GEOMETRIC METHOD FOR STABILITY OF NON-LINEAR ELASTIC THIN SHELLS

GEOMETRIC METHOD FOR STABILITY OF NON-LINEAR ELASTIC THIN SHELLS

by

Jordanka Ivanova
Institute of Mechanics
Bulgarian Academy of Sciences
Sofia, Bulgaria

Franco Pastrone
Department of Mathematics
Universita' di Torino
Torino, Italy

SPRINGER SCIENCE+BUSINESS MEDIA, LLC

Library of Congress Cataloging-in-Publication Data

A C.I.P. Catalogue record for this book is available
from the Library of Congress.

ISBN 978-0-7923-7524-1 ISBN 978-1-4615-1511-1 (eBook)
DOI 10.1007/978-1-4615-1511-1

Printed on acid-free paper.

To our Parents and Children

TABLE OF CONTENTS

PREFACE

This book deals with the new developments and applications of the geometric method to the nonlinear stability problem for thin non-elastic shells. There are no other published books on this subject except the basic ones of A. V. Pogorelov (1966,1967,1986), where variational principles defined over isometric surfaces, are postulated, and applied mainly to static and dynamic problems of elastic isotropic thin shells.

A. V. Pogorelov (Harkov, Ukraine) was the first to provide in his monographs the geometric construction of the deformed shell surface in a post-critical stage and deriving explicitely the asymptotic formulas for the upper and lower critical loads. In most cases, these formulas were presented in a closed analytical form, and confirmed by experimental data.

The geometric method by Pogorelov is one of the most important analytical methods developed during the last century. Its power consists in its ability to provide a clear geometric picture of the postcritical form of a deformed shell surface, successfully applied to a direct variational approach to the nonlinear shell stability problems. Until now most Pogorelov's monographs were written in Russian, which limited the diffusion of his ideas among the international scientific community. The present book is intended to assist and encourage the researches in this field to apply the geometric method and the related results to everyday engineering practice.

Further developments of the geometric method are carried out in this book, and are directed to stability of thin shells in the case of elastic anisotropy, elastic anisotropy with linear memory and elasto-plastic properties of the shell material. Pogorelov's variational principle for elastic isotropic shells is extended here to non-elastic shell and the proper asymptotical analysis of the corresponding nonlinear partial differential equations is performed. This analysis confirms the validity of hypotheses of the geometric method when applied to the considered shells. The postcritical behavior of cylindrical and strongly convex thin shells under static, combined (static and short-time impulse) and axial impact load is fully investigated. The corresponding deformed shell surfaces are approximated by Pogorelov's isometric surfaces. A new isometric surface is constructed in the case of impacted cylindrical shell. The corresponding critical loads are obtained in closed asymptotic analytical forms and compared with experimental data.

These formulas could be used for a rapid estimation of the global stability of nonlinear elastic thin shells.

Readers should have a basic understanding of introductory surface theory, stability of shells and partial differential equations. The book also provides the basis of Pogorelov's construction of the isometric surfaces, approximating the deformed shell surface in postcritical stage.

The book is intended to serve both as a textbook for post-graduate students in structural engineering and applied mathematics, and as a reference monograph for academic and industrial researchers.

ACKNOWLEDGEMENTS

The first author would like to express her gratitude to Academician A. V. Pogorelov and to Professor V. A. Babenko of Institute of Low Temperatures, Ukrainian Academy of Sciences, Harkov, Ukraine, for their excellent knowledge and scholarship on the geometric method, which provoked our deep investigations presented in this book. We are extremely grateful to our co-authors Professor V. A. Babenko, Dr. Pl. Pirgov and Dr. L. Parashkevova of Institute of Mechanics, Bulgarian Academy of Sciences, Sofia, Bulgaria.

We wish to express our cordial thanks to Professor J. Brankov and Assoc. Professor S. Tabakova for their critical comments on the editing of the manuscript and to Assoc. Professor V. Valeva for her technical assistance in preparing figures in camera-ready form.

This research has been partially supported by the Italian MURST COFIN 2000: " Mathematical Models for Material Sciences", by Department of Mathematics, University of Torino, Italy and by CNR (Italy) through the contract CNR-BAS (Bulgaria).

Finally, we thank our families for the patience and for not complaining during the long period of preparing this book.