
FEMANOLA: A finite element nonlinear software for masonry structures

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Abstract

In the present paper, a novel nonlinear finite element model to analyze masonry structures in plane-loaded is proposed. The software works within a heterogeneous discretization of masonry walls in-plane loaded where bricks are assumed elastic and joints are reduced to interfaces with a cohesive frictional behavior with mode 1 and 2 failures truly coupled. In particular, for bricks four noded elastic elements in plane stress are used, whereas for interfaces a modification of the standard four noded element is proposed. The joint nonlinear behavior is thus obtained by enforcing the normal stress along the joint direction to vanish, with normal and tangential stresses acting along the interface coupled by means of a constitutive model ruled by two distinct fracture energies in modes 1 and 2, a compressive behavior defined by a multilinear hardening/softening monoaxial relationship, and a dependence of the tangential post-peak behavior which obeys a parabolic nondimensional law. The procedure is benchmarked on a single mortar joint subjected contemporarily to bending, normal compression and shear, and then tested to reproduce some experimental data available from the literature for triplets subjected to standard shear and normal precompression. A final structural analysis is carried out for a windowed panel tested at TU Delft, for which several previously presented numerical models are available. Excellent agreement with both experimental data and outcomes from numerical literature is found, at a very reduced computational time, promoted by a fully explicit sawtooth elastic algorithm used to deal with nonlinearity and softening of the interfaces.

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