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Calibration strategies for the nonlinear modeling of masonry structures

Abstract

Numerical modeling is vital for the seismic assessment of masonry structures. Accurate prediction of the structural response require comprehensive knowledge of the mechanical characteristics. Using material-scale models for panel-scale structures causes errors where a calibration process is needed to ensure consistency, influenced by the user experience, model features, and complexity. The intention is to integrate two different modeling techniques (i.e., FEM and EFM) to achieve a comparable response from both numerical modeling methods.

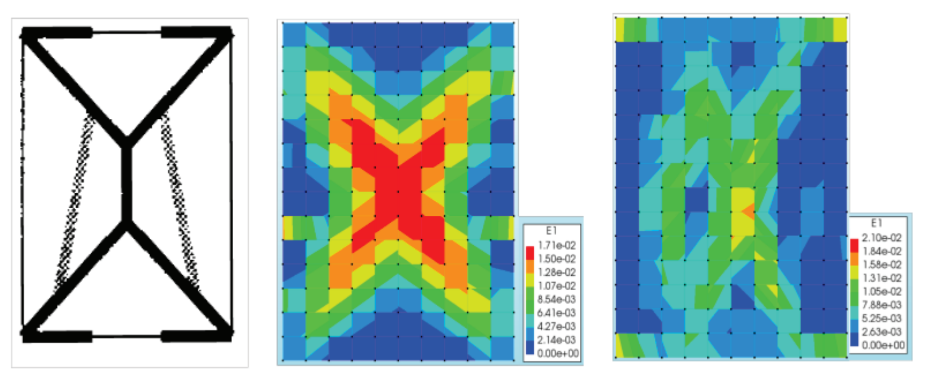


Figure 1. Comparison of the damage from experiment with the predictions from total strain-based crack model and engineering masonry model (LOWSTA wall in the DIANA documentation).

Methodology

This study focuses on a two-story wall (i.e., Pavia Door Wall) tested at the University of Pavia. To calibrate the panel's strength, numerical calibration utilizing the existing analytical criteria is employed. Finite element models of the masonry pier are created using DIANA FEA by incorporating various aspect ratios and load configurations. However, because the experimental material data is insufficient, the fracture energies are assumed based on the literature survey of similar type of structures.

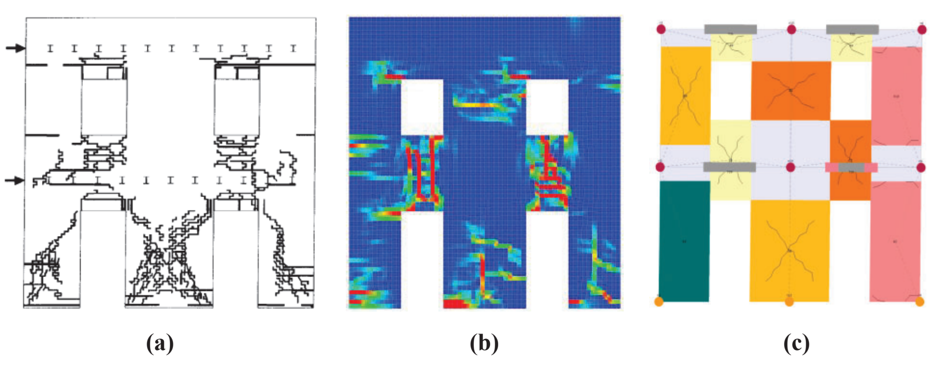


Figure 2. Comparison of the calibrated numerical models against the experimental response. The damage pattern is shown at 21mm displacement in the horizontal direction: **(a)** Experimental response [ref], **(b)** Finite element model, **(c)** Equivalent frame model.

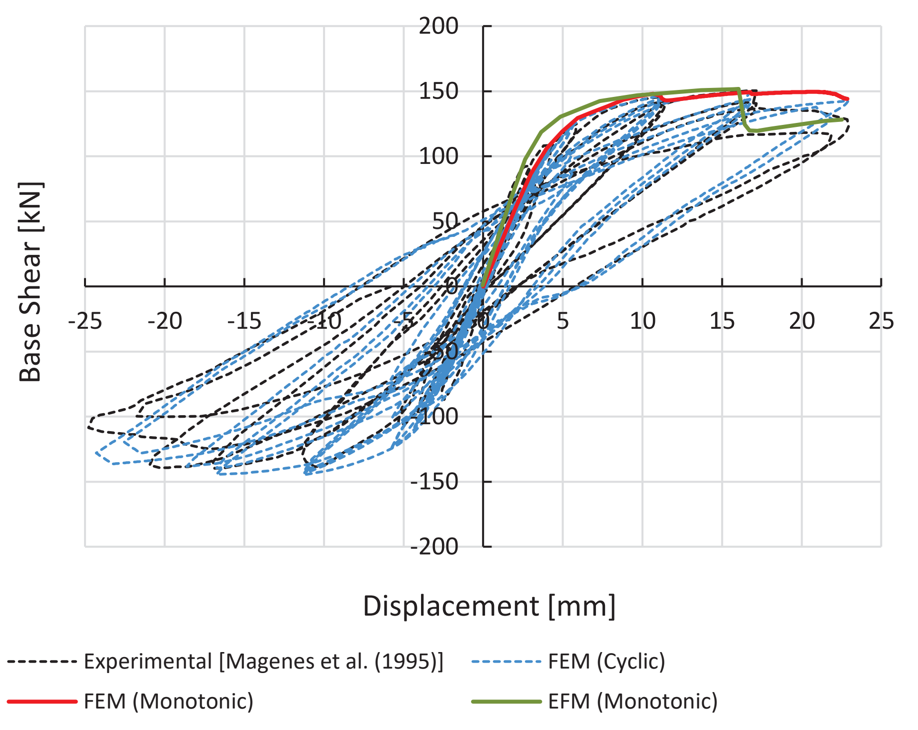


Figure 3. Comparison of the calibrated cyclic and monotonic response of the Pavia Door Wall using finite element (FEM) and equivalent frame method (EFM).

Results

The analytical results are compiled for many combinations of material characteristics employed for the micro-scale piers of various aspect ratios. The calibration shows a strong correlation between the Finite Element Analysis (FEA) and the failure modes derived from the Equivalent frame method (EFM). Moreover, the fracture energies show a minimal impact on the monotonic base shear capacity, at least at the micro-scale level.

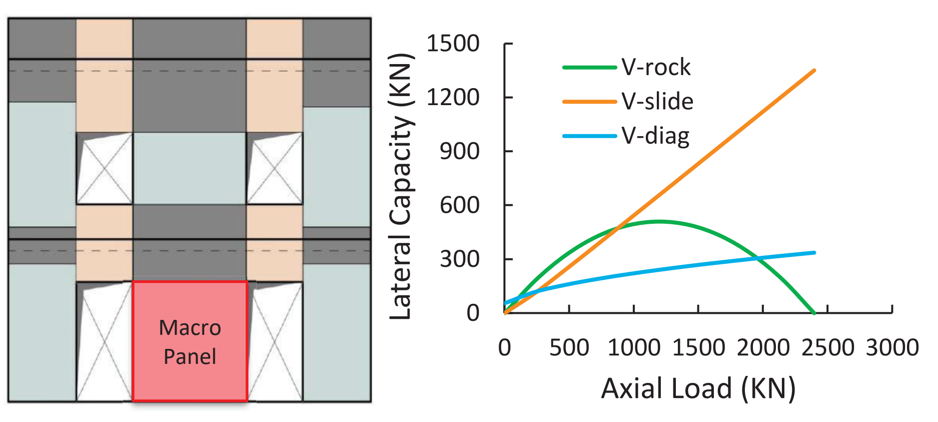
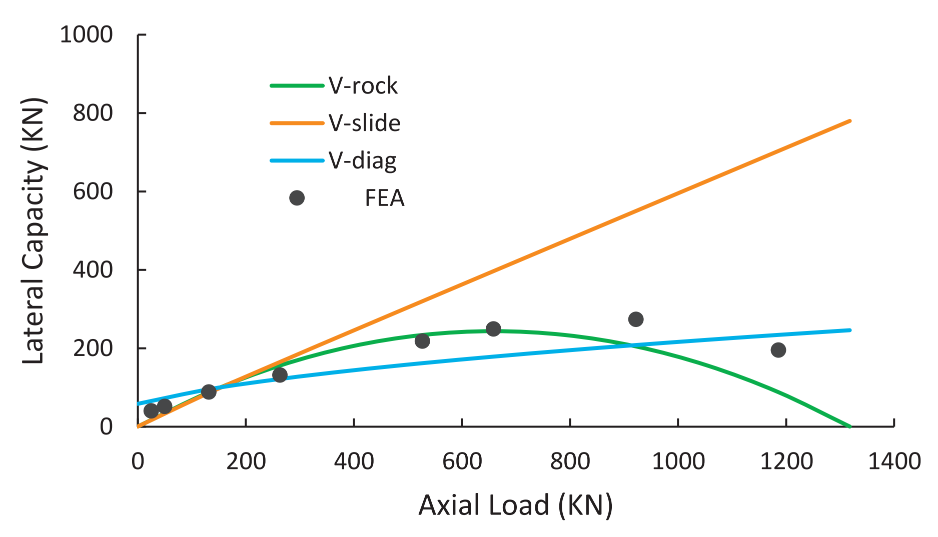
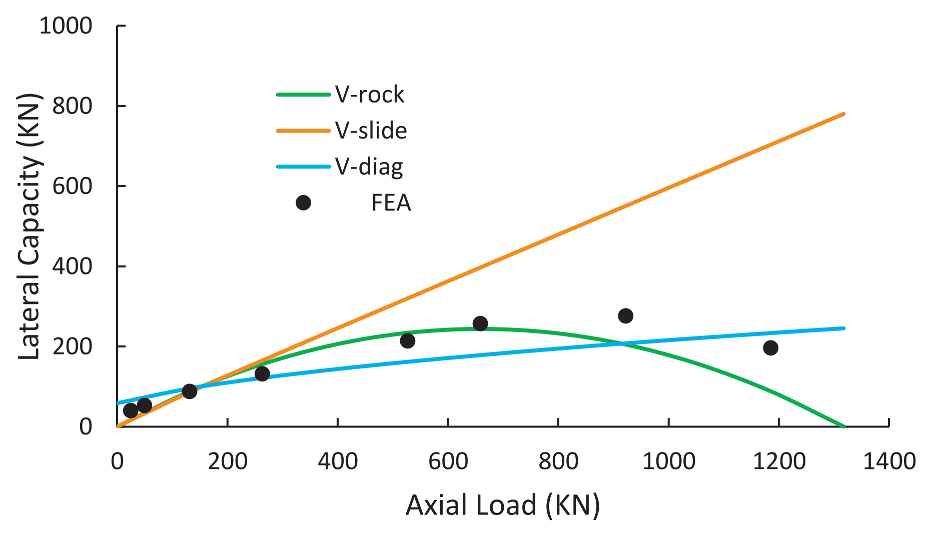


Figure 4. Failure mode interaction of the macro-scale panel (shaded in red).



G_t=35N/m G_c=12×10³N/m G_s=250N/m



G_t=50N/m G_c=20×10³N/m G_s=500N/m

Figure 5. Failure mode interaction based on the tensile (G_t), compressive (G_c), and shear (G_s) fracture energy.

Reference

Magenes, G., Kingsley, G., Calvi, G. M. (1995). Seismic Testing of a full-scale, two-Story masonry building: Test procedure and measured experimental response – Report: In *"Experimental and Numerical Investigation on a Brick Masonry Building Prototype - Numerical Prediction of the Experiment"*.

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