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Surkay D. Akbarov · Zafer Kutug ·
Muhammad Yousaf Anwar

Non-axisymmetric Local Stability Loss of a Hollow Cylinder

Three-Dimensional Stability Loss in Time-Dependent Composites

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To my grandson Mete Han Akbarov for the joy and hope for the future which he gave me

—Surkay D. Akbarov

To my mother Gülsüm and grandmother Turçin for their valuable support towards my education. And to my daughter Gülsu Turçin and son Efe Kutay for their patience and support

—Zafer Kutug

To my parents and siblings for their unconditional support and love

—Muhammad Yousaf Anwar

Preface

The contents of this book deal with the development and formulation for three-dimensional non-axisymmetric local stability loss problems in hollow cylindrical shells made up of materials exhibiting time-dependent deformation, i.e., viscoelastic materials.

The main body of this work employs the initial imperfection approach (stability loss criterion) for stability loss analysis. This approach assumes an initial imperfection in the structure of the considered element that grows with time. The state of this imperfection is analyzed through the 3D geometrically nonlinear field equations of the theories of elasticity and viscoelasticity for anisotropic bodies.

The first author of this book, along with his students, has contributed pioneering knowledge to the field of stability loss in time-dependent materials/composites. This work completes the consideration of non-axisymmetry in local stability loss where deformation in both the longitudinal as well as the radial direction is taken into account. This makes it, geometrically, the most general form of formulation for analyzing buckling loss in viscoelastic cylindrical shells.

The contents of this book are designed for audiences from different engineering backgrounds; mechanical engineers analyzing and designing mechanical elements made from viscoelastic composites, civil engineers studying the use of time-dependent materials for seismic isolation, and material engineers involved in the design of lightweight composites.

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—Zafer Kutug

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—Muhammad Yousaf Anwar

Contents

Acronyms

CDM	Critical Deformation Method
FG	Functionally Graded
IGA	Isogeometric Analysis
KL	Kirchhoff-Love theory
NURBS	Non-Uniform Rational B-Splines
RF	Refined Theory
TDLTS	Three-Dimensional Linearized Theory of Stability
TORST	Third Order Refined Shell Theory

Introduction

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Abstract

A brief introduction on the current state of the three-dimensional linearized theory of stability (TDLTS) is presented in a concise form with special focus on the justification of development of the TDLTS, the history of development of the TDLTS equations, different methods used to arrive at the equations of TDLTS, the use of TDLTS in different system of coordinates, and the use of initial imperfection rule. Details of historical and latest literature are provided for studies on materials exhibiting time-dependent strain, i.e., viscoelastic materials.

1.1 A Brief Background

For the investigation of buckling problems in elements of a structure or isolated solid bodies, the problem's solution is usually simplified by employing auxiliary hypotheses that simplify the solution into either two-dimensional or one-dimensional theories. However, this translates into an oversimplification when investigating stability loss in elements whose material or geometry or both have special properties. Examples of such cases are buckling in thick-walled elements (shells, plates), elements made of composed materials that can be classified as thin-walled structures having low shear capacity, stability loss in elastomers such as rubbers, buckling in composites that are fabricated in layered form with embedded fibers, and many more problems with special properties. The study of buckling (both global and local) in such cases calls for the use of the Three-Dimensional Linearized Theory of Stability instead of employing assumptions that reduce the problem to 2D or 1D theories.

The Three-Dimensional Linearized Theory of Stability (TDLTS) is widely used for investigating various types of failures in structural and non-structural elements fabricated from different types of conventional and composite materials. Apart from vibration analysis,

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