On the integrated use of continuous FE-based computational approaches for the structural analysis of 2D compression-only structures

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Abstract

The assessment of masonry structures and, more generally, compression-only systems requires accurate modelling of stress distributions and fracture patterns induced by external loads and boundary displacements. However, in engineering scenarios where time constraints are critical, stereotomy is difficult to obtain, or during the early stages of the design process, discontinuous approaches are often unsuitable, as they fail to explore broad solution spaces from both static and kinematic perspectives. For this reason, continuous approaches offer significant advantages in terms of computational efficiency and modelling options.
To this aim, this research explores, compares, and discusses the integrated use of two continuous methods, namely the CASS (1) and CDF (2) methods, highlighting their respective advantages and limitations. Both computational strategies model the material as Normal No-Tension (NNT) (3) and solve the corresponding boundary value problem using two dual-energy approaches based on minimising total potential and complementary energy, respectively. The domain is discretised using finite element meshes, and the numerical problems are formulated and solved as second-order cone programming (SOCP) problems.

Various applications are presented and discussed, ranging from simple yet meaningful engineering examples to more complex real-case studies. Internal stress conditions and fracture patterns induced by combined loadings and boundary settlements are examined, and their evolution is tracked up to structural failure.

(1) Montanino, A., & Iannuzzo, A. (2024). A quadrilateral plate-type finite element to model stress singularities in no-tension materials. *Computer Methods in Applied Mechanics and Engineering*, *432*, 117433.

(2) Iannuzzo, A., Block, P., Angelillo, M., & Gesualdo, A. (2021). A continuous energy-based numerical approach to predict fracture mechanisms in masonry structures: CDF method. *Computers & Structures*, *257*, 106645.
(3) Angelillo, M. (2014). Practical applications of unilateral models to Masonry Equilibrium. In *Mechanics of masonry structures* (pp. 109-210). Vienna: Springer Vienna.

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