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FINITE ELEMENT FORMULATION FOR THE NONLINEAR ANALYSIS OF MASONRY WALLS

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ABSTRACT

The work moves from several experiences over the last 7 years in the nonlinear context of the in-plane behavior of masonry walls. Such behavior is characterized by nonlinear phenomena, such as strain localization, damage, friction, etc., which need to be modeled at fine scales. Fully fine modelling are very hard to be reliably managed in numerical simulations, being extremely expensive (e.g. [1]), and requiring either very sophisticated multigrid-like numerical strategies (e.g. [2,3]) and suitable coarser modelling, which, besides, are hard to be tuned up because of the strong evolving behavior inhomogeneities (e.g. [4,5]). Moreover, both modelling and numerical problems magnify when also the out-of-plane behavior is considered and the structural interaction between the different walls composing the masonry buildings is investigated.

However, the numerical simulations driven by different solution schemes, and both the real structures and the experimental tests on masonry walls showed how the wall structural capacity in collapse conditions is essentially determined by the frictional response, at least in the plane of the same wall. In fact, masonry walls usually present widespread damage patterns caused either by existing conditions in ancient buildings or seismic cyclic loads which rapidly damage the structure.

This is the starting point of the present work where we propose an assumed stress-based Finite Element formulation, using yield surface obtained by setting a discrete number of squeezing planes on the Element where plastic conditions are imposed on average as Mohr-Coulomb laws. In this way, we can drastically reduce the computational costs to the ones of standard Finite Element formulation in elasto-plasticity.

Obviously, the model cannot simulate the pre-critical and critical behavior due to the damage evolution, but it captures the meaningful features of the global structural response, such as final toughness and hysteresis dissipation under cyclic loads. We will show this by comparing the model with experimental tests on masonry walls (e.g. [6]), and we will also test how the numerical results of the proposed formulation do not significantly differ from the ones obtained from richer formulations (see Figure 1).

Eventually, even if we don't deal with the out-of-plane behavior, we believe that the proposed model, in virtue of its simplicity, could be more easily improved in such a direction, in comparison with other more sophisticated formulations.

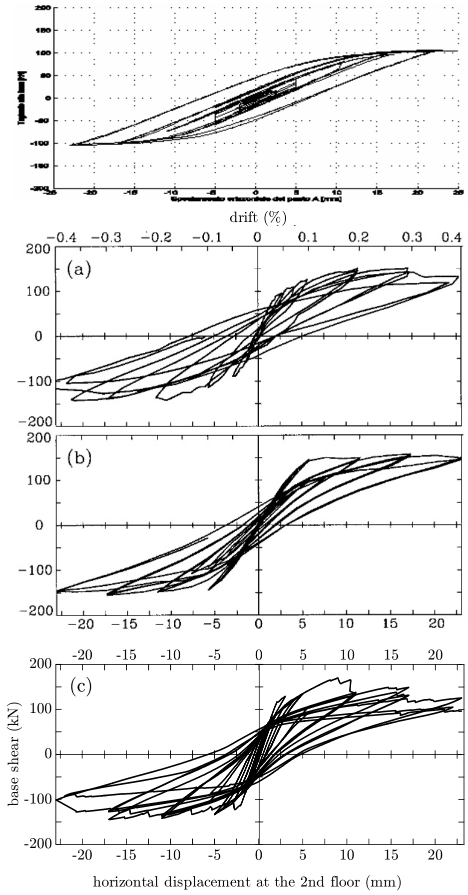

Figure 1: equilibrium path of the Pavia test [6]: comparison between our simulation and (a) the experimental results; (b) the numerical simulation in [5]; (c) the numerical simulation in [2].

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