A TWO-SURFACE COMPUTATIONAL MODEL FOR THE ANALYSIS OF THIN SHELL STRUCTURES

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Abstract

A *Two-Surface* discrete computational model has been developed which us suitable for the analysis of general doubly curved, elastic, deep, classical, and then shell structures. The stretching effects are modelled by means of either a pin-jointed *truss* network or the *constant strain triangula*r (CST) finite element, while the bending effects are modelled by a system of *overlapping hinged facets,* which cover the truss or CST network exactly, like scales. The two surfaces are automatically coupled by the compatibility condition that the two surfaces must be coincident, sharing the same nodes and degree of freedom.

The principal innovation has been the development of the hinged bending elements, which, although based on a simple physical analogy, are closely related to both the finite difference and finite element methods. The hinged bending elements are based on local quadratic *overlapping* assumed displacement functions, which results in constant local stress representation, and permits simple rectangular Cartesian translational nodal degrees of freedom to be employed. This is a significant advantage over most other currently available then shell finite elements, which employ translational, rotational and higher order nodal variables. The use of rotational and higher order degrees of freedom has, in general, resulted in considerable difficulties in the implementation and application of shell finite elements. This, together with the complexities of shell theories and geometry has ensured that no single finite element has so far achieved acceptance by the engineering community.

The Two-Surface model has been applied to a range of linear elastic small-deflection “benchmark” shell problems, including flat plate, cylindrical and hemispherical shell problems. These problems test various aspects of the performance of the model, including stress evaluation, bending stretching interaction, cost of analysis, and numerical control of analyses. The method has been extended to model geometrically nonlinear large-deflection

problems, and also shell vibration problems. A limited experimental programme has been undertaken to test the performance of the nonlinear version of the model.

The Two-Surface model is simple in concept, implementation and application, and performs competitively against some standard shell finite elements that appear in the literature, and which employ up to four times as many degrees of freedom per node.