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Debris Flow Damage Incurred to Buildings: An In-Situ Back Analysis

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The flash-flood debris event of the October 1st 2009 in the area of Messina, Sicily, Italy has led to loss of life and significant damage to the constructed environment. Focusing the attention on an eighteenth masonry building (damaged and upgraded after the Messina-Reggio Calabria Earthquake of 1906) located in the village of Scaletta Zanclea, we have strived to reconstruct analytically the damages incurred to this building due to the debris flow event of 2009.
In order to re-construct the damages incurred to the building due to the flash flood/debris flow event, hydrostatic and hydrodynamic force envelopes, calculated via a 2D hydrodynamic finite element model specifically designed for debris flow spatial propagation, have been applied to the building in question (assuming perfect coherence between static and dynamic maxima). The hydrograph for the solid discharge is then estimated by scaling up the liquid volume to the estimated debris volume. The hydrodynamic model used for the debris flow propagation proved to be well suited for these specific applications. The debris flow diffusion is simulated by solving the differential equations for a single-phase 2D flow employing triangular mesh elements, taking into account also the channeling of the flow through the building. The damage to the building is modeled, based on the maximum hydraulic actions caused by the debris flow, using 2D finite shell elements, modeling the boundary conditions provided by the openings, floor slab, orthogonal wall panels and the foundation.
The finite element approach showed its capability in describing the complex geometries of the urban environments as the distributed nature of the 2D code allows to derive a reliable spatial distribution of debris flow actions. The reconstruction of the event and the damages to the case-study building confirms the location of the damages induced by the event.