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A regularized eXtended Finite Element framework coupled to multi-surface plasticity for wooden beams

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Over millennia, owing to its remarkable mechanical properties, such as flexural strength combined with extreme lightness, wood has been used as a construction material. Wood exhibits an anisotropic non-linear behavior: ductile-plastic at compression, and brittle at tensile and shearing loads. In the literature, wooden structures are mainly modeled with multi-surface plasticity models [1, 2], and cracks and detachment along interfaces are simulated by means of interfacial [3] or cohesive elements [4]. As an alternative to cohesive elements, cracks can be dealt with by means of the eXtended Finite Element Method [5], where the set of standard finite element shape functions is enriched with suitable shape functions reproducing displacement jumps and crack tip singularities. This allows to describe the cracks inside the finite element mesh without re-meshing. The present contribution presents a novel elasto-damaging-plastic constitutive model with regularized discontinuities for an effective numerical simulation of wooden structures. The model couples, for the first time, the multi-surface plasticity model developed by Schmidt and Kaliske [2] with a regularized special version of the eXtended Finite Element Methods [6, 7], that, by introducing a regularization length into the model, eliminates any softening-induced mesh dependency. Numerical results obtained by means of the proposed approach are compared to experimental and numerical reference results for validation purposes.

References

[1] Mackenzie-Helnwein, P., Eberhardsteiner, J., Mang, H. A., "A multi-surface plasticity model for clear wood and its application to the finite element analysis of structural details", Computational Mechanics, **31**, 204–218 (2003).

[2] Schmidt, J., and Kaliske, M., "Zur dreidimensionalen Materialmodellierung von Fichtenholz mittels eines Mehrflächen-Plastizitätsmodells", Holz als Roh-und Werkstoff, **64**, 393-402 (2006).

[3] Schmidt, J., and Kaliske, M., "Simulation of cracks in wood using a coupled material model for interface elements", Holzforschung, **61**, 382-389 (2007).

[4] Danielsson, H., Gustafsson, P. J., "A three dimensional plasticity model for perpendicular to grain cohesive fracture in wood", Engineering Fracture Mechanics, **98**, 137-152 (2013).

[5] Moës, N., Dolbow, J., Belytschko, T., "A finite element method for crack growth without remeshing", International journal for numerical methods in engineering, **45**, 131-150 (1999).

[6] Benvenuti, E., "A regularized XFEM framework for embedded cohesive interfaces", Computer Methods in Applied Mechanics and Engineering, **197**, 4367-4378 (2008).

[7] Benvenuti, E., Orlando, N,. "Failure of FRP-strengthened SFRC beams through an effective mechanism-based regularized XFEM framework", Composite Structures, **172**, page 345-358 (2017).