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EXPERIMENTAL STUDIES OF SERIAL ROAD-AIRPORT REINFORCED CONCRETE SLAB

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Abstract. The results of experimental studies of the load-bearing capacity and crack resistance of the serially produced road-airfield reinforced concrete slab PAG, manufactured at Velikodolinsky Reinforced Concrete Plant LLC by order of the Odessa State Academy of Construction and Architecture, are presented. In accordance with the regulatory documents in force in Ukraine, one of two possible loading schemes was considered — with a load by a concentrated force applied on the cantilever part of the slab. The slab was tested on a specially made stand, which consists of four support posts connected in pairs by beams on which the slab rested. The load was applied along the width of the slab in steps — 0.04 from the destructive load, along two concentrated vertical stripes. Each load stage ended with a five-minute hold, at the beginning and end of which readings were taken on the measuring instruments. All tests were carried out using two 30t jacks and a 50t dynamometer. The principle of operation of the jack was that its lower plane pressed on a two-level cross-beam system, and through it the load was distributed onto the slab. During testing, the applied load, deflections and deformations were recorded on the slabs. Dial indicators and deflectometers were used as measuring instruments. The process of crack formation on the surfaces of the slabs was observed using a Brinell tube in the places of the greatest opening of the cracks.

As a result of the tests, the load-bearing capacity of the slab was 163.2 kN with a bending moment of 78.3 kNm. The load corresponding to the onset of cracking is 86.4 kN with a bending moment of 36.9 kNm. The maximum crack opening width was 1.0 mm. Based on the indicator readings, graphs of the dependence of relative deformation on load were constructed. Graphs of the dependence of deflections on load are constructed using data from two deflection meters. Before the first crack appears, the maximum deflection of the slab is 12.0% of the deflection recorded at the end of the tests.

Keywords: reinforced concrete, PAG slab, load-bearing capacity, deformability, crack resistance, experimental studies.

ЕКСПЕРИМЕНТАЛЬНІ ДОСЛІДЖЕННЯ СЕРІЙНОЇ ДОРОЖНО-АЕРОДРОМНОЇ ЗАЛІЗОБЕТОННОЇ ПЛИТИ

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Анотація. Наведено результати експериментальних досліджень несучої здатності та тріщиностійкості дорожньо-аеродромної залізобетонної плити ПАГ, що серійно випускається, виготовленої на ТОВ «Великодолинський завод ЗБК» на замовлення Одеської державної академії будівництва та архітектури. Відповідно до нормативних документів, що діють в Україні, розглянуто одну з двох можливих схем навантаження — при навантаженні зосередженою силою, прикладеною на консольній частині плити. Плита випробовувалась на спеціально виготовленому стенді, що складається з чотирьох опорних стійок, пов'язаних попарно між собою балками, на які спиралася плита. Навантаження прикладалося по ширині плити сходами — по 0,04 від руйнівного, по двох зосереджених вертикальних смуг. Кожна ступінь навантаження закінчувалася п'ятихвилинною витримкою, на початку і наприкінці якої знімалися показання на вимірювальних приладах. Усі випробування проводилися з використанням двох домкратів 30 т та 50-тонного динамометра. Принцип роботи домкрата полягав у тому, що його нижня площина тиснула на дворівневу перехресно-балкову систему, а через неї навантаження розподілялося на плиту. У процесі випробування плити фіксували прикладене навантаження, прогини та деформації. Як вимірювальні прилади використовувалися індикатори годинного типу і прогиноміри. Процес тріщиноутворення на поверхнях плит спостерігався за допомогою трубки Брінелля у місцях найбільшого розкриття тріщин.

В результаті випробувань несуча здатність плити склала 163,2 кН при згинальному моменті 78,3 кНм. Навантаження, що відповідає початку тріщиноутворення, дорівнює 86,4 кН при згинальному моменті 36,9 кНм. Максимальна ширина розкриття тріщин становила 1,0 мм. За показаннями індикаторів побудовано графіки залежності відносної деформації від навантаження. Графіки залежності прогинів від навантаження, побудовані за даними двох прогиномірів. До появи першої тріщини максимальний прогин плити становить 12,0% від прогину, зафіксованого наприкінці випробувань.

Ключові слова: залізобетон, плита ПАГ, несуча здатність, деформативність, тріщиностійкість, експериментальні дослідження.

1 INTRODUCTION

PAG series slabs (smooth airfield slab) are widely used in the construction of runways and airfield sites, as well as in road construction. Such slabs are used to create platforms and roads designed to accommodate heavy equipment. Such slabs are used on construction sites, especially those where the capabilities of a tower crane cannot be dispensed with. As you know, the design of such a crane is designed in such a way that it can easily move along rail tracks. And it is the airfield slab that often becomes the basis for arranging a site for rails.

Of course, the main purpose of PAG slabs is runways and airfield sites. Practice shows that such plates can withstand a load of 50-80 tons, which ensures safe movement of any aircraft along the runway. An important quality of PAG is the preservation of ideal condition even under extreme climatic conditions: severe frosts, exposure to precipitation, abundant sunlight. Such unique properties and a wide range of applications attract special attention from scientists and operators in different countries who strive to constantly improve the characteristics of PAG slabs.

2 LITERATURE ANALYSES AND PROBLEM STATEMENT

Experimental studies of airfield slabs, as well as methods for their calculation, are very diverse. Relevant work is being carried out in many countries, but it should be noted that testing PAG slabs requires special equipment, is labor-intensive and expensive. Most tests of airfield slabs are full-scale tests, which can be static (under the action of stepwise applied static loads) or dynamic (under the action of repeatedly repeated moving loads). Such tests are usually carried out at airfields. Tests in laboratory conditions are carried out extremely rarely.

The US Federal Aviation Administration has tested coatings with three different flexural strength limits for two base options. The formation of cracks near transition seams was considered. Sections of the pavement were tested using a moving load simulating an aircraft [1]. The results of full-scale accelerated tests to assess the remaining service life of a rigid airfield pavement at Fort Worth Meacham International Airport, USA are presented in [2]. Full-scale fatigue tests of 15 large-scale slabs with four different types of foundations are described in [3]. The condition of the slabs was monitored using temperature sensors and strain gauges [4] over a two-year period from the moment they were laid at Incheon International Airport (Incheon, South Korea). No less interesting field studies are described in [5-7] and a number of other works.

Now about laboratory tests. The article [8] describes the evolution of precast concrete pavements in different countries and, in particular, in the USA. An overview of the results of accelerated loading tests using a heavy vehicle simulator is presented. In [9], the results of experimental studies of the load-bearing capacity of reinforced concrete road surface slabs, prestressed slabs and threshold unevenness of the test site are presented. The influence of incomplete contact of the PAG slab with the base on the stress-strain state of both the slab itself and its base is considered in [10]. In [11] the results of tests of sixteen airfield slabs for fatigue strength are presented. The article [12] is devoted to the same problem.

3 PURPOSE AND OBJECTIVES OF THE STUDY

The purpose of this work is to experimentally study the load-bearing capacity and crack resistance of a serial road-airfield reinforced concrete slab PAG in laboratory conditions.

4 MATERIALS AND METHODS OF RESEARCH

We studied a serial reinforced concrete slab 1P30-18-30, manufactured at Velikodolinsky Reinforced Concrete Plant LLC by order of the Odessa State Academy of Construction and Architecture (OSACA). The mass of the slab was 2.2 tons, overall dimensions were 3000x1750x170 mm. For reinforcement, type AI reinforcement KR5, KR11, with a diameter of 12 mm, was used [13]. The load was applied in small steps to study in detail the process of deformation of the slab. At each stage, instrument readings were recorded twice, and also, starting from the moment of formation of the first crack, the opening width of the cracks was measured. Dial indicators, deflectometers, and a Brinell tube were used as measuring instruments [14]. According to the regulatory documents in force in Ukraine [15], airfield slabs (like road slabs) are calculated according to two loading schemes — with a load by a concentrated force applied in the middle of the span, and with a load by a concentrated force applied on the console. Here we considered a cantilever loading scheme. The tests were carried out in the laboratory of the Department of Structural Mechanics of OSACA.

5 RESEARCH RESULTS

For testing, a special stand was developed, which consists of four support posts connected in pairs by beams. The road slab rested on the beams. The load was applied along the width of the slab in steps — 0.04 from the destructive load, along two concentrated vertical stripes. Each load stage ended with a five-minute hold, at the beginning and end of which readings were taken on the measuring instruments.

All tests were carried out using two 30t jacks and a 50t dynamometer. The principle of operation of the jack was that its lower plane pressed on a two-level cross-beam system, and through it the load was distributed onto the slab (Fig. 1).

Fig. 1. Test bench

During the test of the slab (the loading diagram is shown in Fig. 2), the applied load, deflections and deformations were recorded. Deformations were measured using dial indicators with a scale of 0.01 mm and a base of 24 cm in the cantilever part of the slab, 36 cm in the span. The process of crack formation on the surfaces of the slabs was observed using a Brinell tube in the places of the greatest opening of the cracks. The Brinell tube division value was 0.1 mm.

In accordance with the accepted loading scheme, two rows of indicators were installed on the upper surface of the slab (Fig. 3). The first group of seven indicators (2*i* – 6*i*) is installed in the upper span of the slab, and the second group (9*i* – 13*i*) is installed on the cantilever loading area. Indicators 8*i*, 14*i* were mounted on the side faces in the support area of the cantilever section. A pair of indicators 1*i*, 7*i* recorded the deformation of the compressed zone in the span of the slab.

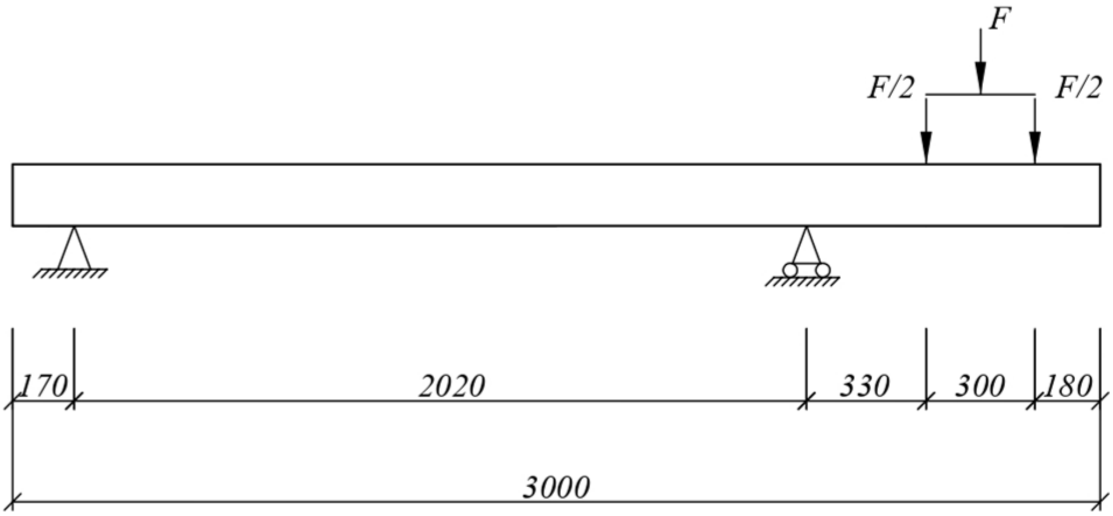

Fig. 2. Cantilever loading scheme

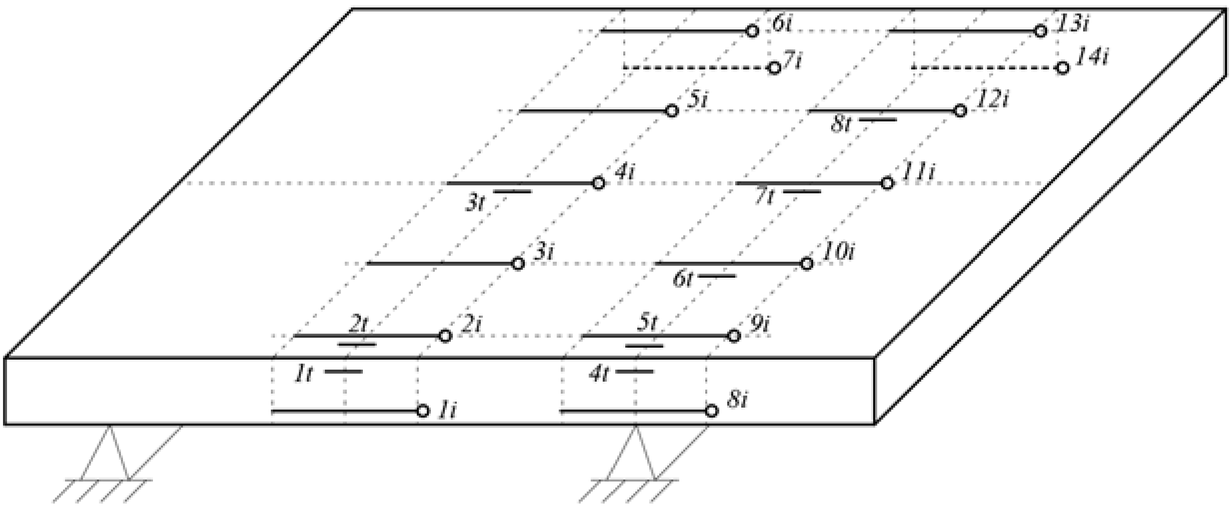

Fig. 3. Indicator location

As a result of the tests, the load-bearing capacity of the slab was 163.2 kN with a bending moment of 78.3 kNm.

The load corresponding to the onset of cracking is 86.4 kN with a bending moment of 36.9 kNm.

6 DISCUSSION OF RESEARCH FINDINGS

The test results obtained at each loading stage are presented in table 1.

Table 1

Slab test results

Load stage number	Load, kN	Crack opening width, mm	
		Initial	Ultimate
1	19,2		
2	38,4		
3	48,0		
4	57,6		
5	67,2		
6	76,8	1 – 0,1	1 – 1,0
7	86,4		
8	96,0	2 – 0,1	2 – 0,5
9	105,6	3 – 0,05	3 – 1,0
10	115,2	4, 5, 6 – 0,1	4, 5, 6 – 0,1
11	124,8		
12	134,4		
13	144,0	7 – 0,05	7 – 0,05
14	153,6	8 – 0,05	8 – 0,05
15	163,2	9 – 0,05	9 – 0,05

In Fig. 4 shows graphs of the dependence of relative deformation on load, constructed according to indicator readings.

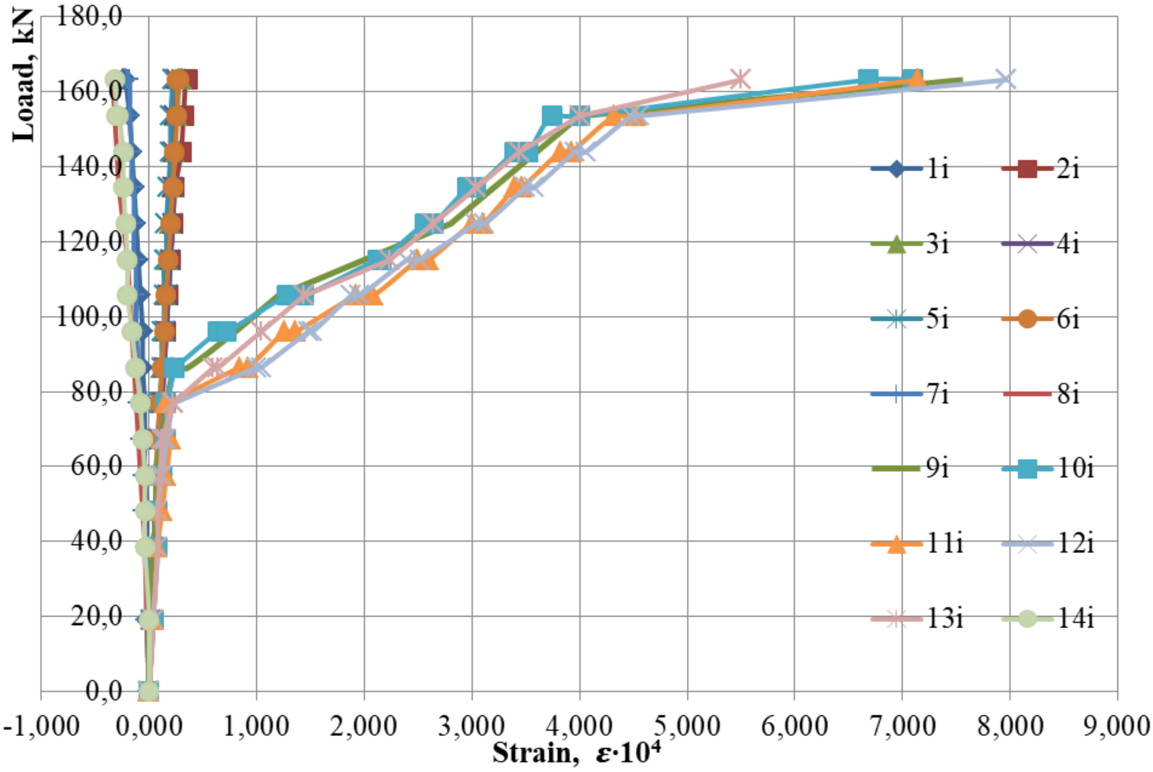

Fig. 4. Relative deformation according to indicator readings

Graphs of the dependence of deflections on load, constructed using data from two deflectometers, are shown in Fig. 5.

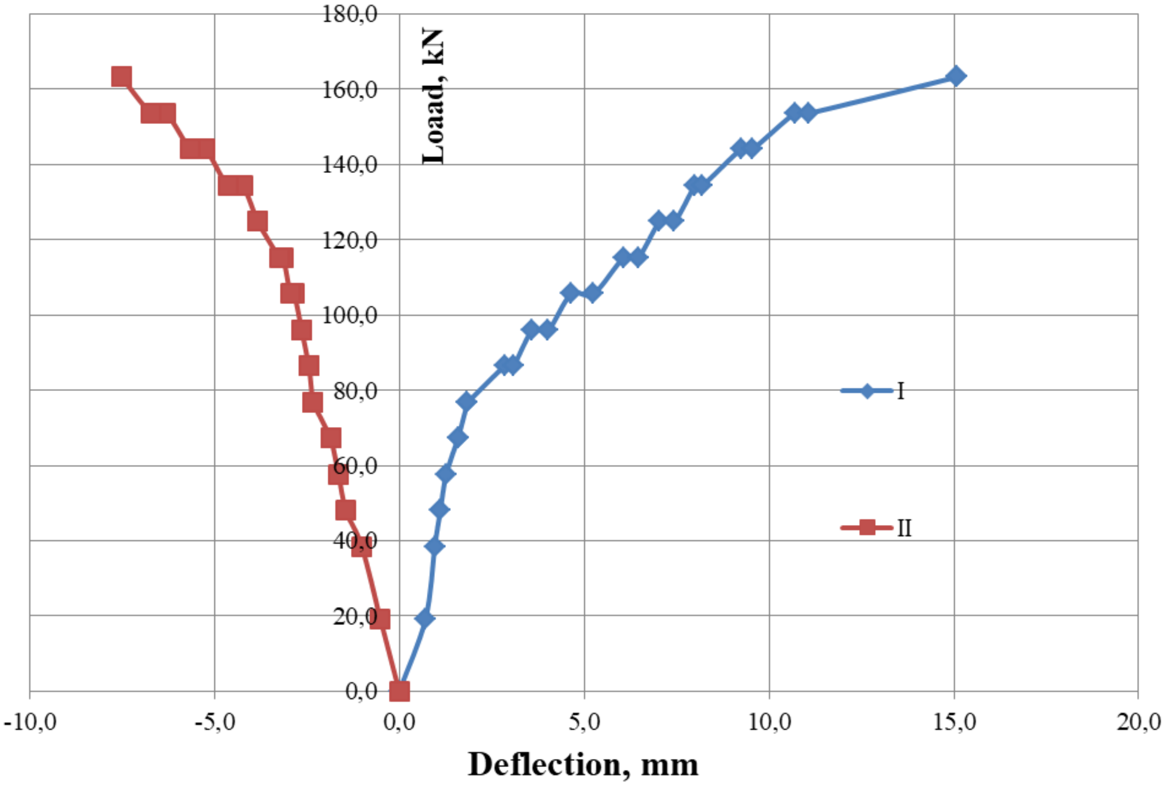

Fig. 5. Slab deflections

Before the first crack appears, the maximum deflection of the slab is 12.0% of the deflection recorded at the end of the tests.

7 CONCLUSIONS

Thus, experimental studies of the load-bearing capacity and crack resistance of the commercially produced road and airfield reinforced concrete slab PAG, manufactured at Velikodolinsky Reinforced Concrete Plant LLC, were carried out under laboratory conditions. The tests were carried out on a specially made stand.

Dial indicators and deflectometers were used as measuring instruments. The process of crack formation on the surfaces of the slabs was observed using a Brinell tube in the places of the greatest opening of the cracks.

As a result of the tests, the load-bearing capacity of the slab was 163.2 kN with a bending moment of 78.3 kNm. The load corresponding to the onset of cracking is 86.4 kN with a bending moment of 36.9 kNm. The maximum crack opening width was 1.0 mm. Based on the indicator readings, graphs of the dependence of relative deformation on load were constructed. Graphs of the dependence of deflections on load are constructed using data from two deflection meters. Before the first crack appears, the maximum deflection of the slab is 12.0% of the deflection recorded at the end of the tests.

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