SOME STUDIES ON GEOMETRICALLY NONLINEAR AXISYMMETRIC RESPONSE OF CYLINDRICALLY ORTHOTROPIC CIRCULAR PLATES AND SHALLOW SPHERICAL SHELLS

by

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CERTIFICATE

This is to certify that the thesis entitled "SOME STUDIES ON GEOMETRICALLY NONLINEAR AXISYMMETRIC RESPONSE OF CYLINDRICALLY ORTHOTROPIC CIRCULAR PLATES AND SHALLOW SPHERICAL SHELLS", submitted by Mr.Mohan Lal Gandhi for the award of the degree of Doctor of Philosophy, to the Indian Institute of Technology, Delhi, is a record of bonafide research work carried out by him. Mr. M.L.Gandhi fulfils all the requirements of the regulations laid down for the degree. The contents of this thesis have not been submitted to any other University or Institute for the award of any degree or diploma.

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ABSTRACT

With the introduction of new materials and systems exposed to severe operating conditions, the literature on the geometric and material nonlinear behaviour of thin plates and shells is steadily growing. The object of the thesis is to use the orthogonal point collocation method in space domain and Newmark -β scheme in time domain to analyse some geometrically nonlinear problems of static and dynamic axisymmetric behaviour of thin elastic cylindrically orthotropic circular plates and shallow spherical shells undergoing moderately large deflections. An attempt has been made to investigate the effect of orthotropic parameter support stiffness parameters, annular ratio, overhang ratio, mass ratio, shell parameter, etc., on the static and dynamic response as well as stability. An independent check on the balance of total energy has been employed to ensure the validity and accuracy of the results.

von Karman - Marguerre type governing differential equations have been employed. A comparative study of some implicit time-marching schemes and choice of collocation points for typical problems has established that Newmark-β scheme for time marching and zeros of a Legendre polynomial as collocation points are the optimum choices. Several problems have been analysed using this method.

The deflection and stress response of orthotropic circular plates with inplane and rotational edge restraints, subjected to uniformly distributed as well as central point loads has been investigated. Transient response to step function, exponential decay function, N shaped pulse, rectangular pulse, full and half sine-wave pulses has been studied. Similar studies have been carried out for annular plate with free hole,plugged

hole, and annulus supported at the inner edge subjected to uniformly distributed and edge loads. Postbuckling of full and annular orthotropic circular plates with rotational edge restraint under inplane radial loads has been investigated. Static and transient response of orthotropic circular plates supported on a concentric circle subjected to uniformly distributed and ring loads has been studied including the effect of inplane and rotational support stiffnesses. The studies on plates have revealed a significant participation of higher modes in both the deflection and the stress response, being more pronounced in the stresses.

The static and transient response of orthotropic shallow spherical shells with flexible supports has been analysed for small values of shell geometric parameter. Similar studies have been carried out for annular spherical caps with free and clamped hole under uniformly distributed and central loads. Static and dynamic axisymmetric buckling of orthotropic spherical caps with flexible supports has been investigated. The influence of initial imperfection on buckling load has been studied. Similar studies have been undertaken for annular spherical shells with and without a rigid plug subjected to uniformly distributed and ring loads at the hole.

The essential contribution of the thesis is to demonstrate the effectiveness of orthogonal point collocation method to yield accurate results even with lower order approximation for axisymmetric problems in the area of plates and shells. The present results are in good agreement with the available results. The new results reported in the thesis illustrating the effect of various parameters may be of some interest in the analysis and design of thin circular plates and shallow spherical shells.

The following research papers have been prepared till now from the work reported in this thesis:

1. Choice of Collocation Points for Axisymmetric Nonlinear Two Point Boundary Value Problems in Statics of Shallow Spherical Shells.

   Accepted for publication in "Engineering Transactions"No.3/83 of Archives of Mechanics.

2. Nonlinear Transient Response of Isotropic Circular Plates.

   Accepted for publication in Computers and Structures.

3. Nonlinear Axisymmetric Transient Analysis of Orthotropic Thin Circular Plates with Elastically Restrained Edge.

   Accepted for publication in Journal of Sound and Vibration.

4. Nonlinear Static and Transient Analysis of Orthotropic Thin Circular Plates with Elastically Restrained Edge Under Central Load.

   Accepted for publication in Journal of Composite Materials.

5. Axisymmetric Static and Dynamic Buckling of Orthotropic Shallow Spherical Caps with Flexible Supports.

   Revised manuscript communicated to Acta Mechanica.

6. Nonlinear Axisymmetric Transient Analysis of Orthotropic Thin Annular Plates with a Rigid Central Mass.

   Communicated to Journal of Sound and Vibration.

7. Postbuckling of Orthotropic Annular Plates with Rotational Edge Restraint.

   Communicated to International Journal of Science and Engineering.

8. Nonlinear Axisymmetric Transient Analysis of Elastic Orthotropic Thin Circular Plates with Overhang.

   Communicated to International Journal of Nonlinear Mechanics.

9. Axisymmetric Static and Dynamic Buckling of Orthotropic Shallow Spherical Caps with Initial Imperfections.

   Communicated to Archives of Mechanics.

10. Axisymmetric Static and Dynamic Buckling of Orthotropic Shallow Spherical Cap with Circular Hole.

    Communicated to Computers and Structures.

11. Nonlinear Axisymmetric Transient Analysis of Orthotropic Thin Annular Plates.

    Accepted for publication in Fibre Science and Technology.

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