NASA TECH BRIEF

Computer Program Analyzes Buckling of Shells of Revolution with Various Wall Constructions

A computer program (entitled BOSOR) has been developed to perform stability analyses for a wide class of shells without unduly restrictive approximations. The program uses numerical integration and finite difference techniques to solve with reasonable accuracy a wide variety of buckling problems for shells of revolution which have "orthotropic" properties oriented with principal axes in the axial and circumferential directions. For this type of shell in the prebuckling state, axisymmetrical loads produce axisymmetrical displacements. The program performs a nonlinear axisymmetric prebuckling analysis and then solves an eigenvalue problem to determine buckling loads.

For the geometry of the meridian, the general branch of the program calls for input in the form of cartesian coordinates for a number of points along the meridian. Special branches are provided for cylindrical, conical, spherical, and toroidal shells.

The general branch for the shell wall stiffness data calls for input in the form of coefficients of the constitutive equations. Special branches calling for simpler input data are provided for: shells with ring and stringer stiffening; shells with skew stiffeners; fiber reinforced shells; layered shells; corrugated ring stiffened shells; and shells with one corrugated and one smooth skin. The eccentricity of the stiffening is accounted for, but the stiffness coefficients must be constant along the meridian.

The most general form of the boundary conditions for the prebuckling analysis is a set of 4 nonhomogeneous equations containing 20 coefficients. For the stability analysis, the homogeneous boundary conditions consist of 8 equations with 64 coefficients which are called for as input by the general branch. The boundary conditions can be calculated internally (with only control integers required as input) by several branches provided in the program and include force or displacement boundary conditions, support by elastic edge rings, or support by an elastic medium. The shell can be open or closed at the apex. When the program makes use of the nonlinear prebuckling analysis, the boundary conditions for the prebuckling solution are consistent with the stability analysis.

In the first part of the analysis, the Newton–Raphson procedure is used to solve the set of nonlinear algebraic equations. These equations result from a finite-difference analog of the pair of nonlinear, nonhomogeneous, second-order ordinary differential equations governing the prebuckling state of the shell. The solution of the equations yields the prebuckling meridional rotation and meridional and circumferential stress resultants.

The second part of the analysis solves the stability equations (Donnell-type formulation) which are a pair of linear, homogeneous, fourth-order, partial differential equations having coefficients determined from the prebuckling analysis. Since the dependent variables are harmonic, dependence on the circumferential coordinate can be eliminated and the resulting ordinary differential equations solved by the method of finite differences. The stability analysis is formulated as an eigenvalue problem with the lowest eigenvalue of the stability equations corresponding to the critical load.

Notes:
1. This program is written in Fortran IV for use on the IBM 7094 computer.

2. Inquiries concerning this program may be made to:
    COSMIC
    Computer Center
    University of Georgia
    Athens, Georgia 30601
    Reference: B68-10226

Patent status:
No patent action is contemplated by NASA.

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