Analytical solutions for open nonshallow spherical shell vibrations

G. F. Lin

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FRIDAY MORNING, 1 DECEMBER 1978 KAHUKU ROOM, 8:00 A.M.

Session FFF. Shock and Vibration V: (a) Seismics, Shells and Smashes. (b) Plates, Ribs, and Panels.

Gideon Maidanik, Cochairman

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Contributed Papers

8:00

FFF1. Assessment of acoustical technology for minimizing seismic damage to urban utility system network. Arun G. Jhaveri (City of Seattle, Seattle, WA 98104)

The Puget Sound region of Washington State is one of the most seismically active areas in the country, as demonstrated by two major earthquakes, one in 1949 and the other in 1965. The United States Geological Survey (USGS) report, *A Study of Earthquake Losses In the Puget Sound, Washington Area* (Open File Report 75-375), concludes that the maximum credible earthquake that can be expected in the Puget Sound area is 7.5 on the Richter Scale of magnitude, and that extensive damage would result, including the deaths of some 2000 people. Earthquakes are a potential threat to the continuous functioning of a city's lifelines (e.g. water and power utilities, communication and transportation networks); however, until recently seismic considerations have not been an integral part of the planning, design, construction, and operational phases of urban lifeline systems. Acoustical technology can play an important role in both the new and retrofitting system design as well as construction of structures, equipment, and facilities associated with such utility components as metropolitan water supply and distribution network. Vibration dampening, shock absorption/isolation techniques, and acoustical instruments for preventive maintainence and potential damage/risk analyses are specific areas of investigation discussed in this paper.

8:11

FFF2. Analytical solutions for open nonshallow spherical shell vibrations. G. F. Lin (Code 1965, David W. Taylor Naval Ship R & D Center, Bethesda, MD 20084)

This paper is concerned with axisymmetric as well as nonsymmetric vibrations of open nonshallow thin elastic spherical shells. Without employing the usual auxiliary variables for reduction of shell motion equations introduced by Van der Neut and Berry, independent analytical solutions for middle-surface displacements are obtained and explicitly expressed in terms of associated Legendre functions. In order to gain physical insights into the free-vibration characteristics of an open nonshallow shell, theoretical calculations together with asymptotic descriptions are made of natural frequencies and mode shapes of a hemispherical shell with a free edge. The numerical predictions obtained herein compare excellently against the experimental results obtained previously by Hwang and recently in the David W. Taylor Naval Ship R & D Center, Bethesda, Maryland. Essential features of shell dynamics are ultimately displayed by normalized frequency (Ω) and nondimensional shell thickness parameter (β). Five families of natural frequencies, i.e., low Rayleigh bending, mixed bending-membrane, torsional, bending, and membrane frequencies, are found. The corresponding mode shapes exhibit distinctive displacement patterns. [Work supported by Naval Sea Systems Command.]

8:22

FFF3. Structure response to free-field acoustic excitation using the statistical energy analysis method. D. M. Wong (The Aerospace Corporation, Bldg. A2, Room 2069, P.O. Box 92957, Los Angeles, CA 90009)

The statistical energy analysis (SEA) method has been used very successfully in the prediction of structural response to reverberant acoustic fields. This paper will extend the method to the free field acoustic excitation. The coupling loss factor (an important parameter in the SEA method) between the plate and the exciting acoustic field was derived. The analytical results compare reasonably well with test data obtained during the Space Shuttle (OV-101) acoustic test conducted at Dryden Flight Research Center. In that test two F-104 jets were used as sound sources. Accelerometer readings were obtained both at the cargo bay door and the side wall. Also, the correlation constants of the pressure field were obtained from the test.

8:33

FFF4. A method to estimate collision point of a rod. Osamu Ikeda, Takuso Sato, Jiro Yamamoto, and Akira Manabe (Faculty of Science and Engineering, Tokyo Institute of Technology, Midoriku, Yokohama, 227 Japan)

A method to estimate a collision point on a metal rod is presented, which is based on spectral analyses of the signal detected by a single accelerometer attached to the rod. First, the transfer function from a forcing point to the detector is derived, where space-variant and dispersive characteristics of the rod are taken into consideration in connection with varying diameter, the change of surrounding condition along the axis, and various transmission and reflection loss characteristics. Then an algorithm to estimate collision point is derived by using the obtained transfer function. The fundamental experimental results obtained by using a 17S aluminum rod of 2003 mm length and 10 mm diameter show that the estimated positions agree with the actual collision positions with a precision of less than 1 cm [O. Ikeda, T. Sato, J. Yamamoto and A. Manabe, J. Acoust. Soc. Am (to be published)].