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Distinct element modelling of the seismic response of historical masonry constructions: insight on the out-of-plane collapse of façades

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Façades belonging to historical masonry constructions, such as vernacular structures and churches, under seismic actions, typically fail by out-of-plane mechanisms [1].
The estimate of their out-of-plane capacity is not a trivial task, due to the different possible collapse modes (overturning, bending, disaggregation, leaf separation, sliding) and to the discontinuous nature of masonry, influencing the non-linear seismic behaviour of walls. Simplified approaches, proposed by building codes, mainly based on the mechanics of the rigid-block, may not always be suitable for the purpose [2]. Indeed, they disregard the real morphology of masonry, which instead influences weaker failure mechanisms (such as disaggregation and leaf separation). Furthermore, they neglect the interaction of the façade with the rest of the building and the interlocking between its blocks and those of transversal walls.
These shortcomings can be overcome resorting to distinct element method (DEM) modelling, which considers masonry as an aggregation of discrete units and no-thickness interfaces and allows to account for the actual morphology of constructions [3].
In this paper, DEM is adopted to investigate the out-of-plane seismic behaviour of façades through non-linear dynamic analyses, by focusing on vertical bending and overturning failure mechanisms. The former is studied through the comparison between results of shake table tests on both single-leaf and double-leaf masonry walls and of DEM simulations, in which walls are subject to natural accelerograms. The latter is analysed by comparing evidences of dynamic pulse-based DEM simulations to the actual state of seismic-induced damage detected on single-nave churches in central Italy. In both cases DEM results are also compared to rigid-body ones. Distinct element method provided a realistic description of the behaviour of façades under earthquake loadings, in terms of both seismic capacity and crack pattern.

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