8th World Congress on Computational Mechanics (WCCM8)
5th European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

SHEAR CORRECTION OF A THIN PLATE ELEMENT IN ABSOLUTE NODAL COORDINATES

Oleg Dmitrochenko and Aki Mikkola

Department of Mechanical Engineering
Lappeenranta University of Technology
Skinnarilankatu 34, Lappeenranta 53851, Finland
Oleg.Dmitrochenko@lut.fi and *Aki.Mikkola@lut.fi*

Key Words: *shear deformation, thin plates, absolute nodal coordinate formulation*

ABSTRACT

This study is a continuation of an alternative approach to account for transverse shear deformation in the absolute nodal coordinate formulation (ANCF). In the formulation, shear deformation is usually defined by employing the slope vectors in the element transverse direction. This leads to the description of deformation modes that are, in practical problems, associated with high frequencies.

These high frequencies, in turn, complicate the time integration procedure burdening numerical performance. In previous studies [1] and [2], the description of transverse shear deformation is accounted for in a two-dimensional beam element based on the absolute nodal coordinate formulation without the use of transverse slope vectors. In the introduced shear deformable beam element, slope vectors are replaced by vectors that describe the rotation of the beam cross-section. This procedure represents a simple enhancement that does not decrease the accuracy or numerical performance of elements based on the absolute nodal coordinate formulation.

In the current study, the same approach is implemented for a thin rectangular plate element. Numerical results are presented in order to demonstrate the accuracy of the introduced element in static and dynamic cases. The numerical results obtained using the introduced element agree with the results obtained using previously proposed shear deformable plate elements.

The research is supported by the Academy of Finland, project 122899.

SOME IMPLEMENTATION DETAILS

In the previous study, a two-dimensional beam element was presented. Instead of the conventional set of coordinates for such an element, $\left\{\mathbf{r}_0^{\mathrm{T}} \quad \mathbf{t}_0^{\mathrm{T}} \quad \mathbf{r}_l^{\mathrm{T}} \quad \mathbf{t}_l^{\mathrm{T}}\right\}^{\mathrm{T}}$, where $\mathbf{r}$ denotes position vectors and $\mathbf{t} = \mathrm{d}\mathbf{r}/\mathrm{d}s$ means slope vectors, such an alternative set is used:

$$\mathbf{q} = \left\{\mathbf{r}_0^{\mathrm{T}} \quad \mathbf{n}_0^{\mathrm{T}} \quad \mathbf{r}_l^{\mathrm{T}} \quad \mathbf{n}_l^{\mathrm{T}}\right\}^{\mathrm{T}},$$

where $\mathbf{n}$ denotes normal vector to the cross section. A simple relation holds: $\mathbf{n} = \mathbf{t} + \boldsymbol{\theta}$, where $\boldsymbol{\theta}$ is a shear vector, see Figure 1.

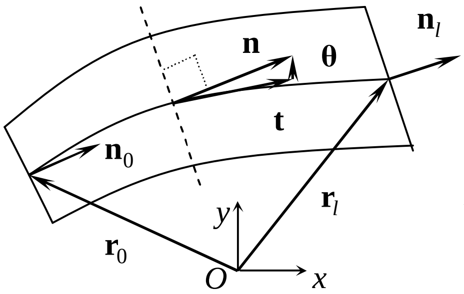

Figure 1. Beam element

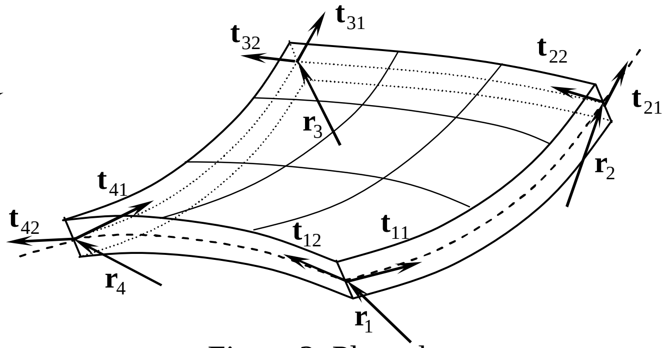

Figure 2. Plate element

The main effort of this paper is the idea of extend this formulation to thin plates. We define the coordinate set for the plate element as follows:

$$\mathbf{q} = \left\{ \mathbf{q}_1^{\mathrm{T}} \quad \mathbf{q}_2^{\mathrm{T}} \quad \mathbf{q}_3^{\mathrm{T}} \quad \mathbf{q}_4^{\mathrm{T}} \right\}^{\mathrm{T}}$$

where each node of the plate introduces such nodal vectors following the idea for the beam element above:

$$\mathbf{q}_k = \left\{ \mathbf{r}_k^{\mathrm{T}} \quad \mathbf{n}_{k1}^{\mathrm{T}} \quad \mathbf{n}_{k2}^{\mathrm{T}} \right\}^{\mathrm{T}},$$

instead of conventional set of nodal vectors $\left\{ \mathbf{r}_k^{\mathrm{T}} \quad \mathbf{t}_{k1}^{\mathrm{T}} \quad \mathbf{t}_{k2}^{\mathrm{T}} \right\}^{\mathrm{T}}$ shown in Figure 2. Vectors $\mathbf{n}_{k1}, \mathbf{n}_{k2}$ are not presented in the figure.

REFERENCES

[1] Aki Mikkola, Oleg Dmitrochenko, and Marko Matikainen, “Shear deformable beam finite element for dynamic analysis of multibody systems”, Lappeenranta University of Technology, Dept. of Mech. Engineering, Research Report 71, 20 pp. (2007).

[2] Aki Mikkola, Oleg Dmitrochenko, and Marko Matikainen, “A Procedure for the Inclusion of Transverse Shear Deformation in a Beam Element Based on the Absolute Nodal Coordinate Formulation”, Proc. of ASME 2007 IDETC & CIE, 6th Int. Conf. on Multibody Systems, Nonlinear Dynamics and Control (MSNDC-4-2), September 4-7, 2007, Las Vegas, http://www.asmeconferences.org/IDETC07/TechnicalProgramOverview.cfm#303