CURVED QUADRATIC TRIANGULAR DEGENERATED- AND SOLID- SHELL ELEMENTS

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Automatic meshing and adaptive mesh refinement are becoming standard features of the state-of-the-art finite element software. Compared to the quadrilateral mesh, the triangular mesh is often the more robust and efficient choice for many mesh generator programs. Consequently, the improvement of triangular elements should be envisaged.

In the last decade, a considerable amount of research effort has been channeled into the development of solid-shell elements. The most distinctive feature of solid-shell elements as compared to degenerated-shell elements is that the former elements do not possess any rotational d.o.f.s. As degenerated- and solid-shell elements are normally equipped with respectively five and six d.o.f.s per director, solid-shell elements give rise to a larger system matrix. However, when solid-shell elements are employed in albeit of degenerated-shell elements in analyses involving bulky and thin-walled portions, solid-shell elements can exempt the laborious task of defining algebraic constraints or introducing solid-to-shell transition elements. Furthermore, the complicated update of finite rotations in degenerated-shell elements is not necessary in solid-shell elements. Formulating solid-shell elements is, however, more demanding than formulating degenerated-shell elements. Besides shear and membrane lockings, solid-shell elements can also be plagued by trapezoidal and thickness lockings.

Compared to the large number of curved quadrilateral degenerated- and solid-shell elements, there are only very few degenerated- and even fewer solid-shell curved triangular elements. In this paper, the recently developed six-node degenerated-shell element with five d.o.f.s/node and the twelve-node solid-shell element with three d.o.f.s/node are reviewed [1-3]. These elements have been developed with the following criteria in mind: (a) their kinematics has not been modified by the Kirchhoff or zero transverse shear constraints so that they are applicable to thick and composite/sandwich plates/shells; (b) they do not possess any commutable mechanism; (c) they pass constant moment, constant membrane stress and constant transverse shear patch tests under the flat plate geometry; (d) they do not exhibit any of the aforementioned locking phenomena. The obstacles and the methods devised to overcome them are discussed. Linear and geometric nonlinear benchmark tests are presented to examine the numerical performance of the two elements. As optimal strain sampling is employed, the elements are not susceptible to mesh distortion.

References

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