THE MULTILAMINATE MODEL FOR PUSHOVER ANALYSIS OF LARGE SCALE UNREINFORCED MASONRY STRUCTURES

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The masonry buildings are one of the oldest structural systems which have been common since past decades. Modeling is the first step in evaluation and assessment of seismic strengthening buildings. Numerical modeling of Masonry in the framework of strength methods generally divides into three categories including the micro-modeling (Akhaveissy, 2011), macro-modeling (Akhaveissy and Desai, 2011), and macro-element or equivalent element (Akhaveissy, 2012).

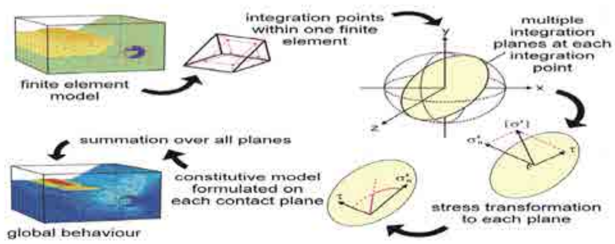
In macro-modeling, a brick wall is assumed as a homogeneous and uniform material with equivalent mechanical properties. In this modeling the behavior of a public proper unit cell is calculated in order to predict the masonry global behavior by deriving a straight constitutive law between average stress and strain states.

A simple 2D model for evaluating the seismic performance of large scale in-plane loaded unreinforced masonry structures is presented. The approach is fully two dimensional and allows performing pushover analyses on large scale structures without reducting walls to an equivalent frame in comparison with 1D codes. In this model a macroscopic approach is used where the so called Multilaminate concept is used to characterize the constitutive behavior of masonry. Due to the concept of the multilaminate framework where yield and plastic potential functions are defined on a number of independently acting planes, plastic flow is developed independently on different planes. Therefore multilaminate models are able to simulate the induced anisotropy intrinsically. This anisotropy is observed due to the creation of the crack which is perpendicular to main tensile stress orientation, so this model is capable to identify the direction of crack without the need of any added parameters in contrast to other models which use homogenization techniques (Anthoine, 1995) or macro-experiments enforced to a masonry panel (Lourenco et al., 1998).

The multilaminate framework is based on the slip theory which was originally proposed by Taylor (1938) for modelling plastic behaviour of metals. The basic assumption was that sliding at any orientation is a function of the plastic shear strain at the respective orientation which depends on the shear stress history (Galavi, 2007). In the masonry global structural behavior analysis, the effect of interaction between brick and mortar is usually considered by a prism equivalent behavior which consists of clay bricks and mortar joints. The used Exprimental parameters in the multi-laminate model which are shown in Figure 1 for stress-strain curves are expressed in Table 1.

Table 1. Mechanical properties of the masonry unit and joints

$E\ (MPa)$	$C\ (MPa)$	$f'_m\ (MPa)$	$f_t\ (MPa)$	φ_f
2500	0.15	3.0	0.1	26.56



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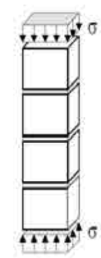

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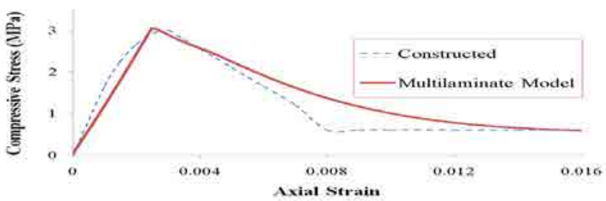

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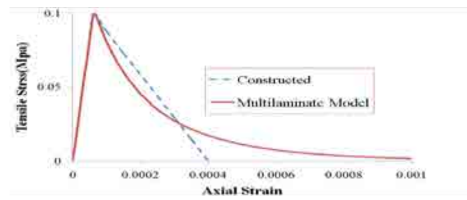

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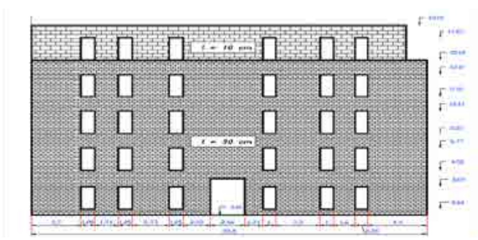
Figure 1. (a) General concept of multilaminate models, (b) Schematic representation of a test specimen, (c) Comparison between Multilaminate Model predictions and Exprimental data for compressive and (d) Tensile behavior of a masonry prism

The model is validated at the element level using the parameters presented in Table 1. In the specimen level, predictions are obtained by integrating the incremental constitutive relations. In the structural level the Numerical simulations of masonry structures and load-displacement responses were considered for an inner wall of a five-story building located in via Martoglio (Catania, Italy). The failure pattern observed in this wall is shown in Figure 2. The other model in 2D simulation needs many parameters and too much time for the analysis and is not user frindly. The pushover curves obtained with the proposed model are compared to those obtained by means of standard equivalent frames and existing literature models.



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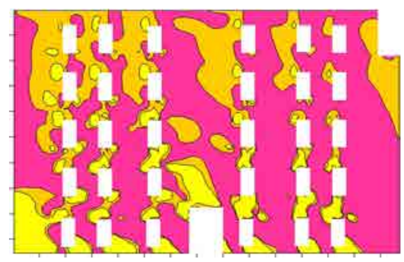

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Figure 2. a) Building with five stories. Geometry (in meters) of the inner wall (Akhaveissy and Desai , 2011) and b) failure pattern observed in this wall by variation of the total strain at gauss points of the elements

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