A focus on waves

For model tests, the correct generation of a realistic representation of a natural wave field is vital, as the environmental conditions determine the starting point for all the following analyses of any behaviour of a marine structure.

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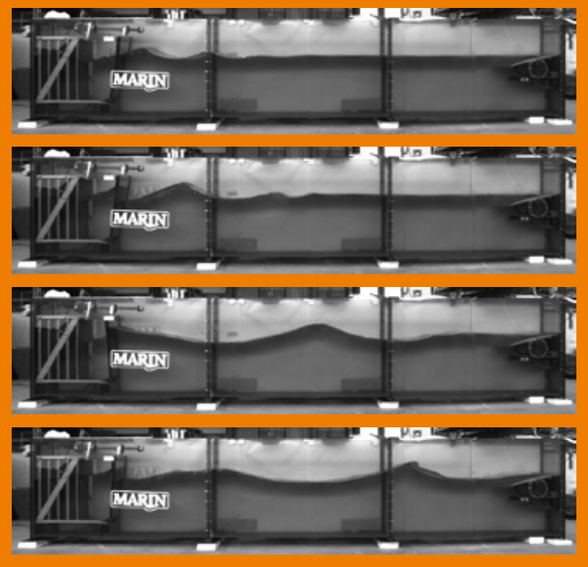


Example of focused wave in MARIN's demonstration basin

A peak wave height of 1.5 m (15 m at scale of lifeboat in picture), which surprised the unsuspecting visitors during the MARIN open day

In recent years MARIN faced several research challenges which required advanced wave modelling techniques. For special applications in-house wave generation software has been developed. This software tool was used for generating a Focusing Wave, with a peak wave height of 1.5 m (15 m at scale of the lifeboat pictured), which surprised the unsuspecting visitors at a recent Open Day at MARIN!

Waves with a long period travel faster than waves with a short period. This phenomenon is used when generating a focusing wave. If the short period waves are made before the long period waves, the long period waves overtake the short period waves. Calculated timing of the waves with different periods results in all waves meeting at the so-called focal point. This principle can be used to generate a Focusing Wave, (as shown during the Open Day), but it can also be applied to generate predefined time series of waves at certain locations in the basin (deterministic wave generation).

To be able to make a deterministic wave, a proper understanding of the wave maker flap motions and geometry, the transfer of the flap motions to the waves and the propagation of the waves through the basin are required. The deterministic wave generation process for a double flap wave maker for example, can be divided into four steps, as illustrated (see also [1]).

1. Definition of the target wave train: The target position in time and space is selected. For example, the position of the focal point of the focusing wave or the location where a ship encounters the wave train at a given time. At this location, the target wave train is designed based on spectral parameters or a wave record.

2. Upstream transformation: The target wave train is transformed upstream to the position of the wave maker, e.g. by means of a linear wave propagation model.

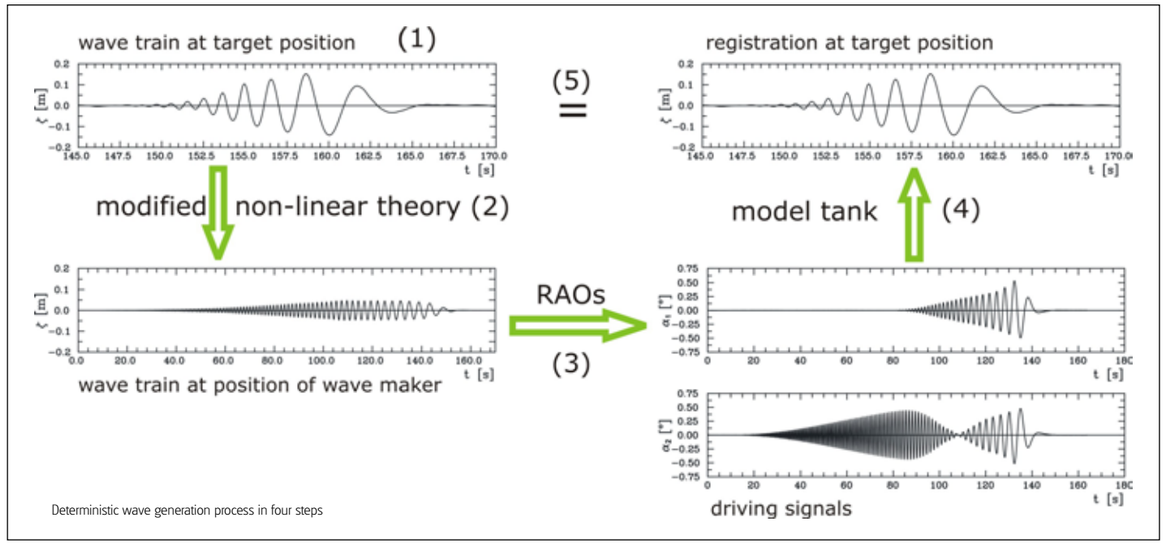
3. Calculation of control signals: The corresponding control signals are calculated using adequate transfer functions of the wave generator.

4. Performing the model tests: The control signals are used to generate the specified wave train, which is measured at selected positions in the tank.

Practical application of a Focusing Wave A Focusing Wave contains a series of wave components with different periods and has a clear focusing point. This makes it particularly suitable to improve the understanding of a basin's inherent limitations. The focusing wave technique can be used to determine the hydraulic and electrical transfer function of wave makers, to assess the reflection coefficient of beaches and to investigate the non-linear aspects of transfer functions in shallow water conditions amongst other things.

Considering the Open Day – would there be more applications for this type of wave in model testing? The deterministic wave generation approach will also be used in the new BreaKin JIP (see page 14) to generate different types of (near) breaking waves to investigate associated impact loads. These particularly interesting wave trains will be rerun at a different scale to determine their kinematics at Imperial College. More examples of model testing with focusing waves are presented in [2] and [3].

The Focusing Wave is an example of advanced basin wave modelling with a deterministic wave generation technique. Other aspects that are the subject of investigation are basin inherent limitations (for instance reflection and its amplification due to shallow water effects) and appropriate wave analysis techniques to judge the quality of the generated basin wave (such as directional analysis and non-linear wave crest statistics).



Deterministic wave generation process in four steps

Future of wave generation The success of model tests is not solely dependent on wave generation capabilities but also on the realistic definition of the environmental conditions at the test location and the propagation of waves in the basin. A realistic representation of natural wave fields is of major importance for the analysis of the behaviour of the marine structure. Therefore, MARIN continues to invest in developing wave modelling techniques to improve wave modelling standards.

[1] Schmittner, C. E., Scharnke J., Pauw W.H., van den Berg J., Hennig J.,., 2014 "New methods and insights in advanced and realistic basin wave modelling", In OMAE 2014 - 33th International Conference on Ocean, Offshore and Arctic Engineering. OMAE2014- 2013-11445

[2] Schmittner, C. E., Brouwer J., Hennig J., 2014 "Application of focusing wave groups in model testing practice", In OMAE 2014 - 33th International Conference on Ocean, Offshore and Arctic Engineering. OMAE2014-23949.

[3] Hennig, J., and Schmittner, C. E., 2009. "Experimental Variation of Focusing Wave Groups for the Investigation of their Predictability". In OMAE 2009 - 28th International Conference on Ocean, Offshore and Arctic Engineering. OMAE2009-80128.