ASSESSMENT OF HISTORICAL MASONRY STRUCTURES UNDER EXTREME LOADING

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SEVENTH FRAMEWORK PROGRAMME

MARIE CURIE ACTIONS

INTRODUCTION

The structural behaviour under earthquake loading of many historical unreinforced masonry (URM) buildings is generally not adequate and has led in the recent past to heavy damage and collapse (Fig. 1), causing considerable loss of human life. A crude structural analysis under seismic action could lead to either underestimating or overestimating the safety of URM structures. Obviously, the former case is associated with serious risk to life safety, whereas the latter could require excessive strengthening measures which effect undesirable changes in the original structure. Recently, significant efforts were dedicated to developing general and effective analysis tools for existing URM buildings under extreme loading conditions. Relevant results were obtained, but a general, accurate and effective numerical tool had yet to be developed.

Figure 1: Damage and collapse of historical masonry structures

PROPOSED NUMERICAL APPROACH

A novel numerical approach has been developed in this work to represent accurately most of the failure modes of URM structures. This approach is based on the use of detailed mesoscale descriptions coupled with domain partitioning and parallel computing for modelling the nonlinear response of large-scale structures under extreme loading conditions.

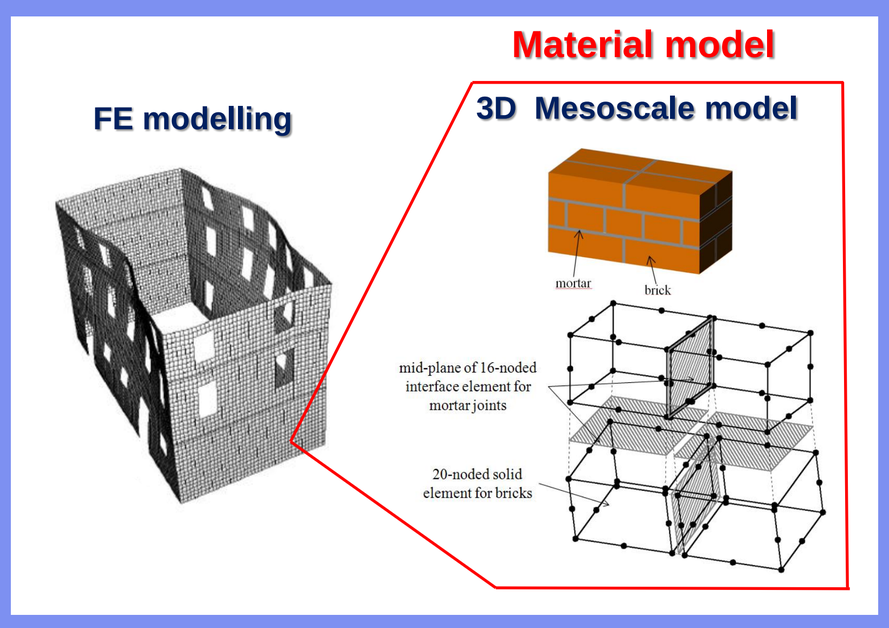

Figure 2: 3D mesoscale model for URM structures

3D MESOSCALE MODEL

In the proposed modelling approach [1], the actual geometry of brick-masonry is considered by modelling brick and mortar separately. The blocks are modelled using 3D continuum solid elements, while the mortar and brick-mortar interfaces are modelled by means of a 2D nonlinear interface element (Fig. 2). This enables the representation of any 3D arrangement for brick-masonry, accounting for the in-plane stacking mode and the through-thickness geometry. Importantly, it also allows the investigation of both the in-plane and the out-of-plane response of unreinforced masonry panels.

NONLINEAR INTERFACE ELEMENT

An advanced interface element for nonlinear analysis of URM structures has been developed [2]. A co-rotational approach is employed (Fig.3a), which shifts the treatment of geometric nonlinearity to the level of discrete entities. In this respect, the internal interface forces are modelled by means of elasto-plastic material laws based on work-softening plasticity and employing multi-surface plasticity concepts (Fig. 3b).

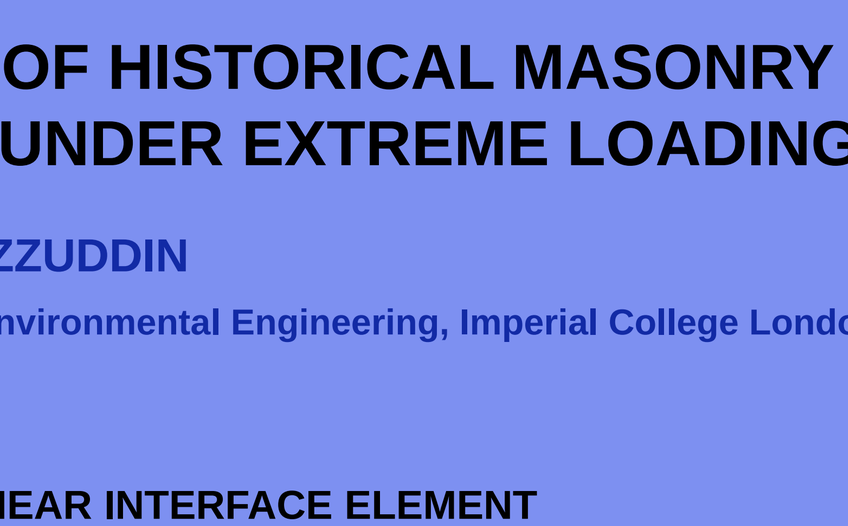

Figure 3: (a) Co-rotational approach, (b) plastic surfaces and potentials

PREDICTION ACCURACY

Numerical analyses have been carried out to investigate both the in-plane (Fig. 4) and the out-of-plane response (Fig. 5) of brick-masonry panels up to collapse, comparing the numerical results against experimental outcomes. It was shown that the main features of the structural behaviour, including initial stiffness, maximum capacity and post-peak response, can be accurately determined using the proposed modelling approach.

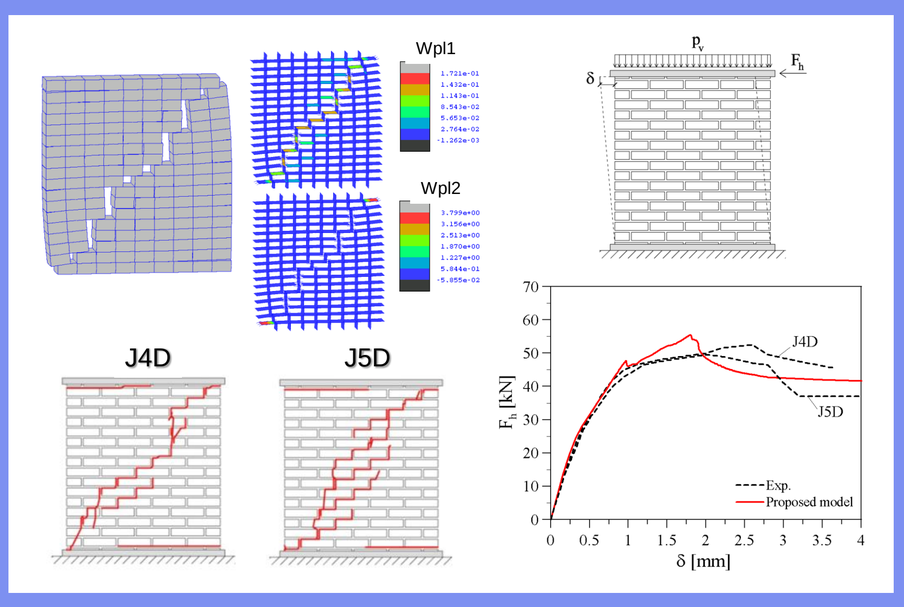

Figure 4: Numerical-experimental comparisons on in-plane response

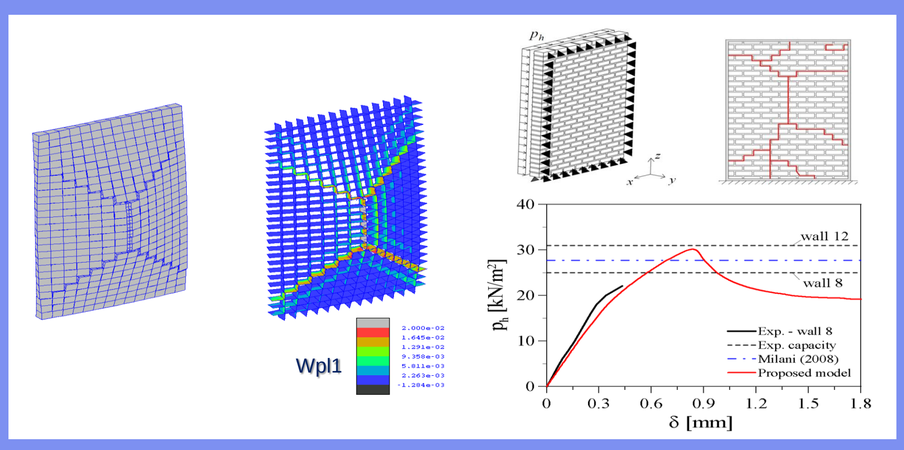

Figure 5: Numerical-experimental comparisons on out-of-plane response

REFERENCES

[1] Macorini, L., and Izzuddin, B. A. (2010). *3D mesoscale modelling for nonlinear analysis of brick-masonry*. 8th International Masonry Conference 2010, Dresden, July 2010.

[2] Macorini, L., and Izzuddin, B. A. (2010). *A Nonlinear Interface Element for 3D Mesoscale Analysis of Brick-Masonry Structures,* International Journal for Numerical Methods in Engineering, Wiley , *(accepted)*.