

Development of Seismic Vulnerability Scores for Masonry Buildings Using the Applied Element Method

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ABSTRACT

As an approach to the problem of seismic vulnerability evaluation of existing buildings using the predicted vulnerability method, analytical procedures can be applied to produce vulnerability curves for different building classes. For some building types, mainly masonry structures, the development of those curves will be complicated and time consuming if a Finite Element-based method is used. This is because the model has to represent the structural geometry and relationships between different structural elements through the element connectivity. Moreover, the FEM may not be able to represent the large displacements and separations in progressive collapse simulations, properly. Therefore, the Applied Element Method that combines the advantages of FEM with that of the Discrete Element Method in terms of accurately modeling a deformable continuum of discrete materials is used here to develop vulnerability curves for those challenging building classes. The incremental dynamic analysis of a 6-storey industrial masonry building built in 1906 in Montreal, Canada has been carried out using 14 sets of synthetic and real ground motions representing three M, R categories. The application of the incremental dynamic analysis method makes it possible to thoroughly calculate displacements and observe collapse progress under seismic loads. For such a first-mode-dominated masonry building, spectral acceleration values at the structure's first-mode period and inter-storey drifts are chosen as intensity (IM) and damage measures (DM), respectively. Intensity and damage measures are pointed on the IDA curves at the three structural performance levels, immediate occupancy, life safety, and collapse prevention, for each ground motion. The statistical analysis of those points is then carried out to determine means and standard deviations of the building's vulnerability curve for each structural performance level. Those vulnerability curves are compared with the vulnerability curve data for masonry buildings provided by NIBS in *HAZUS-MH MR1 Technical and User's Manual* and applied to develop a new set of vulnerability scores. Those scores actually correlate potential structural deficiencies with structural characteristics for the studied building. In a larger scale, those vulnerability scores are used in the probabilistic seismic vulnerability evaluation of the building under study by comparing its seismic response with different seismic demands.

Keywords: Applied Element Method, Incremental Dynamic Analysis, Masonry Building, Score Assignment Method, Vulnerability Curves, Structural Performance Levels, Finite Element Method