FEM meso-scale modelling of perimetral brick walls subjected to impacts and blasts: Formulation and laboratory test validation

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Perimetral walls are crucial components of the building envelope, providing insulation and structural support. While they are primarily designed to support axial loads, these walls can be subjected to extreme loads generated by impacts and blasts. Brick walls are particularly vulnerable to these actions, and pose significant risks when damaged, including flying debris hazards and risk of progressive collapse. As a result, careful engineering judgment is needed to assess their strength and design protection solutions. This study is devoted to the creation and validation of a 3D FEM meso-scale modelling strategy, a typology of numerical model usually employed for unreinforced masonry structures, as it ensures good fidelity at a reasonable computational cost. The scientific literature leverages the use of dedicated simulation tools or specific user-defined material models for commercial tools, which can be difficult to access and utilize by the common practitioner. In this study, the model was deliberately created in a well-known, general-purpose, proprietary FEA software package, making use of the material models available in it, and run within the offered computational framework. Bricks were modelled as nonlinear solid elements with expanded geometry to cover the mortar joints, which, in turn, are replaced by contact interfaces with cohesive-frictional damage behavior. The model was built upon the results of quasi-static four-point bending and impact pendulum tests, which were both conducted at RISE Research Institutes of Sweden under a variety of wall configurations. Once validated, the ability of the model to conduct blast simulations was demonstrated on the tested wall configurations and was later extended to larger geometries and structural solutions found in existing buildings. For each case, P-I curves were constructed based on experimentally built damage indicators. The numerical work undertaken in this study complements the experimental work conducted at RISE to understand and characterize the response of brick walls under extreme loading conditions. It will assist the analyst evaluate the blast resistance of brick facades, allowing for a more precise assessment of urban areas at risk of damage.