Wave Impacts on Caisson Breakwaters Situated in Multidirectionally Breaking Seas

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Wave Impacts on Caisson Breakwaters situated in Multidirectionally Breaking Seas

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1. Introduction

Attention has been addressed to the effects of wave obliquity and multidirectionality on the wave loads on vertical caisson breakwaters situated in non breaking seas. Within the joint European (MAST-LIP-TAW) research project, a 3D model investigation was carried out at Delft Hydraulics to assess these effects. The results have been published by several researchers, among them Franco et al., 1995. The effects of wave breaking and impact forces on vertical structures have been investigated by several researchers in the past, and it is, however, still generally acknowledged that the impact loading of vertical structures is the main damage source. Oumeraci et al., 1995. The research work on impact loading has mainly been based on 2D breaking waves. So far, no attention has been paid to the effects of wave obliquity and mulitidirectionality on the wave loads on caisson breakwaters placed in deep water breaking seas. To assess these effects, a physical model study has been carried out at the Hydraulics and Coastal Engineering Laboratory at Aalborg University.

2. Experimental setup and test conditions

The physical model tests were carried out in the 3D wave basin. A caisson breakwater model constructed in plywood was used in the tests. The model was placed on a one layer smooth foundation constructed in concrete. The size of the model did not refer to any particular prototype structure, however, a Froude scaling of 1:20 - 1:25 seems appropriate for this type of structures. Two different crest freeboards were applied in the tests. A plan view of the model setup and the cross section of the model are seen in Figure 1.

To assess the effects of wave obliquity and multidirectionality of the waves, the wave induced pressures were measured on a 2.4 m wide test section, giving the opportunity to study these effects on a single vertical element of the test section as well as on the total width of the test section. To eliminate the disturbance from wave diffraction at the two ends of the model, the total length of the model was 6.0 meter.

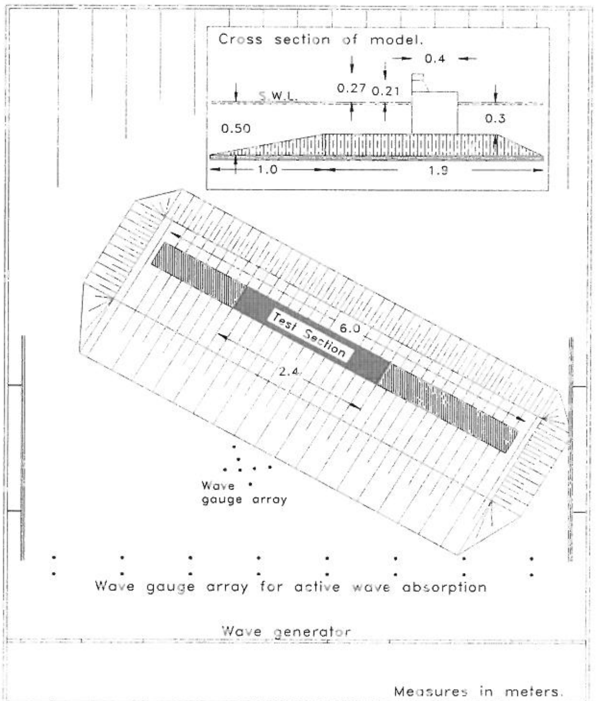

***Figure 1** - Model setup.*

As the main objective of the study was to assess the effect of wave obliquity and multidirectionality in breaking seas, the changes on test conditions were mainly the incident mean direction of the waves and the directional spreading of the waves. The wave parameters are summarized in table 1.

Wave spectrum	JONSWAP, $\gamma = 3.3$
Peak period	1.2 sec
Wave height	0.16 and 0.18 m
Crest freeboard	0.21 and 0.27
Water depth	0.3 m
Angle of wave attack	0° to 48°
Type of spreading	Cosine squared

***Table 1** - Wave parameters.*

To obtain an adequately statistically validity of the test results, rather long time series were performed with no test series having less than 1800 waves.

3. Data analysis

The wave pressures were measured by a set of 50 pressure transducers placed on the test section as shown below. By means of the vertical distributions of the horizontal pressures, the lateral distribution of the horizontal forces can be studied, and not only the lateral distribution of the horizontal pressures, which is important due to the unknown correlation between the lateral distribution of the horizontal pressure and the lateral distribution of the horizontal force.

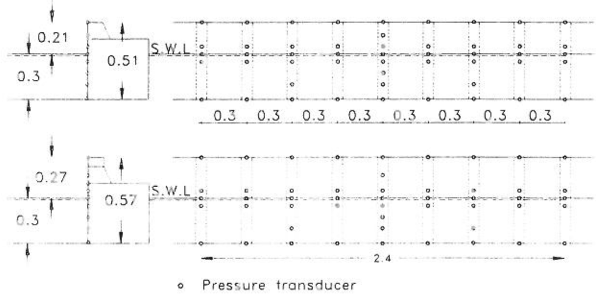

Figure 2 *- Pressure transducer placement.*

So far, only the data concerning the horizontal forces in one vertical section of the model have been analyzed. The forces are determined by integrating the measured pressures over the height of the model. The pressures were sampled at 800 Hz. In order to compare the results of tests with the prediction formula of Goda and to compare the results of tests with different wave heights, the measured forces are expressed in terms of the statistical force parameter $F_{1/250}$. In Figure 2, the results of 4 test series are shown.

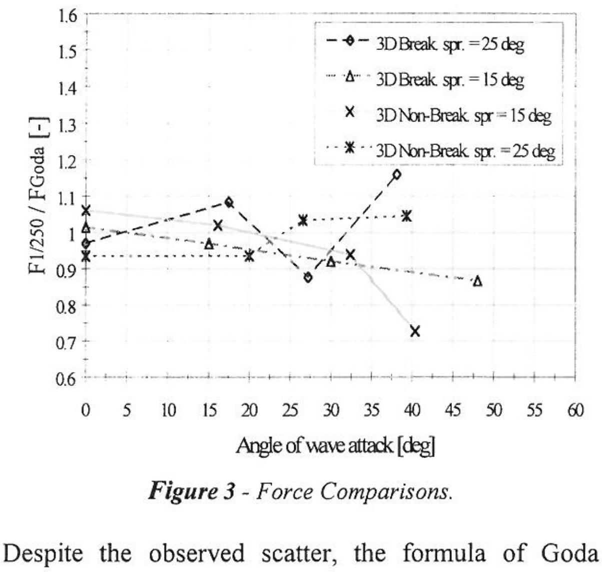

Figure 3 *- Force Comparisons.*

Despite the observed scatter, the formula of Goda seems to apply well for both the non breaking waves as well as the breaking waves. Most of the calculated forces are seen to deviate less than 10% from the forces predicted by the formula of Goda. Apparently, the Goda formula applies best in case of waves within a range of 0 to 35°.

Franco et al. 1995 found that the forces predicted by the formula of Goda, which does not take into account the multidirectionality of the waves, should be reduced with about 10%. This trend is, however, not seen in the results of this study.

4. Conclusions

Regarding the effects of wave obliquity and multidirectionality on the wave impacts on vertical caisson breakwaters, only minor differences between breaking and non breaking waves are observed so far in this study. These insignificant differences between the forces from breaking waves and the forces from the non breaking waves might appear odd. However, kept in mind that the present study concerns deep water breaking waves (spilling breakers) and not shallow water breaking waves (plunging breakers), which have a completely different physical behaviour, these findings seem reasonable.

Ongoing analysis and further model tests are focusing on the effects of wave obliquity and multidirectionality on the lateral distribution of the horizontal force. The results and findings of this study will be included in the presentation in Copenhagen and in the final paper for the Proceedings.

5. References

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