

ADVANCED MODELLING APPROACHES FOR MASONRY ARCH STRUCTURES

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BACKGROUND

In the UK masonry arch bridges represent most of existing bridges. A part of these structures have been deteriorating due to ageing, while current requirements of transportation networks are significantly more demanding than those considered in the original design. Therefore, there is a pressing need to assess their actual performance and predict residual life. In the last decades, this has led to a large amount of research devoted to investigate the behaviour of masonry arch bridges and improve assessment methods and maintenance strategies. Considering numerical modelling, the prediction of masonry bridge response under different loading conditions is very complex, as it depends upon the 3D nature of masonry bridges.

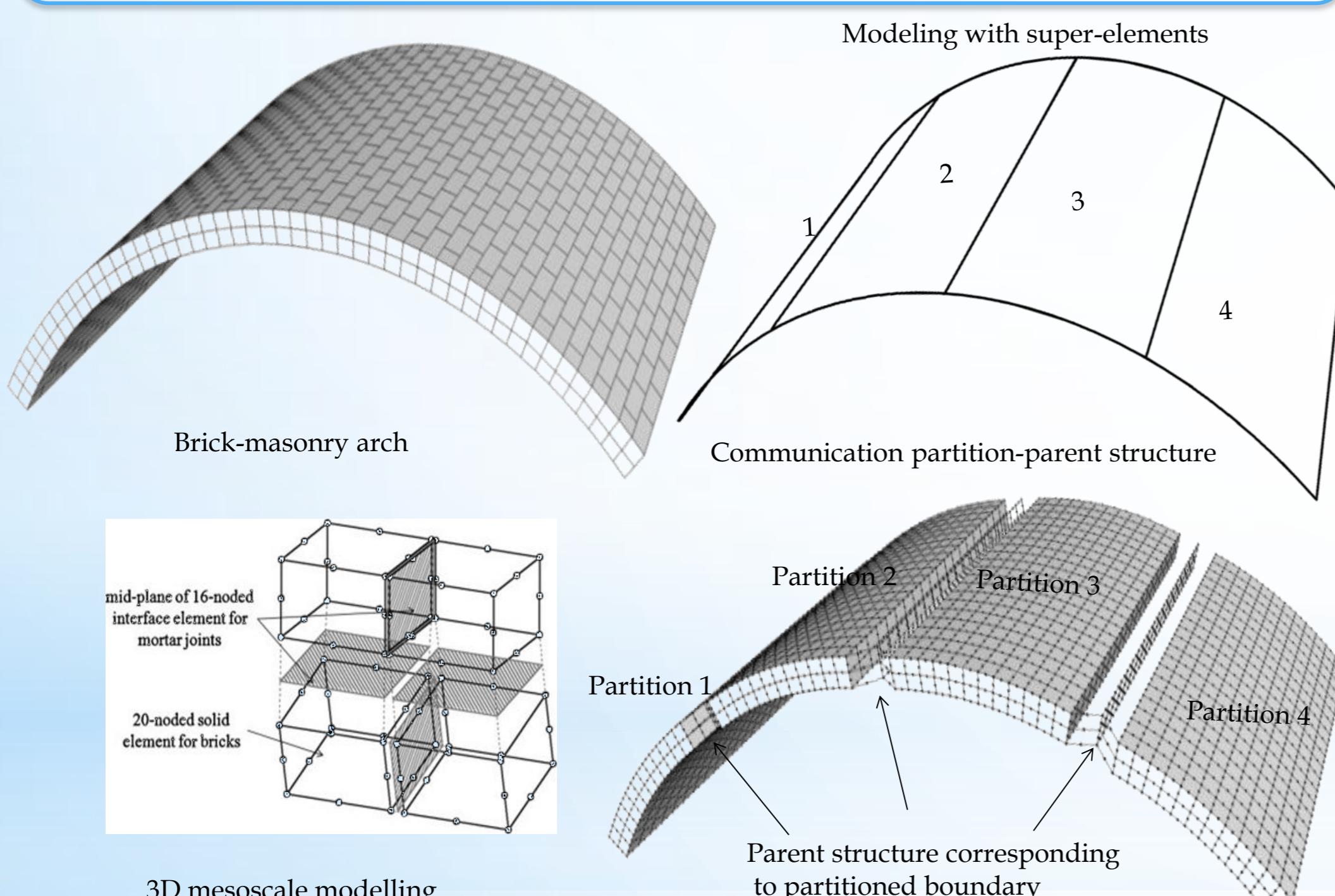


OBJECTIVES

This research aims to define an accurate mesoscale representation for masonry arch structures, accounting for material and geometric nonlinearity under different loading condition.

MODELLING STRATEGY

To overcome the limitations of most of the current modelling approaches for masonry arches which are based on the use of 2D descriptions, an accurate and efficient numerical strategy is used (Figure 2).



3D Mesoscale description

A 2D non-linear interface element [1] is employed to represent mortar and brick-mortar interfaces, while 3D elastic continuum solid elements are used for modelling the brick blocks.



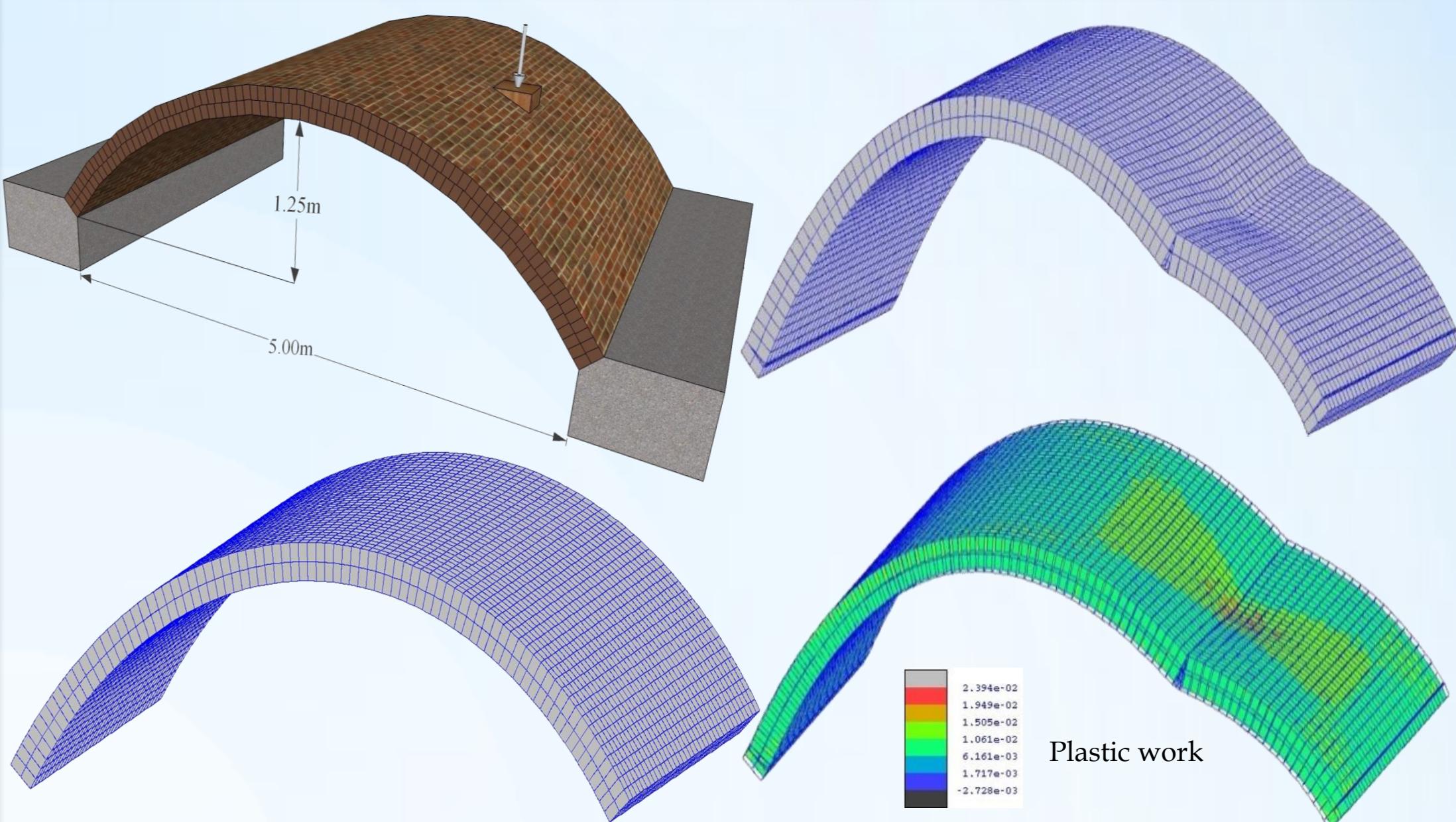
Domain Partitioning Approach

The analysed masonry arch (parent structure) is divided into super elements which are separately modelled as partitions represented through a detailed mesoscale model [2].

Advanced Modeling Strategy

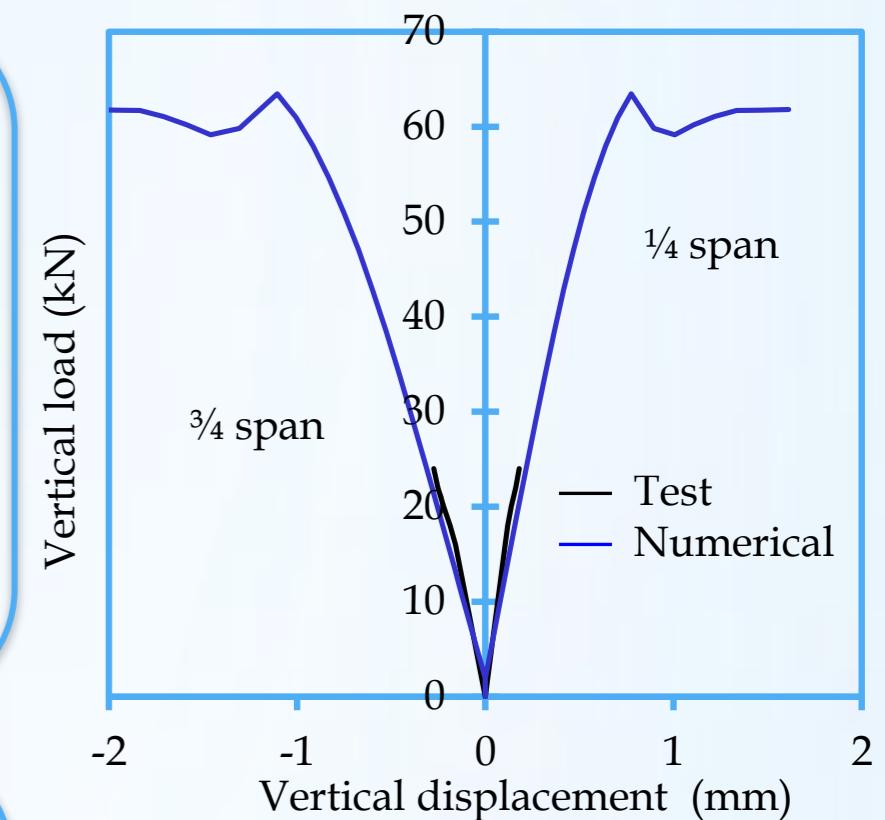
APPLICATIONS

The potential of the proposed modelling strategy has been checked in several numerical examples, including comparisons with experimental tests on the 3D response of realistic masonry arches.



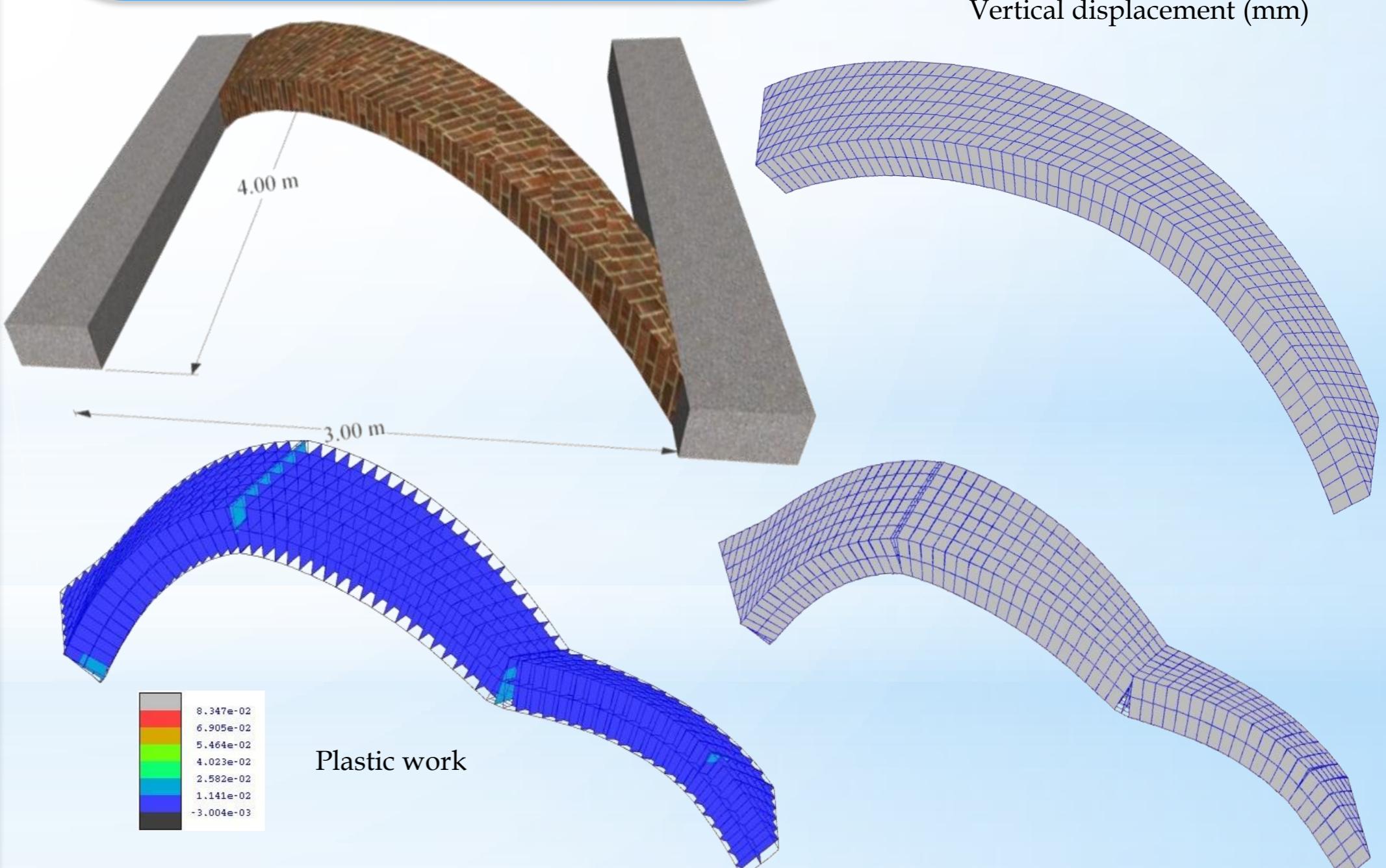
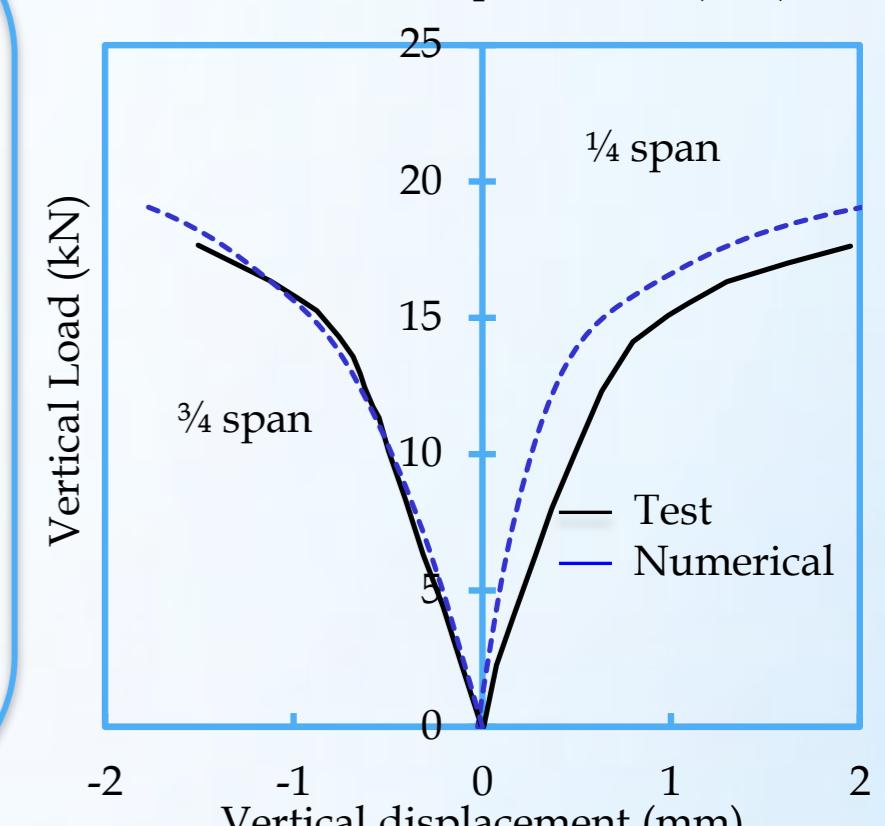
Square Arch Model

The 3D response of a wide square arch under point load is predicted with good accuracy in term of crack propagation and global response. Numerical curves are compared with experimental data on vertical displacements at $\frac{1}{4}$ and $\frac{3}{4}$ span are shown in the top line chart.



Skew Arch Model

Skew arches with complex geometry are characterized by complicated 3D response also under simple loading conditions. This renders the use of simple 2D descriptions unrealistic. According to the proposed strategy, the original 3D arrangement of brick and mortar can be accurately modelled. The bottom chart shows the experimental and numerical displacement curves for a 45° skew arch.



CONCLUSIONS

The proposed modelling strategy utilises a detailed mesoscale description for brick masonry and the domain partitioning approach for the analysis of large systems. It allows an accurate prediction of the response of realistic large masonry arch structures. These has been shown in different examples considering square and skew arches.

REFERENCES

- [1] Macorini L, Izzuddin BA. A Non-Linear Interface Element for 3D Mesoscale Analysis of Brick-Masonry Structures. International Journal for Numerical Methods in Engineering, 85:1584-1608, 2011. [2] Jokhio G.A, Izzuddin B.A. Parallelisation of nonlinear structural analysis using dual partition super-elements. Advances in Engineering Software, DOI: 10.1016/j.advengsoft.2012.10.004.