Halcrow	CALCULATION SHEET	No: 1	Rev: 0
Project: Runswick Bay Strategy Study 2013		By: M Cali	Date: 01/11/2013
Subject: Overtopping of Upgarth Hill concrete seawall (defence element 240/6507)		Checked:	Date:

A code for dike height design and examination
J.W. Van der Meer (1998) More Info

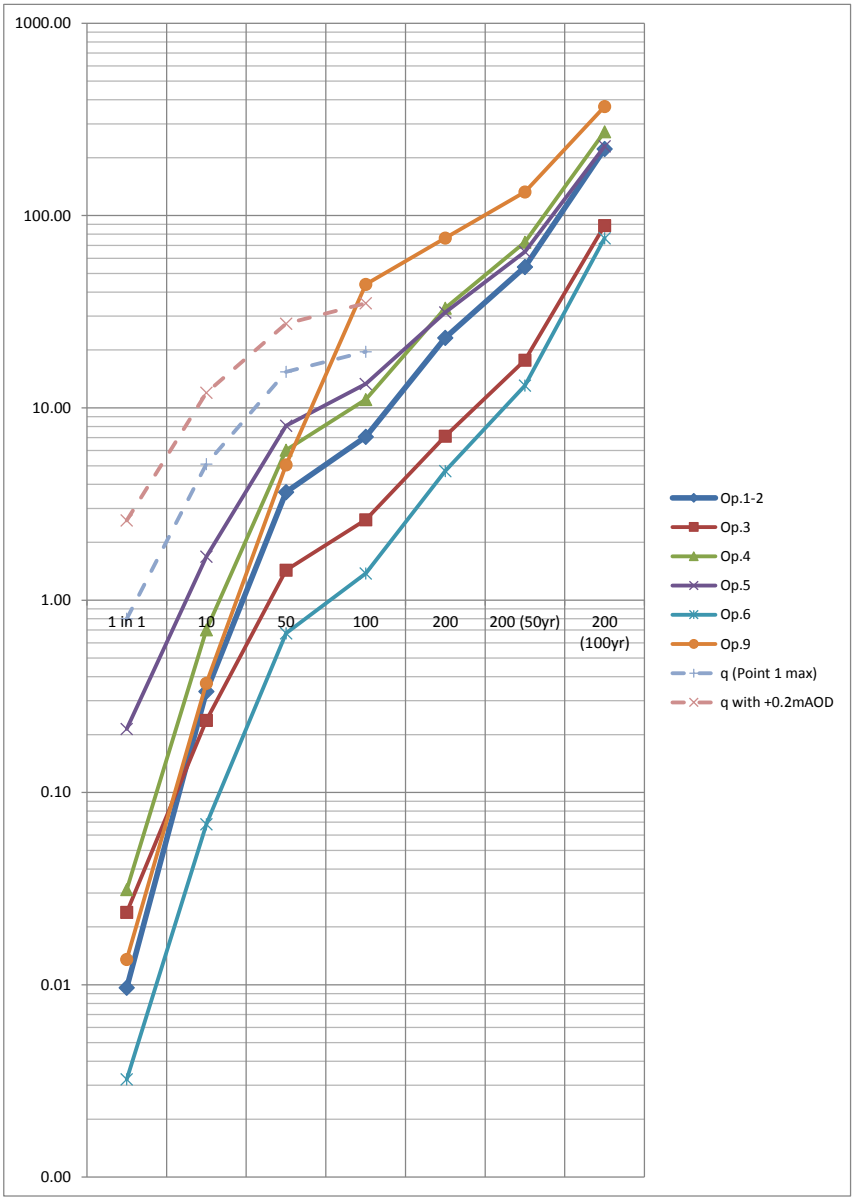
Subject: Overtopping of Upgarth Hill concrete seawall (defence element 240/6507)

Compare options (l/s/m)

Return Period	1 in 1	10	50	100	200	200 (50yr)	200 (100yr)		
Op.1-2	0.01	0.34	3.64	7.07	23.11	54.09	222.19	2.3	9.6
Op.3	0.02	0.24	1.43	2.62	7.12	17.72	88.84	2.5	12.5
Op.4	0.03	0.70	6.03	11.06	33.04	72.72	273.29	2.2	8.3
Op.5	0.21	1.69	8.07	13.32	31.38	64.88	229.29	2.1	7.3
Op.6	0.00	0.07	0.67	1.38	4.69	13.06	76.33	2.8	16.3
Op.9	0.01	0.37	5.05	43.89	76.34	132.83	369.03	1.7	4.8

Results from HR Report EX 4350

q (Point 1 max)	0.80	5.10	15.40	19.60
q with +0.2mAOD	2.60	12.00	27.40	35.00



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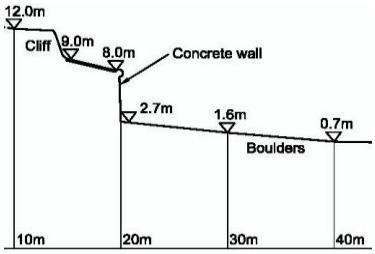
Wave Overtopping Op.1-2 DN & DMin Existing seawall at 8mAOD



Conditions suggest joint probablity dominated by SWL return period and confirmed by HR Report EX 4350. Hence use 1 in 1 yr waves for different SWL return periods. Base existing overtopping and compare to future overtopping risk with climate change. Analyse options to reduce ovetopping in future to be equivalent to present day.

Input Parameters — Basic 1 in 1 yr event

Nearshore Slope	s_b	(1:?)	15.0	
Toe Level	h_t	(mODN)	2.70	
Offshore Wave Height	H_s	(m)	4.00	
Wave Period (Zero-crossing)	T_z	(s)	8.00	
Still Water Level	SWL	(mODN)	3.30	1 in 1 yr
Crest Level	h_c	(mODN)	8.00	Conc wall
Upper Slope	s_u	(1:?)	0.10	
Berm Width	B_w	(m)		no berm
Berm Crest Level	h_b	(mODN)		no berm
Lower Slope	s_l	(1:?)		no berm
Wave Angle	β	(o)	0	from East
Roughness reduction factor	γ_f		1.00	Conc wall

Constants

g	(m/s^2)	9.81
π		3.14

Calculations

Depth of water at Toe	d	(m)	0.60	Combination of all reduction factors	γ_{all}		1.00
Wavelength	L	(m)	18.68	Irribarren No.	ξ_{op}		128.33
Depth/Wavelength	d/L		0.03	Wave Steepness	s_{op}		6.07E-03
Wave Celerity	c	(m/s)	2.43	Berm Freeboard	d_h	(m)	3.30
Shoaling Coefficient	K_s		1.67		d_h/H_s		3.37
Wave Height at Toe (Goda)	H_{si}	(m)	0.98		d_h/x		1.69
Wave Period (Peak)	T_p	(s)	10.16	Crest Freeboard	R_c	(m)	4.70
Length of Slope	L_{slope}	(m)	0.5	Dimensionless crest height (broken)	R_b		0.04
Length of Berm	L_{berm}	(m)	0.1	Dimensionless crest height (unbroken)	R_n		4.80
Average Slope Angle	α	(1:?)	0.1	Discharge	Q_{break}	($m^3/s/m$)	6.192
Berm reduction factor	γ_b		1.00	Maximum Limiting Discharge	Q_{max}	($m^3/s/m$)	0.00
Wave Angle reduction factor	γ_β		1.00				

Results

Wave Type	NOT BREAKING		
Discharge Rate	Q	($m^3/s/m$)	0.00001
Discharge Rate	Q	(l/s/m)	0.0

Limitations

B_w Slope < 1:15	$Q = Q_{break}$	when $\xi_{op} < 2$
$0.3 < R_b < 2$	$Q = Q_{max}$	when $\xi_{op} > 2$
$0.5 < \gamma_f\gamma_b\gamma_\beta < 1$		

Input Parameters			Return Period (Years) or Defence Code						
			1 in 1	10	50	100	200	200 (50yr)	200 (100yr)
Nearshore Slope	s_b	(m)	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Toe Level	h_t	(mODN)	2.70	2.70	2.70	2.70	2.70	2.70	2.70
Offshore Wave Height	H_s	(m)	4.00	4.60	5.90	6.00	6.90	6.90	6.90
Wave Period (Zero-crossing)	T_z	(s)	8.00	8.60	9.70	9.80	12.10	12.10	12.10
Still Water Level	SWL	(mODN)	3.30	3.61	3.85	3.99	4.10	4.40	5.04
Crest Level	h_c	(mODN)	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Upper Slope	s_u	(1:?)	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Berm Width	B_w	(m)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Berm Crest Level	h_b	(mODN)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lower Slope	s_l	(1:?)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wave Angle	β	(°)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Roughness reduction factor	γ_f		1.00	1	1	1	1	1	1

Calculations			1 in 1	10	50	100	200	200 (50yr)	200 (100yr)
Depth of water at Toe	d	(m)	0.60	0.91	1.15	1.29	1.40	1.70	2.34
Wavelength	L	(m)	18.68	26.00	32.94	35.67	43.35	49.57	60.26
Depth/Wavelength	d/L		0.03	0.03	0.03	0.04	0.03	0.03	0.04
Wave Celerity	c	(m/s)	2.43	2.99	3.36	3.56	3.71	4.08	4.79
Shoaling Coefficient	K_s		1.67	1.56	1.57	1.53	1.66	1.59	1.47
Wave Height at Toe (Goda)	H_{si}	(m)	0.98	1.28	1.62	1.74	2.05	2.26	2.70
Peak Wave Period	T_p	(s)	10.16	10.92	12.32	12.45	15.37	15.37	15.37
Length of Slope	L_{slope}	(m)	0.5	0.6	0.6	0.7	0.7	0.8	0.9
Length of Berm	L_{berm}	(m)	0.1	0.1	0.2	0.2	0.2	0.2	0.3
Average Slope Angle	α	(1:?)	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Berm reduction factor	γ_b		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Wave Angle reduction factor	γ_β		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Combination of all reduction factors	γ_{all}		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Irribarren No.	ξ_{op}		79.02	83.74	93.62	93.23	114.95	111.15	104.12
Wave Steepness	s_{op}		6.07E-03	6.86E-03	6.86E-03	7.18E-03	5.56E-03	6.12E-03	7.31E-03
Crest Freeboard	d_h	(m)	3.30	3.61	3.85	3.99	4.10	4.40	5.04
	d_h/H_s		3.37	2.82	2.37	2.30	2.00	1.95	1.87
	d_h/x		1.69	1.41	1.18	1.15	1.00	0.98	0.93
Crest Freeboard	R_c	(m)	4.70	4.39	4.15	4.01	3.90	3.60	2.96
Dimensionless crest height (broken	R_b		0.06	0.04	0.03	0.02	0.02	0.01	0.01
Dimensionless crest height (unbrok	R_n		4.80	3.44	2.55	2.31	1.90	1.60	1.10
Discharge	Q_{break}	($m^3/s/m$)	4.353	7.119	11.511	12.695	20.033	22.441	27.635
Maximum Limiting Discharge	Q_{max}	($m^3/s/m$)	0.000	0.000	0.004	0.007	0.023	0.054	0.222

Results			1 in 1	10	50	100	200	200 (50yr)	200 (100yr)
Wave Type	Wave Type		NOT BREAK	NOT BREAK	NOT BREAK	NOT BREAK	NOT BREAK	NOT BREAK	NOT BREAK
Discharge Rate	Q	($m^3/s/m$)	0.00001	0.00034	0.00364	0.00707	0.02311	0.05409	0.22219
Discharge Rate	Q	(l/s/m)	0.0	0.3	3.6	7.1	23.1	54.1	222.2

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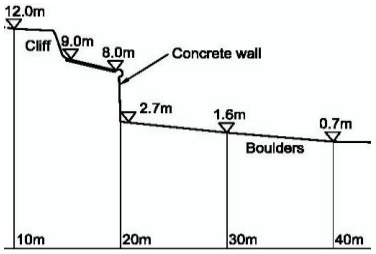
A code for dike height design and examination
J.W. Van der Meer (1998) More Info

Wave Overtopping Op.3 Rock apron at 6mAOD



Conditions suggest joint probablity dominated by SWL return period and confirmed by HR Report EX 4350. Hence use 1 in 1 yr waves for different SWL return periods. Base existing overtopping and compare to future overtopping risk with climate change. Analyse options to reduce ovetopping in future to be equivalent to present day.

Input Parameters			Basic 1 in 1 yr event	
Nearshore Slope	s_b	(1:?)	30.0	
Toe Level	h_t	(mODN)	1.30	
Offshore Wave Height	H_s	(m)	4.00	
Wave Period (Zero-crossing)	T_z	(s)	8.00	
Still Water Level	SWL	(mODN)	3.30	1 in 1 yr
Crest Level	h_c	(mODN)	8.00	Conc wall
Upper Slope	s_u	(1:?)	0.10	
Berm Width	B_w	(m)	3.00	rock
Berm Crest Level	h_b	(mODN)	6.00	rock
Lower Slope	s_l	(1:?)	2.00	rock
Wave Angle	β	(o)	0	from East
Roughness reduction factor	γ_f		0.60	rock

Constants

g	(m/s^2)	9.81
π		3.14

Calculations

Depth of water at Toe	d	(m)	2.00	Combination of all reduction factors	γ_{all}		0.50
Wavelength	L	(m)	37.21	Irribarren No.	ξ_{op}		4.74
Depth/Wavelength	d/L		0.05	Wave Steepness	s_{op}		1.02E-02
Wave Celerity	c	(m/s)	4.35	Berm Freeboard	d_h	(m)	-2.70
Shoaling Coefficient	K_s		1.26		d_h/H_s		-1.64
Wave Height at Toe (Goda)	H_{si}	(m)	1.65		d_h/x		0.55
Wave Period (Peak)	T_p	(s)	10.16	Crest Freeboard	R_c	(m)	4.70
Length of Slope	L_{slope}	(m)	13.3	Dimensionless crest height (broken)	R_b		1.20
Length of Berm	L_{berm}	(m)	6.5	Dimensionless crest height (unbroken)	R_n		5.70
Average Slope Angle	α	(1:?)	2.1	Discharge	Q_{break}	(m^3/s/m)	0.008
Berm reduction factor	γ_b		0.80	Maximum Limiting Discharge	Q_{max}	(m^3/s/m)	0.00
Wave Angle reduction factor	γ_β		1.00				

Results

Wave Type	NOT BREAKING		
Discharge Rate	Q	(m^3/s/m)	0.00002
Discharge Rate	Q	(l/s/m)	0.0

Limitations

B_w Slope < 1:15	$Q = Q_{break}$	when $\xi_{op} < 2$
$0.3 < R_b < 2$	$Q = Q_{max}$	when $\xi_{op} > 2$
$0.5 < \gamma_f\gamma_b\gamma_\beta < 1$		

			Return Period (Years) or Defence Code						
Input Parameters			1 in 1	10	50	100	200	200 (50yr)	200 (100yr)
Nearshore Slope	s_b	(m)	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Toe Level	h_t	(mODN)	1.30	1.30	1.30	1.30	1.30	1.30	1.30
Offshore Wave Height	H_s	(m)	4.00	4.60	5.90	6.00	6.90	6.90	6.90
Wave Period (Zero-crossing)	T_z	(s)	8.00	8.60	9.70	9.80	12.10	12.10	12.10
Still Water Level	SWL	(mODN)	3.30	3.61	3.85	3.99	4.10	4.40	5.04
Crest Level	h_c	(mODN)	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Upper Slope	s_u	(1:?)	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Berm Width	B_w	(m)	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Berm Crest Level	h_b	(mODN)	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Lower Slope	s_l	(1:?)	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Wave Angle	β	(°)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Roughness reduction factor	γ_f		0.60	0.6	0.6	0.6	0.6	0.6	0.6
Calculations			1 in 1	10	50	100	200	200 (50yr)	200 (100yr)
Depth of water at Toe	d	(m)	2.00	2.31	2.55	2.69	2.80	3.10	3.74
Wavelength	L	(m)	37.21	42.98	51.02	52.93	66.50	70.14	77.11
Depth/Wavelength	d/L		0.05	0.05	0.05	0.05	0.04	0.04	0.05
Wave Celerity	c	(m/s)	4.35	4.67	4.93	5.06	5.23	5.47	5.98
Shoaling Coefficient	K_s		1.26	1.26	1.30	1.29	1.41	1.38	1.32
Wave Height at Toe (Goda)	H_{si}	(m)	1.65	1.90	2.19	2.29	2.54	2.72	3.11
Peak Wave Period	T_p	(s)	10.16	10.92	12.32	12.45	15.37	15.37	15.37
Length of Slope	L_{slope}	(m)	13.3	13.5	14.0	14.0	14.6	14.6	14.6
Length of Berm	L_{berm}	(m)	6.5	7.0	7.6	7.8	8.3	8.7	9.5
Average Slope Angle	α	(1:?)	2.1	1.8	1.7	1.6	1.5	1.4	1.2
Berm reduction factor	γ_b		0.80	0.73	0.70	0.69	0.69	0.69	0.69
Wave Angle reduction factor	γ_β		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Combination of all reduction factors	γ_{all}		0.50	0.50	0.50	0.50	0.50	0.50	0.50
Irribarren No.	ξ_{op}		4.74	5.36	6.22	6.40	7.90	8.18	8.75
Wave Steepness	s_{op}		1.02E-02	1.02E-02	9.25E-03	9.46E-03	6.90E-03	7.39E-03	8.42E-03
Crest Freeboard	d_h	(m)	-2.70	-2.39	-2.15	-2.01	-1.90	-1.60	-0.96
	d_h/H_s		-1.64	-1.26	-0.98	-0.88	-0.75	-0.59	-0.31
	d_h/x		0.55	0.42	0.33	0.29	0.25	0.20	0.10
Crest Freeboard	R_c	(m)	4.70	4.39	4.15	4.01	3.90	3.60	2.96
Dimensionless crest height (broken	R_b		1.20	0.86	0.61	0.55	0.39	0.32	0.22
Dimensionless crest height (unbrok	R_n		5.70	4.61	3.79	3.51	3.07	2.64	1.91
Discharge	Q_{break}	(m^3/s/m)	0.006	0.046	0.197	0.278	0.632	1.240	2.499
Maximum Limiting Discharge	Q_{max}	(m^3/s/m)	0.000	0.000	0.001	0.003	0.007	0.018	0.089

Results			1 in 1	10	50	100	200	200 (50yr)	200 (100yr)
Wave Type	Wave Type		NOT BREAK	NOT BREAK	NOT BREAK	NOT BREAK	NOT BREAK	NOT BREAK	NOT BREAK
Discharge Rate	Q	(m^3/s/m)	0.00002	0.00024	0.00143	0.00262	0.00712	0.01772	0.08884
Discharge Rate	Q	(l/s/m)	0.0	0.2	1.4	2.6	7.1	17.7	88.8

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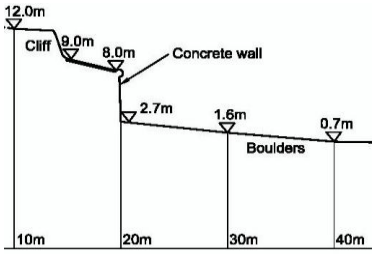
Wave Overtopping Op.4 **Concrete buttressing at 6mAOD**



Conditions suggest joint probablity dominated by SWL return period and confirmed by HR Report EX 4350. Hence use 1 in 1 yr waves for different SWL return periods. Base existing overtopping and compare to future overtopping risk with climate change. Analyse options to reduce ovetopping in future to be equivalent to present day.

Input Parameters			Basic 1 in 1 yr event	
Nearshore Slope	s_b	(1:?)	14.0	
Toe Level	h_t	(mODN)	2.60	
Offshore Wave Height	H_s	(m)	4.00	
Wave Period (Zero-crossing)	T_z	(s)	8.00	
Still Water Level	SWL	(mODN)	3.30	1 in 1 yr
Crest Level	h_c	(mODN)	8.00	Conc wall
Upper Slope	s_u	(1:?)	0.10	
Berm Width	B_w	(m)	1.50	conc
Berm Crest Level	h_b	(mODN)	6.00	conc
Lower Slope	s_l	(1:?)	0.20	conc
Wave Angle	β	(o)	0	from East
Roughness reduction factor	γ_f		1.00	concrete

Constants

g	(m/s^2)	9.81
π		3.14

Calculations

Depth of water at Toe	d	(m)	0.70	Combination of all reduction factors	γ_{all}		0.95
Wavelength	L	(m)	20.82	Irribarren No.	ξ_{op}		52.36
Depth/Wavelength	d/L		0.03	Wave Steepness	s_{op}		6.69E-03
Wave Celerity	c	(m/s)	2.62	Berm Freeboard	d_h	(m)	-2.70
Shoaling Coefficient	K_s		1.61		d_h/H_s		-2.50
Wave Height at Toe (Goda)	H_{si}	(m)	1.08		d_h/x		0.83
Wave Period (Peak)	T_p	(s)	10.16	Crest Freeboard	R_c	(m)	4.70
Length of Slope	L_{slope}	(m)	2.3	Dimensionless crest height (broken)	R_b		0.09
Length of Berm	L_{berm}	(m)	1.8	Dimensionless crest height (unbroken)	R_n		4.61
Average Slope Angle	α	(1:?)	0.2	Discharge	Q_{break}	($m^3/s/m$)	3.331
Berm reduction factor	γ_b		0.95	Maximum Limiting Discharge	Q_{max}	($m^3/s/m$)	0.00
Wave Angle reduction factor	γ_β		1.00				

Results

Wave Type	NOT BREAKING		
Discharge Rate	Q	($m^3/s/m$)	0.00003
Discharge Rate	Q	(l/s/m)	0.0

Limitations

B_w Slope < 1:15	$Q = Q_{break}$	when $\xi_{op} < 2$
$0.3 < R_b < 2$	$Q = Q_{max}$	when $\xi_{op} > 2$
$0.5 < \gamma_f\gamma_b\gamma_\beta < 1$		

			Return Period (Years) or Defence Code						
Input Parameters			1 in 1	10	50	100	200	200 (50yr)	200 (100yr)
Nearshore Slope	s_b	(m)	14.0	14.0	14.0	14.0	14.0	14.0	14.0
Toe Level	h_t	(mODN)	2.60	2.60	2.60	2.60	2.60	2.60	2.60
Offshore Wave Height	H_s	(m)	4.00	4.60	5.90	6.00	6.90	6.90	6.90
Wave Period (Zero-crossing)	T_z	(s)	8.00	8.60	9.70	9.80	12.10	12.10	12.10
Still Water Level	SWL	(mODN)	3.30	3.61	3.85	3.99	4.10	4.40	5.04
Crest Level	h_c	(mODN)	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Upper Slope	s_u	(1:?)	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Berm Width	B_w	(m)	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Berm Crest Level	h_b	(mODN)	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Lower Slope	s_l	(1:?)	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Wave Angle	β	(°)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Roughness reduction factor	γ_f		1.00	1	1	1	1	1	1

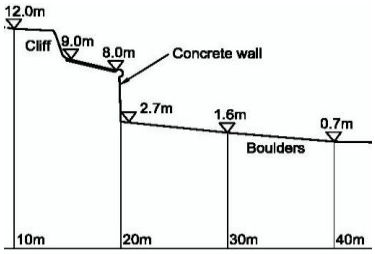
Calculations			1 in 1	10	50	100	200	200 (50yr)	200 (100yr)
Depth of water at Toe	d	(m)	0.70	1.01	1.25	1.39	1.50	1.80	2.44
Wavelength	L	(m)	20.82	27.75	34.71	37.32	45.53	51.45	61.70
Depth/Wavelength	d/L		0.03	0.04	0.04	0.04	0.03	0.03	0.04
Wave Celerity	c	(m/s)	2.62	3.15	3.50	3.69	3.84	4.20	4.89
Shoaling Coefficient	K_s		1.61	1.52	1.53	1.50	1.63	1.56	1.45
Wave Height at Toe (Goda)	H_{si}	(m)	1.08	1.39	1.74	1.86	2.18	2.39	2.84
Peak Wave Period	T_p	(s)	10.16	10.92	12.32	12.45	15.37	15.37	15.37
Length of Slope	L_{slope}	(m)	2.3	2.4	2.5	2.5	2.7	2.7	2.9
Length of Berm	L_{berm}	(m)	1.8	1.9	2.0	2.1	2.2	2.2	2.4
Average Slope Angle	α	(1:?)	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Berm reduction factor	γ_b		0.95	0.70	0.60	0.60	0.60	0.60	0.60
Wave Angle reduction factor	γ_β		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Combination of all reduction factors	γ_{all}		0.95	0.70	0.60	0.60	0.60	0.60	0.60
Irribarren No.	ξ_{op}		52.36	55.87	61.01	61.33	72.62	72.06	70.64
Wave Steepness	s_{op}		6.69E-03	7.44E-03	7.36E-03	7.68E-03	5.92E-03	6.49E-03	7.71E-03
Crest Freeboard	d_h	(m)	-2.70	-2.39	-2.15	-2.01	-1.90	-1.60	-0.96
	d_h/H_s		-2.50	-1.72	-1.23	-1.08	-0.87	-0.67	-0.34
	d_h/x		0.83	0.57	0.41	0.36	0.29	0.22	0.11
Crest Freeboard	R_c	(m)	4.70	4.39	4.15	4.01	3.90	3.60	2.96
Dimensionless crest height (broken	R_b		0.09	0.08	0.07	0.06	0.04	0.03	0.02
Dimensionless crest height (unbrok	R_n		4.61	4.53	3.97	3.60	2.98	2.51	1.74
Discharge	Q_{break}	($m^3/s/m$)	3.331	3.731	5.098	5.730	9.204	10.593	13.648
Maximum Limiting Discharge	Q_{max}	($m^3/s/m$)	0.000	0.001	0.006	0.011	0.033	0.073	0.273

Results			1 in 1	10	50	100	200	200 (50yr)	200 (100yr)
Wave Type	Wave Type		NOT BREAK	NOT BREAK	NOT BREAK	NOT BREAK	NOT BREAK	NOT BREAK	NOT BREAK
Discharge Rate	Q	($m^3/s/m$)	0.00003	0.00070	0.00603	0.01106	0.03304	0.07272	0.27329
Discharge Rate	Q	(l/s/m)	0.0	0.7	6.0	11.1	33.0	72.7	273.3

Halcrow	CALCULATION SHEET	No: 1	Rev: 0
Project: Runswick Bay Strategy Study 2013		By: M Cali	Date: 01/11/2013
Subject: Overtopping of Upgarth Hill concrete seawall (defence element 240/6507)		Checked:	Date:

A code for dike height design and examination
J.W. Van der Meer (1998) More Info

Wave Overtopping Op.5 **Concrete steps at 6mAOD**



Conditions suggest joint probablity dominated by SWL return period and confirmed by HR Report EX 4350. Hence use 1 in 1 yr waves for different SWL return periods. Base existing overtopping and compare to future overtopping risk with climate change. Analyse options to reduce ovetopping in future to be equivalent to present day.

Input Parameters			Basic 1 in 1 yr event	
Nearshore Slope	s_b	(1:?)	30.0	
Toe Level	h_t	(mODN)	1.80	
Offshore Wave Height	H_s	(m)	4.00	
Wave Period (Zero-crossing)	T_z	(s)	8.00	
Still Water Level	SWL	(mODN)	3.30	1 in 1 yr
Crest Level	h_c	(mODN)	8.00	Conc wall
Upper Slope	s_u	(1:?)	0.10	
Berm Width	B_w	(m)	2.00	steps
Berm Crest Level	h_b	(mODN)	4.70	steps
Lower Slope	s_l	(1:?)	2.00	steps
Wave Angle	β	(o)	0	from East
Roughness reduction factor	γ_f		0.95	stepped conc

Constants

g	(m/s^2)	9.81	
π		3.14	

Calculations

Depth of water at Toe	d	(m)	1.50	Combination of all reduction factors	γ_{all}		0.66
Wavelength	L	(m)	32.29	Irribarren No.	ξ_{op}		6.40
Depth/Wavelength	d/L		0.05	Wave Steepness	s_{op}		8.37E-03
Wave Celerity	c	(m/s)	3.79	Berm Freeboard	d_h	(m)	-1.40
Shoaling Coefficient	K_s		1.35		d_h/H_s		-1.04
Wave Height at Toe (Goda)	H_{si}	(m)	1.35		d_h/x		0.35
Wave Period (Peak)	T_p	(s)	10.16	Crest Freeboard	R_c	(m)	4.70
Length of Slope	L_{slope}	(m)	8.9	Dimensionless crest height (broken)	R_b		0.82
Length of Berm	L_{berm}	(m)	4.8	Dimensionless crest height (unbroken)	R_n		5.26
Average Slope Angle	α	(1:?)	1.7	Discharge	Q_{break}	($m^3/s/m$)	0.036
Berm reduction factor	γ_b		0.70	Maximum Limiting Discharge	Q_{max}	($m^3/s/m$)	0.00
Wave Angle reduction factor	γ_β		1.00				

Results

Wave Type	NOT BREAKING		
Discharge Rate	Q	($m^3/s/m$)	0.00021
Discharge Rate	Q	(l/s/m)	0.2

Limitations

B_w Slope < 1:15	$Q = Q_{break}$	when $\xi_{op} < 2$
$0.3 < R_b < 2$	$Q = Q_{max}$	when $\xi_{op} > 2$
$0.5 < \gamma_f\gamma_b\gamma_\beta < 1$		

			Return Period (Years) or Defence Code						
Input Parameters			1 in 1	10	50	100	200	200 (50yr)	200 (100yr)
Nearshore Slope	s_b	(m)	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Toe Level	h_t	(mODN)	1.80	1.80	1.80	1.80	1.80	1.80	1.80
Offshore Wave Height	H_s	(m)	4.00	4.60	5.90	6.00	6.90	6.90	6.90
Wave Period (Zero-crossing)	T_z	(s)	8.00	8.60	9.70	9.80	12.10	12.10	12.10
Still Water Level	SWL	(mODN)	3.30	3.61	3.85	3.99	4.10	4.40	5.04
Crest Level	h_c	(mODN)	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Upper Slope	s_u	(1:?)	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Berm Width	B_w	(m)	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Berm Crest Level	h_b	(mODN)	4.70	4.70	4.70	4.70	4.70	4.70	4.70
Lower Slope	s_l	(1:?)	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Wave Angle	β	(°)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Roughness reduction factor	γ_f		0.95	0.95	0.95	0.95	0.95	0.95	0.95
Calculations			1 in 1	10	50	100	200	200 (50yr)	200 (100yr)
Depth of water at Toe	d	(m)	1.50	1.81	2.05	2.19	2.30	2.60	3.24
Wavelength	L	(m)	32.29	38.13	45.74	47.78	59.67	63.90	71.74
Depth/Wavelength	d/L		0.05	0.05	0.04	0.05	0.04	0.04	0.05
Wave Celerity	c	(m/s)	3.79	4.16	4.45	4.59	4.75	5.06	5.59
Shoaling Coefficient	K_s		1.35	1.33	1.37	1.35	1.47	1.43	1.36
Wave Height at Toe (Goda)	H_{si}	(m)	1.35	1.60	1.89	1.99	2.24	2.42	2.81
Peak Wave Period	T_p	(s)	10.16	10.92	12.32	12.45	15.37	15.37	15.37
Length of Slope	L_{slope}	(m)	8.9	9.1	9.6	9.6	10.2	10.2	10.2
Length of Berm	L_{berm}	(m)	4.8	5.4	6.0	6.2	6.7	7.1	7.9
Average Slope Angle	α	(1:?)	1.7	1.5	1.3	1.3	1.2	1.1	1.0
Berm reduction factor	γ_b		0.70	0.67	0.68	0.69	0.71	0.72	0.75
Wave Angle reduction factor	γ_β		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Combination of all reduction factors	γ_{all}		0.66	0.64	0.65	0.65	0.67	0.68	0.71
Irribarren No.	ξ_{op}		6.40	7.28	8.38	8.64	10.51	10.93	11.78
Wave Steepness	s_{op}		8.37E-03	8.61E-03	7.99E-03	8.22E-03	6.09E-03	6.57E-03	7.61E-03
Crest Freeboard	d_h	(m)	-1.40	-1.09	-0.85	-0.71	-0.60	-0.30	0.34
	d_h/H_s		-1.04	-0.68	-0.45	-0.36	-0.27	-0.12	0.12
	d_h/x		0.35	0.23	0.15	0.12	0.09	0.04	0.06
Crest Freeboard	R_c	(m)	4.70	4.39	4.15	4.01	3.90	3.60	2.96
Dimensionless crest height (broken	R_b		0.82	0.59	0.40	0.36	0.25	0.20	0.13
Dimensionless crest height (unbrok	R_n		5.26	4.28	3.38	3.09	2.58	2.17	1.48
Discharge	Q_{break}	($m^3/s/m$)	0.036	0.143	0.488	0.660	1.635	2.325	4.255
Maximum Limiting Discharge	Q_{max}	($m^3/s/m$)	0.000	0.002	0.008	0.013	0.031	0.065	0.229
Results			1 in 1	10	50	100	200	200 (50yr)	200 (100yr)
Wave Type	Wave Type		NOT BREAK	NOT BREAK	NOT BREAK	NOT BREAK	NOT BREAK	NOT BREAK	NOT BREAK
Discharge Rate	Q	($m^3/s/m$)	0.00021	0.00169	0.00807	0.01332	0.03138	0.06488	0.22929
Discharge Rate	Q	(l/s/m)	0.2	1.7	8.1	13.3	31.4	64.9	229.3

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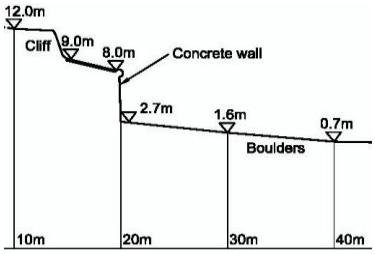
Subject: Overtopping of Upgarth Hill concrete seawall (defence element 240/6507)		Checked:	Date:

A code for dike height design and examination
J.W. Van der Meer (1998) More Info

Wave Overtopping Op.6 **Rock fillet at 4.7mAOD**



Conditions suggest joint probablity dominated by SWL return period and confirmed by HR Report EX 4350. Hence use 1 in 1 yr waves for different SWL return periods. Base existing overtopping and compare to future overtopping risk with climate change. Analyse options to reduce ovetopping in future to be equivalent to present day.

Input Parameters			Basic 1 in 1 yr event	
Nearshore Slope	s_b	(1:?)	19.0	
Toe Level	h_t	(mODN)	1.90	
Offshore Wave Height	H_s	(m)	4.00	
Wave Period (Zero-crossing)	T_z	(s)	8.00	
Still Water Level	SWL	(mODN)	3.30	1 in 1 yr
Crest Level	h_c	(mODN)	8.00	Conc wall
Upper Slope	s_u	(1:?)	0.10	
Berm Width	B_w	(m)	2.00	rock
Berm Crest Level	h_b	(mODN)	4.70	rock
Lower Slope	s_l	(1:?)	2.00	rock
Wave Angle	β	(o)	0	from East
Roughness reduction factor	γ_f		0.60	rock

Constants

g	(m/s^2)	9.81
π		3.14

Calculations

Depth of water at Toe	d	(m)	1.40	Combination of all reduction factors	γ_{all}		0.50
Wavelength	L	(m)	31.18	Irribarren No.	ξ_{op}		6.36
Depth/Wavelength	d/L		0.04	Wave Steepness	s_{op}		8.80E-03
Wave Celerity	c	(m/s)	3.67	Berm Freeboard	d_h	(m)	-1.40
Shoaling Coefficient	K_s		1.37		d_h/H_s		-0.99
Wave Height at Toe (Goda)	H_{si}	(m)	1.42		d_h/x		0.33
Wave Period (Peak)	T_p	(s)	10.16	Crest Freeboard	R_c	(m)	4.70
Length of Slope	L_{slope}	(m)	9.1	Dimensionless crest height (broken)	R_b		1.04
Length of Berm	L_{berm}	(m)	5.0	Dimensionless crest height (unbroken)	R_n		6.63
Average Slope Angle	α	(1:?)	1.7	Discharge	Q_{break}	($m^3/s/m$)	0.014
Berm reduction factor	γ_b		0.70	Maximum Limiting Discharge	Q_{max}	($m^3/s/m$)	0.00
Wave Angle reduction factor	γ_β		1.00				

Results

Wave Type	NOT BREAKING		
Discharge Rate	Q	($m^3/s/m$)	0.00000
Discharge Rate	Q	(l/s/m)	0.0

Limitations

B_w Slope < 1:15	$Q = Q_{break}$	when $\xi_{op} < 2$
$0.3 < R_b < 2$	$Q = Q_{max}$	when $\xi_{op} > 2$
$0.5 < \gamma_f\gamma_b\gamma_\beta < 1$		

			Return Period (Years) or Defence Code						
Input Parameters			1 in 1	10	50	100	200	200 (50yr)	200 (100yr)
Nearshore Slope	s_b	(m)	19.0	19.0	19.0	19.0	19.0	19.0	19.0
Toe Level	h_t	(mODN)	1.90	1.90	1.90	1.90	1.90	1.90	1.90
Offshore Wave Height	H_s	(m)	4.00	4.60	5.90	6.00	6.90	6.90	6.90
Wave Period (Zero-crossing)	T_z	(s)	8.00	8.60	9.70	9.80	12.10	12.10	12.10
Still Water Level	SWL	(mODN)	3.30	3.61	3.85	3.99	4.10	4.40	5.04
Crest Level	h_c	(mODN)	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Upper Slope	s_u	(1:?)	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Berm Width	B_w	(m)	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Berm Crest Level	h_b	(mODN)	4.70	4.70	4.70	4.70	4.70	4.70	4.70
Lower Slope	s_l	(1:?)	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Wave Angle	β	(°)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Roughness reduction factor	γ_f		0.60	0.6	0.6	0.6	0.6	0.6	0.6
Calculations			1 in 1	10	50	100	200	200 (50yr)	200 (100yr)
Depth of water at Toe	d	(m)	1.40	1.71	1.95	2.09	2.20	2.50	3.14
Wavelength	L	(m)	31.18	37.06	44.58	46.66	58.16	62.54	70.60
Depth/Wavelength	d/L		0.04	0.05	0.04	0.04	0.04	0.04	0.04
Wave Celerity	c	(m/s)	3.67	4.05	4.35	4.49	4.65	4.95	5.51
Shoaling Coefficient	K_s		1.37	1.35	1.38	1.37	1.49	1.44	1.37
Wave Height at Toe (Goda)	H_{si}	(m)	1.42	1.70	2.02	2.12	2.41	2.60	3.02
Peak Wave Period	T_p	(s)	10.16	10.92	12.32	12.45	15.37	15.37	15.37
Length of Slope	L_{slope}	(m)	9.1	9.4	10.0	10.0	10.7	10.8	10.9
Length of Berm	L_{berm}	(m)	5.0	5.6	6.2	6.5	7.1	7.5	8.3
Average Slope Angle	α	(1:?)	1.7	1.5	1.3	1.3	1.2	1.1	1.0
Berm reduction factor	γ_b		0.70	0.68	0.69	0.70	0.72	0.73	0.76
Wave Angle reduction factor	γ_β		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Combination of all reduction factors	γ_{all}		0.50	0.50	0.50	0.50	0.50	0.50	0.50
Irribarren No.	ξ_{op}		6.36	7.19	8.23	8.46	10.25	10.60	11.30
Wave Steepness	s_{op}		8.80E-03	9.11E-03	8.51E-03	8.77E-03	6.53E-03	7.06E-03	8.18E-03
Crest Freeboard	d_h	(m)	-1.40	-1.09	-0.85	-0.71	-0.60	-0.30	0.34
	d_h/H_s		-0.99	-0.64	-0.42	-0.33	-0.25	-0.12	0.11
	d_h/x		0.33	0.21	0.14	0.11	0.08	0.04	0.06
Crest Freeboard	R_c	(m)	4.70	4.39	4.15	4.01	3.90	3.60	2.96
Dimensionless crest height (broken	R_b		1.04	0.72	0.50	0.45	0.32	0.26	0.17
Dimensionless crest height (unbrok	R_n		6.63	5.17	4.12	3.78	3.24	2.77	1.96
Discharge	Q_{break}	($m^3/s/m$)	0.014	0.083	0.337	0.473	1.289	1.903	3.705
Maximum Limiting Discharge	Q_{max}	($m^3/s/m$)	0.000	0.000	0.001	0.001	0.005	0.013	0.076
Results			1 in 1	10	50	100	200	200 (50yr)	200 (100yr)
Wave Type	Wave Type		NOT BREAK	NOT BREAK	NOT BREAK	NOT BREAK	NOT BREAK	NOT BREAK	NOT BREAK
Discharge Rate	Q	($m^3/s/m$)	0.00000	0.00007	0.00067	0.00138	0.00469	0.01306	0.07633
Discharge Rate	Q	(l/s/m)	0.0	0.1	0.7	1.4	4.7	13.1	76.3

Halcrow	CALCULATION SHEET	No: 1	Rev: 0
Project: Runswick Bay Strategy Study 2013		By: M Cali	Date: 01/11/2013
Subject: Overtopping of Upgarth Hill concrete seawall (defence element 240/6507)		Checked:	Date:

A code for dike height design and examination
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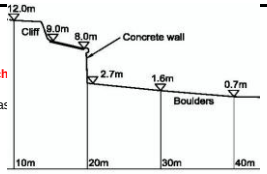

Wave Overtopping Op.9 **Shingle beach**

Conditions suggest joint probablity dominated by SWL return period and confirmed by HR Report EX 4350. Hence use 1 in 1 yr waves for different SWL return periods. Base existing overtopping and compare to future overtopping risk with climate change. Analyse options to reduce ovetopping in future to be equivalent to present day.

Input Parameters			Bas	
Nearshore Slope	s_b	(1:?)		
Toe Level	h_t	(mODN)		
Offshore Wave Height	H_s	(m)		
Wave Period (Zero-crossing)	T_z	(s)	**8.00**	
Still Water Level	SWL	(mODN)	**3.30**	1 in 1 yr
Crest Level	h_c	(mODN)	**8.00**	Conc wall
Upper Slope	s_u	(1:?)	**0.10**	
Berm Width	B_w	(m)	**10.00**	shingle
Berm Crest Level	h_b	(mODN)	**3.50**	shingle
Lower Slope	s_l	(1:?)	**10.00**	shingle
Wave Angle	β	(o)	**0**	from East
Roughness reduction factor	γ_f		**0.75**	**shingle**

Constants

g	(m/s²)	9.81
π		3.14

Calculations						
Depth of water at Toe	d	(m)	3.30	Combination of all reduction factors	γ_{all}	**0.52**
Wavelength	L	(m)	47.23	Irribarren No.	ξ_{op}	**1.57**
Depth/Wavelength	d/L		0.07	Wave Steepness	s_{op}	1.42E-02
Wave Celerity	c	(m/s)	5.52	Berm Freeboard	d_h (m)	-0.20
Shoaling Coefficient	K_s		1.13		d_h/H_s	-0.09
Wave Height at Toe (Goda)	H_{si}	(m)	**2.29**		d_h/x	0.03
Wave Period (Peak)	T_p	(s)	10.16	Crest Freeboard	R_c (m)	4.70
Length of Slope	L_{slope}	(m)	**46.7**	Dimensionless crest height (broken)	R_b	2.49
Length of Berm	L_{berm}	(m)	**33.1**	Dimensionless crest height (unbroken)	R_n	3.92
Average Slope Angle	α	(1:?)	**5.3**	Discharge	Q_{break} (m³/s/m)	**0.000**
Berm reduction factor	γ_b		**0.70**	Maximum Limiting Discharge	Q_{max} (m³/s/m)	0.00
Wave Angle reduction factor	γ_β		**1.00**			

Results

Wave Type	**BREAKING WAVES**		
Discharge Rate	Q	(m³/s/m)	**0.00001**
Discharge Rate	Q	(l/s/m)	**0.0**

Limitations

B_w Slope < 1:15	$Q = Q_{break}$	when $\xi_{op} < 2$
$0.3 < R_b < 2$	$Q = Q_{max}$	when $\xi_{op} > 2$
$0.5 < \gamma_f\gamma_b\gamma_\beta < 1$		

			Return Period (Years) or Defence Code						
Input Parameters			**1 in 1**	**10**	**50**	**100**	**200**	**200 (50yr)**	**200 (100yr)**
Nearshore Slope	s_b	(m)	**50.0**	**50.0**	**50.0**	**50.0**	**50.0**	**50.0**	**50.0**
Toe Level	h_t	(mODN)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Offshore Wave Height	H_s	(m)	**4.00**	**4.60**	**5.90**	**6.00**	**6.90**	**6.90**	**6.90**
Wave Period (Zero-crossing)	T_z	(s)	**8.00**	**8.60**	**9.70**	**9.80**	**12.10**	**12.10**	**12.10**
Still Water Level	SWL	(mODN)	**3.30**	**3.61**	**3.85**	**3.99**	**4.10**	**4.40**	**5.04**
Crest Level	h_c	(mODN)	**8.00**	**8.00**	**8.00**	**8.00**	**8.00**	**8.00**	**8.00**
Upper Slope	s_u	(1:?)	**0.10**	**0.10**	**0.10**	**0.10**	**0.10**	**0.10**	**0.10**
Berm Width	B_w	(m)	**10.00**	**10.00**	**10.00**	**10.00**	**10.00**	**10.00**	**10.00**
Berm Crest Level	h_b	(mODN)	**3.50**	**3.50**	**3.50**	**3.50**	**3.50**	**3.50**	**3.50**
Lower Slope	s_l	(1:?)	**10.00**	**10.00**	**10.00**	**10.00**	**10.00**	**10.00**	**10.00**
Wave Angle	β	(°)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Roughness reduction factor	γ_f		**0.75**	**0.75**	**0.75**	**0.75**	**0.75**	**0.75**	**0.75**

Calculations			**1 in 1**	**10**	**50**	**100**	**200**	**200 (50yr)**	**200 (100yr)**
Depth of water at Toe	d	(m)	3.30	3.61	3.85	3.99	4.10	4.40	5.04
Wavelength	L	(m)	47.23	53.19	62.25	64.00	80.68	83.51	89.18
Depth/Wavelength	d/L		0.07	0.07	0.06	0.06	0.05	0.05	0.06
Wave Celerity	c	(m/s)	5.52	5.78	6.00	6.10	6.24	6.46	6.89
Shoaling Coefficient	K_s		1.13	1.15	1.19	1.19	1.29	1.27	1.24
Wave Height at Toe (Goda)	H_{si}	(m)	**2.29**	**2.53**	**2.80**	**2.89**	**3.13**	**3.30**	**3.66**
Peak Wave Period	T_p	(s)	10.16	10.92	12.32	12.45	15.37	15.37	15.37
Length of Slope	L_{slope}	(m)	**46.7**	**47.2**	**49.0**	**49.0**	**51.5**	**51.1**	**50.3**
Length of Berm	L_{berm}	(m)	**33.1**	**35.6**	**38.3**	**39.2**	**41.6**	**43.4**	**47.0**
Average Slope Angle	α	(1:?)	**5.3**	**4.9**	**4.6**	**4.5**	**4.4**	**4.2**	**3.7**
Berm reduction factor	γ_b		**0.70**	**0.72**	**0.74**	**0.75**	**0.77**	**0.78**	**0.81**
Wave Angle reduction factor	γ_β		**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
Combination of all reduction factors	γ_{all}		**0.52**	**0.54**	**0.56**	**0.56**	**0.57**	**0.58**	**0.61**
Irribarren No.	ξ_{op}		**1.57**	**1.75**	**1.98**	**2.04**	**2.46**	**2.55**	**2.74**
Wave Steepness	s_{op}		**1.42E-02**	**1.36E-02**	**1.18E-02**	**1.20E-02**	**8.50E-03**	**8.96E-03**	**9.94E-03**
Crest Freeboard	d_h	(m)	-0.20	0.11	0.35	0.49	0.60	0.90	1.54
	d_h/H_s		-0.09	0.04	0.12	0.17	0.19	0.27	0.42
	d_h/x		0.03	0.02	0.06	0.08	0.10	0.14	0.21
Crest Freeboard	R_c	(m)	4.70	4.39	4.15	4.01	3.90	3.60	2.96
Dimensionless crest height (broken	R_b		**2.49**	1.84	1.34	1.21	0.88	0.73	0.49
Dimensionless crest height (unbrok	R_n		3.92	3.22	2.66	2.47	2.17	1.86	1.33
Discharge	Q_{break}	(m³/s/m)	**0.000**	**0.000**	**0.005**	0.010	0.065	0.146	0.570
Maximum Limiting Discharge	Q_{max}	(m³/s/m)	0.004	0.012	0.031	**0.044**	**0.076**	**0.133**	**0.369**

Results			**1 in 1**	**10**	**50**	**100**	**200**	**200 (50yr)**	**200 (100yr)**
Wave Type	Wave Type		**BREAK**	**BREAK**	**BREAK**	**NOT BREAK**	**NOT BREAK**	**NOT BREAK**	**NOT BREAK**
Discharge Rate	Q	(m³/s/m)	**0.00001**	**0.00037**	**0.00505**	**0.04389**	**0.07634**	**0.13283**	**0.36903**
Discharge Rate	Q	(l/s/m)	**0.0**	**0.4**	**5.1**	**43.9**	**76.3**	**132.8**	**369.0**