EXACT SOLUTIONS OF PROBLEMS OF STATICS, DYNAMICS AND STABILITY OF NON-CLOSED CIRCULAR CYLINDRICAL SHELLS STRENGTHENED IN ONE DIRECTION BY "ALMOST REGULARLY PLACED" RIBS

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Non-closed circular cylindrical shells simply supported on longitudinal edges strengthened by "almost regular" systems of longitudinal or annular ribs are considered. Exact solutions of the problems of statics, dynamics and stability of the shells are obtained in the form of trigonometric series with respect to the coordinate orthogonal to the ribs. Previously such solutions have been found only for the closed shells strengthened by regular systems of longitudinal ribs.

At a regular placement all mechanical and geometrical parameters of ribs are equal. The distances between ribs are equal and distances from edges of shells up to the nearest ribs are equal to the distances between the ribs. At "almost regular" placement of the ribs, as opposed to regular placing, distances from the shell edges up to the nearest ribs are equal to half of the distance between the ribs. In both placing cases a shell is segmented by ribs, the number of segments is equal to the number of ribs.

The obtained solutions are convenient both for calculations and for the analysis of deformation of shells, as they lead to the sufficiently simple transcendental equations for determination of characteristic numbers, critical stresses at loss of stability, natural frequencies of vibrations and wave parameters.

The "almost regular" placement of ribs is widely used in many structural designs of elements and mechanical constructions.

These are the problems that are solved for shells strengthened by longitudinal ribs:

A. A common solution of a non-homogeneous system of equations of balance is obtained. It enables studying both the character of influence of loadings at a curvilinear edge of a semi-infinite shell on its stress-strain state and the influence of a discrete ribs placement on a zone extent in which it is essential.

B. The problem of finding critical stresses at loss of stability of the shells simply supported on all edges under joint action of a longitudinal tension or compression and external or internal pressure is reduced to the calculation of minimal roots of the transcendental equations of three types, differing by character of wave formation:

1. The wavelength in the circumferential direction is almost independent of a ribs arrangement (in this case critical stresses depend on all rigidity characteristics of the ribs).
2. The maxima of the form of deflection are on axes of ribs (in this case critical stresses depend only on ribs rigidity in bending in a radial plane and in tension - compression).
3. Nodes of the deflection curve are on the axes of the ribs (in this case critical stresses depend only on ribs rigidity in bending in the planes equally distant to tangents to the shell surfaces, and in torsion).

As a result of the analysis of the above-mentioned transcendental equations, the simple approximate formulas for calculation of the shells stability are suggested at a large sufficiently number of ribs. The condition of applicability of the structurally orthotropic shell theory is formulated.

C. The problem of determination of natural frequencies of vibration of shells which are simply supported on all edges is also reduced to calculation of the roots of the transcendental equations of the specified three types. Their analysis permits obtaining simple expressions to find low natural frequencies at a sufficiently large number of ribs and to formulate conditions of applicability of the constructively orthotropic shell theory.

D. It is found that investigation of the influence of a discrete ribs placement on wave parameters of harmonic waves propagating along shells is reduced to the determination of roots of transcendental equations of the same three types. The analysis of these equations is fulfilled.

For non-closed shells which are simply supported on all edges strengthened by “almost regular” systems of annular ribs the problem of determination of critical stresses under joint action of compression (tension) and external (internal) pressure is solved. Their calculation is reduced to the determination of the minimal roots of the transcendental equations of the three types similar to those obtained for shells strengthened by longitudinal ribs. Previously for the shells strengthened by regular systems of annular ribs only the approximate equations of two types (the first one and the third one) have been derived.

The determination of natural frequencies of vibrations of the shells strengthened by “almost regular” systems of annular ribs is also reduced to the calculation of roots of the transcendental equations of the three types. For mentioned shells the obtained approximate expressions enable calculation of the critical stresses and natural frequencies of vibrations at a sufficiently large number of ribs.

Similar exact solutions and approximate formulas are also deduced for the closed shells strengthened by “almost regular” systems of annular ribs.