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Experimantal researches of the achievements of a current burdening course plates

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The article presents the results of the experimental study of the peculiarities of the work under the calculation load of planar superstructural plates of the developed system of non-beating overlap. Great attention is paid to the construction of bearing structures prototype. The design of auxiliary equipment is described, which enabled to test the investigating U-block in conditions that imitate real resistance. The method of performing experimental research with indication of methods and means of measuring geometrical and physical parameters that characterize the stress-strain state and bearing capacity of the test plate is given. The conducted investigations enabled to determine the nature of deformation and destruction of the superstructure slabs as a separate element in the developed system of non-beating ceiling. Attention is drawn to the fact that the achievement of the bearing capacity is not accompanied by the process of destruction, but is characterized by significant movements of the supporting plots in the vertical plane.

Keywords: displacement, bearing capacity, deformed state, experimental research, unbounded overlap

Експериментальні дослідження надколонної плити збірного безбалкового перекриття

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У статті наведено результати експериментального дослідження особливостей роботи під розрахунковим навантаженням плоских надколонних плит розробленої системи безбалкового перекриття. Приділено велику увагу конструюванню дослідних зразків несучої конструкції. Особливістю плити, що досліджується є скошені майданчики спирання по зовнішньому периметру для міжколонних та пролітних плит. Описано конструкцію допоміжного устаткування, яке дозволило випробовувати досліджувальну надколонну плиту в умовах, що імітують реальне спирання. Описано конструкцію та технологію виготовлення додаткового устаткування, що імітацує спирання надколонної плити на колонну у вигляді сталезалізобетонного стакану квадратного перерізу. А також опорну конструкція, що імітує спирання міжколоних та пролітних плит. Дослідні конструкції плити і допоміжного устаткування виготовлено на обладнанні та в умовах діючого заводу залізобетонних виробів. Наведено методику виконання експериментальних досліджень із вказуванням методів і засобів вимірювання геометричних та фізичних параметрів, що характеризують напружено-деформований стан та несучу здатність дослідної плити. Проведені дослідження дали змогу встановити характер деформування і руйнування надколонних плит як окремого елемента у розробленій системі безбалкового перекриття. Аналіз характеру деформування свідчить, що деформації розтягу на верхній грані дослідної плити наростають швидше ніж деформації стиснення (нижньої грані). При цьому відбувається зменшення величини стискаючих деформацій до місця спирання дослідних зразків на опорну раму. Це підтверджує припущення про передачу навантаження від міжколонних та пролітних плит на надколонну за принципом «лінійного шарніру». Звернута увага на те, що досягнення несучої здатності не супроводжується процесом руйнування, а характеризується суттєвими переміщеннями опорних консольних ділянок у вертикальній площині.

Ключові слова: переміщення, несуча здатність, деформований стан, експериментальне дослідження, безбалкове перекриття

Introduction

Modern tasks of construction development raise new requirements for the production of building structures and their modernization on the basis of scientific and technological progress. The significant effect when introducing new upgraded constructive solutions can be achieved at the expense of the optimal combination of physical and technical parameters of elements under the scheme "design-material-technology". According to this scheme, the main part of the economy is formed, firstly, due to the wider use of the existing potential of prefabricated reinforced concrete structures, in particular the use of round-bottomed slabs, and secondly, the use of advanced steel reinforced concrete structures that combine the advantages of steel and concrete and enable to reduce structural height of the frame elements.

At present, the bulky, non-skidding and non-rigid overhead structures are widely used in construction. Such constructive systems provide the possibility of constructing buildings of arbitrary configuration in terms of different volumetric-planning solutions. A further step in the modification of prefabricated and prefabricated monolithic frames of buildings and structures is a combination of prefabricated round-bottomed slabs, their modifications and a steel-loose-binder non-white frame. The tasks are aimed at finding rational parameters of such structures, studying their durability and deformability, and implementing the results in construction are feasible and relevant.

Review of research sources and publications

Along with existing types, new progressive structures from steel reinforced concrete have been developed, which enable to reduce costs during installation of structures, to refuse the arrangement of shuttering and additional racks and to increase the mounting speed. Sufficiently widely considered are various systems of non-white floorings in work [1,7-8,10]. All of them have advantages, but they are not defective either. Material and labour costs for their installation are significant.

The system of non-white roofing with modified multi-hollow slabs [2-3,5-6] has been developed by the authors. It is capable of providing optimum with regard to the overall length and strength of the joints of the plate layout and does not require large material and labour costs for the installation and assembly of joints between individual slabs. It is achieved by the use of intercalary, interlayer and flying slabs in prefabricated reinforced concrete bezel, with slabs around the perimeter having slanted lateral faces forming a platform for the adjacency of the adjacent slabs [4,9]. The general stiffness of the overlap is achieved by welding between the mortar parts, which are provided on all plates. For the implementation of the practice of building such overlapping systems, the necessary proposals for their design and, in particular, the calculation of the strength of individual elements and the whole system as a whole.

Definition of unsolved aspects of the problem

At the moment, there is practically no data on the work of individual boards as part of the unbroken overlap. As a prototype, a full-size superstructure slab of non-white floor was selected, which enabled to obtain the most complete information about the object of research.

Problem statemen

The purpose of conducting experimental research is to establish a valid stress-strain state and determine the bearing capacity of individual structural elements of the developed flat non-white floor.

Basic material and results

To reveal the features of the superstructure plates work under the influence of external load, a program of their experimental research was developed (Fig. 1). According to the adopted program of experimental research, a series of prototypes was manufactured. For samples, concrete structures and reinforcing rods were used, which were in the presence of Svetlovodsk ferro-concrete products factory. The thickness of the previous samples of the plates is 220 mm. For precise installation in the design position of samples, on their surfaces were made special markings. Experimental samples were filled with concrete of class C25 / 30 for durability.

Designs of samples and technology of their manufacturing.

For the production of prototype superclone boards, an individual formwork was made (Fig. 2). The overall dimensions of the slab in the plan were 1200×1200 mm. In the middle of the slab there is a hole with the dimensions of 410×410 mm to allow for its installation after the installation of the column. This hole is framed by a "glass" of steel sheets in thickness of 8 mm. On the contour of the plate there are projections with slanted surfaces for the possibility of interlocking and flying slabs on them.

Technique for conducting an experiment.

From each cup, concrete was cemented with 3 standard cubes and 3 standard prisms. Prisms and cubes were made in metal collapsible formwork. For the purpose of creating for prisms and cubes the same conditions for concrete hardening in the test plates, the deck was executed at the age of 28 days.

The method of conducting experimental research includes the production of additional equipment, a choice of power equipment and measuring instruments.

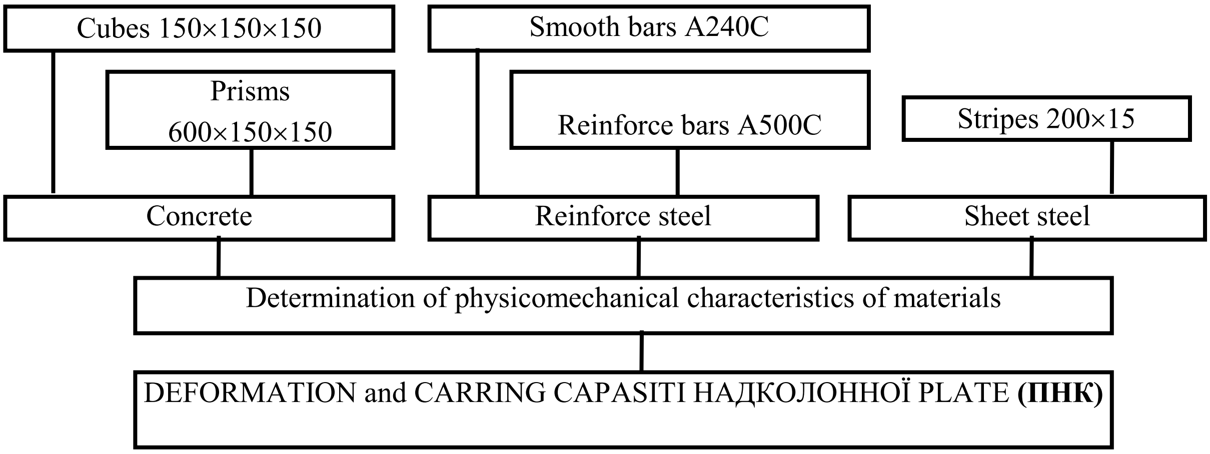

Figure 1 – The program of experimental researches of the superconducting slabs of the base slab system

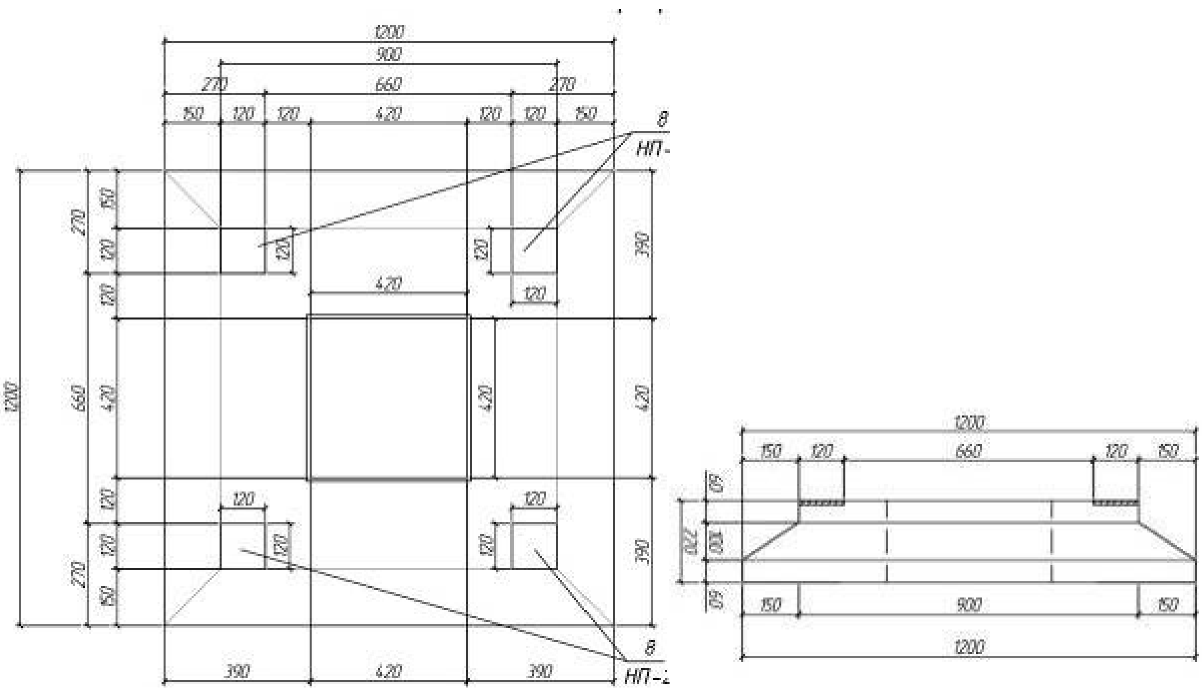

Figure 2 – Geometric dimensions of U-shaped slabs (PNCs)

Fig. 3 shows the assembled design of the support for PNK overhead pillars.

An additional equipment was designed and manufactured for the superconductor coil simulation (Fig. 3). It is a steel-concrete square cross-section with a steel console around the perimeter. Such a construction imitates a part of the column with the place of the superstructure coil. The column part is formed by four segments of equal-angle angles ⌊ 125×10 with a length of 400 mm. The interior space between the corners is filled with concrete. From the bottom, the corners are combined with a steel plate 400×400×12 mm. At a distance of 180 mm from the upper corner of the corners around the perimeter fixed console of steel twill ⌊ 125×10. The connection of steel elements is made using electric welding.

Figure 4 shows an experimental sample located in a pilot plant. The samples were tested after the concrete has reached the design strength, but not earlier than for 28 days. Testing of samples took place at a specially constructed facility at the laboratory of the Department of Structures on Metal, Wood and Plastics of Poltava National Technical Yuri Kondratyuk University. The equipment consists of a hydraulic installation with a capacity of 300 kN and a bearing beam. The latter through a system of two strains is fixed from the vertical displacements by connecting with the force floor of the laboratory. The efforts on the PNC plate were transmitted through a pre-installed jack.

The loading was carried out in steps of 0.1 from the predicted theoretical calculation of the destructive load N. Each load was maintained for at least 5 minutes. At all stages, relative and absolute deformations were measured. Measurement of deformations was carried out by two methods: with the help of watch-type indicators with a price of a section of 0.01 mm on the basis of 200 mm and an electron-tonal method (Fig. 5 – 6). The base of the electric resonator was 50 mm. For strain-gauge tests an automatic gauge of deformations of GNP-8 was used, the accuracy of which is 1×10^{-5}.

In all samples, for the determination of relative deformations on the upper part, hourglass indicators with a price of 0,01 mm divisions are installed on the basis of 200 mm parallel longitudinal axis between the supporting surfaces. Indicators are fixed using specially made brackets. The brackets were screwed into previously welded N8 screws (Fig. 4).

The locations of the electro-tensile resistors were sealed to a mirror luster, degreased with acetone and based on glue BF-2. After 24 hours gluing of the electro-tensile resistors was performed.

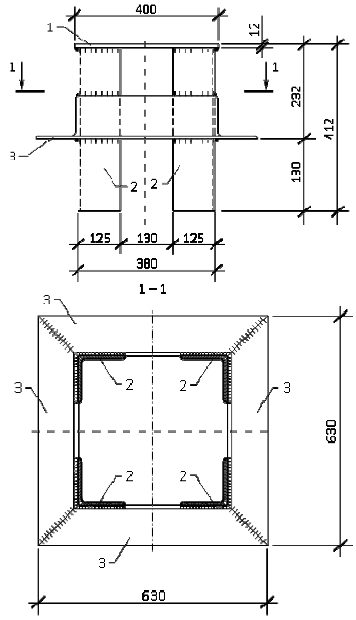

Figure 3 – The support and device imitating the location of the backbone on the PNA:
1 – steel plate 400×400×12; 2 and 3 – a corner 125×10

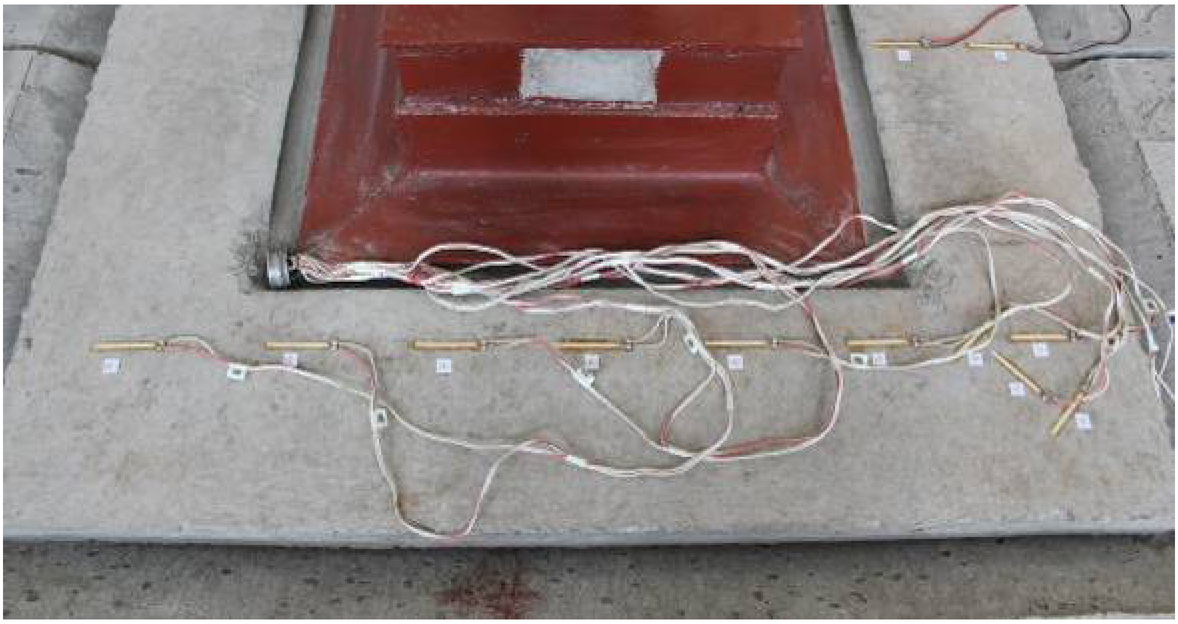

Figure 4 – The layout of the measuring devices on the prototype samples of the PNA series

Figure 5 – Electro-thrust resistors on PNC plates

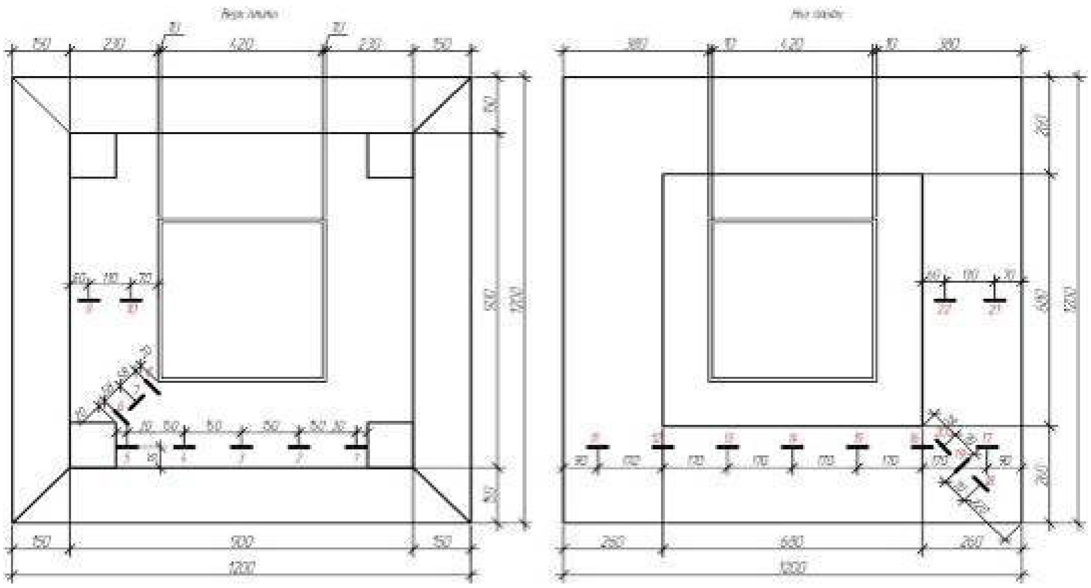

Figure 6 – Scheme of arrangement of electro-tensile resistors on PNA plates

Results of experimental researches and their analysis.

Figure 7 shows graphs showing the change in relative deformations of the most stretched (points 1-5) and the most compressed (points 11-17) of the fibers of the PNA plate.

Measured values of deformations according to the parameters of the electric resonators, the chains of which are located in the cross section between the supporting surfaces. According to the graphs given above, it can be seen that the tensile deformations on the upper edge of the PNA plate grow faster than the deformation of the compression (lower face). In this case, the attenuation of compressive (11-17) deformations occurs to the point of reference of the prototype to the support frame. This confirms the assumption of transferring the load from interconnect (PMK) and flying (software) slabs based on the principle of "linear hinge".

Although no apparent destruction of the experimental prototype of the superconductor slab was detected, attention should be paid to the avalanche-like increase in stretching strains at the location of the electrotensor resistor # 3. With a total load of 210 kN, this electroplating resistor is out of operation. At this moment, the transverse cracks opened up intensively. After removing the external load of their banks turned to the place, but completely the crack was not closed. The distribution of formed cracks can be seen in Figure 9. The depth of crack opening was half the height of the cross section of the PNC plate.

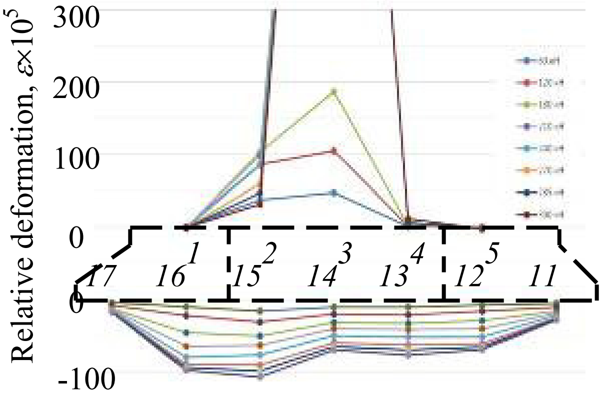

Figure 7 – Distribution of relative deformations on the upper (1-5) and lower (11-17) surfaces of a sample of a series of PNA depending on the value of the payload

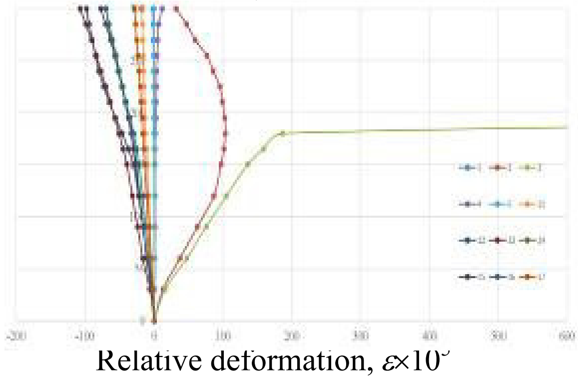

Figure 8 – Distribution of relative deformations for electro-tensor resistors 1-5 and 11-17 surface samples of a series of PNA depending on the value of the payload

Figure 9 – Distribution of cracks in the upper stretched surface of a sample of PNA series after unloading

Interesting is the distribution of deformations at the edges of the PNC plate. The values of compression (t. 11 and t. 17) and stretching (t.1 and t. 5) deformations throughout the loading are close to zero values. But in this place the load is transferred in the form of a reference reaction. Therefore, it can be concluded that the decisive efforts to calculate the supporting part of the PNC plate are the magnitude of the cut-off force.

Figure 8 shows the graphs of relative deformations in the electric resonators 1 - 5 and 11 - 17 from the magnitude of the external imposition. On these charts, the line belonging to the electro-tensor resistor No. 3 is most distinct. It is located in a stretched zone, interspersed with the passage. So, when the value reached 190 kN load, there was a phenomenon of "fluidity". One can make a conclusion that in this place work reinforcement has reached the limit of fluidity. The confirmation of this is the reduction of deformations in the electric resonators No.2 and No.4. Considering the peculiarities of the PNA experimental plate reinforcement, the redistribution of internal forces from the reinforcement linear elements is possible on the ring.

Figure 10 shows graphs showing the change in the relative deformations of the stretched (point 7) and compressed (points 18 and 20) of the fibers of the PNA plate. These points are located in a diagonal section. It should be noted that the growth of tensile strains (point 7) is more intense than compression deformations (points 18 and 20). With an external force of 210 kN, the electric resonator, fixed at point 7, was torn and out of order. But at the same time the design of the experimental plate of the PNC continued to perceive the external force, which continued to grow.

The distribution of deformations on the sloping section of the knot and on the adjoining sites does not change significantly when the external load is increased. The maximum values of compression effort do not exceed the value of 50×10^{-5}. It indicates that the internal bending moment, which is a reaction to the effect of the external load, does not lead to any destruction of the reinforced concrete in this area. And the value of transverse forces remains decisive.

Figure 11 shows the graphs of the relative deformations in the electro-tensor resistors 7, 18 and 20 from the magnitude of the external imposition. On these charts, the line belonging to the electro-tensor resistor No. 7 is most distinct. It is located in a stretched zone, diagonally between the outer and inner angles of the PNA plate. So when the external forces reached the value of 210 kN, deformations began to intensively increase and reached a critical value for concrete of 200×10^{-5}. Although there was no such significant change on the compressed face.

A grid of cracks in this zone has a complex picture in the form of cross-curved lines. It should be noted that there is the presence of a long crack, which has crossed the backs of the design diagonal from the outer to the inner angles. Its appearance indicates the need to make changes in the design of the reinforcing frame of the PNC plate.

Figure 12 shows graphs where the change in relative deformations of stretched (points 9 and 10) and compressed (points 21 and 22) of PNA fiber fibers are shown. These points are located on an average cross-section, which intersects the inner square hole. Points 9 and point 22 are located along one normal to the horizontal sides of the structure. It is obvious that in this place the general picture of the deformed state is preserved - deformation of the tension is more intensive than the deformation of compression. But the absolute value of the deformation on the surface of the design does not reach the critical value, which corresponds to the strength of the concrete.

This area is perpendicular to the reference face. It can be explained by the fact that the deformed state of the minorities than in the extreme sections parallel to the plane of the deflections. Figure 13 shows the graphs of relative deformations in the electric resonators 9, 10, 21, and 22 of the external imposition magnitude. On these charts the line is the most distinct.

The maximum external force applied to the experimental extracobble plate (PNC) was 300 kN. Clearly, the destruction of the plate did not take place, and the cracks that appeared on the stretched surface of the concrete after the unloading were almost closed, leaving only filament marks. The general nature of the crack propagation is shown in Figure 14. All the cracks were transverse, and inclined cracks were not detected.

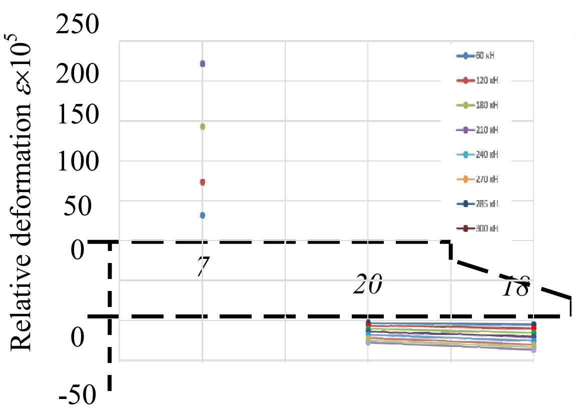

Figure 10 – Distribution of relative deformations on the upper (7) and lower (18, 20) surfaces of a sample of a series of PNA depending on the value of the payload

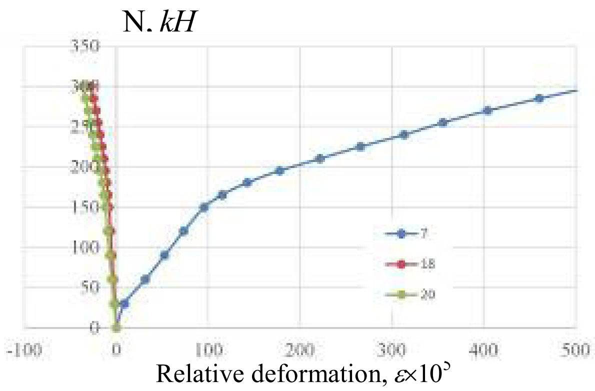

Figure 11 – Distribution of relative deformations for electro-tensor resistors 7 and 18, 20 surface samples of a series of PNA depending on the value of the payload

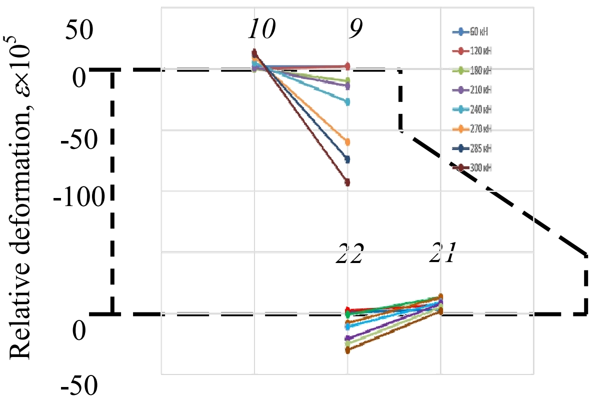

Figure 12 – Distribution of relative deformations on the upper (9-10) and lower (21-22) surfaces of a sample of a series of PNA depending on the value of the payload

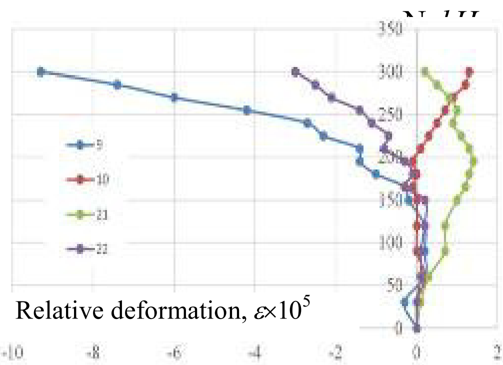

Figure 13 – Distribution of relative deformations for the 9 -10 and 21-22 surface of the electro-conductors of a sample of a series of PNA depending on the value of the payload

Figure 14 – Cracks in the concrete surface of a sample of PNA series

Conclusions

According to the results of the research experimental part, the following conclusions can be drawn:

1. The program of experimental research is developed considering the possibility of using the material base of the existing production of building structures. That enabled to design and make prototypes in the natural size of the real bearing structures of flat nonwhite floor. Materials of constructions (steel and concrete) are applied in real bearing structures. The test equipment is certified.

2. The maximum aggregate load transferred to the superconducting plate of the PNA series was 300.00 kN. The test sample could not be destroyed. The boundary condition for such a design is the achievement of the yield strength by the extended fittings in individual locations. Therefore, as a bearing capacity, an effort equal to 195.00 kN is taken.

3. The advantage of the proposed separate plates of the developed system of non-stop overlap is that none of the tested structures was destroyed during experimental studies. As the boundary state it is necessary to consider the states of the second group.

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