Antisymmetric modes of vibration of a circular plate elastically restrained against rotation and subjected to a hydrostatic state of in-plane stress

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THURSDAY, 18 NOVEMBER 1976 SUNRISE ROOM, 8:30 A.M.

Session GG. Shock and Vibration IV

Clive Dym, Chairperson

Bolt Beranek and Newman, Inc., Cambridge, Massachusetts 02138

Contributed Papers

8:30

GG1. Antisymmetric modes of vibration of a circular plate elastically restrained against rotation and subjected to a hydrostatic state of in-plane stress. P. A. A. Laura, L. E. Luisoni, and A. Arias (Institute of Applied Mechanics, Base Naval, Puerto Belgrano, Argentina)

The analysis of flexural vibrations of plates with edges elastically restrained against rotation is of interest to the design engineer since ideal supports or clamps are difficult to obtain in practice. A survey of the literature reveals that several investigations have been performed in the past on (a) vibrating circular edges (without in-plane loading) and (b) vibrating simply supported and clamped circular plates subjected to hydrostatic in-plane loading. The present paper deals with the determination of very simple, approximate frequency equations which allow prediction of natural frequencies in the case of a vibrating circular plate which executes antisymmetric modes. It is shown that use of simple polynomial expression and a variational approach leads, in some cases, to numerical values which are more accurate than those available in the technical literature. The approach followed in the present investigation can be extended in a straightforward fashion to the case where the edge has translational flexibility.

8:45

GG2. Vibrations of prolate spheroidal shells of constant thickness. Courtney B. Burroughs (Bolt Beranek and Newman Inc., Cambridge, MA 02138) and Edward B. Magrab (Institute for Basic Standards, National Bureau of Standards, Washington, DC 20234)

The general displacement-equilibrium equations, which include the effects of transverse shear and rotary inertia, have been derived for a prolate spheroidal shell of constant thickness. The solution is formulated for a shell that is immersed in an inviscid fluid of infinite extent and subjected to an harmonically time-varying, arbitrarily spatially distributed force normal to the shell surface. The approximate formal solutions for the three displacements of the shell surface and the two rotations of the shell cross section are obtained using an extension of Galerkin's variational method developed by Chi and Magrab [*Proceedings of the International Conference on Variational Methods in Engineering* (University of Southampton, 1974)]. Numerical results are presented for the lowest seven axisymmetric natural frequencies of the shell *in vacuo*. Using 15-term solutions for both thick and thin shells, which have eccentricities that vary from 0.46 to 0.99, the approximate natural frequencies are found to converge to within less than 1% their final value. Good agreement with other published results for the approximate natural frequencies of a thin prolate spheroidal shell and for the exact natural frequencies of a thick spherical shell is obtained. Additional results for the natural frequencies of moderately thick shells as a function of shell eccentricity, mode number, and shell thickness are presented.

9:00

GG3. Flexural waves generated in glass fibers by fracture. P. G. Simpkins (Bell Laboratories, Murray Hill, NJ 07974)

In 1948 Davies noted that flexural waves could be created in a rod by an unsymmetrical load applied to one end. Miklowitz applied this observation to the hypothesis that during tensile fracture a moment pulse is exerted on the specimen which generates a flexural wave. He went on to suggest that this flexural wave could augment the stress induced in the rod by a reflected longitudinal wave when the two were coincident; thereby causing the secondary failures observed in brittle materials. The nature of the failure in fused silica fibers qualitatively suggests that it alters as the strength increases. While the low-strength fibers simply fracture at one point, the high strength fibers (UTS > 2.8 GN/m^2) appear to disintegrate into a particulate cloud. Recent photographic studies show that a flexural wave emanates from the primary fracture. When the strength is sufficient this flexural wave causes secondary *explosive* failures at other points along the fiber. These result in a particulate cloud of debris as the fiber appears to be progressively pulverized. Observations of the flexural wave amplitude show it to be a strong function of fiber strength. The observed group velocity of the flexural waves compares favorably with the classical time harmonic theories and the first-mode Timoshenko approximation.

9:15

GG4. Time-average holographic study of a singing wine glass. R. Tonin and D. A. Bies (Department of Mechanical Engineering, University of Adelaide, Adelaide, South Australia 5001)

Previous attempts to determine the motion of a free edge vibrating cylinder using time average optical holography have been inconclusive. On the assumption of strictly radial motion attempts at the interpretation of the fringes produced in orthogonal views has lead to the contradiction that the implied motion motion was not single valued [S. D. Liem *et al.*, J. Sound Vib. **29**, 475—481 (1973)]. In the latter reference it was suggested that the problem lay with the physical location of the optical fringes in the reconstructed image. However, as already shown by Rayleigh the motion of the free edge of a vibrating cylinder has both radial and tangential components of displacement and this point had not been taken into account. In this paper it is shown how the theory of time-average optical holography may be extended to account for generalized elliptic motion of a vibrating surface under study and how the optical system may be arranged to unambiguously interpret the motion. It is shown that good argument is obtained between the predicted and observed motion for a singing wine glass and for a free edge rectangular cylinder vibrating in a Love mode.

9:30

GG5. Vibrations of two concentric cylindrical shells containing a viscous fluid. T. T. Yeh and S. S. Chen (Components Technology Division, Argonne National Laboratory, Argonne, IL 60439)

This study was motivated by the need to design the thermal shield in reactor internals to avoid detrimental flow-induced vibrations. The system component is modeled as two coaxial shells separated by a viscous fluid. In the analysis, Flugge's shell equations of motion and linearized Navier—Stokes equation for viscous fluid are employed. First, a traveling-wave-type solution is taken for shells and fluid. Then, from the interface conditions between the shells and fluid, the solution for the fluid medium is expressed in terms of shell displace-