8th International Conference on Seismology & Earthquake Engineering
11-13 Nov. 2019, Tehran, Iran

DEVELOPING AND EVALUATION A NEW DISCRETE MACRO-ELEMENT FOR MODELING AND NONLINEAR ANALYZING OF UNREINFORCED MASONRY WALLS

Yeganeh Sadat SADEGHI
M.Sc. Student, University of Science and Culture, Tehran, Iran
sadeghiusc@gmail.com
Alireza AGHABABAIE MOBARAKE
Assistant Professor, University of Science and Culture, Tehran, Iran
aghababaie@usc.ac.ir

Keywords: Unreinforced masonry walls, Discrete macro-element, two-dimensional element, unreinforced masonry panels

Seismic studies of both existing and newly designed unreinforced masonry buildings, which have various material characteristics as well as different construction techniques around the world, have led to nonlinear analysis with rather complicated and different features caused by uncertainties (Mobarake et al., 2017).

The purpose of this paper is to characterize a new analytical platform for practical applications in recent seismic studies of the unreinforced masonry buildings. The proposed platform, as a practice-oriented approach, was fashioned based on introducing a two-dimensional discrete macro-element, which is simply adapted to load on most structural analysis software. The proposed platform comprises of a two-dimensional basic macro-element for modeling the piers.

Figure 1 provides a schematic representation of the proposed basic macro-element. At first, this element was used for modeling of cold-formed steel sheathed shear wall frames (Kechidi et al., 2017). In the more accurate projection, the basic macro-element, is made-up of four sub-elements including upper and lower rigid beams, right and left (bilateral) nonlinear trusses, solid X-bracing trusses and a nonlinear zero-length sub-element between the upper and lower V-inverted V-bracing truss sub-elements. Similar to the macro-element discretization approaches, each panel of the unreinforced masonry walls, i.e. piers, is modelled by using a single proposed basic macro-element. The middle node of the lower and upper beam sub-elements is applied in order to connect these macro-elements to the supports as well as the rigid interface macro-elements.

In this research, a complete set of constitutive equations and behavioral specifications is proportionally characterized and discussed for the basic macro-element based on its phenomenology and the past experimental studies. The proposed approach provides a rather simple and efficient platform for linear or nonlinear, static and dynamic analyses by considering the in-plane behavior of the unreinforced masonry panels.

In the proposed macro-element, evaluating the responses of different sub-elements simultaneously will first, determine which failure modes are activated, and second, show the prevailing failure mode. The prevailing failure mode is the mode that reach ultimate strength or displacement faster when the force-deformation responses are simultaneously compared with pertinent capacity relations.

The validation and potential significance of the proposed approach was be investigated by means of pushover and cyclic nonlinear analysis, conducted on some cases of unreinforced masonry wall panels and walls that have been theoretically and experimentally investigated in different reliable and valid researches (such as Franklin et al., 2017). As a sample, in Figure 2, a complete comparison between the force-deformation of the experimental and analytical responses of the proposed model for a selected specimen is demonstrated.

The comparisons, which comprised of the ultimate strength, prevailing failure mode, displacement capacity, and hysteretic behavior, indicated satisfactory agreement between the test and numerical analysis results.

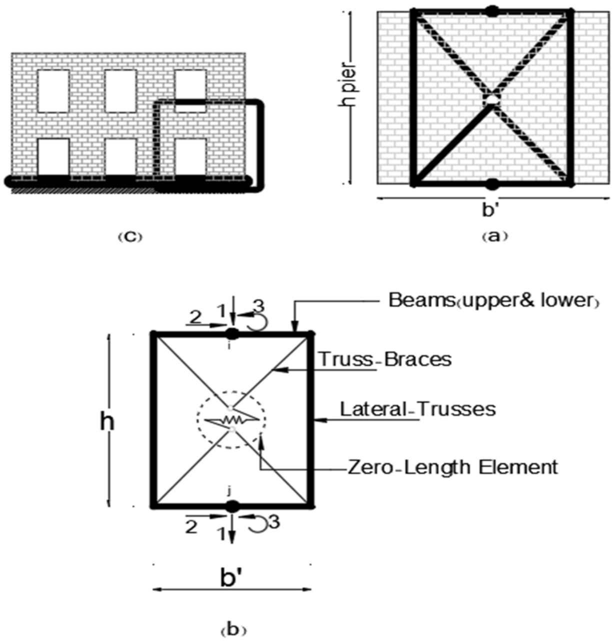

Figure 1. (a) Proposed macro-element, (b) basic macro-element.

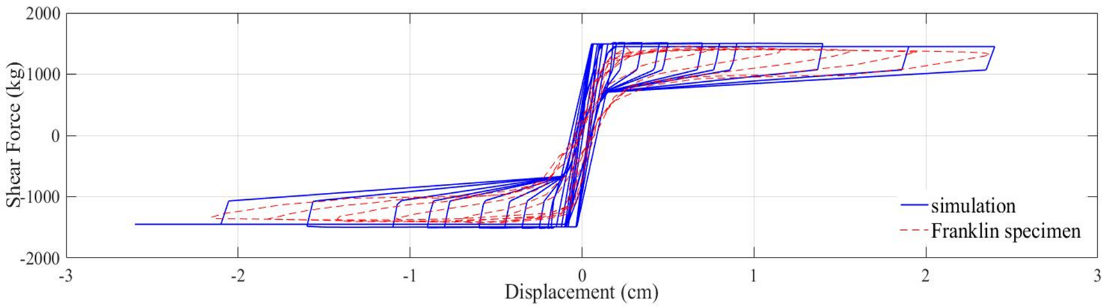

Figure 2. Comparison of experimental and analytical result for a selected specimen.

As another interesting case, derivation and interpretation of the results in the proposed approach is straightforward and simple; hence, engineers can use this approach for seismic design or retrofit studies. The proposed platform can be effectively used for modeling a large building or numerous buildings. Also, the equivalence between the wall panels and the basic macro-element as well as the framework capabilities, which could be loaded on many existing structural software, can make the numerical results interpretable in a simple and straightforward way.

REFERENCES

Franklin, S., Lynch, J., and Abrams, D.P. (2003). *Performance of Rehabilitated URM Shear Walls: Flexural Behavior of Piers*. Mid-America Earthquake Center CD Release 03-03.

Kechidi, S., Bourahla, N., and Castro, J.M. (2017). Seismic design procedure for cold-formed steel sheathed shear wall frames: Proposal and evaluation. *Journal of Constructional Steel Research*, 128, 219-232.

Mobarake, A.A., Khanmohammadi, M., and Mirghaderi, S.R. (2017). A new discrete macro-element in an analytical platform for seismic assessment of unreinforced masonry buildings. *Journal of Engineering Structures*, 152, 381-396.