Nonlinear dynamic mesoscale analysis of masonry buildings subjected to earthquake loading

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Abstract

Unreinforced masonry buildings constitute an important part of the architectural and engineering heritage. A large number of these structures is located in earthquake prone regions, but their seismic response is often inadequate, and they commonly suffer substantial damage when subjected to earthquake loading. Therefore, at present there is a pressing need to develop accurate assessment strategies providing realistic response predictions under dynamic loading which are critical to address the development of effective strengthening solutions. In practical assessment of unreinforced masonry buildings, macro-models are usually employed because of their simplicity and computational efficiency. However, the complexity of the dynamic response of masonry structures under extreme loading can be captured only by employing detailed modelling strategies, where all sources of nonlinearities are taken into consideration. In this work, a detailed 3D mesoscale modelling approach is adopted, where cracks in mortar joints and masonry units are represented using nonlinear interface elements with detailed material descriptions allowing for degradation of strength and stiffness under cyclic loading. An advanced domain partitioning approach utilising parallel computational resources is employed to enhance computational efficiency, and mesh-tying for non-conforming meshes is considered to connect different walls components within a building structure. Finally, a novel inverse analysis strategy is employed for the identification of model material parameters leading to realistic response predictions. The potential of this approach is demonstrated considering the dynamic response of a full-scale building tested in laboratory in previous research. The results of this study reveal that the proposed approach, although computationally demanding, is capable of predicting the seismic response of entire buildings with good accuracy, at both the local and global levels. The modal dynamic characteristics, along with the main structural resistance mechanisms, the crack patterns and the base shear-floor displacement curves are captured in very good agreement with the experimental observations. The influence of repeated earthquake loading on the response of the masonry building is also investigated, comparing the numerical predictions against experimental results.

Keywords: **Zero-thickness interface; Surrogate-based identification; Mesh tying; Partitioned modelling.**