Mathematical modelling of transport of coal stockpiles by tsunami at Sines port

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Introduction: The global energy trade is still significantly dependant on the coal supply chain, justifying the extensive infrastructures aimed at stocking massive quantities of this natural resource. However, most of these facilities are located at ports and are therefore exposed to extreme coastal hazards. The 2011 Tohoku tsunami is reported to have resulted in severe losses of coal, due to the washing of stockpiles, and major environmental problems due to sea water contamination. In Portugal, the port of Sines features an apparently exposed stockpile area, extending over more than 24 ha (Fig. 1). The aim of this work is to simulate the impact of the propagation of a tsunami whose order of magnitude is equal or larger than the historical event occurred in November 1755.

Methodology: A tsunami scenario at the Sines Port will comprise a forecasting exercise for a recent 2DH mathematical model, STAV2D, developed at CEHIDRO (IST) [1, 2] which is particularly suited for tsunami propagation over complex and dynamic geometries. The discretization scheme is based on a finite-volume method using a flux-splitting technique featuring a reviewed Roe–Riemann solver, with appropriate source-term formulations to ensure full conservativeness. The model has been validated with both laboratory data and paleo-tsunami evidence.
The modelling of the port plannimetry is fully explicit, featuring all the relevant structures and enabling the interactions between built environment and an overland propagating tsunami.
A layer of mobile material, composed of coal-like particles, will virtually reproduce the existing stockpile geometry. The sediment transport features from STAV2D will then act on this layer and provide an overview of coal dispersion over the port area.

Results: The Sines port is protected against surge storms but not effectively against tsunamis. The dominant surface wave direction is NW, while the main tsunaminogenic faults are located to the south of the port. This difference leaves sensitive facilities exposed, such as the new terminal container and the coal stockpile (Fig. 1), by virtue of the existing openings between the south breakwater and these structures.
The impact of a large tsunami is expected to wash away more than 30% of the coal deposits, constituting major losses on both economic and environmental perspectives.

Fig. 1: *Overview of Sines port: coal stockpile and new container terminal*

Recommendations: The exposure of the underlined port areas might require a protective barrier to be built. The data provided by this work may aid the design of such barrier.

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References:

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