APPLICATION OF SMOOTHED PARTICLE HYDRODYNAMICS ON A LOW LEVEL QUAY DECK

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INTRODUCTION

Rising sea water level projections challenge the existing levels within ports. Although air gaps have been a traditional means to avoid a fight with the force of the sea, such principle cannot be implemented easily in existing ports, or even for new projects, since these projects require interfacing with their surroundings. More and more, the interaction between the sea (and in particular extreme wave climates) and existing low quay deck levels for open types of quay walls has to be estimated. Apart from relying on physical model testing, the numerical world comes to our rescue. Significant advances have been made over the past decennium with the practical commercial implementation of smoothed particle hydrodynamics for practical engineering problems. This article describes a practical example of such an assessment for a particular project in the port of Ostend, Belgium.

2D PREPARATION

First, the input for the environmental conditions was ascertained from existing studies of the wave penetration within the port of Ostend, so the design conditions (wave heights, periods and water levels), could be associated with a relevant return period. Then a hydraulic numerical model was tested under the most relevant conditions in two numerical 2D flumes, a beam model and a deck model, capturing the main characteristics of a complex deck structure consisting of prefabricated prestressed beams and a deck structure on top. Through the use of these two models, it was possible to find beam and deck forces as separate time series. Finally these time series were inserted into a separate dynamic structural model to produce time series of all internal forces in the different deck elements. This then allowed – after post-processing – to perform the structural verifications of the different elements.

THE 3D EXERCISE

The results of the 2D modelling showed that it was not reasonable to combine the calculated forces at beam and at deck level in a realistic design of the deck, because of the inherent limitations to grasp the fluid dynamics of the real 3D situation. Indeed, water hitting the bottom flange of the beams can still profit from the structural porosity created by the voids in between the beams. The beam forces in a 2D model are therefore necessarily overestimations. Moreover, the wave pattern created by the different structural geometries in the two 2D models is fundamentally different, raising doubts on any combination of the time series of these two models. Therefore, a new 3D hydraulic model was run and it clearly contradicted the 2D approach, e.g. with respect to the relative importance of the dynamic impacts on the beams and the deck in the global impact. It also produced coherent results in time. Finally, it succeeded in bringing the load levels down to an order of magnitude that appeared to be manageable for a reasonable structural design.

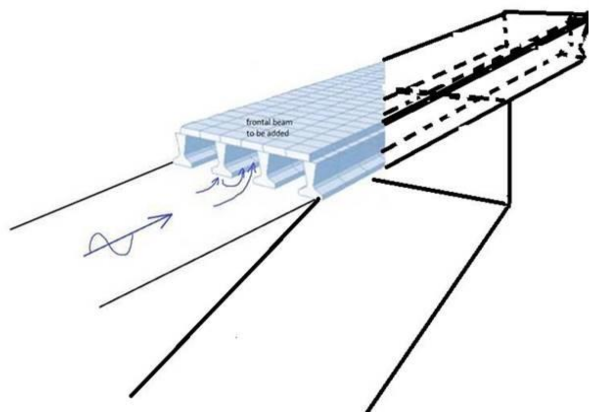

Figure 1 – Principle of the 3D geometry of the deck of the quay, port of Ostend

FUTURE PROSPECTS

The 3D model still remains a simplified setup with respect to the real case since head-on long-crested waves have been used. Therefore, the 3D model resembles an experimental wave flume facility and some relevant corrections have to be made for wave obliqueness and shielding caused by deck supporting piles.

In future, as the calculation capacity in our world is on the rise, it is expected that final results can be delivered as a result of a model that deals both with the smoothed particles as with the structural dynamics, so the interfacing of large amounts of data between both types of packages can be avoided overall.

REFERENCE

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