In-plane shear behaviour of masonry wall under constant normal load -Experimental investigation and discrete element modelling

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Abstract — An experimental and numerical study is proposed on a ½ scale masonry wall in order to validate a discrete element model with frictional and cohesive interface. The methodology consists in (*i*) identification of the cohesive characteristics of the mortars, (*ii*) macro-scale numerical discrete element simulation in which the previous characteristics are used as input parameter of the model, and (*iii*) confrontation between the numerical and experimental responses in order to validate the model. The confrontation between experimental and numerical displacement fields indicates that the DEM method simulate correctly the failures modes observed experimentally. The model is also predictive in term of maximum horizontal strength.

Key Words — Masonry; DEM; Mortar joint; Cohesive zone model; Mixed mode; Experimental characterization

Introduction

The context of this work is architectural heritage preservation. The aim of the study is to validate a numerical model [1] which simulate the mechanical behaviour of masonry wall. To achieve this objective, we carried out an experimental assessment and a simulation of the in-plane mechanical behaviour of a masonry wall subjected to in-plane shear load under constant normal load (corresponding to a global normal stress on the horizontal mortar joints of 0.3 MPa). The wall which represents a ½ scale real structure is composed of limestone blocks bounded by thin lime mortar (figure 1).

Figure 1: wall subjected to shear load under constant normal load

Multi-scale Methodology

Firstly, the fracture behaviour of mortar joints is described (**meso-scale study**). In this way, identification of the cohesive parameters in pure mode I and mode II is carried out from mechanical characterization tests on samples composed of the same limestone and mortar used for the construction of the wall tested. Then, the identified mechanical and cohesive properties are used as input parameter for the **macro-scale** numerical discrete element simulation of the masonry wall. Finally, the numerical and experimental responses are confronted and analysed.

Confrontation Experimental Test vs. Numerical Simulation

The figure 2 presents the experimental and numerical curves *"horizontal forces vs. horizontal displacement"*. It can be observed that the maximum shear load (approximately 60 kN) is correctly estimated by the numerical simulation.

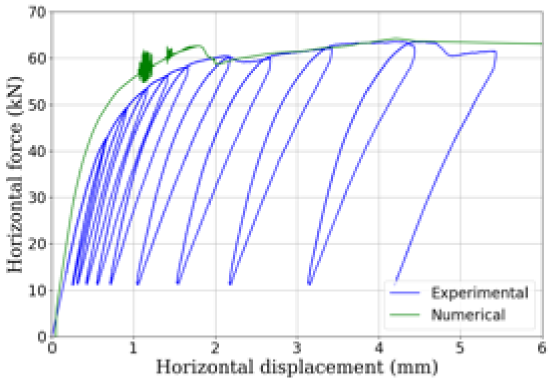
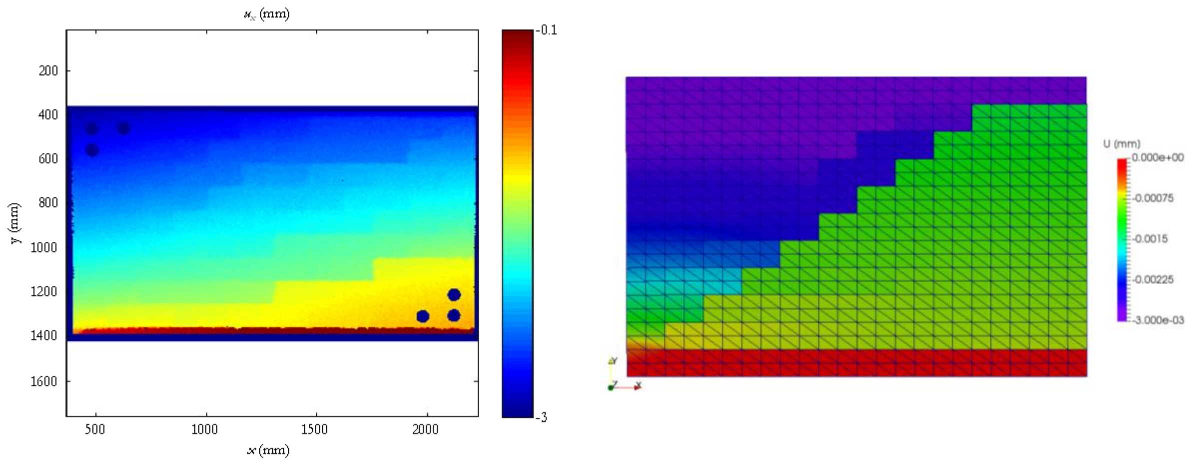


Figure 2: Horizontal force vs. Horizontal displacement

A Nikon D810 digital camera with a AF-S 50mm F/1.8G lens is used (36 MPixels images). The in-plane displacement fields are measured by a local DIC algorithm using a Normalized Cross Correlation criterion with constant shape functions. Subpixel resolution is reached by interpolating the correlation criterion in the vicinity of the discrete maximum [2]. Square subsets are used with a 20-pixels size. The pitch between two measurement points is 2 pixels. Individual information of each block's kinematics is obtained by projecting the measured displacement on polynomial shape functions. The figure 3 presents the horizontal displacement fields for an applied displacement of d=3mm. Two cracks can be observed on both numerical and experimental fields. This failure mode is described in details in the literature [3]. We can notice that the different failure modes of the wall and their sequence are fairly simulated from the DEM method.



(a) *(b)*

Figure 3: Horizontal displacement fields for d=3mm: (*a*) experimental, (*b*) numerical DEM.

Conclusion and perspectives

The results of this work validates the multi-scale methodology proposed. The confrontation between experimental and numerical displacement fields indicates that the DEM modeling simulate correctly the failures modes observed experimentally. The perspectives of this work are to carry out a local analysis of the experimental field for each block in order to identifying by reverse analysis the crack opening in mode I and II at each stage of the test.

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