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VIBRATIONS OF VARIABLE THICKNESS SPHERICAL SHELLS

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ABSTRACT

Spherical shells are extensively used in many structural engineering applications such as aerospace vehicles, roof domes, storage tanks, adaptive smart membranes and active shells, laminated transducers and sensors, ballistic missile bulkhead and submarines. Free vibration problems for shells are of interest from the view point of tuning out the frequencies of external excitation, eliminating undesirable vibrations, etc.

The present research deals with the natural vibration frequencies and modes of spherical shells which may have variable thickness general type of material properties and any kind of boundary condition. The variation of geometric and material parameters is taken in a polynomial form. A wide range of spherical shells can be described in this way, to any desired accuracy. The primary objective of this study is to present a simple yet accurate procedure for obtaining modal characteristics of a spherical shell structure by using an exact approach.

In this work the first order shear deformation shell theory, in which the effects of both transverse shear stresses and rotary inertia are accounted, was applied to the analysis of thick isotropic shells, composite shells, and shells made from functionally graded materials. The dynamic behavior of variable thickness shells is governed by a set of partial differential equations with variables coefficients. The present procedure enables to deal directly with the governing equations, while this might not always hold for other approaches. The solution is based on assuming harmonic vibrations in time and an expansion of the variables in circumferential direction into several one-term analyses of the Fourier series. The solution in the meridian direction is done by employment of the Exact Element Method [1,2]. The dynamic analysis of the shell has been done by the Dynamic Stiffness Method [3]. The dynamic stiffness matrix which is derived from the differential equations of motion is free of membrane and shear locking as the shape functions that are used are the exact solution of the differential equations of motion.

Numerical examples for constant thickness hemispherical caps with annular cutout at apex, variable thickness spherical annular segment (Figure 1a), and variable thickness spherical barrel shell (Figure 1b) are presented in order to demonstrate the applicability and versatility of the present method, and compared with those of the FE

analysis of Gautham and Ganesan [4] , and three-dimensional analysis by Ritz method reported in a Corrigendum to the paper by Kang and Leissa [5].

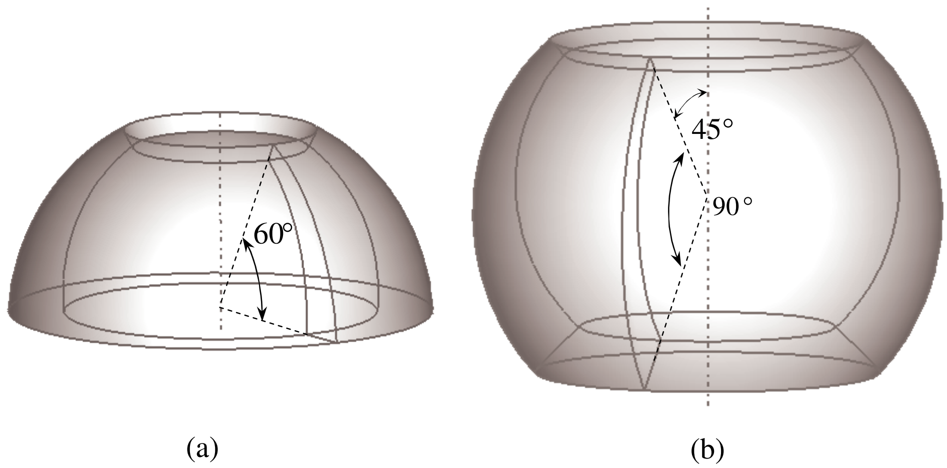

Figure 1: Spherical shells with linearly variable thickness, a) hemispherical annular segment; b) spherical barrel shell.

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