Modelling of out-of-plane loaded vertically spanning unreinforced masonry walls under static and dynamic loading: comparison between four modelling approaches

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Abstract

Vertically spanning unreinforced masonry walls represent a simple yet important case study for practitioners in earthquake engineering. Four modelling approaches are put forward and compared for this case study: (1) a refined discrete element model, which makes use of an explicit time-marching scheme to solve the equations of motion [1] and follows closely the joint crack-initiation up to the complete joint detachment and rocking of portions of wall [2,3]; (2) an analytical model based on the Euler-Bernoulli engineering beam theory, which assumes the wall as an homogeneous elastic no-tension material undergoing large out-of-plane deflections [4]; (3) a rigid-plastic beam model, which is built on the analytical development of a limit analysis homogenization approach [5] based on a one-dimensional micropolar continuum [6]; (4) a single-degree-of-freedom system equivalent model, which captures the force-displacement curve of the wall through a tri-linear relationship [7]. The advantages and the drawbacks of each modelling approach in representing the static and dynamic response of the walls are discussed. The equivalent model is finally benchmarked against the results from discrete element simulations and is proposed as a simplified but accurate tool for non-linear time-history analyses of the unreinforced masonry walls.

Keywords: **masonry, out-of-plane, one-way bending, rocking, DEM, homogenization**

References

[1] Hart R, Cundall PA, Lemos J V. Formulation of a three-dimensional distinct element model—Part II. Mechanical calculations for motion and interaction of a system composed of many polyhedral blocks. Int J Rock Mech Min Sci Geomech Abstr 1988;25:117–25. doi:10.1016/0148-9062(88)92294-2.

[2] Godio M, Beyer K. Evaluation of force-based and displacement-based out-of-plane seismic assessment methods for unreinforced masonry walls through refined model simulations 2018;submitted:1–22.

[3] Godio M, Stefanou I, Sab K. Effects of the dilatancy of joints and of the size of the building blocks on the mechanical behavior of masonry structures. Meccanica 2018;53:1629–1643. doi:10.1007/s11012-017-0688-z.

[4] Godio M, Beyer K. Analytical model for the out-of-plane response of vertically spanning unreinforced masonry walls. Earthq Eng Struct Dyn 2017;46:2757–76. doi:10.1002/eqe.2929.

[5] Godio M, Stefanou I, Sab K, Sulem J, Sakji S. A limit analysis approach based on Cosserat continuum for the evaluation of the in-plane strength of discrete media: Application to masonry. Eur J Mech - A/Solids 2017;66:168–92. doi:10.1016/j.euromechsol.2017.06.011.

[6] Trovalusci P, Masiani R. Non-linear micropolar and classical continua for anisotropic discontinuous materials. Int J Solids Struct 2003;40:1281–97. doi:10.1016/S0020-7683(02)00584-X.

[7] Godio M, Beyer K. Tri-linear model for the out-of-plane seismic assessment of vertically-spanning unreinforced masonry walls 2018;Und.review.