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MODELLING THE EFFECTS OF TSUNAMI-INDUCED FORCES ON BUILDING FACADES

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EXTENDED SUMMARY

Tsunami waves cause severe structural and non-structural damages in the shallow water and inundation areas. The intense development that coastal areas have experienced in the last decades, with a rapid growth in population and economy, has increased their exposure to tsunami waves.

The Indian Ocean (2004) and Tohoku (2011) tsunamis are recent examples of catastrophic earthquake-induced tsunamis with tragic consequences to the people, environment and economic activity. The Gulf of Cadiz is a tsunami prone area (linked with the western segment of the Eurasia-Nubia plate boundary) where the occurrence of major tsunamis has been described, at least, since 60 BC (Baptista and Miranda, 2009). The Algarve (the southernmost region of mainland Portugal and part of the Gulf of Cadiz Northern boundary) is a region susceptible to the seismic activity with origin at the Eurasia-Nubia plate boundary and at local tectonic faults. Major cities in the Algarve, situated near the coastline, suffered from a fast growth in urbanization due to the main economic activity in the region: tourism.

Recent research on tsunami modelling has been mainly centred in the hydrodynamic issues (e.g., propagation). However, the major losses, human lives and economic, occur at the inland areas, and so further knowledge on what happens in these areas is needed. Main goal of this research is the assessment of inland buildings resilience to tsunami-induced flooding. Focus is given to the simulation of the effects of tsunami-induced forces on inland structures by coupling seismic-tectonic, hydrodynamic and structural models. At the present stage and for the purpose of this work the tsunami-wave height and velocity were obtained from Baptista et al. (2010) and Omira et al. (2011). Hydrostatic, hydrodynamic and impact forces were considered and obtained accordingly to FEMA P646 (2008) and FEMA P-55 (2011) design codes. Other tsunami-induced forces as buoyant, surge or braking-wave were not considered at the current phase of this study.

A finite-element linear structural analysis was carried out using SAP2000 (Computers & Structures, INC.). A highly-detailed 3D model with 33066 solid elements was created to simulate the behaviour of a single brick wall with cement render (Figure 1a). The facade with 2.82 m of height by 5.36 m of length has vertical concrete piles and a concrete slab respectively at the lateral and upper extremities of the masonry wall (0.27 m width). Dead loads were not considered for the purpose of this analysis. Different values of tsunami-wave height were considered, with a maximum of 10 m as observed at the coastline near to the city of Faro (capital city of the district of Algarve) during the tsunami subsequent to the 1755 Lisbon Earthquake (Baptista et al., 2010). The finite-element analysis (Figure 1b) revealed to be particularly useful to evaluate structural and non-structural damages and evidenced that building facades with single ceramic brick walls and Portland cement mortar (typical construction in the Algarve from the 60's to the 80's) can suffer major damages from tsunami-induced forces (e.g., hydrostatic forces; see Figure 1c). In order to reduce these damages it is vital a better understanding of the behaviour of building facades under tsunami waves.

The preliminary results from this simple numerical experience show that future work will be needed to develop our knowledge on this subject. Computational nonlinear structural analysis and laboratory simulations are currently in progress to evaluate the response of different types of building facades (e.g., materials, construction methods). The authors hope that this research may give a useful tool to engineers and planners who deal with flood risk assessment in coastal areas and ultimately help to improve resiliency of building facades.

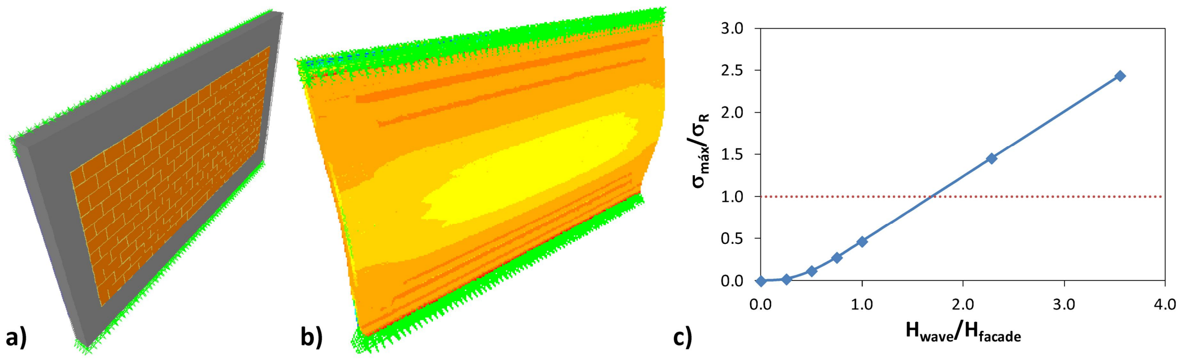

Figure 1. a) Finite-element wall model; b) Example of principal tension stress distribution for hydrostatic load; c) Principal tension stress to mortar rupture tension stress ratio vs. wave height to facade height ratio.

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