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Numerical analysis of engineering structures composed of surface and line elements

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SUMMARY

This paper presents the new isoparametric shell finite element and its features in the numerical analysis of complex engineering structures. Each element node has six degrees of freedom, i.e. three translations and three rotations. This shell finite element is derived from the 20-node three dimensional element and it is based on the degenerated continuum concept. The introduction of the finite rotational stiffness of the shell around the normal into its middle surface, which usually absents in the shell analysis, is performed in the same way as the inclusion of the rotational degree of freedom into a membrane.

In this paper, the drilling degree of freedom in the shell element node is evaluated from the equilibrium equations of the Cosserat continuum by abandoning the usual assumption that the stress tensor is symmetric. The procedure is based on the variational formulation which implies independent displacement and rotation fields.

The new isoparametric shell finite element with six degrees of freedom per node enables a combination with different types of finite elements because it ensures compatibility of displacements and rotations at their connections. It is also suitable for modelling folded shell structures.

This work deals with a combination of this shell element with the standard beam finite element, so that an efficient tool for the numerical analysis of structures composed of shells, plates, walls, beams and columns is obtained. The capabilities of the proposed shell element are given through various numerical and practical examples.