

Revisited hydraulic functioning of permeable pile groins

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INTRODUCTION

Since 1965, a new type of permeable groins (or 'pile screens' referred to Bakker et al.,(1984)), which consist of wooden pile rows with a high permeability, have been widely used to protect the coastline from recession in the Netherlands, especially at southwestern coastline. However, the hydraulic functioning of such structures has not been understood well compared to traditional impermeable pebble mound groins. As the wooden pile groins become older and the maintenance costs increase, the issue of their effectiveness has become of importance, while no serious research has been undertaken. This paper tries to tackle this issue. Based on experimental data which was obtained at Delft Hydraulics(Hulsbergen and Horst, 1973), the functioning of pile groins has been revisited and analyzed by an advanced numerical model. The simulations give deeper insights into the effectiveness of permeable pile groins under well controlled laboratory conditions.

PHYSICAL EXPERIMENT

In 1973, a pioneering and systematic experiment was carried out in Delft hydraulics, which was done in an open air wave basin. This basin area is 12.1 m wide and 35.35 m long. The scale is 1:40. A regular wave with 0.03 m wave height, and 1.04 s wave period was produced. Additionally, the representative tidal induced alongshore current of 1 m/s magnitude at 10 m water depth was chosen, which amounts to 0.168 m/s in the laboratory. The model piles are in 0.006 m diameter. And each pile row has varying heights across-shore to align with beach profile(figure 1), and a varying permeability increases from 50% near landward root to 76% at seaward head. Different pile groin configurations were explored in this experiment. In this paper, only one layout of groin system have been analyzed for conciseness.

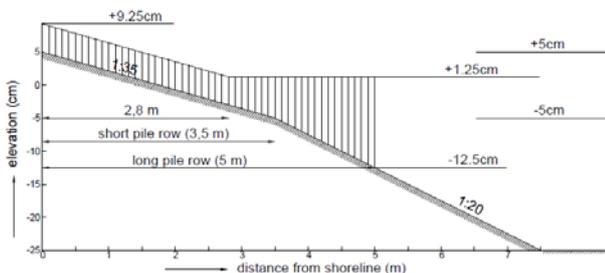


Figure 1 -Cross shore beach profile and pile groin configuration

NUMERICAL SIMULATION

The advanced phase-resolving wave-flow model SWASH (Simulating Waves till Shore) was used to simulate the interaction between pile groins and near shore currents. The governing equations are non-linear shallow water equations including non-hydrostatic effects.

Seen from figure 2, overall the simulation results have good agreement with measured magnitude of alongshore current velocity, except an underestimation at the transition zone(2 m to 4 m) between wave induced

longshore current dominated breaker zone(0 m to 2 m) and steady flow dominated nearshore zone. This may be due to less accurate vertical and horizontal mixing process in this model.

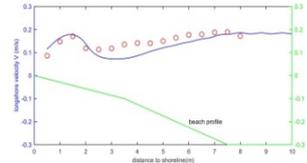


Figure 2 -Cross shore distribution of alongshore current under combined wave and current condition without groins(red dots denote measured data and blue line presents calculated results) .

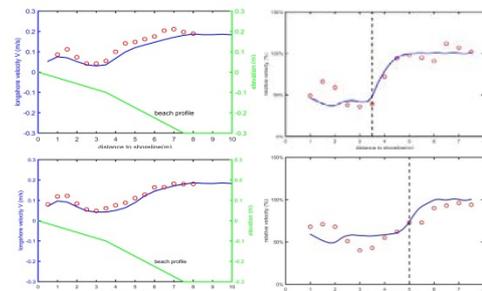


Figure 3 -Cross shore distribution of alongshore current under combined wave and current condition with short(up) and long (bottom)groins, longshore velocity(left) and relative velocity(right) (black dot lines indicate the head location of pile groin).

DISCUSSION

Both short and long pile groins are effective to reduce alongshore current velocity in groin field. The reduced longshore current velocity is about 50% of non-groin disturbed current. The deviation (underestimation in breaker zone and overestimation in transition zone) needs further compare locally, as here the velocity are averaged alongshore within groin fields.

CONCLUSIONS

The numerical model is capable to reproduce the flow field gained in the laboratory. And the well validated model could be used to explore more detailed spatial distribution of the flow field which was not observed in the laboratory.

Pile groins are effectively reduced longshore current velocity by 50%. Compared to long groins, the short groins produce larger velocity gradient across-shore. Based on validated hydraulic simulation, morphological change of pile groins engineered beach could be predicted.

REFERENCES

- Bakker, Hulsbergen et al., 1984. Permeable groynes: experiments and practice in the Netherlands, in: Coastal Engineering Proceedings. pp. 1983-1996.
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