Pros and cons of various equivalent frame models for nonlinear analysis of URM buildings

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Masonry is considered as an old construction material. Several cultural heritage assets including churches, towers, and fortifications are made of unreinforced masonry (URM) which is susceptible to earthquake due to the brittle behavior. Equivalent frame method (EFM) is a nonlinear modeling method which has been widely utilized for the seismic analysis of URM buildings with lower computational efforts compared to finite element method. Various macroelements consisting of nonlinear shear or flexural springs, nonlinear fiber beam column elements have been developed to simulate the URM structural components [1].

Unified method (UM) is considered as the simplest method in this study. In UM each perforated or unperforated URM wall is simulated with a macroelement consisting of a nonlinear shear spring. Composite spring method (CSM) is the second EFM that each pier is simulated with a nonlinear shear spring that connect to the linear spandrel elements. However as the most detailed approach, each pier and spandrel are modeled using the double modified multiple vertical line element (DM-MVLEM) modelelement considering the effect of axial moment interaction [2].

In this study three EFM macroelements have been utilized to model three case studies with different configurations of openings. DM-MVLEM is accurate enough for the prediction of load bearing behavior and damage pattern of perforated URM walls compared to CSM and finite element method. It is investigated that the CSM cannot reflect the weak spandrel elements and conservative results are concluded from the seismic analysis of the models developed using UM compared to CSM and DM-MVLEM.

REFERENCES

[1] A. Shabani, M. Kioumarsi, M. Zucconi, State of the art of simplified analytical methods for seismic vulnerability assessment of unreinforced masonry buildings. *Eng. Struct*, Vol. 239, 2021.
[2] A. Shabani, M. Kioumarsi, A novel macroelement for seismic analysis of unreinforced masonry buildings based on MVLEM in OpenSees. *J. Build. Eng*, 2022 (under review).