0.1 Equations

0.1.1 Overtopping discharge and volume

This part rewrites information given in EurOtop (2007). The steepness of a wave with height H_{m0} and period $T_{m-1,0}$ is defined as

$$s_0 = \frac{2\pi}{g} \cdot \frac{H_{m0}}{T_{m-1,0}^2} \tag{1}$$

The breaker parameter or surf similarity is $\xi_0 = \tan\alpha/\sqrt{s_0}$. The mean wave overtopping discharge q produced by the wave height H_{m0} on a dike with the free board R_c is

$$\frac{q}{\sqrt{g \cdot H_{m0}^3}} = \frac{0.067}{\sqrt{\tan\alpha}} \cdot \xi_0 \cdot exp\left(-4.75 \cdot \frac{R_c}{H_{m0}} \cdot \frac{1}{\xi_0}\right) \tag{2}$$

Here a coefficient of 4.75 is used corresponding to the probabilistic design suggested in EurOtop (2007). The 2% wave run-up level is

$$\frac{R_{u,2\%}}{H_{m0}} = 1.65 \cdot \gamma_b \cdot \gamma_f \cdot \gamma_\beta \cdot \xi_0 \tag{3}$$

Note that a coefficient of 1.65 is used corresponding to the probabilistic design suggested in EurOtop (2007). Here γ_f is 1 with the assumption of a smooth seaward slope. Probability of overtopping P_{ov} in case of a crest freeboard R_c is

$$P_{ov} = exp\left[-\left(\sqrt{-ln0.02} \cdot \frac{R_c}{R_{u,2\%}}\right)^2\right] \tag{4}$$

And with different value of x, $R_{u,x\%}$ can be calculated as

$$R_{u,x} = R_{u,2\%} \cdot \sqrt{\frac{lnP_{ov}}{ln0.02}} \tag{5}$$

Probability that a wave overtops the dike crest is

$$P_{ov} = \frac{N_{ov}}{N_w} \tag{6}$$

The exceedance (smaller?) probability P_V of an overtopping volume V per wave is

$$P_V = P(\underline{V} \leq V) = 1 - exp\left[-\left(\frac{V}{a}\right)^{0.75}\right] \tag{7}$$

in which the scale factor a is related to wave period, mean discharge and overtopping probability

$$a = 0.84 \cdot T_m \cdot \frac{q}{P_{ov}} \tag{8}$$

The wave volume V can be calculated from a and P_V as

$$V = a[-ln(1 - P_V)]^{4/3} \tag{9}$$

In case of $V_{2\%}$ we have $(1 - P_V) = 0.02/P_{ov}$.

0.1.2 Water-layer thickness and flow velocity at the seaward crest edge

The following equations are established by analysing the data sets of van Gent (2002) (fully) and Schüttrumpf et al. (2001) (partly as only six wave conditions are reproduced). Figures 1 and 2 compare the measured data and computed results using Equations (10) and (11), respectively. For tests of Schüttrumpf et al. (2001), the values of T_m are derived from the spectra wave period $T_{m-1,0}$ with a relation $T_m = 1.1/1.15T_{m-1,0}$.

Water-layer thickness

$$h_{A,2\%} = c_A^h \frac{V_{2\%} \cdot \sin\alpha}{R_{u,2\%} - R_c} \tag{10}$$

in which c_A^h is 0.872 with a R-square of 0.20.

Flow velocity

$$u_{A,2\%} = c_A^u \cdot \cos\alpha \sqrt{\frac{gV_{2\%}}{\sin\alpha H_{m0}}} \tag{11}$$

in which c_A^u is 0.887 with a R-square of 0.55.

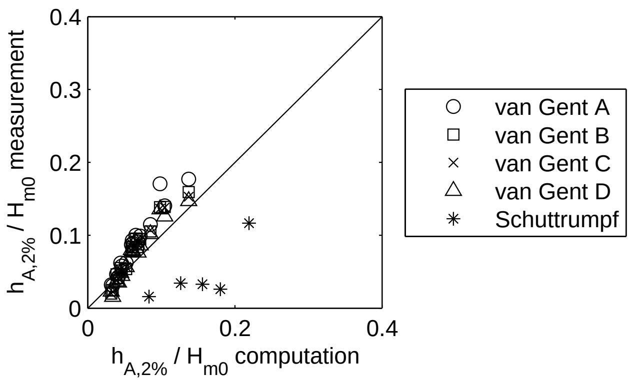

Figure 1: Water-layer thickness $h_{A,2\%}$ at the seaward crest edge, measurement of van Gent (2002) and Schüttrumpf et al. (2001) versus Equation (10).

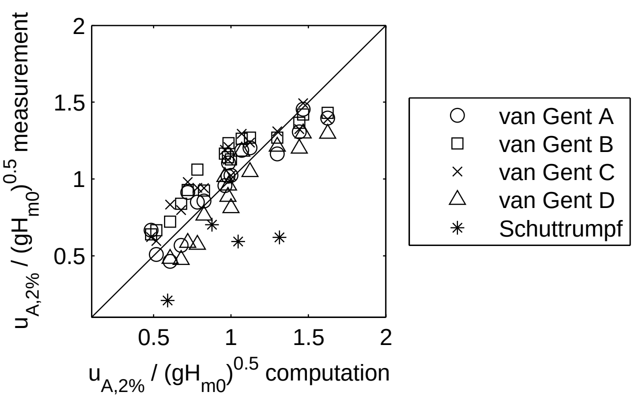

Figure 2: Flow velocity $u_{A,2\%}$ at the seaward crest edge, measurement of van Gent (2002) and Schüttrumpf et al. (2001) versus Equation (11).

0.2 Flow dike results

The values of $h_{A,2\%}$ and $u_{A,2\%}$ at the seaward crest edge are reproduced from the previous work of van der Meer et al. (2010). The experiments were performed on a 1/3 slope which is made by plywood and covered with sand. Flow dike 07 has a crest freeboard of 0.2 m while flow dike 06 has a 0.1 m freeboard. Table 1 gives the measured values of $h_{A,2\%}$ and $u_{A,2\%}$ associated with different wave heights and periods. Note that wave steepness s_0 and wave period $T_{m-1,0}$ are derived from the measured values of H_{m0} and ξ_0.

Table 1: Water-layer thickness and flow velocity of Flow dike.

H_{m0}	$R_{u,2\%}$	ξ_0	s_0	$T_{m-1,0}$	$h_{A,2\%}$ 07	$u_{A,2\%}$ 07	$h_{A,2\%}$ 06	$u_{A,2\%}$ 06
m	m			s	m	m/s	m	m/s
1	2	3	4	5	6	7	8	9
0.068	0.198	2.119	0.025	1.330		0.808	0.026	
0.065	0.160	1.554	0.046	0.955		0.576		
0.095	0.292	2.182	0.023	1.619	0.019	1.163	0.039	
0.095	0.230	1.480	0.051	1.095	0.011	0.889	0.027	
0.140	0.437	2.179	0.023	1.960	0.046	1.528	0.067	
0.141	0.361	1.529	0.048	1.379	0.027	1.334	0.048	
0.075	0.229	2.022	0.027	1.330		0.742	0.019	1.084
0.072	0.181	1.442	0.053	0.931	0.011	0.581		
0.096	0.290	2.081	0.026	1.552	0.017	0.875	0.035	1.433
0.100	0.252	1.443	0.053	1.095	0.007	0.742	0.024	1.348
0.133	0.383	2.234	0.022	1.960	0.045	1.135	0.067	2.010
0.149	0.337	1.490	0.050	1.379	0.024	1.012	0.040	1.777

0.3 Application of the new equations

Equations (10) and (11) are deployed to estimate the water-layer thickness and flow velocity at the seaward crest edge for various wave conditions given in van der Meer et al. (2010) and Lorke et al. (2011). As the values of T_m are not available, $T_{m-1,0}$ are used to calculate the mean period $T_m = 1.1/1.15T_{m-1,0}$ in Equation (8) of the scale factor a. The computed values and measured data given in Table 1 are compared in Figures 3 and 4.

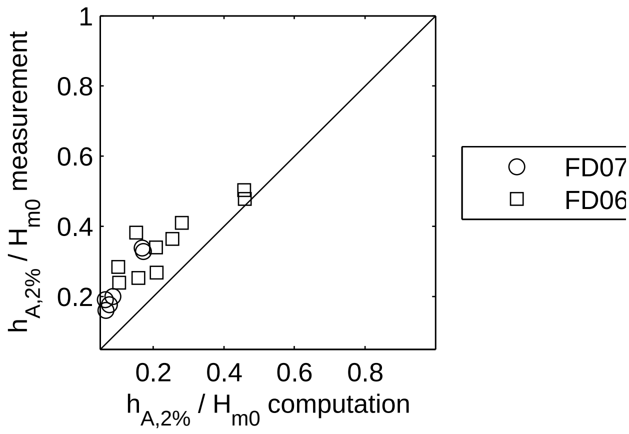

Figure 3: Water-layer thickness $h_{A,2\%}$ at the seaward crest edge, measurement of Flowdike versus Equation (10).

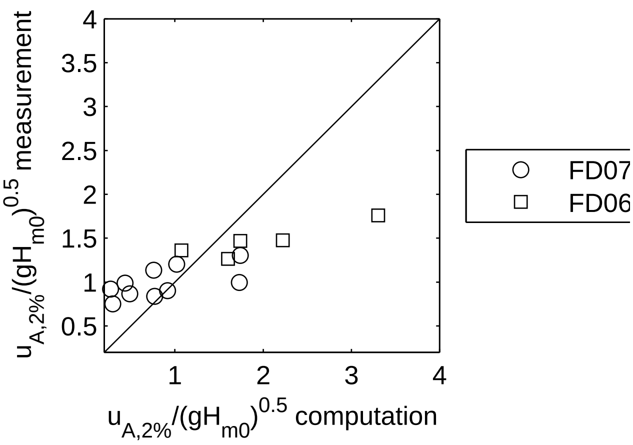

Figure 4: Flow velocity $u_{A,2\%}$ at the seaward crest edge, measurement of Flowdike versus Equation (11).

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