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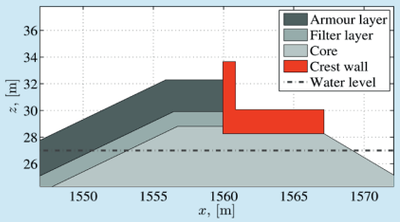
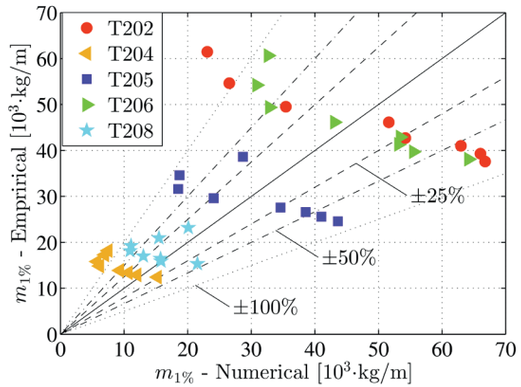
Optimising coastal structures with numerical modelling

Coastal structures are an essential part of the design of ports: they provide shelter from storms and allow for safe operations. Coastal structures are often made from permeable material that may include everything from sand and gravel to large boulders and concrete blocks. The traditional approach to design is based on empirical formulations and experience from past works. Designs are then tested in physical laboratory settings. Alongside physical model testing, numerical models can be used to analyse different conditions and configurations. This allows for a more flexible and cost-efficient optimisation of the structure geometry.



The joint industry project (JIP) Coastal Foam focuses on the development of numerical tools to predict the stability of various components of coastal structures, and particularly on the open source CFD-toolbox OpenFoam. One of the studies looks at open filters in which rock material is placed on top of a sand core. Traditional guidelines state that the sand should not be allowed to move. Nevertheless, the combination of laboratory experiments and newly developed numerical methods has indicated that less strict design rules can be used while ensuring structural integrity.

Another area studied in the Coastal Foam JIP was slamming loads from breaking waves on crest wall elements. Crest wall elements are concrete structures on top of a breakwater and only a small number of empirical relationships are available to design these structures. This limited experimental evidence leads to huge uncertainties in the required weight of the crest wall and therefore uncertainty about the material required. The numerical model was validated on the basis of new laboratory experiments and its predictive power was found to be excellent. The model was then applied to a design exercise in which the weight of the crest wall element was optimised with either an existing empirical formulation from the Rock Manual or with the validated numerical model. This comparison showed that the methods can produce results that can easily vary by a factor of two. More worrying, however, was the fact that the empirical formulations did not necessarily produce conservative results.



This project shows that detailed numerical modelling is an accurate design tool that is also easy to apply early in the design process. The tool is likely to replace the existing empirical formulations for forces on crest walls since the predictive power of the latter is limited.

Further reading:
Jacobsen et al (2017). Numerical modeling of the erosion and deposition of sand inside a filter layer. Coastal Engineering, 120, 47-63.