

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. Paliwal *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 problem. 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 on 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 ν , 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_{xx} , $K_{\theta\theta}$, K_{rr} , and $K_{\phi\phi}$, 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 φ_1 and φ_2 . The geometry and generalized model of the structure are shown in Fig.1.

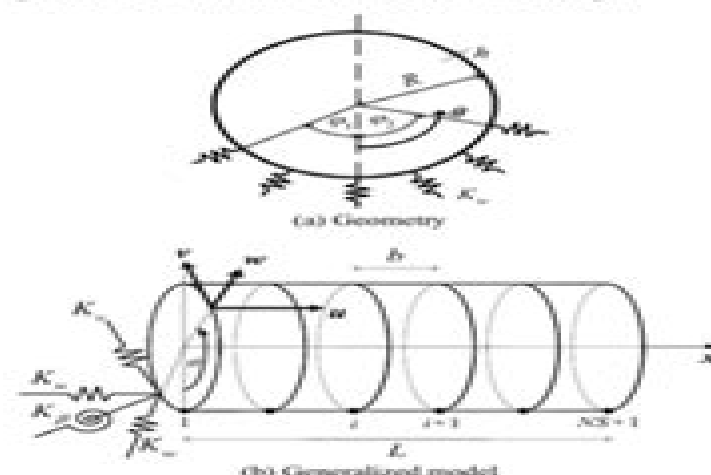


Fig.1. Cylindrical shell on elastic foundation.

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 Anthony E. Armenàkas, Denos C. Gazis, George Herrmann, 2013-10-22
Free Vibrations of Circular Cylindrical Shells deals with thin walled structures that undergo dynamic loads application thereby resulting in some vibrations Part I discusses the treatment of problems associated with the propagation of plane harmonic waves in a hollow circular cylinder In such search for solutions the text employs the framework of the three dimensional theory of elasticity The text explains the use of tables of natural frequencies and graphs of representative mode shapes of harmonic elastic waves bounding in an infinitely long isotropic hollow cylinder The tables are found to be useful as they can be used to check validity and provide estimates of the range of applicability of various shell theories The purpose of the frequency equation and that of the numerical computations likewise are considered The book includes a computer program written in the FORTRAN language to show how it is used in the computations except in cases when H the thickness of shell and L axial half of wavelength result in extremely small values Part II consists of related tables and graphs Physicists engineers students and researchers in advanced sciences will find this book of interest **Free vibrations of circular cylindrical shells** Anthony E. Armenakas, Denos C. Gazis, George Herrmann, 1969 Vibration of Shells Arthur W. Leissa, 1973 The vibrational characteristics and mechanical properties of shell structures are discussed The subjects presented are 1 fundamental equations of thin shell theory 2 characteristics of thin circular cylindrical shells 3 complicating effects in circular cylindrical shells 4 noncircular cylindrical shell properties 5 characteristics of spherical shells and 6 solution of three dimensional equations of motion for cylinders 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. Armenakas, 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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On the Nonlinear Free Vibrations of Thin Circular Cylindrical Shells J. Mayers,Stanford University. Department of Aeronautics and Astronautics,B. G. Wrenn,1966 A study was made of the influence of higher order and nonlinear effects on the free vibration behavior of thin circular cylindrical shells A recent solution utilizing the Karman Donnell strain displacement relations is examined and criticized A new solution is carried out which removes the basis for criticism and discloses the existence of a nonperiodic vibration behavior a phenomenon heretofore unknown Further solutions are obtained employing the strain displacement relations deduced by Sanders and applied in an appropriately modified manner by Mayers and Rehfield to the shell postbuckling problem The effect of the improved strain displacement relations in predicting the vibration behavior attendant to a modal shape possessing a small number of circumferential waves is assessed and recommendations are made for directing future effort on the problem Author **Thin Plates and Shells** Eduard

Ventsel,Theodor Krauthammer,2001-08-24 Presenting recent principles of thin plate and shell theories this book emphasizes novel analytical and numerical methods for solving linear and nonlinear plate and shell dilemmas new theories for the design and analysis of thin plate shell structures and real world numerical solutions mechanics and plate and shell models for engineering applications It includes computer processes for finite difference finite element boundary element and boundary collocation methods as well as other variational and numerical methods It also contains end of chapter examples and problem solution sets a catalog of solutions for cylindrical and spherical shells and tables of the most commonly used plates and shells

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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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Table of Contents Free Vibrations Of Circular Cylindrical Shells

1. Understanding the eBook Free Vibrations Of Circular Cylindrical Shells
 - The Rise of Digital Reading Free Vibrations Of Circular Cylindrical Shells
 - Advantages of eBooks Over Traditional Books
2. Identifying Free Vibrations Of Circular Cylindrical Shells
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Free Vibrations Of Circular Cylindrical Shells
 - User-Friendly Interface
4. Exploring eBook Recommendations from Free Vibrations Of Circular Cylindrical Shells
 - Personalized Recommendations
 - Free Vibrations Of Circular Cylindrical Shells User Reviews and Ratings
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 - Free Vibrations Of Circular Cylindrical Shells Enhanced eBook Features
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 - Highlighting and Note-Taking Free Vibrations Of Circular Cylindrical Shells
 - Interactive Elements Free Vibrations Of Circular Cylindrical Shells
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 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Free Vibrations Of Circular Cylindrical Shells
9. Balancing eBooks and Physical Books Free Vibrations Of Circular Cylindrical Shells
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Free Vibrations Of Circular Cylindrical Shells
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Free Vibrations Of Circular Cylindrical Shells
 - Setting Reading Goals Free Vibrations Of Circular Cylindrical Shells
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Free Vibrations Of Circular Cylindrical Shells
 - Fact-Checking eBook Content of Free Vibrations Of Circular Cylindrical Shells
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
 - Integration of Multimedia Elements

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