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Computer Program for Determination of Natural Frequencies of Closed Spherical Sandwich Shells

The problem:

To obtain the equations of motion of a spherical sandwich shell and to derive frequency equations for the free vibrations of a closed shell. Many modern shell structures incorporate a sandwich construction consisting of a core layer covered by relatively thin facing sheets having material properties different from the core. The dynamics of such shells have received little attention compared with those devoted to shells of monocoque construction. Although the analysis of shells having simple geometries, such as cylinders and spheres, has been considered, the frequencies of sandwich shells had to be calculated on the basis of a monocoque shell, and the effects of transverse normal stress and transverse shear deformation had to be neglected.

The solution:

Solutions for the axially symmetric motion of an elastic spherical sandwich shell have been obtained from a theory of shells which includes the effects of transverse shear deformation and rotary inertia. Frequency equations and mode shapes are derived for the full vibrations of a closed spherical shell. From these equations, a computer program was developed which gives the natural frequencies of any elastic spherical sandwich shell.

How it's done:

The axially symmetric motions of shells of revolution are either of a torsional or of a torsionless character. In the former case the motion is exclusively in the circumferential direction, while in the latter there is no motion in that direction. This program presents frequency equations for both the torsionless and the torsional modes of free vibration of the closed sandwich sphere.

Assume that the facing layers have the same material properties, are of equal thickness, and are much thinner than the core. They carry only direct stress and have no flexural rigidity about their own middle surfaces. Poisson's ratio is assumed to be the same in the facings and the core. The effect of transverse normal stress in the core layer is taken into account. However, it is assumed that $E_f h_2/E_c h_1$ is much larger than unity so that the core layer contributes negligibly to the moment resultants and membrane stress resultants of the composite shell. Thus the equations of motion may be obtained from E. Reissner's paper on the statics of sandwich shells with the addition of the appropriate inertia terms.

If the effect of transverse normal stress is neglected, that is, if it is assumed that the core layer is infinitely stiff in the radial direction, then a simple substitution concerning the material and geometric constants shows that the uncoupled equations of the present analysis have the same form as those obtained for a spherical monocoque when the effect of transverse shear deformation is retained in the analysis. In that case, the frequency equations derived previously by Wilkinson for the spherical monocoque are applicable when certain substitutions are made.

Notes:

1. The program was written for the IBM 7090/94.
2. Fortran IV is the programming language used.

(continued overleaf)

3. Additional details are contained in: *Natural Frequencies of Closed Spherical Sandwich Shells,* by J. P. D. Wilkinson, North American Aviation, Inc., SID65-1604, December 1965. Copies of this report are available from:

   COSMIC
   Computer Center
   University of Georgia
   Athens, Georgia 30601
   Reference: B67-10279

Patent status:

No patent action is contemplated by NASA.

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