L100suast [001-002]: Suastika et al. (2000) flume experiment

Purpose

Suastika et al. (2000) and Suastika (2004) studied partial and complete wave blocking under non-uniform adverse current in a laboratory flume. This experiment is a potential validation case for wave-current interaction in SWAN, and the associated steepness-induced dissipation, found in the tidal inlets in the Wadden Sea.

Situation

Suastika et al. (2000) used a 35 m long flume, with a 12 m measurement section at its centre (Figure 5.1). Waves were mechanically generated at the one end of the flume. A water head difference induced current flow along the flume, running in the up-wave direction. Within the measurement section, the discharge entering at the upstream (and down-wave) end was gradually withdrawn along the section, through the bottom of the flume by pumps, so that the current was zero at the downstream (up-wave) end of the measurement section. The result was a counter-current that reduced approximately linearly in the up-wave direction. At the respective ends of the flume, the total flume width and height (0.8 by 1.0 m) was available to the waves and current, but within the measurement section the flow was contracted to 0.4 m by 0.7 m by a false wall and bottom. This false perforated bottom allowed withdrawal of discharge into the adjacent dummy half of the flume, which acted as a sump for the suction pumps.

Suastika (2004) reports results of both periodic and random waves for both partially and fully blocking situations of this experiment. Under fully blocking conditions, the significant wave height increases steadily moving upstream up to about x = 22 m (see co-ordinates included in the bottom right hand panel of Figure 5.1). Further upstream of this point the wave height decreases strongly, so that at x = 23 m, where the blocking region is located, the wave energy is dissipated almost entirely. The mean wave period first reduces due to Doppler-shifting as the increasing adverse current is met. However, as the blocking region is approached, the mean period increases, as progressively lower frequencies become blocked. Under partial blocking conditions, on the other hand, a more modest increase in the significant wave height is found moving upstream. After reaching a maximum at x = 23 m, the significant wave height decreases gradually. The mean wave period first reduces upon meeting the adverse current, after which it increases. However, since the spectrum is only partially blocked, the increase in mean frequency at the end of the flume is not as strong as for full blocking.

WL (2007a) performed a SWAN hindcast study for a selection of the investigated conditions. Under strong adverse current, large Doppler shifting of the wave spectrum is found. The resulting strong increase in wave steepness enhances steepness-induced (whitecapping) dissipation in the model. Finally, the wave spectrum is either partially or fully blocked. It is noted that Suastika (2004) describes two additional sources of dissipation relevant for this experiment, but not included in SWAN, namely dissipation in the side wall boundary layers, and dissipation due to orbital motion through the perforated false bottom. Also, higher-order propagation effects not included in SWAN, such as amplitude dispersion, play a role. These should be borne in mind when comparing model outcomes to the observations. Despite these reservations, this laboratory experiment is considered suitable to study wave-current interaction as occurring in the tidal inlets in the Wadden Sea, since it provides a comparable situation under idealised conditions.

Case selection

WL (2007a) selected two cases from the test program of Suastika et al. (2000), namely random wave conditions with a JONSWAP spectrum, featuring respectively full and partial blocking, referred to as conditions S1 and S2. These two cases are representative of the conditions studied in this experiment. These conditions, which are taken over for the present purpose, are given in Table 5.1 below.

Case	H_{m0}	T_p	Q	u	**Condition**
	[m]	**[s]**	**[m^3/s]**	**[m/s]**	
S1	0.05	1.1	0.120	0.6	Fully blocking
S2	0.05	1.1	0.078	0.4	Partially blocking

Table 5.1: Experimental conditions of Suastika et al. (2000) considered, based on WL (2007a). Wave conditions measured 9 m from the wave maker, and flow conditions as at the (down-wave) discharge point.

Model setup

This experiment is simulated in the one-dimensional mode of SWAN. The wave spectra measured upwave in the flume (x = 9 m) are imposed on the upwave model boundary. The remainder of the waves recorded in the 12 m measurement section is available for model comparison. Currents measured along the flume are imposed over the model domain. The only dissipation mechanism explicitly considered is wave breaking (whitecapping), since turbulent dissipation on the flume side walls and dissipation due to the perforated false bottom, as applied by Suastika (2004), are not included in SWAN.

Both the completeness and quality of this set of observational data is considered as being good. The data set is suitable for studying wave-current interaction and partial wave blocking, such as found in the tidal inlets of the Wadden Sea, under laboratory conditions. Hence, these cases are considered to be suitable to take up as validation cases in SWIVT.

Default settings

The following settings are default for this case:

```
GEN3 KOM
WCAP KOM cds2=2.36e-5 stpm=3.02e-3 powst=2.0 delta=0 powk=0.0
BREA CON alpha=1.0 gamma=0.73
TRIAD trfac=0.05 cutfr=2.5

$ --- Numerieke parameter settings
NUM STOPC 0.00 0.01 0.001 101.0 STAT mxitst=30 alfa=0.005 SIGIMPL
EPS1=0.

$ *** Integrate over frequency range [FMIN,FMAX] to obtain wave
parameters
QUANT HS TMM10 TM01 TM02 FMIN 0.5 FMAX 4.0
```

For the remainder of the settings, we refer to the SWAN command files.

References

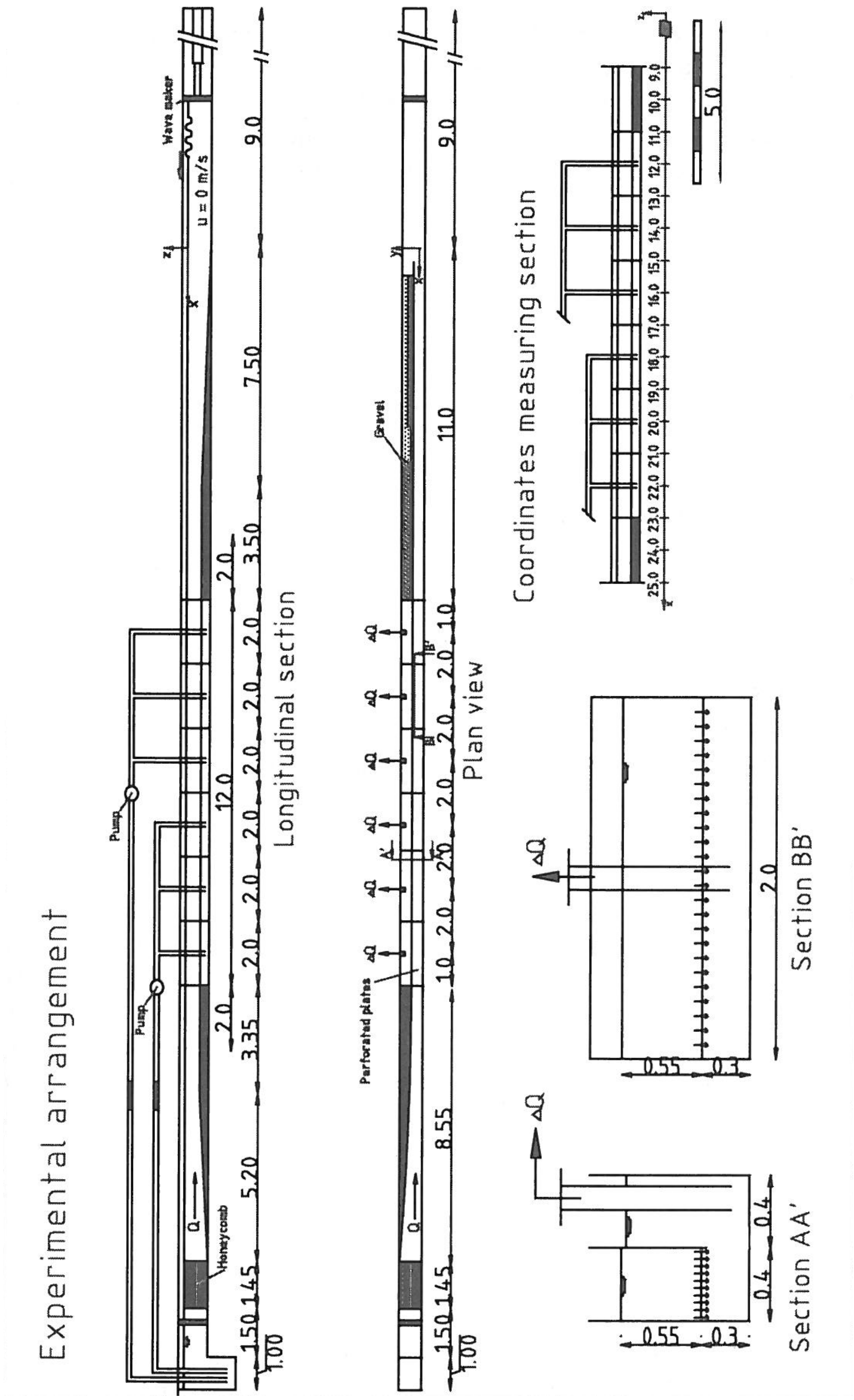
Suastika, I. K. (2004). Wave blocking, Ph.D Thesis. Technical report, Fac. of Civil Engineering, Delft University of Technology.

Suastika, I. K., M. P. C. de Jong and J. A. Battjes (2000). Experimental study of wave blocking. Proc. 27th Int. Conf. Coastal Eng., 227-240.

WL (2007a). Evaluation and development of wave-current interaction in SWAN. WL | Delft Hydraulics Report H4918.60, November 2007.

Acknowledgements

Deltares gratefully acknowledges Delft University of Technology for supplying, and giving their permission to use all of the data on which the Suastika et al. (2000) validation cases are based.



Experimental setup of the laboratory case of Suastika et al. (2000)	Validation cases SWIVT	
DELTARES	H5107.66	Fig. 5.1