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Rotation-free triangular plate and shell elements

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SUMMARY

The paper describes how the finite element method and the finite volume method can be successfully combined to derive two new families of thin plate and shell triangles with translational degrees of freedom as the only nodal variables. The simplest elements of the two families based on combining a linear interpolation of displacements with cell centred and cell vertex finite volume schemes are presented in detail. Examples of the good performance of the new rotation-free plate and shell triangles are given. Copyright © 2000 John Wiley & Sons, Ltd.

KEY WORDS: rotation-free; thin plate and shell triangles; finite elements; finite volumes

INTRODUCTION

The need for efficient plate and shell elements is essential for solving large-scale industrial problems such as the analysis of shell structures in civil, mechanical, naval and airspace engineering, the study of vehicle dynamics and crash-worthiness situations and the design of sheet metal forming processes among others. Despite recent advances in the field [1–3], the derivation of simple triangles capable of accurately representing the deformation of a plate or a shell structure under complex loading conditions is still nowadays a challenging topic of intensive research.

The development of plate (and shell) finite elements was initially based on the so called thin plate theory following Kirchhoff's main assumption of preserving orthogonality of the normals to the mid-plane [1, 4]. Indeed, most plates and shells can be classed as 'thin' structures and therefore Kirchhoff's theory can reproduce the essential features of the deformation in many practical cases. The well known problems to derive conforming C_1 continuous thin plate and shell elements motivated a number of authors to explore the possibilities of Reissner–Mindlin theory. This theory relaxes the normal orthogonality condition, thereby introducing the effect of shear deformation which can be of practical importance in thick situations, such as the analysis of some bridge slabs and, more important, it requires only C_0 continuity for the deflection and rotation fields. Unfortunately Reissner–Mindlin plate and shell elements suffer from the so called 'shear locking' deffect which pollutes the numerical solution in the thin limit. This defficiency has jeopardized the full success of Reissner–Mindlin plate/shell elements for practical engineering analysis, an exception

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