AIRPORTS AND THEIR INFRASTRUCTURE

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INVESTIGATION OF PRECAUST PRESTRESSED SHELL

The paper focuses on construction, production and erection of elements, methodology of testing and researching results of precaust prestressed shell from light concrete with dimensions 12×24m, which is used for covering of industrial building.

Розглядаються конструкція, виготовлення і монтаж елементів, методика випробувань та результати досліджень збірної попередньо завчасно напруженої призматичної складки із легкого бетону розміром 12×24 м, що застосовується для покриття промислової будівлі.

Introduction

The building of auto park for 200 cars is projected with covering in the form of prismatic long shells from light concrete, which perform bearing, fence and heat insulation functions. The building with area 5200 m^2 is covered by 18 shells with dimensions in plan 12×24 m each one (fig. 1).

Shell was tested on different dynamic and static loads. The results of testing proved the possibility of shell's calculation having the openings for lengthen.

Covering consists of plane prefabricated elements, cross-section is the 7-facet prism 5 facets of which form the slab of covering and 2 contour beams. Hook rise is the 1/7 of wave length [1; 2].

For sections without lengthens the covering is erected from 20 plane light concrete slabs with dimensions 5930×2480 mm, precaust prestressed contour beams and diaphragms of arch type. For section with opening, two middle slabs are changed for closed reinforced concrete frames. The dimensions of opening in cross-section are 1/4.8 of span.

Slabs of covering are made from light concrete class B12.5 with weight 1100 kg/m^3, corner slabs – light concrete class B20 with weight 1200 kg/m^3.

Armature of slabs are double nets, longitudinal and perpendicular armature with step 150 mm and diameter 6.8 mm AI.

Corner slabs in longitudinal and cross-section are armed by smooth wire with diameter 10 mm. Armature has end joints. Contour beams with dimensions 100×960×23960 mm are prestressed from heavy concrete class B50 armed by 6 stressed rods with diameter 28mm from steel AIII. Arched diaphragms and lengthen frames are made also from concrete B50. Upper chord of diaphragms has permanent section 200×230 mm armed by 2 plane carcasses.

Tie of section 200×200 mm armed by 4 stressed rods with diameter 18 mm from steel class AIII. Lengthen frame has rectangular section with dimensions 150×300 mm, armed by plane carcasses [1].

For carrying out of tensile stresses the side and face surfaces of precaust elements of shell have tooth shape.

The construction is calculated for its own weight and snow load 70 kg/m^2.

All precaust elements were produced on the plant of reinforced concrete constructions.

Plane slabs were produced from ceramist concrete of nonautoclave hardening. Contour beams, lengthen frames and arched diaphragms were made from heavy concrete. Armature was tensioned on the form.

As the experiment showed, the technology of producing of precaust elements is simple and doesn't differ from technology of producing of usual flat constructions [2].

Before erecting of covering the research of separate shell with actual dimensions was carried out. Besides learning of stress-strain state of construction under the action of statical loads there was also performed the determination of terms and forms of oscillations.

The flat slabs of tested shell were produced from ceramsit foam concrete with the following material expenditures of 1 m^3: cement – 370 kg, ceramist – 1.3m^3, foam maker – 40l.

Contour beams, arch diaphragms and lengthen frames were produced from heavy concrete with composition 1:0.5:1.68 (on weight) and water cement ratio 0,28.

Average durability of concrete is 430 kg/cm^2.

Durability of concrete of monoliting of joints at the moment of testing of shell equaled 313 kg/cm^2.

Research analysis

The loading of construction by statical load was performed by concrete stones and load was transmitted as concentrated forces.

Every slab and lengthen frame is loaded in 8 points and the distance between points of load application in transversal direction is 120 cm and in longitudinal – 150 cm.

On the surface of shell the stress was transmitted on 160 points.

Dynamical load on shell is created with the help of vibroengine fixed on lengthen frame.

The maximum value of pulsing force is proportional to the square of rotation number of engine (3000 rot/min) under the frequency of 50 Hz was 225 kg.

While testing of shell such parameters as settlement of supports, deflections and deformations of contour beams and arch diaphragms, longitudinal and transversal deformations in armature and concrete were estimated.

Shell was tested on different kinds of loads. Loading by uniformly distributed and concentrated loads by projection of shell was performed in parts of 45 kg/m^2.

This scheme was accepted for simplification of construction research, because in real conditions it is hard to imagine the overloading of contour beams. The testing construction was made for covering of industrial building, that is why under its testing was accepted uniformly distributed load exceeding the calculated one in 1.5-1.6 times.

The experimental data coincide sufficiently with calculated data. And some diversities happen because of difference of the construction and its calculation scheme (sag of diaphragms elongation of ties, resistance of torsion of contour beams and lengthen frames, etc.)

The first cracks appeared in corner slabs from action of main tensile stresses under the load consisted of 75 % from normative one. Crack opening under the normative load didn't exceed 0.15 mm. In contour prestressed beams crack appeared under the normative load and their opening from 0.05 to 0.1mm. In arch diaphragms ties cracks were observed under normative load, and distance between them in average was 25 cm, opening was 0.05-0.1 mm.

Simultaneously they appeared in upper chord of diaphragm.

Analysis of work of tensor gauges showed that tensile stresses are concentrated not only in the lower chord (tie), but also in the girder.

Under the action of great chopping loadings the upper chord of diaphragm works as eccentrically tensioned element. With the load increase the direction of cracks in slabs was changed.

But their openings didn't exceed 0.15 mm.

On the last stage of loading the cracks in contour beams developed on height, and in ties opened up to 0.2 mm.

Character of cracks development show the space work of construction.

With load increasing and cracks development the neutral axes moved upper. On the last stage of loading the longitudinal stresses in the slab equalled 80 kg/cm^2 i.e. which was close to the durability of ceramist foam concrete.

Deflections of contour beams under the normative load after 16 hours were equal to 2.53 cm or 1/950 of span. The middle of shell saged correspondently to the contour beams by 0.4 cm. All this testifies to the great rigidity of construction. The summary load on the shell on the last stage of loading is 268 kg/m^2, which in 1.8 times exceeds the normative load.

Analysis on testing of non loaded shell shows that first of oscillations coincide with the diagram of transversal bending moments (fig. 2). It means that the theoretical solution of the task can be considered as the oscillations of massive contour beam on strain base with four strain characteristics which form the basis of method of own oscillations frequency calculation.

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Under dynamical testing theoretical and experimental parameters of shell were considered. The oscillation indication was performed only in vertical direction. The estimation of shell work was without external load, under the normative load on the construction.

Under the instant application of concentrated load to the slab of shell the minimal value for slab was 5.26 Hz, for contour beams – 2.63-2.7 Hz.

The kind of interruption source has the influence only on the first period of oscillations. For example, on the point of concentrated load application on the min frequency 5.26 Hz the high frequency oscillations above 19-17 Hz were plotted.

The experimental and theoretical resonance frequencies are shown below, which are obtained for non-loaded and loaded construction taking into consideration one half wave in longitudinal direction.

As shown in table the open prismatic shell has dense range of resonance frequencies and, consequently, frequencies of own oscillations.
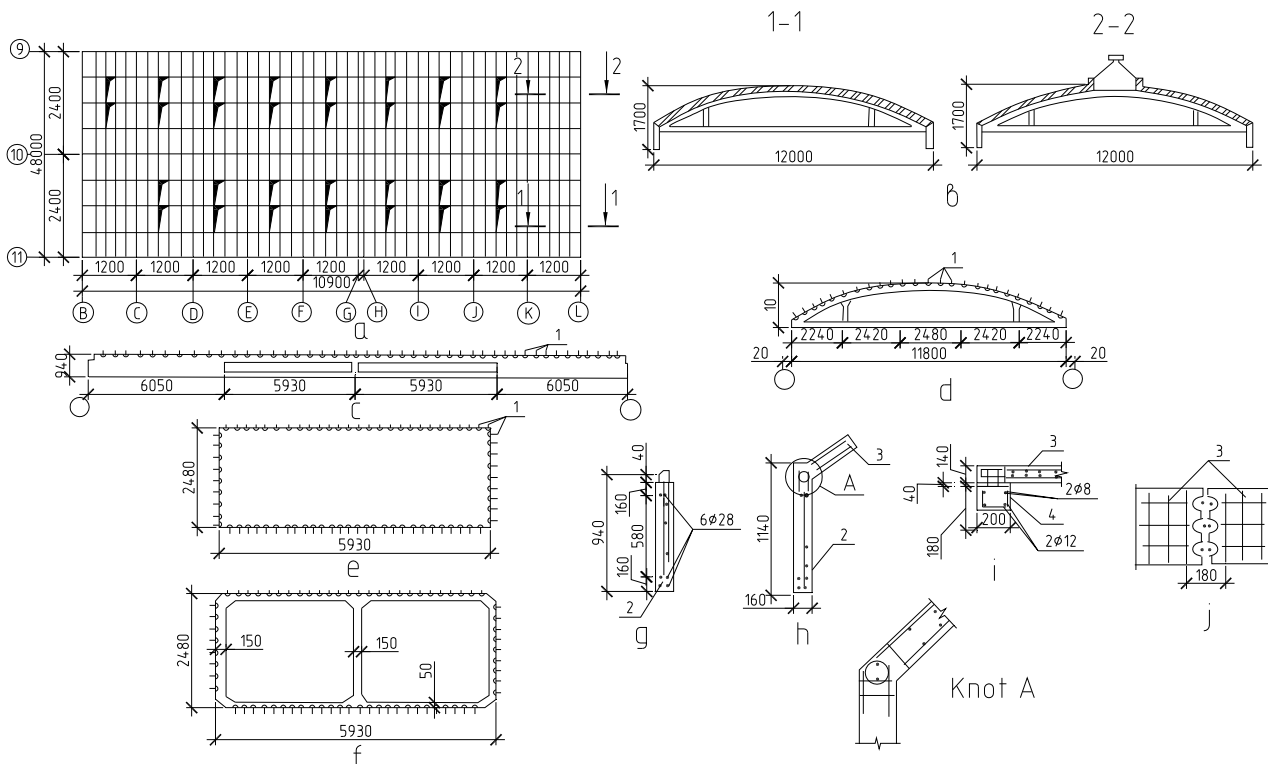
Fig. 1. Construction of shell:
a is the auto park plan;
b is sections; c — contour beam;
d is arch diaphragm;
e is slab of shell;
f is lengthen frame;
g is section of contour beam;
h is joint of contour beam with slab;
i is joint of arch and diaphragm with slab;
j is joint of slabs between each other in transversal direction;
1 is armature ends every 150 mm;
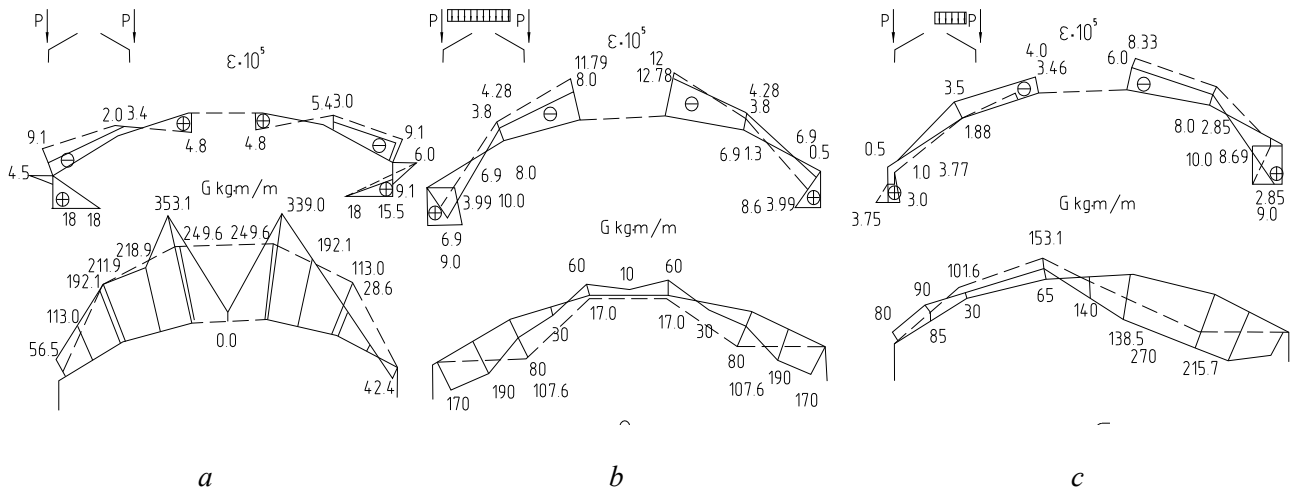*2* is contour element;
3 is slab;
4 is diaphragm

Fig. 2. Longitudinal deformations and transversal bending moments in the middle section of shell under the action of symmetrical concentrated load (*a*), uniformly distributed load (*b*), one-sided uniformly distributed load (*c*)

The experimental and theoretical resonance frequencies, Hz

Reso-nance zone	Non-loaded shell			Loaded shell	
	experiment		calcula-tion	experiment	
	beam	slab	slab	beam	slab
1	2.63	5.26	5.212	2.0	2.5
2	11.11	11.11	11.022	10.0	10.0
3	16.65	16.65	15.785	15.6	15.6
4	33.3	33.3	30.469	26.3	26.3

In the interval from 0 to 50 Hz 5 resonances on every pattern were detected.

The certain values of resonance frequencies coincide with the form of shell oscillations, and differ in the number of knot lines.

The stresses on the shell from seismic load which is determined according to the obtained frequency of own oscillation were so small so they can be neglected.

After testing the mounting of the shell was done with the help of the conductor.

Contour beams and arch diaphragms were installed on the columns. After the conductor estimation the slabs of covering were mounted. Middle slabs of shells and lengthen frames were installed on supports.

The edge slabs were supported by one side on contour beam and the other one – on the conductor. The joints were monolithing by heavy concrete.

The shells applications enabled the decrease of the budget estimation of building-erection works by 9 %, and their own weight of covering by 23 %.

Conclusion

1. Technology of producing of precaust elements constituting parts of the shell is simple and doesn't differ from the technology of usual flat consructions;

2. Joint of elements is not complicated in the construction and provides the transmitting of stresses (compression, tension, bending, shear and their combination);

3. Analysis of the results of the statical and dynamical testings of the construction and their comparison with the calculation shows their sufficiently coincidence;

4. Precaust shell has necessary durability, rigidity and crack resistance.

References

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