Multi-layer anisotropic beam with variable fiber directions: enhanced stress recovery and numerical solution via isogeometric collocation.

Giuseppe Balduzzi*†, Simone Morganti‡, Josef Füssl†, Alessandro Reali§, Ferdinando Auricchio§

† Institute for Mechanics of Materials and Structures (IMWS)
TU Wien - Vienna University of Technology
Karlsplatz 13/202, 1040 Vienna, Spain
e-mail: {Giuseppe.Balduzzi, Josef.Fuessl}@tuwien.ac.at - Web page: https://www.imws.tuwien.ac.at/

‡ Department of Industrial Engineering and Informatics
University of Pavia
Via Ferrata 1, 27100 Pavia, Italy
e-mail: simone.morganti@unipv.it - Web page: http://www.unipv.it/compmech/

§ Department of Civil Enigneering and Architecture (DICAr)
University of Pavia
Via Ferrata 1, 27100 Pavia, Italy
e-mail: {alessandro.reali, ferdinando.auricchio}@unipv.it - Web page: http://www.unipv.it/compmech/

ABSTRACT

Glued laminated timber beams are characterized by smooth variations of mechanical properties and grain direction due to the unavoidably presence of knots and other defects. On one hand, modern technology allows for the detection of grain direction on the surface of boards constituting the beam, allowing for enhanced structural analysis, performed mainly by highly expensive 2D or 3D FE analysis [1]. On the other hand, [2] discusses a beam model capable to handle the non-trivial effects that material anisotropy has on the structural response of the beam. Finally, [3] highlights that every smooth variation of mechanical properties within the beam body produces non-trivial distribution of shear stresses and deformations. This contribution discusses an effective Timoshenko-like planar beam that effectively handles both the material anisotropy and the smooth variation of mechanical properties. The resulting model is naturally represented by a system of six ordinary differential equations with variable coefficients in which both internal forces and beam generalized displacements are the independent variables.

Complexity of beam equations and variability of its coefficients do not allow for an easy computation of the model analytical solution, making the use of numerical tools mandatory. Unfortunately, classical approaches like mixed finite elements might entail several issues (e.g., shear locking, ill-conditioned matrices, etc.). Conversely, the isogeometric collocation method, allowing an equal order approximation of all unknown fields without affecting the stability of the solution, is particularly suitable for solving the system of ODEs governing the proposed beam model. A rigorous comparison with highly refined 2D FE analysis will demonstrate the effectiveness of the proposed modeling strategy.

REFERENCES

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