THE ELASTIC INSTABILITY OF SPHERICAL SHELLS

J.M.T. Thompson

Abstract

Part I of the dissertation represent an investigation into the well-known discrepancy between experimental and theoretical (eigenvalue) analyses of elastic shell instability. The buckling and post-buckling of a 'perfect' and 'imperfect' complete spherical shell under uniform external pressure are studied.

An electrolytic method, applicable to the manufacture of thin shells of various profiles, is developed for the production of near-perfect metallic specimens. The shells are suitable for instability and model stress analyses.

Pressure tests on electroplated copper, and polyvinyl chloride shells confirm the reported premature experimental failures. Many types of 'imperfection' were eliminated from the shells, and the magnitudes of the remaining imperfections are assessed. The 'classical' nature of the experimental snap is demonstrated, and the rotationally symmetric post-snapping states are analysed.

The initial and post-buckling behaviours of a perfect shell are analysed theoretically by a well established energy method. The use of a digital computer allows a considerable advance over previous theoretical treatments, and the uniqueness of the post-buckling states is discussed.

The experimental and theoretical post-buckling analyses show good agreement equilibrium states in the field of shell instability.

Theoretical analyses of an imperfect shell, together with the experimental shell, together with experimental conclusions, show that middle-surface and thickness irregularities can, and in many cases do represent the primary cause of the premature failures. Loading imperfections are unimportant.

Part II represents a unified presentation of several fundamental stability concepts of large-deflection elasticity. Four theorems concerning the stability of the system, which includes both a general structure and its loading device, are established. The first theorem

incorporates the ‘classical’ stability concept, which identifies the ‘critical; condition with the existence of an ‘adjacent position of equilibrium’.

Used conjointly the theorems are a powerful tool in any investigation into the stability of a structure, for which the load-deflection characteristics are known. This practical usefulness of the theorems is demonstrated in several examples.