6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11-15 June 2018, Glasgow, UK

ENRICHED BEAM FINITE ELEMENT WITH WARPING FOR THE DYNAMIC ANALYSIS OF THIN-WALLED STRUCTURES

Paolo Di Re[1]* and Daniela Addessi[1]

[1] Department of Structural and Geotechnical Engineering, Sapienza University of Rome, Via Eudossiana 18, 00184 Rome, Italy, {paolo.dire, daniela.addessi}@uniroma1.it

Keywords: *Thin-walled Beams, Warping, Mixed Formulation, Dynamic Response.*

In the last decades, a keen interest has been shown in the development of beam-column finite elements (FE) for nonlinear dynamic analysis of framed structures under severe loading conditions. In this context, force-based and mixed beam models have been successfully adopted, preferring them to classical displacement-based beam formulations and bi-dimensional or three-dimensional FEs, because these can provide accurate results with a limited computational burden. However, existing beam formulations suitable for nonlinear dynamic analyses are usually based on the Euler-Bernoulli or Timoshenko beam theory, assuming rigid plane cross-sections, or consider simplifying hypotheses to include the effects of shear and torsional forces. Hence, these fail in representing the multi-axial coupling of the stress components due to the warping deformation of the cross-section, which is an essential aspect in the analysis of thin-walled framed structures.

This work presents a 2-node 3D mixed beam FE for the nonlinear dynamic analysis of thin-walled beams. This is based on an enriched Timoshenko beam theory that accounts for out-of-plane deformations of the cross-sections [1], independently interpolating the warping displacements from the rigid section displacements, the generalized section strains and the material stresses. The consistent element mass matrix is properly defined by applying a numerical integration procedure to compute the exact element shape functions [2], also including the effects of the out-of-plane cross-section displacements. Material nonlinearities are accounted for through the definition of a cross-section fiber discretization, that allows a better description of the shear and axial stress interaction.

Numerical tests and correlation studies on real structural elements are performed to validate the model and investigate its capabilities under complex loading conditions.

REFERENCES

[1] P. Di Re, D. Addessi and F.C. Filippou, A mixed 3D beam element with damage plasticity for the analysis of RC members under warping torsion. *J Struct Eng ASCE*, 2018 (In press), DOI 10.1061/(ASCE)ST.1943-541X.0002039.

[2] O. Soydas and A. Saritas, Free vibration characteristics of a 3d mixed formulation beam element with force-based consistent mass matrix. *J Vib Control*, Vol. **23**, pp. 2635–2655, 2015.