STABILITY ANALYSIS OF RING STIFFENED SHELLS OF REVOLUTION USING FINITE ELEMENT METHOD

By
J. SUBBIAH
Department of Applied Mechanics

Submitted
In Fulfilment of the Requirements of
the Degree of Doctor of Philosophy

Indian Institute of Technology,
New Delhi

June 1980

CERTIFICATE

This is to certify that the thesis entitled Stability Analysis of Ring Stiffened Shells of Revolution Using Finite Element Methods , being submitted by J. Subbiah to the Indian Institute of Technology, Delhi (India) for the award of the degree of Doctor of Philosophy in Applied Mechanics Department is a record of bonafide research work carried out by him under our supervision and guidance. The thesis work, in our opinion, has reached the standard fulfilling the requirements for the Degree of Doctor of Philosophy. The research report and the results presented in this thesis have not been submitted in part or in full to any other University or Institute for the award of any degree or diploma.

(V.P.GARG)
Commodore, Indian Navy
Director of Naval Construction
Naval Headquarters,
New Delhi-110 011

(R.NATARAJAN)
Assistant Professor,
Dept. of Applied Mechanics
Indian Institute of Technology,
New Delhi-110 029

ACKNOWLEDGEMENT

I wish to express my sincere gratitude to Dr. R.Natarajan and CMDE. V.P.Garg for the valuable guidance, help and encouragement.

I would also like to place on record my gratitude to the Air Headquarters Computer Centre where all the computer programs were developed, since the Computer Centre at IIT, Delhi was not operational during this period.

Computer facilities made available during the later part of the research at IIT, Delhi are also gratefully acknowledged.

Finally, I wish to thank Miss K.Verma and Miss S.Arora for their expert typing and the Directorate of Naval Design for the Xerox facilities made available.

(J.SUBBIAH)

New Delhi,
4 June 1980

ABSTRACT

Structural design of submarine pressure hulls is mainly governed by elastic stability requirements. Two of the most important modes of collapse, interframe buckling and general instability, have been studied by ·ral authors using analytical methods. Several short comings of the existing literature have been overcome in the present research programme using Finite Element methods.

A finite element formulation based on linear bifurcation buckling method is presented in the first part of the thesis. The method can be used to obtain collapse pressures for stiffened shells of revolution subjected to external hydrostatic pressure. The same program will give collapse pressures in both general instability and interframe buckling mode. The effect of boundary conditions and type of stiffening on the collapse pressure had been studied and discussed. A sophisticated theoretical model has been presented to treat the hydrostatic pressure as a load system with follower force effects and its influence on the collapse pressure is also reported.

In the second part of the thesis, a non-linear large deformation finite element formulation is presented. The effect of initial geometric imperfection on the load displacement response and general instability is reported. The effect of inclusion of second order geometric non linearities is also reported.

In the third part of the thesis, a new procedure which is a combination of both non-linear large deformation and linear bifurcation buckling method is presented. Using this procedure, the imperfection sensitivity of stiffened cylinders under various boundary conditions and type of stiffening has been recorded. The results obtained from the quadratic eigen value problem have been compared with the traditional linear eigen value problem.

Several sophisticated computational details developed during the course of the research together with comparative CPU Times are also reported.

Consideration has been given to the application of the programs developed during the three phases of the work to the design of submarine pressure hulls.

CONTENTS