

# Free Vibrations of Cylindrical Shells Containing Liquid on Elastic Foundations

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## 1. Introduction

Cylindrical shells as structural components are used in many engineering fields in the form of storage tanks, water ducts, storage, vessels, pipelines, and many others. They are used because of their strength and effectiveness. This paper examines the interactive behavior between shell, foundation, and internal liquid.

Lakis *et al.*[1-2] have developed the hybrid finite element formulation for circular cylindrical shells based on the analytical shape functions which are derived from governing equation of shell. The analysis of whole buried pipeline subjected to sinusoidal seismic wave, differential settlement, and dislocation of ground has been investigated by Yang *et al.*[3] using the shell finite element. Palwal *et al.*[4-5] have studied the free vibrations of the whole buried cylindrical shells in Winkler and Pasternak foundations by direct solution to the governing equations of motion. In the paper, the elastic foundations are distributed uniformly both in the circumferential and in the longitudinal directions. However, cylindrical shells are generally laid on elastic foundation, so that the foundation only covers certain parts of the shell in the circumferential direction. This leads to more complex problems. Amabili *et al.*[6] have investigated the free vibrations of cylindrical shell simply supported at both ends with a non-uniform elastic foundation in the circumferential direction based on the Rayleigh-Ritz method. The elastic foundation has to be assumed distributed uniformly over the whole cylinder length in the longitudinal direction. Gunawan *et al.*[7-8] have studied the static and free vibration of cylindrical shells partially buried in the elastic foundation based on the semi-analytical finite element method where the simple polynomials were used as shape function in the longitudinal direction.

This paper presents the dynamic characteristics (i.e. natural frequencies and mode shapes) of fluid-filled cylindrical shells on elastic foundation by means of the semi-analytical finite element method where shape functions based on the governing equations of shell are used in the analysis. The shell is discretized into cylindrical finite elements. Soil as a foundation is represented by four parameter elastic springs and may be distributed by a Fourier series and an element mesh strategy in the circumferential and in the longitudinal directions, respectively. The internal fluid is described by the potential flow. Hydrodynamic pressure acting on the shell is derived from the condition for dynamic

coupling of the fluid-structure. The influence of internal fluid, shell geometries, and foundation parameters (i.e. spring stiffness and enclosed angle) on the natural frequency of the vibrating system is presented systematically for both symmetrical and asymmetrical vibrations.

## 2. Model and formulation

The structure is an isotropic thin elastic cylindrical shell with Young's modulus  $E$ , Poisson's ratio  $\nu$ , radius of the middle surface  $R$ , thickness  $h$ , and length  $L$ . The foundation is represented by continuous elastic (axial, circumferential, radial, and rotational) springs and distributed on a limited arc. The axial, circumferential, radial, and rotational spring coefficients are denoted by  $K_x$ ,  $K_\theta$ ,  $K_r$ , and  $K_\rho$ , respectively. In the analysis, all the spring coefficients are assumed to be constant along the enclosed arc. The angles that define the enclosed arc are denoted by  $\varphi_1$  and  $\varphi_2$ . The geometry and generalized model of the structure are shown in Fig.1.

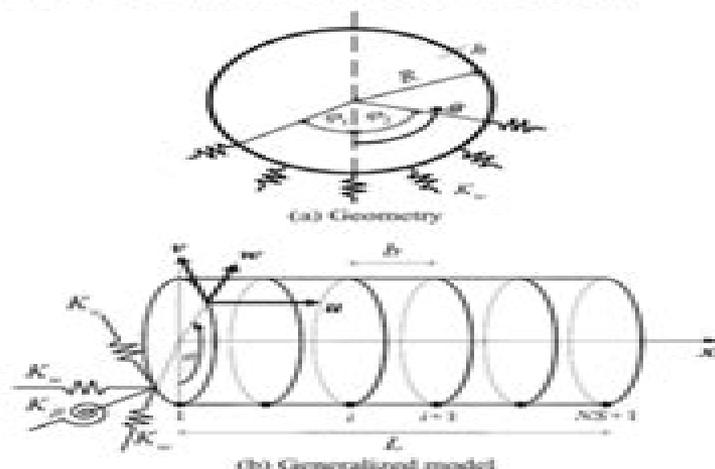


Fig.1. Cylindrical shell on elastic foundation.

The displacement of a point on the middle surface in the axial, circumferential, and radial directions is indicated by  $u$ ,  $v$ , and  $w$ , respectively. The displacement functions which include the symmetrical (superscript S) and asymmetrical

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Free Vibrations of Circular Cylindrical Shells Sushil Kumar Sharma, 1971 In this report bending theory of shells is used to determine the natural frequencies and mode shapes of circular cylindrical shells The governing eighth order system of differential equations has been put in a form which is especially suitable for numerical integration and application of different sets of homogeneous boundary conditions The Holzer method is used to solve the eigenvalue problem During numerical integration of the differential equations the exponentially growing solutions are suppressed whenever they become larger than previously selected values Numerical results are obtained for various shell geometry parameters and for three different sets of homogeneous boundary conditions These results are compared with the energy method solutions developed by Rayleigh and by Arnold and Warburton The difference between the results obtained by the numerical integration method and the energy method has been found to be less than 10 percent for all the cases Abstract leaf ii

*Free vibrations of circular cylindrical shells, by Anthony E. Armenakias, Denos C. Gazis* Anthony E. Armenàkas, **FREE VIBRATIONS OF CYLINDRICAL SHELLS.** V. I. Petrov, R. M. Finkelshtein, FOREIGN TECHNOLOGY DIV WRIGHT-PATTERSON AFB OHIO., 1968 General analysis of free vibration of closed circular cylindrical shells is based on fundamental relationships taken from the theories of shells The shells are radially supported at their faces The effect of terms usually neglected in equations of shell motion on frequency is discussed

The simplifying assumptions concerning shell behavior which are associated with these terms are examined for a wide range of variations in shell geometry Expressions are extended for free vibration of orthogonally anisotropic shells and a formula for their natural frequencies is obtained Two layer shells stiffened by stringers and transverse frames and sandwich shells are analyzed as particular cases *Free Vibration of Circular Cylindrical Shells of Finite Length* Bert Louis Smith,1966

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Eremeyev, Gennadi I. Mikhasev, Nikita F. Morozov, 2022-01-01 This book presents the various approaches in establishment the basic equations of one and two dimensional structural elements In addition the boundaries of validity of the theories and the estimation of errors in approximate theories are given Many contributions contain not only new theories but also new applications which makes the book interesting for researcher and graduate students The Shock and Vibration Digest, 1993 **Free Vibrations of Thin Circular Cylindrical Shells with Exponential Wall Thickness** Jean Maxime José Jullienne, 1965 **Theory and analysis of Plates** Mr. Rohit Manglik, 2024-07-26 EduGorilla Publication is a trusted name in the education sector committed to empowering learners with high quality study materials and resources Specializing in competitive exams and academic support EduGorilla provides comprehensive and well structured content tailored to meet the needs of students across various streams and levels *Applied Mechanics Reviews*, 1972

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