Discrete element modelling of single-nave churches during the 2009 earthquake in L'Aquila, Italy

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ABSTRACT

Earthquakes that recently struck Italy, put in evidence that masonry churches are particularly vulnerable to the out-of-plane collapse of the façade. Nowadays, these mechanisms are currently analysed having recourse to a rigid body model and using either Limit Analysis with the kinematic approach, according to the Italian Building Code, or dynamic analysis for a rocking motion. However, both the aforementioned methods neglect the interaction with the lateral wall, leading generally to an underestimation of the effective structural capacity under seismic action.

The main goal of this work is therefore to investigate the effect of the interlocking between the façade and the transversal wall in the out-of-plane collapse mechanism, by means of a refined model of masonry through a Discrete Element Method. The structural model is therefore defined starting from a detailed recognition of the construction characteristics, while the seismic action is simulated by means of sinusoidal pulses, which can be related to the expected ground motion through the Maximum Incremental Velocity. The displacement capacity is investigated and compared to that calculated through limit analysis.

The proposed methodology is then applied on a sample of single-nave churches that suffered damages during the L'Aquila 2009 earthquake. The comparison between the crack pattern deriving from the numerical model and the real damage experienced during the seismic event demonstrates the ability of the Discrete Element Method to capture the effective seismic behaviour. On the other hand, the comparison with the rigid body rocking model underlines the influence of the connection on the seismic response.