Geophysical Research Abstracts
Vol. 17, EGU2015-12540, 2015
EGU General Assembly 2015

Mathematical modelling of tsunami impacts on critical infrastructures: exposure and severity associated with debris transport at Sines port, Portugal.

Daniel Conde (1), Maria Ana Baptista (2), Carlos Sousa Oliveira (1), and Rui M. L. Ferreira (1)

(1) CEris - Instituto Superior Técnico, University of Lisbon (Portugal), (2) Instituto Dom Luiz and Instituto Superior de Engenharia de Lisboa (Portugal)

Global energy production is still significantly dependant on the coal supply chain, justifying huge investments on building infrastructures, capable of stocking very large quantities of this natural resource. Most of these infrastructures are located at deep-sea ports and are therefore exposed to extreme coastal hazards, such as tsunami impacts. The 2011 Tohoku tsunami is reported to have inflicted severe damage to Japan's coal-fired power stations and related infrastructure.

Sines, located in the Portuguese coast, hosts a major commercial port featuring an exposed coal stockpile area extending over more than 24 ha and a container terminal currently under expansion up to 100ha. It is protected against storm surges but tsunamis have not been considered in the design criteria. The dominant wind-generated wave direction is N to NW, while the main tsunamigenic faults are located S to SW of the port. This configuration potentially exposes sensitive facilities, such as the new terminal container and the coal stockpile area. According to a recent revision of the national tsunami catalogue (Baptista, 2009), Portugal has been affected by numerous major tsunamis over the last two millennia, with the most notorious event being the Great Lisbon Earthquake and Tsunami occurred on the 1st November 1755.

The aim of this work is to simulate the open ocean propagation and overland impact of a tsunami on the Sines port, similar to the historical event of 1755, based on the different tsunamigenic faults and magnitudes proposed in the current literature. Open ocean propagation was modelled with standard simulation tools like TUNAMI and GeoClaw. Near-shore and overland propagation was carried out using a recent 2DH mathematical model for solid-fluid flows, STAV-2D from CERIS-IST (Ferreira et al., 2009; Canelas, 2013). STAV-2D is particularly suited for tsunami propagation over complex and morphodynamic geometries, featuring a discretization scheme based on a finite-volume method using a flux-splitting technique with a reviewed Roe–Riemann solver and appropriate source-term formulations to ensure full conservativeness. Additionally, STAV-2D features Lagrangian-Eulerian coupling enabling solid transport simulation under both continuum and discrete approaches, and has been validated with both laboratory data and paleo-tsunami evidence (Conde, 2013a; Conde, 2013b).

The interactions between the inundating flow and coal stockpiles or natural mobile bed reaches were simulated using a continuum debris-flow approach, featuring fractional solid transport, while the containers at the new terminal were advected with an explicit Lagrangian method. The meshwork employed at the port models the existing geometry and structures in great detail, enabling explicitly resolved interactions between the current infrastructure and the overland propagating tsunami.

The obtained preliminary results suggest that several structures, some of them critical in a nationwide context, are exposed to tsunami actions. The coal deposition pattern and the final location of monitored containers were determined for two magnitude scenarios (8.5 Mw and 9.5 Mw) in the case of a tsunami generated at the Horseshoe fault and one magnitude scenario (9.5 Mw) for a tsunami generated at the Gorringe bank. The inland washing of the coal stockpiles may impose great loss of both economical and environmental value, while the impact of large mobile debris, such as the containers in the terminal area, significantly increases the severity of infrastructural damage.

Acknowledgements
This work was partially funded by FEDER, program COMPETE, and by national funds through the Portuguese Foundation for Science and Technology (FCT) with project RECI/ECM-HID/0371/2012.

References

Baptista M.A. & Miranda, J.M. (2009), Revision of the Portuguese catalog of tsunamis. Nat. Hazards Earth Syst. Sci., 9, 25–42.

Canelas, R.; Murillo, J. & Ferreira, R.M.L. (2013), Two-dimensional depth-averaged modelling of dam-break flows over mobile beds. Vol 51(4) pp. 392-407.

Conde, D. A. S.; Baptista, M. A. V.; Sousa Oliveira, C. & Ferreira, R. M. L. (2013a), A shallow-flow model for the propagation of tsunamis over complex geometries and mobile beds, Nat. Hazards Earth Syst. Sci., 13, 2533-2542.

Conde, D. A. S.; Canelas, R. B.; Sousa Oliveira, C. & Ferreira, R. M. L. (2013b), Mathematical modelling of transport of coal stockpiles by a tsunami at Sines port, 8th International SedNet Conference 2013, Lisbon, Portugal.

Ferreira, R. M. L.; Franca, M. J.; Leal, J. G. & Cardoso, A. H. (2009), Mathematical modelling of shallow flows: Closure models drawn from grain-scale mechanics of sediment transport and flow hydrodynamics, Can. J. Civil. Eng., 36, 1604–1621, 2009.