AXIAL COLLAPSE OF ROTATIONALLY SYMMETRIC SHELLS

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This is to certify that the thesis entitled **"Axial collapse of Rotationally symmetric shells"** by G L Easwara Prasad 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.

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ABSTRACT

Axial compression of metallic and composite spherical shells, and aluminium conical frusta were performed under both quasi-static and dynamic loading conditions. Quasi-static tests were conducted on an INSTRON machine and the impact tests on the gravity drop hammer setup. Spherical shells of different radii and thicknesses, and frusta of different semi-apical angles and different slenderness ratios were tested to identify various failure modes and to study the energy absorption capacities. Analysis was carried out in each case and the results obtained have been compared with experiments. A comparative study of the results obtained from the quasi-static and impact tests is also presented. A brief description of the work done on spherical shells and conical frusta is given below.

Metallic spherical shells

Aluminium spherical shells of R/t values ranging between 15 to 240 and shells of shallow depth made from aluminium, mild steel and galvanised steel were tested in axial compression. To study the influence of the depth of shells on the collapse modes and the energy absorption capacities, shells of same radii and different depth were also tested. Modes of deformations were studied from experiments. In quasi-static tests, metallic spherical shells were found to collapse due to the formation of axi-symmetric inward dimpling associated with a rolling plastic hinge. The shells of high R/t values, in the later stages of compression have shown buckling with non-symmetric shape, consisting of integral number of lobes and stationary plastic hinges formed between consecutive lobes. The variation of the radius of the rolling plastic hinge with compression has been studied from the experiments, typical variation is presented.

To study the influence of the rate of compression on aluminium spherical shells, some experiments were conducted with different rates of compression in the INSTRON machine. From these experiments it is found that there is a transition in the modes of collapse and the load-deformation curves. Some experiments were conducted on these shells in annealed and as received conditions, significant changes were not observed in their modes of collapse.

Based on the mechanisms of collapse observed in the quasi-static tests, an analytical model has been developed for the prediction of load-deformation and energy-compression curves. The results obtained from the analytical model compared well with the experiments. The results obtained from the solutions proposed in the earlier studies are presented with those from the present study, for comparison.

Modes of collapse of aluminium spherical shells tested in impact tests are found to be different from those observed in their quasi-static tests. These shells of low R/t values were found to collapse in concertina mode, and shells of high R/t values collapsed in diamond fold mechanism. Mean collapse loads obtained from the impact tests have show an increase of about 17% from their corresponding values obtained in quasi-static tests.

Aluminium conical frusta

Quasi-static and dynamic axial compression tests were performed on aluminium conical frusta of semi-apical angle varying over a wide range from 16.5° to 65° and different slenderness ratios. The modes of collapse and the load-deformation curves were highly influenced by the semi-apical angle of the frusta. Frusta of low semi-apical angles of 16.5° and 30° collapsed in multilobe diamond mode, and those of 44.8°, 53° and 65° collapsed due to the initiation of rolling and stationary plastic hinges.

The slenderness ratios of the frusta were found to influence the load bearing and energy absorption capacities of the frusta. An analytical model is presented for the prediction of load-deformation and energy-compression curves, as well as initial peak and mean collapse loads for the frusta which collapsed due to rolling and stationary plastic hinges. Results obtained from the analytical model matched well with those from the experiments.

Impact tests conducted on the conical frusta have shown the modes of collapse similar to those observed in the quasi-static tests. The initial peak and mean collapse loads of the frusta were found to be higher than those observed in quasi-static tests. The percentage increase in initial peak load is found to increase with the increase in the slenderness ratio of the frusta, but the increase in mean collapse loads is fairly uniform.

Composite spherical shells

Glass/polyester spherical shells fabricated with randomly oriented glass fibre mats and polyester resin by the hand lay-up method were tested. The mechanisms of collapse of these shells were studied in both the quasi-static and dynamic loading conditions. The load-deformation curves and modes of collapse observed from the impact tests have shown similarities with those observed from the quasi-static tests. The results obtained from the analytical model developed were found to compare well with the experiments. The mean collapse loads of the composite shells obtained in the impact tests were higher than those of the quasi-static tests. The percentage increase in the mean collapse loads is found to decrease with increase in thickness of the composite shells.

Thus the thesis presents an extensive experimental study of the axial collapse of rotationally symmetric shells viz., metallic and composite spherical shells and aluminium conical frusta. In all the cases simple analytical models are presented for the prediction of load-deformation and energy-compression curves, and mean collapse loads.

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