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Numerical investigation of seismic performance of historic masonry buildings using the refined DEM

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SUMMARY

There are many historic masonry buildings worldwide. Some types of masonry buildings have particularly low earthquake resistance. Such structures collapse even at low intensities of ground motion and collapse rapidly at high intensities. Therefore, it is necessary to improve the earthquake resistance of these primarily weak masonry buildings to prevent their damage and to leave them for posterity. However, knowledge is still limited as to how the failure begins and proceeds, how buildings collapse, and how earthquake resistance can be improved effectively. With this background, this study aims to investigate the failure occurrence mechanism of masonry buildings during earthquakes and compare the seismic performance of several reinforcement measures by numerically simulations.

Among numerical simulation methods, the finite element method (FEM) is the most common for the analysis of a continuum. It can deal with both elastic and plastic behaviors, but it has difficulty in solving failure and collapse phenomena since it is based on the mechanics of the continuum and uses a continuous shape function. A method based on discontinuum modeling is more suitable for analyzing failure and collapse phenomena. An example of numerical methods for a discontinuum is the distinct element method (DEM). However, the method has disadvantages. In the DEM, a way of determining the spring constant from the material properties has not been established, and the values need to be quantified experimentally. Therefore, the reliability of the results is not high.

As an alternative, the present paper uses a refined version of the distinct element method, which simulates a series of seismic behaviors in three-dimension—from elastic to failure to collapse behaviors—using a refined version of the distinct element method. The new method still cannot handle the poisson's effect like the DEM, but unlike the DEM, the spring constant of each spring is theoretically determinable. Using this method, the seismic behavior of a historic masonry building is simulated, and the performances of reinforcement measures are compared.