# A simple contact model for dynamic analysis of masonry block structures using mathematical programming

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## Abstract

A simple contact model is presented in this paper for dynamic analysis of masonry block structures using mathematical programming. Masonry structures are represented as 2D assemblages of rigid blocks interacting at no-tension, frictional interfaces with infinite compressive strength. To represent interaction at interfaces a point-based contact model is used, with static variables located at the vertices of each interface. Non-penetration conditions at contact points are formulated using gap functions and complementarity conditions to ensure that contact forces occur only if the gap is closed. The equations of motion are discretized with respect to time using the theta method and are expressed at the displacement level.
The contact dynamic problem is formulated as force-based problem under the assumption of associative flow rule for displacement rates at contact points. The formulation of the variational problem associated to dynamics of the block assemblages gives rise to a quadratic mathematical programming problem. To evaluate the accuracy and computational efficiency of the implemented formulation, applications to numerical case studies from the literature are presented. The case studies comprise a rigid block under free rocking motion and earthquake excitation. A bi-block structure under free rocking motion is also investigated for validation. Finally, the wall panels analysed by Ferris and Tin-Loi using limit analysis are considered to compare failure mechanism and magnitudes of lateral loads promoting the collapse.

**Keywords:** Contact dynamics, mathematical programming, point-based contact model, rigid blocks, masonry structures, rocking.