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The formulation of new fully compatible quadrilateral shell finite element

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SUMMARY

This paper describes the formulation of the new fully compatible quadrilateral shell finite element. In the membrane state, i.e. plane state, full compatibility is achieved by introducing in-plane rotational degrees of freedom at each node, thus completely separating the rotational part of the displacement field from the translational part. In the way the shape functions are chosen the continuity of displacements and their first derivatives at the nodes are achieved. In the transverse direction, there exists also the continuity of the displacement field at the nodes; the continuity is satisfied, even, in the combinations with shear deformations. Therefore, this new element can be applied to, both thick and thin plates and shells.

Consequently, it is possible to combine membrane and bending states and hence, the new quadrilateral finite element with six degrees of freedom at each node is obtained. This new finite element is fully compatible by itself but it is also fully compatible in combination with beam and truss elements. Thus, it may be used to model many engineering structures, like shell and flat structures and their combinations with or without beam elements.

Incorporating concentrated forces and moments in the membrane state, either directly by loading or due to the connections of the other elements with membrane elements, results in a phenomenon related to this formulation of finite elements which the authors called **numerical curvature of the space**.

The proposed shell finite element is tested using an appropriate numerical algorithm by the solution procedure for a few practical engineering structures.