INTERNATIONAL MULTIDISCIPLINARY JOURNAL FOR RESEARCH & DEVELOPMENT
SJIF 2019: 5.222 2020: 5.552 2021: 5.637 2022:5.479 2023:6.563 2024: 7,805
eISSN :2394-6334 https://www.ijmrd.in/index.php/imjrd Volume 12, issue 06 (2025)

# LARGE SPAN SHELLS OF UNIQUE BUILDINGS CONSTRUCTED BY A COMBINED INSTALLATION METHOD

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**Abstract**: The results of experimental and theoretical studies developed by a combination of methods for mounting large-span reinforced concrete shells assembled from enlarged mounting elements are presented. The stress-strain state of composite shells with a span of 60 m and their enlarged elements with dimensions of 3x18 m and 3x24 m is studied on models on a scale of 1:10 and 1:4. The work of the structure under various mounting and unloading options is studied. Recommendations on rational methods of constructing covering shells for unique public buildings have been developed.

**Key words**: large-span shell, unique buildings.

**Annotation**: The results of experimental and theoretical studies of the developed long-span reinforced concrete shells assembled from enlarged mounting elements are presented. The stress-strain state of the composite shell with a span of 48 and 96 m, its enlarged elements 3x18m and 3x24m, was studied on a model on a scale of 1:10 and 1:4. Studied with various options for mounting and unwinding the structure. Recommendations are given on rational methods for constructing shells for unique public buildings.

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**Introduction.** The development of structural solutions for large-span unique buildings using reinforced concrete shells is associated with the tasks of improving the methods of their installation and unloading.

Installation of such shells can be carried out with the use of solid scaffolding and conductors, or pre-enlarged arch-type mounting elements, in a hinged way [1-3].

For shallow shells, the use of enlarged mounting elements up to 24 m long is optimal [3-6]. In this case, each enlarged prefabricated element is a vaulted structure. [5, 6].

Effective design solutions were developed and investigated for large-span shells covering unique buildings using a combination of methods for mounting shells using solid scaffolding with sparse supports and methods for enlarging mounting elements by testing models 4, 8x4, 8m and 12x12m.

**Results of shell operation modeling.** Modeling of the installation state of the 60 meter-wide shells was performed on models with a scale of M 1: 10 and M 1: 4. The shells were built using a combined installation method using prefabricated enlarged mounting elements with a scale of M 1: 1-M 1: 10, with dimensions of 3x18 m,0.75 x 8.5 m and 0.3 x 1.8 m.

With this method of assembling the coating, the enlarged elements are installed directly on the diaphragms and on the mounting beams of the rigid shell. After sealing the seams, temporary tightening joints are removed.

The advantage of this method of installation is the absence of temporary supports and reduced labor intensity of installation work.

On models of shells in the field of linear operation loaded with a load of 1.7 kN / m2$^2$, two main methods of unloading were studied. In the first method of unloading, first the mounting beams and supports (racks) were lowered, and then the forces in the installation puffs were removed. In the second method, the mounting bolts were first removed, and then the mounting beams and supports were lowered.

The study of the mounting state of flat ribbed shells was carried out using the combined method of enlarged assembly of elements on cross beams located on four sides-stiffeners with a unified grid of 18x18 m, installed on mounting racks, proposed by the author.

For this purpose, experimental studies were conducted in two stages.

Assessment of the strength, stability, rigidity, crack resistance, reliability and safety of various types of coatings of unique buildings at the stages of installation and transition to operational condition is a poorly studied area [5-7].

**At the first stage of experimental studies** , the stress-strain state of the entire coating was determined in free-standing central and lateral shells of negative Gaussian curvature loaded with a load from their own weight equal to 1.7 kN/$^{m2}$. After that, we studied two ways of unwinding according to the above-mentioned method. The unloading options consisted of 7 consecutive cycles.

Thus, the suggestion is that to perform shell unloading, it is necessary to initially lower the mounting posts and beams, after which it is necessary to remove the tightening forces, which is the most rational way.

In the first method of unloading, when lowering the mounting beams, the forces in tightening the shells were reduced by 21-34%, which greatly facilitates the dismantling of the puffs. The deflection in the central shell was 2.9 mm, or 1/1155 span; in the lateral shell-1.9 mm, or 1/1786 span. Further removal of forces in the installation puffs led to an increase in the initial deflections in the central and side shells, respectively, by 1.2 and 1.15 times.

**At the second stage** of experimental studies, the stress-strain state of the monolithically interconnected central and four side shells installed on four common arched diaphragms and loaded with a load of 1.7 kN/$^{m2}$was studied.

A comparative analysis of studies on two variants of shell unwinding showed that when using the first method of unwinding, deflections for the middle span of the shell and the diaphragm were less, respectively, by 1.65 and 1.4 times. A similar phenomenon was observed for the horizontal displacements of the shell, which decreased by 1.15-1.27 times for different sides of the contour structures of the side elements of the shells.

Analysis of the effectiveness of the developed design solutions of the proposed method of installation of precast-monolithic coating shells with a span of 96 m, provides structural reliability and safety indicates a reduction in labor costs during installation by 26%. The weight of a set of mounting accessories is reduced by 2.4 times, compared with the assembly conductor of the 36x36 m shell. When using solid scaffolding, labor costs are reduced by 33%, and the weight of installation equipment is reduced by 2.25 times.

A numerical study was carried out to test the possibility of applying the results of these studies to evaluate the performance of coating shells of various geometric shapes for unique large-span buildings with spans of 48-96 m or more.

The results of this study indicate the feasibility of using this technique in the

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