A finite element model for masonry structures allowing for spread micro-cracking and localized macro-cracks

Manuela Scamardo, Alberto Franchi, Pietro Crespi

Politecnico di Milano, Italy
e-mail: manuela.scamardo@polimi.it
e-mail: alberto.franchi@polimi.it
e-mail: pietro.crespi@polimi.it

Abstract

The performance of masonry structures under seismic actions is strongly influenced by cracking phenomena that have to be taken into account to obtain a reliable evaluation of the mechanical resources. In spite of all the contributions given by the scientific community in the last years, modeling of fracture is still a great challenge. As experimentally observed, when the tensile damage process begins, spread and stable micro-cracks start to develop. Once the cracks growth becomes unstable, strain localization occurs and macro-cracks develop. The present work wants to present a numerical formulation able to describe this phenomenon of formation and propagation of tensile cracks in masonry. A classical finite element discretization is assumed with the hypothesis of a homogenous continuum material. In the adopted constitutive behavior three different phases can be detected: (i) the elastic phase; (ii) the micro-cracking phase, in which the formation of micro-cracks, spread in the structural members, is accounted assuming a plastic material with a strain hardening stable behavior; (iii) the macro-cracks phase, in which the formation of localized macro-cracks, developing along the edges of finite elements, are simulated by means of softening behavior allowing for the dissipation of a given fracture energy per unit length. All the inelastic mechanical properties are calibrated in order to match the evidence of an experimental diagonal compression test. From a computational point of view, the problem formulation is posed as a parametric linear complementarity problem (PLCP) and it is solved using mathematical programming algorithms. Numerical simulations are presented to validate the proposed approach.

Keywords: Masonry, Cracking, Plasticity, Softening, Finite Elements, PLCP