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A MIXED FINITE ELEMENT FOR GENERALIZED BEAM THEORY

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The diffusion of thin walled profiles had a strong impulse in the last decades due to their characteristics: low strength/weigth ratio, easy of transport, easy of manufacture and assembly. However these elements have complex behavior, including in-plane section distortion, and are prone to instability problems. A significant amount of research has been spent toward the development of analysis tools, which combine the easy usage and good predictive capabilities, to evaluate the structural behavior of structural systems that use thin walled profiles. In the 80's, Schardt proposed the Generalized Beam Theory (GBT) [1] that can be viewed as a generalization of the Vlasov theory [2] able to take into account in-plane cross-section distortions. Recently, many authors have contributed to the improvement of the GBT by adding non-linear effects for the analysis of buckling problems [3] or applying the GBT to analyze cold-formed roof systems [4]. Silvestre and Camotim, moreover, were the first that removed the Vlasov constraint introducing the shear deformation [5] and analized composite thin walled beams in the GBT.

In this context, a mixed stress finite element for GBT is proposed in this work. The starting point is the new formulation of the GBT, recently proposed in [6], that allows to recover classical beam theories and distinguish them from higher order contributions due to distortional in-plane deformations. The variational framework is given by the Hellinger-Reissner variational principle: the kinematics is ruled by edge nodal parameters and an isostatic stress description is assumed. In particular, both static and kinematic fields are developed basing on a linear elastic analytical solution of GBT equations, assuming zero distributed loads and simplified constitutive equations. Numerical results show that the element is very accurate, also on coarse meshes, and appears suitable for an effective reusing in geometrically nonlinear analyses by a corotational approach [7, 8].

REFERENCES

[1] R.P. Shardt. *Verallgemeinerte technische biegetheorie*. Springer, 1989.

[2] V.Z. Vlasov. *Thin-walled elastic beams*. Monson, 1961.

[3] D. Camotim, C. Basaglia and N. Silvestre. GBT buckling analysis of thin walled steel frames: a state-of-the-art report. *Thin Walled Structures*, Vol. **48**, 726–743, 2010.

[4] M. Braham, A. Ruggerini and F. Ubertini. A numerical model for roof detailing of cold-formed purlin-sheeting systems. *Stahlbau*, Vol. **77**, 238–246, 2008.

[5] N. Silvestre and D. Camotim. Nonlinear generalized beam theory for cold-formed steel members. *International Journal of Structural Stability and Dynamics*, Vol. **3**, 461–490, 2003.

[6] S. de Miranda, A. Gutiérrez, R. Miletta and F. Ubertini. A generalized beam theory with shear deformation. *Thin-Walled Structures*, Vol. **67**, 88–100, 2013.

[7] G. Garcea, A. Madeo, G. Zagari and R. Casciaro. Asymptotic post-buckling FEM analysis using corotational formulation. *International Journal for Solids and Structures*, Vol. **46**, 377–397, 2009.

[8] G. Zagari, A. Madeo, R. Casciaro, S. de Miranda and F. Ubertini F. Koiter analysis of folded structures using a corotational approach. *International Journal for Solids and Structures*, Vol. **50(1)**, 755–765, 2013.