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Out of Plane Lower Bound Limit Analysis

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Surveys conducted after severe seismic sequences all around the world and fragility curves produced with techniques at territorial level, plus experimental tests show that the most diffused collapses occurring for existing masonry buildings are partial out-of-plane failures of large rigid portions with variable shape, roto-translating and forming a pre-defined kinematic chain, whose shape depends on several concurring factors, such as masonry texture, membrane loads and the interlocking between perpendicular walls.

Compared with the in-plane studies, the experimental research on out-of-plane loaded masonry is less abundant. Limit analysis seems the most suited tool to deal with the determination of the behavior at failure of out-of-plane loaded masonry panels.

A novel Lower Bound Limit Analysis Finite Element model for the study at failure of masonry walls in two-way bending is presented. In the model, a masonry plate is discretized into infinitely resistant hexahedrons and quadrilateral interfaces where all plastic dissipation occurs. Three internal static variables act on interfaces, namely bending moment, out-of-plane Kirchhoff shear and torque. Equilibrium is imposed on hexahedrons, whereas admissibility is enforced exclusively on interfaces between adjoining elements. The admissibility of the internal actions on masonry interfaces is imposed with a strength domain obtained by means of an already existing LB homogenization technique where joints are reduced to interfaces. The resultant Linear Programming (LP) problem - which allows to estimate collapse loads and distribution of internal actions at collapse - is characterized by a number of variables and constraints relatively limited, which requires a very limited computational burden to be solved through standard interior point LP software. Failure mechanisms are obtained solving the dual LP problem.

The procedure proposed is validated against two existing experimental data sets, namely three series of walls with slender perpendicular walls connected on vertical edges and tested at the University of Adelaide (Australia) [1] and four series of solid (one) and perforated (three) panels tested at the University of Plymouth (UK) [2][3]. A high accuracy of the model proposed in the prediction of the load carrying capacity, failure mechanism and distribution of internal actions at collapse has been found.

REFERENCES

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