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Velocity-based beam model for non-linear analysis of frame-like structures with efficient consideration of strain localization

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Modelling instabilities in structures undergoing complex deformation is usually reflected in sensitive behaviour of numerical solution methods and thus represents a significant challenge in the numerical modeling. In the present work, we address the problem of strain softening which is often observed in brittle heterogeneous materials in combination with non-linear response of spatial frames. When a stress dependent critical condition is reached at a material point of a body, discontinuities in strain field occur due to the loss of uniqueness of strain measures when evaluated from known stresses in the localized region. In our analysis we will focus on beam-like structural elements with proper consideration of non-linear geometry and material non-linearity including the softening regime. Such model requires accurate detection of critical conditions corresponding to the singularity at the cross-sectional level and efficient treatment of discontinuities of the strain field as well as the efficient and robust evaluation of stress resultants and cross-sectional tangent modulus [1]. The proposed approach is based on velocity-based beam formulation with energy preservation by Zupan and Zupan [2] where the tangent space of the non-linear configuration space of the beam is spanned using only additive quantities and thus avoiding typical problems with rotational degrees of freedom. The computational advantages of the formulation are preserved after the efficient detection of cross-sectional singularity and post-critical treatment of localized strains are implemented into the formulation. The efficiency, accuracy, and robustness of the proposed method will be demonstrated by several examples.

REFERENCES

[1] D. Zupan and M. Saje, Analytical integration of stress field and tangent material moduli over concrete cross-sections. *Computers and Structures.*, Vol. **83**, pp. 2368-2380, 2005.

[2] E. Zupan and D. Zupan, On conservation of energy and kinematic compatibility in dynamics of nonlinear velocity-based three-dimensional beams, *Nonlinear Dynamics*, Vol. **95**, pp. 1379–1394, 2019.