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Calculation of Reliability of Hangars for Parking and Maintenance of Vehicles

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Abstract

Thin shells are often used for roofing of large-span constructions including hangars for vehicles. This paper considers the approach to study of strength and stability of such structures.

A geometrically nonlinear mathematical model of deformation of double curvature shallow shells reinforced with ribs is considered. The model is represented with dimensionless parameters. The algorithm is based on the Ritz method and iterative processes.

Analysis of strength and stability was held for six types of shell structures of different radii of curvature and thicknesses with a different number of reinforcing ribs and made of different materials that can be used as roofing of hangars for parking and maintenance of vehicles.

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Keywords: hangars; shells; strength; stability; mathematical model

1. Introduction

Shell structures of different shapes have sufficiently high rigidity; that is why they are often used for roofing of large-span building structures, such as hangars for parking and maintenance of vehicles. As a rule, during structural

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engineering, shallow shells of double curvature are used for such facilities [Espion (2016)] and their particular case — cylindrical shells (Figure 1 [Construction of frameless arch buildings — Severavtodor (electronic resource)]). Many publications describe the study of stability of such shells [Tornabene et al. (2014), Kundu et al. (2007), Reddy and Chandrashekhara (1985), Youssif (2009), Chaudhuri and Kabir (1992), Ziemian (2010)].

Fig. 1. Hangar for parking and repair of vehicles.

At that, the shallow shells are made of different materials: ferroconcrete, steel, plexiglass, etc. In order to increase rigidity of such shells, they are reinforced with ribs. Thus, their rigidity increases considerably, while their thickness remains minimal.

Analysis of strength and stability of these structures made of different materials should be carried out during structural engineering in order to choose the most practical material.

The objective of this paper is to present methods for analysis of strength and stability of shell roofs of hangars for parking and maintenance of vehicles.

2. Main text

2.1. Theory and Methods

Thus wise, we shall consider shallow rectangular shells of double curvature in this paper. The middle surface of the shell with thickness h is taken as a coordinate surface. Axes x, y are directed along the lines of principal curvatures of the shell, while axis z is directed along the normal to the middle surface in the direction of the concavity.

The structure can be reinforced with an orthogonal grid of ribs directed along coordinate lines and located on the inside of the shell.

A mathematical model of deformation for such structural design is based on the functional of total potential energy of shell deformation, which under application of the following dimensionless parameters [Karpov and Semenov (2015)]:

$$\xi = \frac{x}{a}, \quad \eta = \frac{y}{b}, \quad \lambda = \frac{a}{b}, \quad k_\xi = \frac{a^2 k_x}{h}, \quad k_\eta = \frac{b^2 k_y}{h},$$

$$\overline{U} = \frac{aU}{h^2}, \quad \overline{V} = \frac{bV}{h^2}, \quad \overline{W} = \frac{W}{h}, \quad \overline{\Psi}_x = \frac{\Psi_x a}{h}, \quad \overline{\Psi}_y = \frac{\Psi_y b}{h},$$

$$\overline{\sigma}_x = \frac{\sigma_x a^2}{Eh^2}, \quad \overline{\sigma}_y = \frac{\sigma_y a^2}{Eh^2}, \quad \overline{\tau}_{xy} = \frac{\tau_{xy} a^2}{Gh^2}, \quad \overline{P} = \frac{a^4 q}{h^4 E}, \quad \overline{a} = \frac{a}{h}, \quad \overline{z} = \frac{z}{h}. \tag{1}$$