LARGE DEFORMATION STUDIES ON SHELLS

By

N.MOHAMED SHERIFF

Department of Applied Mechanics

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This is to certify that the thesis entitled "**Large deformation studies on shells**" by N. Mohamed Sheriff has been prepared under our supervision and has attained a standard required for a Ph.D. degree of the Institute. The thesis is a record of bonafide research work carried out by him and its contents have not been submitted to any other University or Institute for the award of any degree or diploma.

(Dr. R Velmurugan)

Assistant Professor
Department of Aerospace
Indian Institute of technology, Madras
Chennai-600 036

(Dr. N K Gupta)

Professor
Department of Applied Mechanics
Indian Institute of technology, Delhi
Hauz Khas, New Delhi-110016

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N. MOHAMED SHERIFF

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ABSTRACT

Large deformation studies of metallic spherical shells, frusta of circular cones and combination geometry shells were performed by applying axial load under quasi-static and dynamic load conditions. Quasi-static tests were conducted on an UTM with digital recording facility and impact tests on a gravity drop hammer set-up. Spherical shells of different radii and thicknesses, frusta of different semi-cone angles and different slenderness ratios, combination geometry shells of conical frusta with hemi-spheres and combination shells of two conical frusta with shallow spheres were tested to identify various deformation mechanisms and energy absorption capacities. Analytical model has been developed for each case and the results obtained have been compared with experiments. A comparative study of the results obtained from the quasi-static tests with numerical simulations is also presented. A brief description of the work done on spherical shells, frusta of circular cones and combination geometry shells is given below.

Spherical shells

Aluminium spherical shells of R/t values ranging between 27 and 218 and shallow depth were tested in axial compression. To study the plastic deformation of shells and influence of geometrical parameters on the deformation mode and energy absorption capacities, shells of same radii and different thicknesses and depth were also tested. Large deformation modes were observed from experiments. In quasi-static tests, aluminium shells were found to collapse due to the formation of axisymmetric inward dimpling. In

shells of high R/t values integral numbers of lobes and stationary plastic hinges were formed between consecutive lobes. The variation of the radius of rolling plastic hinge with compression has been observed experimentally and numerically and presented.

Based on the mechanism of deformation observed in quasi-static tests, analytical model has been developed to predict the load deformation curve. The results obtained from analytical model compared well with the experiments. The results obtained by earlier researchers are also presented and compared with the present study.

Deformation modes for aluminium spherical shells tested in dynamic tests are observed and presented. Similarities are observed compared to statically tested specimens. Mean collapse loads obtained from impact tests have shown an increase of about 15% from the values obtained in quasi-static tests.

Aluminium frusta of circular cones

Quasi-static and dynamic axial compression tests were performed on aluminum conical frusta of semi-apical angles varying from 16° to 30° and different slenderness ratios. The deformation modes and the load values were influenced by the semi apical angle and thickness of frusta. Specimens showed combination of multi lobe diamond mode and rolling plastic hinges modes of failures. The slenderness ratio is also varied and its influence on the deformation is studied. An analytical model is developed to predict the load deformation behaviour. Results obtained from analytical model matched well with those obtained from experiments.

Impact tests conducted on the conical frusta have shown the modes of collapse similar to those observed in quasi-static tests. The initial peak load and mean collapse loads of frusta were found to be higher than those observed in quasi-static tests. The percentage varied for various thicknesses.

Combination geometry shells

Quasi-static and dynamic axial compression tests were performed on aluminium combination geometry shells of conical frustum with hemi sphere and two conical frusta with shallow sphere of various semi-apical angles ranging between 16° and 30° and different slenderness ratios. The deformation modes and load values were observed and presented. Numerical simulations are carried out for static and dynamic loads and compared with experimental observations. Mathematical analysis is carried out for combination geometry shells using the mechanism observed from individual spherical and conical frusta specimens. Analytical model developed is capable of predicting the buckling formation as well as the load values during the progressive buckling phenomenon. Results obtained from analytical model matched well with those obtained from experiments.

Impact tests conducted on the combination geometry shells have shown modes of collapse similar to those obtained in quasi-static tests. The presence of spherical portion inside the conical frusta has not made significant contribution to the energy absorption of frusta. The initial peak load and mean collapse load of combination shells were higher than the statically compressed specimens.

Scale-up effect on the geometries was also carried out for combination geometry shells of two conical frusta with shallow sphere on the top, numerically and results are presented.

Acceleration histories of combination shells when they are subjected to free-fall with different impact velocities are studied numerically and the results are presented.

Thus the thesis presents an extensive experimental, numerical and mathematical study of the large deformation of thin-walled shells viz., spherical shells, frusta of circular cones, combination geometry of conical frustum with hemi-sphere and two conical frusta with shallow sphere. In all cases simple analytical models are presented to predict the load-deformation and energy absorption.

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