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The non-smooth tale of Accumoli civic tower

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The dynamics of historical masonry buildings is one of the most difficult tasks to be investigated in structural engineering, since these kinds of structures are commonly heterogeneous, with complex geometry, and with unknown quality of the connections between different structural parts, in particular walls and floors, that often play a crucial role. However, understanding the dynamical behaviour is crucial for a reliable seismic vulnerability assessment, which became more and more important due to recent catastrophic earthquakes (Umbria-Marche 1997–1998, Abruzzo 2009, Emilia-Romagna 2012, Marche-Lazio-Umbria-Abruzzo 2016).
In this work, the nonlinear dynamics of a medieval tower located in Accumoli, a village in central Italy, recently damaged by earthquakes is investigated. Generally, the mechanical response of masonry towers is commonly investigated by finite element methods [1], often including very sophisticated constitutive laws considering post-elastic behaviours and damage. These methods, while being very appealing, do not focus on the possible non-smooth nature of the dynamic response, which can come sliding and impacting between different blocks, and situation that is common just before and during the collapse. For this reason, in the present paper, the dynamics of the tower, schematized as a set of rigid blocks, is investigated by means of a distinct element code that implements the Non-Smooth Contact Dynamics method (NSCD) [2].
The main goal is to determine the weakness zones of the structure during seismic events, and the possible collapse mechanisms.
Harmonic oscillations applied to the basement of the tower are considered first, and a systematic parametric study is done, aimed at correlating the tower vulnerability to the amplitude and frequency of the excitation. In addition, numerical analyses are performed to see the effects of the friction coefficient and of the block's geometry on the dynamics, and on the collapse modes.
Then, the study of the tower stability against recorded seismic excitations is addressed. Attention is paid to the occurrence of out-of-plane torsional overturning mechanisms, and some comparisons of the damage obtained with the present approach and with other numerical models, like continuous finite element approach, are reported.

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