A New Triangular Plate Element in Absolute Nodal Coordinates

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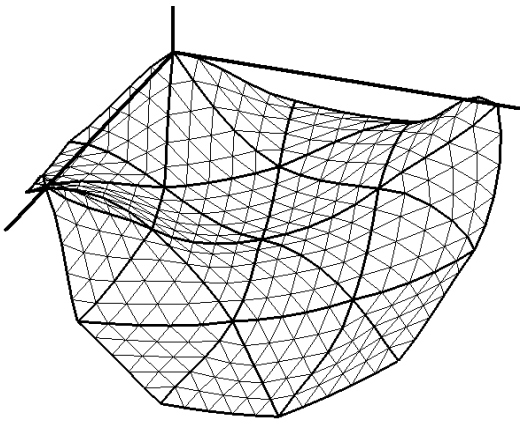
ABSTRACT

A new finite element of thin triangular plate is proposed using a modern absolute nodal coordinate formulation (ANCF). It introduces large displacements of finite elements relative to the global reference frame without using any local frame. The elements employ finite slopes as nodal variables and can be considered as generalizations of ordinary finite elements that use infinitesimal slopes. In contrast to other large deformation formulations, the equations of motion contain constant mass matrices and generalized gravity forces as well as zero centrifugal and Coriolis inertia forces. The only nonlinear term is vector of elastic forces.

A lot of various finite elements have been proposed in ANCF by many authors starting from Shabana and his colleagues, Omar, Yakoub, Mikkola, as well as by other researchers. The variety includes 2D/3D beams and plates both in thin, Euler/Kirchhoff formulations, and in thick, Timoshenko/Mindlin ones. But there has been no known implementations of triangles in ANCF, to our knowledge. We generalize 9-degrees-of-freedom (DOF) triangular plate element used in structural mechanics using the procedure described in [1] to obtain our 27-DOF ANCF element. The use of a special set of nodal shape functions in triangle coordinates L_1,L_2,L_3, proposed by Specht [2], allows obtaining the element passing the linear patch test.

We use Kirchhoff plate theory with nonlinear strain-displacement relationships to obtain elastic forces as well as differential geometry of surfaces to calculate their deformations. We use both analytical and numerical integration approaches to evaluate terms of equations of motion.

Some interesting examples of numerical simulation of very large displacement problems will be presented, such as a circular very elastic plate in the shape of Salvador Dali's melting clocks using triangle-element mesh.



References

[1] Dmitrochenko O. N., Pogorelov D. Yu., 'Generalization of Plate Finite Elements for Absolute Nodal Coordinate Formulation', *Multibody System Dynamics* **10**(1), Kluwer, Dordrecht, 2003, 17-43.

[2] Specht B., 'Modified shape functions for the three-node plate bending element passing the patch test', *Int. J. for Numerical Methods in Engineering* **26**, 1988, 705-715.