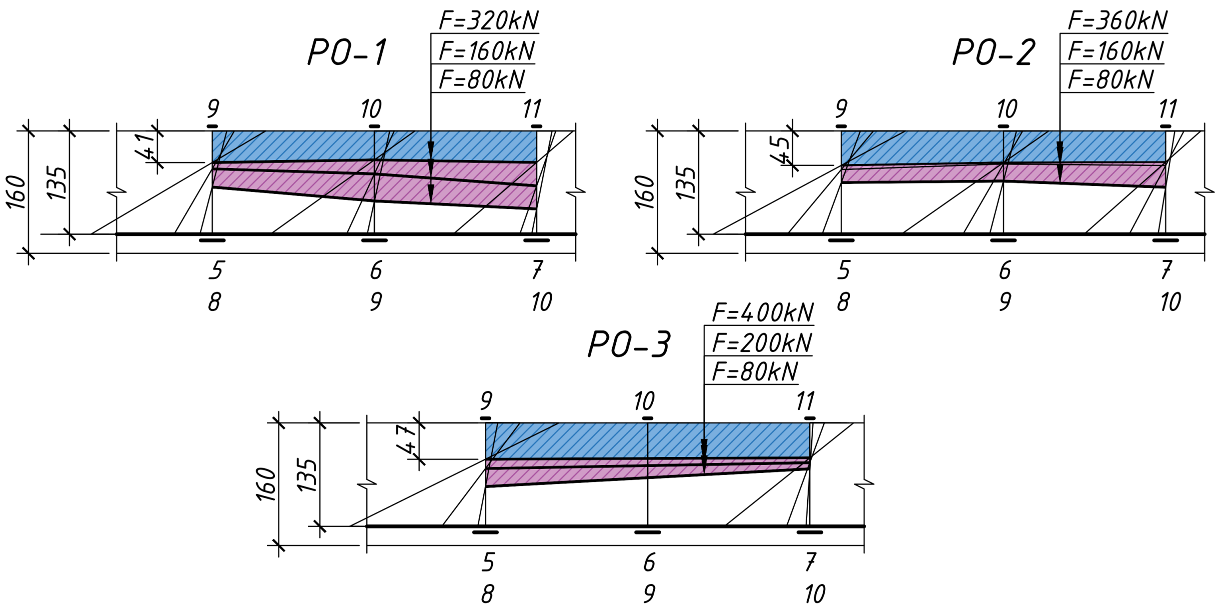



**Figure 17.** Change in the position of the neutral axis in the diagonal direction of the over-columned plates during loading.

One of the tasks set during the experiment was the task of investigating the change in the position of the neutral axis during the loading of the over-columned plate. This became possible thanks to the graphs in figure 17. To plot the graphs of the neutral axis position changing in the diagonal direction of the plate, the material strains plots were used based on the values of the data from the strain gauges.

As can be seen from figure 17, as the load increased, the compressed zone of concrete decreased, and the neutral axis moved up parallel to the most compressed face. This process occurred most intensively up to the value of the external load of 160 kN ($0.3F_{Rd}$), with a further increase in the load, it significantly slowed down, and after reaching the value of 280 kN ($0.5F_{Rd}$), it almost stopped. Based on the above, it can be concluded that the values of the neutral axis depth obtained from the experiment at loads of $0.55F_{Rd}$, $0.6F_{Rd}$ and $0.7F_{Rd}$ (figure 17) for PO-1, PO-2 and PO-3 plates, respectively, are quite close to the value of the neutral axis depth at the time of failure. At the same time, it should be noted that according to the calculation by the yield line method according to [4], the design neutral axis depth at destruction is $x = 43$ mm.

## 5. Conclusions

As a result of conducting experimental tests of full-scale samples of the over-columned plates of precast building frames, the following are established:

1. The scheme of supporting and loading of experimental over-columned floor plates during testing is adopted as close as possible to the actual plate operation scheme as part of a precast flat plate floor system during operation.
2. The average value of deflection l/200 is achieved under a load of $0.5F_{Rd}$, where $F_{Rd} = 580$ kN is the design value of the destructive load, calculated by the yield line method for the over-columned plate according to [4].
3. From the very beginning of the experiment, during the loading of the test samples, the maximum deformations of the reinforcement were observed along the characteristic lines located along the diagonal cracking lines of the over-columned plates.
4. It has been experimentally confirmed that the over-columned plate under the ultimate load is divided into four discs due to the formation of diagonal yield lines, which corresponds to the fracture pattern of the plate obtained by the yield line method according to [4].
5. The plate works in two directions, that is, the concrete of the compressed zone is subjected to flat biaxial compression. This aspect is not taken into account at the moment in the calculations of its carrying capacity. Taking into account the actual stress-strain state of the over-columned plate of the precast building frame will make using principal reinforcement more economical to ensure the strength of the floor structure.
6. The neutral axis depth decreases over the entire load period in all test samples of full-scale floor plates. When the load increases above 280 kN ($0.5F_{Rd}$), the decrease in the neutral axis depth is insignificant. Comparison of the estimated neutral axis depth at the moment of destruction by yield line method [4] $x_{teor} = 43$ mm with experimental data at loads of $0.55F_{Rd}$ (PO-1) $x_1 = 41$ mm; $0.6F_{Rd}$ (PO-2) $x_2 = 45$ mm; and $0.7F_{Rd}$ (PO-3) $x_3 = 47$ mm indicates their convergence.

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