

Modeling of masonry structures

Elio Sacco

Department of Mechanics, Structures & Environment

The structural analysis of masonry constructions is one of the most interesting and challenging research topic in civil engineering. In fact, the evaluation of the safety level of existing constructions, such as monumental and historical buildings, mainly under seismic actions, represents a central issue in the protection and the strengthening of ancient constructions in many Countries.

The key point in performing adequate stress analyses of masonry constructions is the definition of suitable constitutive laws. Specific constitutive laws for the masonry material were proposed adopting different approaches.

The *micro-models* consider the units and the mortar joints separately, characterized by different constitutive laws; thus, the structural analysis is performed considering each constituent of the masonry material. The mechanical properties that characterize the models adopted for units and mortar joints, are obtained through experimental tests conducted on the single material components. This approach leads to structural analyses characterized by great computational effort. Nevertheless, this approach can be successfully adopted for reproducing laboratory tests.

The *multiscale models* consider different constitutive laws for the units and the mortar joints; then, a homogenization procedure is performed obtaining a macro-model for masonry which is used to develop the structural analysis. The micro-macro models appear very appealing, as they allow to derive in a rational way the stress-strain relationship of the masonry, accounting in a suitable manner for the mechanical properties of each material component. Moreover, this approach can lead to effective models, with reduced computational effort for structural analyses.

The *macro-models* are based on the use of phenomenological constitutive laws for the masonry material; i.e. the stress-strain relationships adopted for the structural analysis are derived performing tests on masonry, without distinguishing the blocks and the mortar behavior. A phenomenological model could be unable to describe in a detailed manner some micro-mechanisms occurring in the damage evolution of masonry, but it is very effective from a computational point of view when structural analyses are performed.

The *macro-elements* are simplified models representing often an efficient alternative, for design purpose, to more sophisticated models. They are special structural models able to reproduce the nonlinear mechanical response of typical masonry elements.

The presentation will deal with a brief review of the typical approaches adopted for the modeling of masonry structures, remarking the peculiarities of each model and their specific ambits of application.