Appendix 19 (19-1 to 19-17)

Calculation Analysis of Sand Protection Dyke

APPENDIX: CALCULATION ANALYSIS OF SAND PROTECTION TRAINING DIKE

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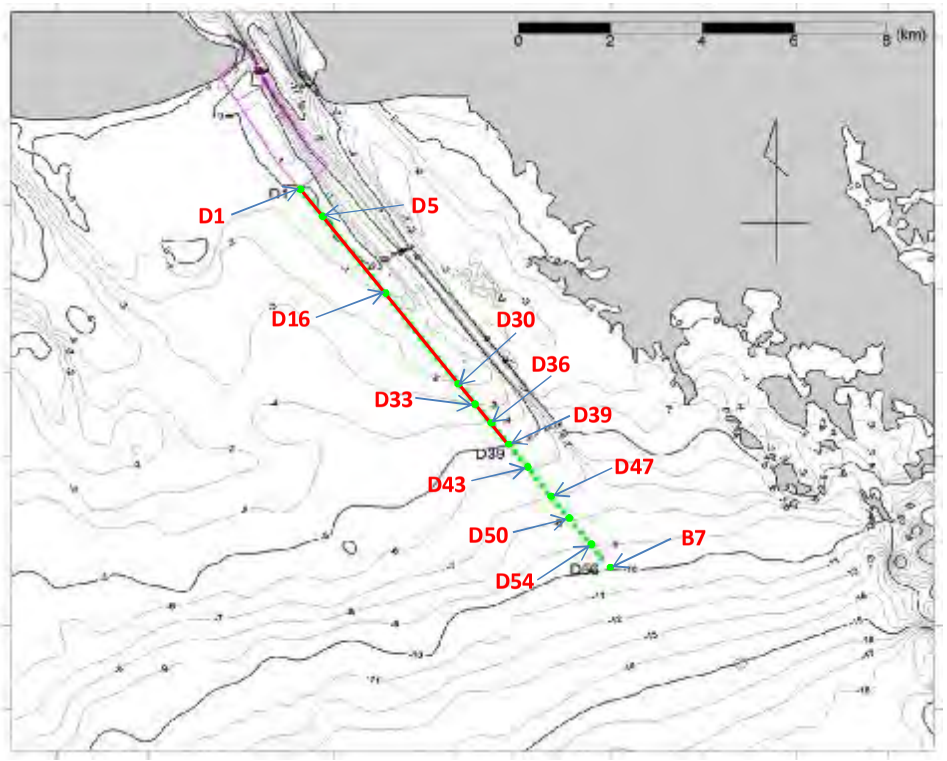
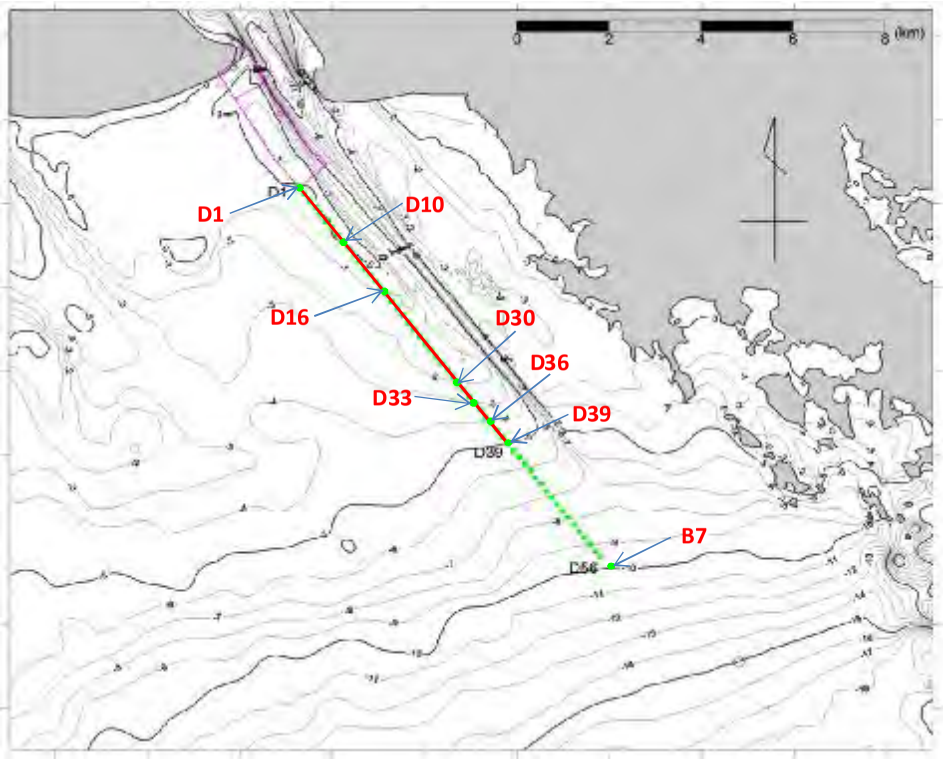
1. SUMMARY OF WAVE CONDITIONS (HWL)



Period	Pos	Tide level	Seabed	To	Offshore side							Channel side						
					DIR	Hmax			H1/3			DIR	Hmax			H1/3		
						Hmax	Beta	L	H1/3	Beta	L		Hmax	Beta	L	H1/3	Beta	L
30 years	D5	HWL	0.0	12.8	SSE	3.82	68.52	77.14	2.67	68.52	64.73	ESE	3.51	-72.63	74.06	2.54	-72.63	63.23
	D16	HWL	-1.0	12.8	SSE	4.23	68.35	81.06	3.08	68.35	69.51	ESE	4.07	-72.31	79.53	3.00	-72.31	68.55
	D30	HWL	-2.0	12.8	SSE	4.76	63.33	85.78	3.58	63.33	74.72	E	4.57	-72.87	84.05	3.47	-72.87	73.66
	D33	HWL	-3.0	12.8	SSE	5.37	60.79	90.82	4.08	60.79	79.62	E	5.19	-69.78	89.36	3.99	-69.78	78.73
	D36	HWL	-4.0	12.8	SSE	6.04	60.93	96.05	4.64	60.93	84.68	ESE	5.95	-74.63	95.41	4.59	-74.63	84.29
	D39	HWL	-5.0	12.8	SSE	6.62	60.95	100.31	4.96	60.95	87.47	ESE	6.53	-73.63	99.67	4.79	-73.63	86.05
	D43	HWL	-6.0	12.8	SSE	7.31	60.77	105.13	5.01	60.77	87.89	ESE	7.23	-72.27	104.59	4.85	-72.27	86.51
	D47	HWL	-7.0	12.8	SSE	7.93	60.21	109.23	5.07	60.21	88.37	ESE	7.84	-71.22	108.63	4.90	-71.22	86.93
	D50	HWL	-8.0	12.8	SSE	8.44	60.17	112.43	5.10	60.17	88.61	ESE	8.20	-69.94	110.93	4.95	-69.94	87.39
	D54	HWL	-9.0	12.8	SSE	8.52	59.97	112.94	5.14	59.97	89.00	ESE	8.29	-68.43	111.49	5.00	-68.43	87.84
	B7	HWL	-10.0	12.8	SSE	8.63	60.12	113.60	5.06	-66.83	88.29	ESE	8.38	-66.83	112.04	5.19	60.12	89.39

2. SUMMARY OF WAVE CONDITIONS (LWL)



Appendix 19-2-1

Period	Pos	Tide level	Seabed	To	Offshore side							Channel side						
					DIR	Hmax			H1/3			DIR	Hmax			H1/3		
						Hmax	Beta	L	H1/3	Beta	L		Hmax	Beta	L	H1/3	Beta	L
30 years	D10	LWL	0.0	12.8	SSE	3.14	32.35	70.13	0.93	68.52	38.51	ESE	1.84	-71.19	53.94	0.71	-71.20	33.68
	D16	LWL	-1.0	12.8	SSE	3.73	57.02	76.21	1.48	57.02	48.48	ESE	3.00	-74.02	68.53	1.36	-74.00	46.49
	D30	LWL	-2.0	12.8	SSE	2.87	65.47	67.12	1.95	65.47	55.56	E						
	D33	LWL	-3.0	12.8	SSE	3.34	61.33	72.30	2.43	61.33	61.84	E						
	D36	LWL	-4.0	12.8	SSE	4.01	60.94	78.98	2.99	68.62	68.42	E	3.92	-71.90	78.10	2.93	-71.90	67.80
	D39	LWL	-5.0	12.8	SSE	4.60	60.68	84.32	3.46	68.92	73.48	E	4.49	-69.80	83.39	3.41	-69.80	73.00
	D43	LWL	-6.0	12.8	SSE	5.30	60.37	88.23	4.04	60.37	79.21	E	5.20	-67.35	89.43	3.98	-67.30	78.68
	D47	LWL	-7.0	12.8	SSE	5.92	59.65	95.19	4.55	59.65	83.88	E	5.80	-65.50	94.25	4.48	-65.50	83.30
	D50	LWL	-8.0	12.8	SSE	6.47	59.60	99.27	4.96	59.62	87.44	E	6.40	-73.73	98.77	4.83	-73.73	86.37
	D54	LWL	-9.0	12.8	SSE	7.17	59.43	104.19	5.02	59.43	87.99	ESE	7.09	-72.05	103.64	4.89	-72.05	86.91
	B7	LWL	-10.0	12.8	SSE	7.82	59.72	108.50	5.08	59.72	88.47	ESE	7.73	-70.08	107.93	4.95	-70.08	87.40

3. STABILITY COEFFICCIENT CALCULATION (K_D)
(According to "The Rock Manual, 2nd edition")
Armour Concrete Unit Layer

Stability parameter:

$$N_s = \frac{H_s}{\Delta D_n} = (K_D cot \propto)^{\frac{1}{3}} \qquad (Eq. 5.134)$$

$$K_D = \left(\frac{H_s}{\Delta D_n}\right)^3 \frac{1}{cot \propto}$$

Where: Ns - stability parameter

Hs - significant wave height, $H_{1/3}$ of the incident waves at the toe of the structure (m)

Δ - relative buoyant density, ρ_c/ρ_w-1

α - slope angle (^{o})

Surf similarity parameter, using the energy wave pediod T_m:

$$\xi_m = \frac{tan\alpha}{\sqrt{\frac{2\pi H_s}{g T_m{}^2}}}$$

Critical surf similarity parameter:

$$\xi_{cr} = \left[\frac{c_{pl}}{c_s} P^{0.31} \sqrt{tan\alpha}\right]^{\frac{1}{P+0.5}} \qquad (Eq. 5.138)$$

For $\xi_m < \xi_{cr}$ wave are plunging and Equation (5.154) applies:

$$\frac{H_s}{\Delta D_n} = \left(8.6\left(\frac{N_{od}}{\sqrt{N}}\right)^{0.5} + 3.94\right) s_{om}{}^{0.2} \qquad (Eq. 154)$$

For $\xi_m > \xi_{cr}$ wave are surging and Equation (5.153) applies:

$$\frac{H_s}{\Delta D_n} = \left(3.75\left(\frac{N_{od}}{\sqrt{N}}\right)^{0.5} + 0.85\right) s_{om}{}^{-0.2} \qquad (Eq. 153)$$

Where: c_{pl} = 6.2, with a standard deviation of σ = 0.4

c_s = 1, with a standard deviation of σ = 0.08

P - notional permeability of structure, 0.1 < P <0.6 (see Fig. 5.39)

N - number of incident waves at the toe, which depends on the duration of the wave conditions

s_{om} - fictitious wave steepness, $s_{om} = \frac{2\pi H_s}{g T^2{}_m}$

N_{od} - the number of displaced unit

T_m - the mean wave period (s)

ρ_c (t/m^3)	ρ_w (t/m^3)	Δ (t/m^3)	α (^{o})	g (m/s^2)	P	N_{od}	Damage level	N
2.3	1.025	1.24	26.57	9.81	0.5	0.5	**5%**	3000

3. STABILITY COEFFICCIENT CALCULATION (K_D)

Return period	Pos	H_s (m)	T_m (s)	s_{om}	ξ_m	ξ_{cr}	N_s	**K_D**
30 yrs Offshore side	D5	2.67	6.30	0.043	2.41	3.54	2.54	**8.2**
	D16	3.08	6.78	0.043	2.41	3.54	2.54	**8.2**
	D30	3.58	7.30	0.043	2.41	3.54	2.54	**8.2**
	D33	4.08	7.80	0.043	2.41	3.54	2.54	**8.2**
	D36	4.64	8.31	0.043	2.41	3.54	2.54	**8.2**
	D39	4.96	8.60	0.043	2.41	3.54	2.54	**8.2**
	D43	5.01	8.64	0.043	2.41	3.54	2.54	**8.2**
	D47	5.07	8.69	0.043	2.41	3.54	2.54	**8.2**
	D50	5.10	8.71	0.043	2.41	3.54	2.54	**8.2**
	D54	5.14	8.75	0.043	2.41	3.54	2.54	**8.2**
	B7	5.06	8.68	0.043	2.41	3.54	2.54	**8.2**
30 yrs Channel side	D5	2.54	6.15	0.04	2.41	3.54	2.54	**8.2**
	D16	3.00	6.68	0.04	2.41	3.54	2.54	**8.2**
	D30	3.47	7.19	0.04	2.41	3.54	2.54	**8.2**
	D33	3.99	7.71	0.04	2.41	3.54	2.54	**8.2**
	D36	4.59	8.27	0.04	2.41	3.54	2.54	**8.2**
	D39	4.79	8.45	0.04	2.41	3.54	2.54	**8.2**
	D43	4.85	8.50	0.04	2.41	3.54	2.54	**8.2**
	D47	4.90	8.54	0.04	2.41	3.54	2.54	**8.2**
	D50	4.95	8.59	0.04	2.41	3.54	2.54	**8.2**
	D54	5.00	8.63	0.04	2.41	3.54	2.54	**8.2**
	B7	5.19	8.79	0.04	2.41	3.54	2.54	**8.2**

4. TETRAPOD WEIGHT CALCULATION

Hudson Formula:

$$W = \frac{\rho_s H_s^3}{K_D \cdot \left(\frac{\rho_s}{\rho_w} - 1\right)^3 \cot \alpha}$$

Where in:

ρ_s - *mass density of armor units (t/m^3)* = 2.3 t/m3

ρ_w - *mass density of water (t/m^3)* = 1.025t/m3

K_D - *stability cofficient* Tetrapod

α - *slope angle* 1 : 2

H_s - *characteristic wave height*

Concrete layer placing Qty. 2

TETRAPOD WEIGHT CALCULATION **Damage level: 5%**

Period	Pos	Seabed Level (m)	Wave height H1/3 (m)	K_D	Tetrapod (tons)						
					W (tons)	Type (tons)	Thickness (m)	Bs (m)	Row of block placing on top	B (m)	B' (m)
30 year Offshore side	D5	0.0	2.67	8.2	1.38	**2.0**	1.90	1.30	2	1.60	2.20
	D16	-1.0	3.08	8.2	2.15	**3.2**	2.20	1.50	2	1.80	2.50
	D30	-2.0	3.58	8.2	3.35	**4.0**	2.40	1.60	2	2.00	2.80
	D33	-3.0	4.08	8.2	4.97	**6.3**	2.70	1.90	2	2.30	3.20
	D36	-4.0	4.64	8.2	7.29	**8.0**	3.00	2.10	2	2.50	3.40
	D39	-5.0	4.96	8.2	8.92	**10.0**	3.20	2.20	2	2.70	3.70
	D43	-6.0	5.01	8.2	9.20	**12.5**	3.50	2.40	2	2.90	4.00
	D47	-7.0	5.07	8.2	9.51	**12.5**	3.50	2.40	2	2.90	4.00
	D50	-8.0	5.10	8.2	9.68	**12.5**	3.50	2.40	2	2.90	4.00
	D54	-9.0	5.14	8.2	9.95	**12.5**	3.50	2.40	2	2.90	4.00
	B7	-10.0	5.06	8.2	9.46	**12.5**	3.50	2.40	2	2.90	4.00
30 year Channel side	D5	0.0	2.54	8.2	1.20	**2.0**	1.90	1.30	2	1.60	2.20
	D16	-1.0	3.00	8.2	1.97	**3.2**	2.20	1.50	2	1.80	2.50
	D30	-2.0	3.47	8.2	3.07	**4.0**	2.40	1.60	2	2.00	2.80
	D33	-3.0	3.99	8.2	4.63	**6.3**	2.70	1.90	2	2.30	3.20
	D36	-4.0	4.59	8.2	7.08	**8.0**	3.00	2.10	2	2.50	3.40
	D39	-5.0	4.79	8.2	8.05	**10.0**	3.20	2.20	2	2.70	3.70
	D43	-6.0	4.85	8.2	8.33	**10.0**	3.20	2.20	2	2.70	3.70
	D47	-7.0	4.90	8.2	8.58	**10.0**	3.20	2.20	2	2.70	3.70
	D50	-8.0	4.95	8.2	8.87	**10.0**	3.20	2.20	2	2.70	3.70
	D54	-9.0	5.00	8.2	9.16	**10.0**	3.20	2.20	2	2.70	3.70
	B7	-10.0	5.2	8.2	10.22	**12.5**	3.50	2.40	2	2.90	4.00

5. STABILITY OF TOE BERM IN FRONT OF VERTICAL IMPERMEABLE WALL STRUCTURE (According to "The Rock Manual, CIRIA 683")

1. Stability parameter due to waves (Madrigal and Valdés, 1995): Two Layers of Armour Stone

$$N_s = \frac{H_s}{\Delta D_{n50}} = \left(5.8\frac{h'}{h_m} - 0.6\right) N^{0.19}{}_{od} \qquad (5.190)$$

$$M_{n50} = \rho_r D^3{}_{n50}$$

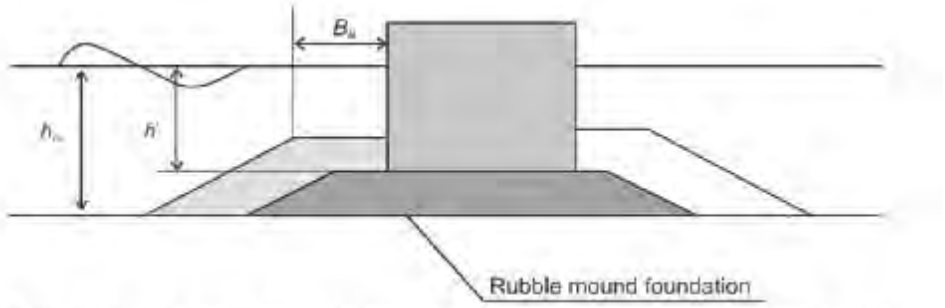


Figure 5.76 *Definition sketch for stability tests described by Madrigal and Valdés (1995)*

Where: Ns - stability parameter

Hs - significant wave height, $H_{1/3}$ of the incident waves at the toe of the structure (m)

Δ - relative buoyant density, ρ_s/ρ_w-1

D_{n50} - equivalent cube length of median stone (m)

h' - depth at crest of rubble mound foundation (m)

h_m - water depth in front of toe berm (m)

N_{od} - number of units displaced out of the armor layer within a strip width of D_{n50}

M_{n50} - medium mass of rocks

ρ_s (t/m^3)	ρ_w (t/m^3)	Δ (t/m^3)	N_{od}	Damage Level	HWL (m)
2.65	1.025	1.59	0.50	almost no damage	3.55

Pos	Seabed Level (m)	H_s (m)	h' (m)	h_m (m)	N_s	D_{n50} (m)	M_{n50} (kg)	
							Cal.	Selected
D10	0.0	2.67	3.05	3.55	3.84	**0.44**	222	**300**
D16	-1.0	3.08	3.05	4.55	2.88	**0.67**	815	800
D30	-2.0	3.58	4.05	5.55	3.18	**0.71**	944	1000
D33	-3.0	4.08	5.05	6.55	3.39	**0.76**	1155	1200
D36	-4.0	4.64	6.05	7.55	3.55	**0.82**	1483	1500
D39	-5.0	4.96	7.05	8.55	3.67	**0.85**	1647	1600
D43	-6.0	5.01	8.05	9.55	3.76	**0.84**	1574	1600
D47	-7.0	5.07	9.05	10.55	3.84	**0.83**	1533	1600
D50	-8.0	5.10	10.05	11.55	3.90	**0.82**	1486	1500
D54	-9.0	5.14	11.05	12.55	3.95	**0.82**	1467	1500
B7	-10.0	5.19	12.05	13.55	4.00	**0.82**	1458	1500

5. STABILITY OF TOE BERM IN FRONT OF VERTICAL IMPERMEABLE WALL STRUCTURE
(According to "The Rock Manual, CIRIA 683")

2. Calculation of foot protection block (Shigeo TAKAHASHI)

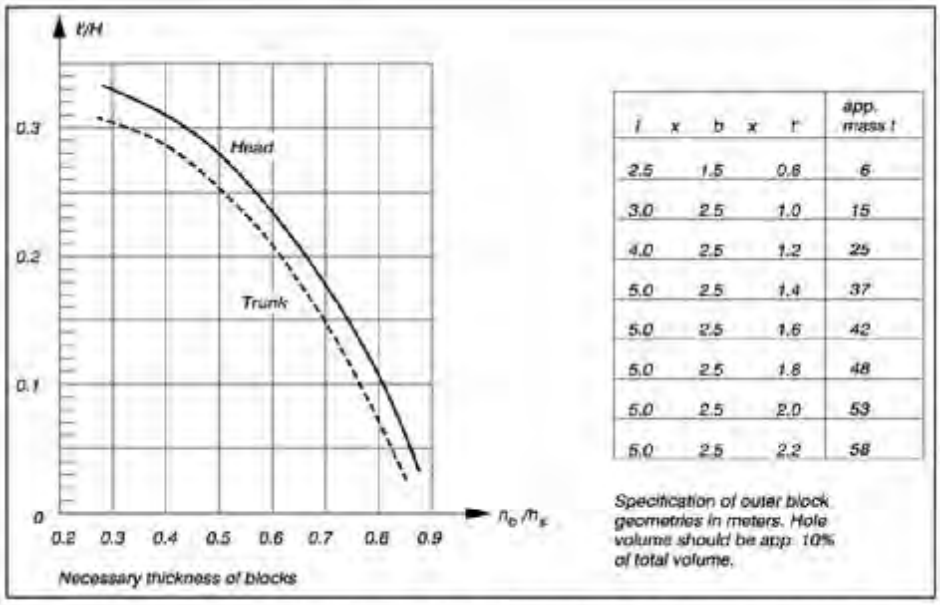


Figure VI-5-53. Design of foot protection blocks according to Japanese practice

Pos	Seabed Level (m)	Bot. Ver. Wall Level (m)	h_s or h (m)	h_b or d (m)	d/h	t'/Hs	t' (m)	
							Cal.	**Select**
D16	-1.0	0.5	4.55	2.25	0.49	0.26	0.80	**0.8**
D30	-2.0	-0.5	5.55	3.25	0.59	0.22	0.79	**0.8**
D33	-3.0	-1.5	6.55	4.25	0.65	0.19	0.75	**0.8**
D36	-4.0	-2.5	7.55	5.25	0.70	0.15	0.70	**0.8**
D39	-5.0	-3.5	8.55	6.25	0.73	0.12	0.60	**0.8**
D43	-6.0	-4.5	9.55	7.25	0.76	0.11	0.55	**0.8**
D47	-7.0	-5.5	10.55	8.25	0.78	0.09	0.46	**0.8**
D50	-8.0	-6.5	11.55	9.25	0.80	0.07	0.36	**0.8**
D54	-9.0	-7.5	12.55	10.25	0.82	0.06	0.31	**0.8**
B7 (Head)	-10.0	-8.5	13.55	11.25	0.83	0.08	0.42	**0.8**

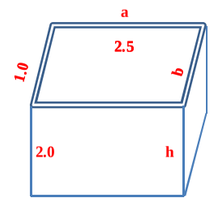
6 STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - CASE A-1 (HWL)

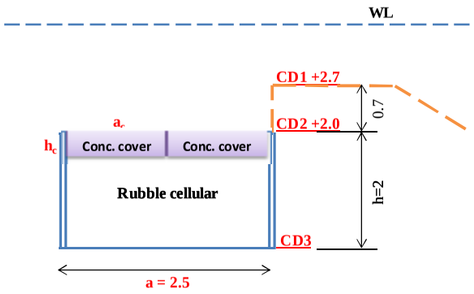
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*
Sand Protection Training Dike - Section for GL upto CD 0.0m

I. Wave Force under Wave Crest

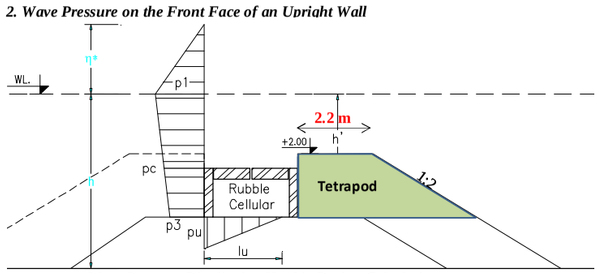
1. Input data:

- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	2.0
- Bottom Upright Wall Level (CDL):	0.0
- Bottom Width of Upright Wall (m):	2.5
- Back Fill Level (CDL):	2.7
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	0.0
- Significant Wave Height ($H_{1/3}$), m:	2.665
- H_{max}, m:	3.821
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	77.14





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	68.519
cos β:	0.366
H_D (m):	3.821
L (m):	77.14
HWL (CDL):	3.55
Sea bed Level (CDL):	0.0
Crest Level (CDL):	2.0
h (m):	3.55
h' (m)	3.55
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	0.578
2 πh/L	0.289
λ	1.000

5.2. Wave pressure on the front face of an Upright wall

η* =	3.92
α_1 =	1.048
α_3 =	0.960
(1+cosβ)	1.366
$\alpha_1 \lambda \rho_0 H_D$	4.104
p_1 (t/m2) =	2.80
p_c (at crest level), (t/m2) =	2.75
p_3 (t/m2) =	2.69

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	5.44
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	9.10

Horizontal Effect (Passive Pressure)

Pp, t/m	9.43
M_{Pp}, t.m	6.29

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	5.97
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	9.10

Sliding	**S.F. (Normal)**	**0.88**
	S.F. (with back fill layer effect)	**2.05**

Overturning	Mu	0.00
	Mp	5.47
	Mtetrapod	6.29
	Mconc. (=W*t)	7.47
	S.F. (Normal)	**1.37**
	S.F. (with back fill layer effect)	**OK**

		30 years	
	CD1	+ 2.7	m
	CD2	+ 2	m
	CD3	0	m
	HWL	**+ 3.55**	m
Cellular	**a**	2.5	m
	h	2	m
	b	1	m
	t	0.20	m
Conc. Cover	h_c	0.50	m
	a_c	1.00	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.24	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	3.41	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.34	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.26	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	1.88	t/m
	ΣW	**5.97**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	2.2	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	13.23	m2
	Wtetrapod	**9.10**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.0	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	$Kp = \tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	9.43	
	Pp, t/m	**9.43**	
	yp, m	0.67	
	M_{Pp}, t.m	**6.29**	

Rubble Cell	x_{sc}	1.25	m
	M (Sc)	**7.47**	t.m/m

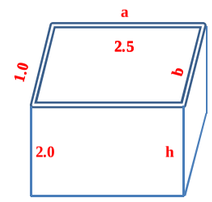
Wave	P	5.44	t/m
	U	0.00	t/m
	y_p	1.004	m
	x_u	2.500	m
	Mp	**5.47**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**5.47**	t.m/m

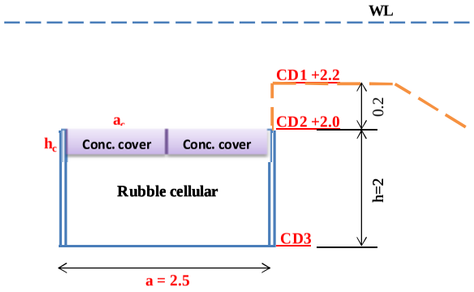
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*
Sand Protection Training Dike - Section for GL upto CD -1.0m

I. Wave Force under Wave Crest

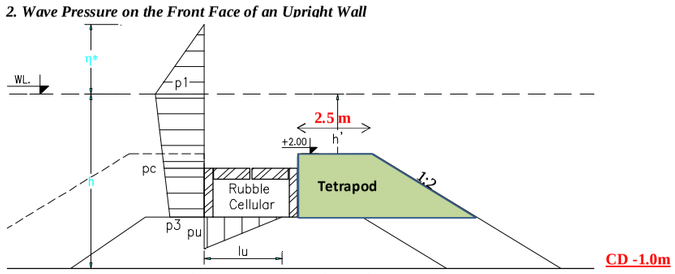
1. Input data:

- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	2.0
- Bottom Upright Wall Level (CDL):	0.0
- Bottom Width of Upright Wall (m):	2.5
- Back Fill Level (CDL):	2.2
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-1.0
- Significant Wave Height ($H_{1/3}$), m:	3.084
- H_{max}, m:	4.234
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	81.06





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^5\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\ \_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	68.349
cos β:	0.369
H_D (m):	4.234
L (m):	81.06
HWL (CDL):	3.55
Sea bed Level (CDL):	-1.0
Crest Level (CDL):	2.0
h (m):	4.55
h' (m)	3.55
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	0.705
2 πh/L	0.353
λ	1.000

5.2. Wave pressure on the front face of an Upright wall

η* =	4.35
α_1 =	1.025
α_3 =	0.954
(1+cosβ)	1.369
$\alpha_1 \lambda \rho_0 H_D$	4.447
p_1 (t/m2) =	3.04
p_c (at crest level), (t/m2) =	2.98
p_3 (t/m2) =	2.90

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	5.89
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	7.11

Horizontal Effect (Passive Pressure)

Pp, t/m	9.43
M_{Pp}, t.m	6.29

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	5.97
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	7.11

Sliding	**S.F. (Normal)**	**0.81**
	S.F. (with back fill layer effect)	**1.66**

Overturning	Mu	0.00
	Mp	5.91
	Mtetrapod	6.29
	Mconc. (=W*t)	7.47
	S.F. (Normal)	**1.26**
	S.F. (with back fill layer effect)	**OK**

		30 years	
	CD1	+ 2.2	m
	CD2	+ 2	m
	CD3	0	m
	HWL	**+ 3.55**	m
Cellular	**a**	2.5	m
	h	2	m
	b	1	m
	t	0.20	m
Conc. Cover	**h_c**	0.50	m
	a_c	1.00	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.24	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	3.41	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.34	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.26	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	1.88	t/m
	ΣW	**5.97**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	2.5	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	10.34	m2
	Wtetrapod	**7.11**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.0	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	Kp = $\tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	9.43	
	Pp, t/m	**9.43**	
	yp, m	0.67	
	M_{Pp}, t.m	**6.29**	

Rubble Cell	x_{sc}	1.25	m
	M (Sc)	**7.47**	t.m/m

Wave	P	5.89	t/m
	U	0.00	t/m
	y_p	1.004	m
	x_u	2.500	m
	Mp	**5.91**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**5.91**	t.m/m

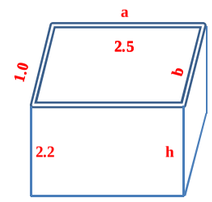
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*

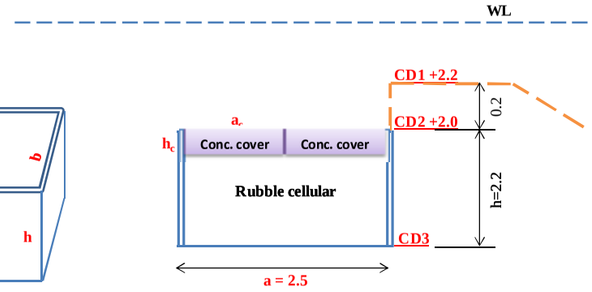
Sand Protection Training Dike - Section for GL upto CD -2.0m

I. Wave Force under Wave Crest

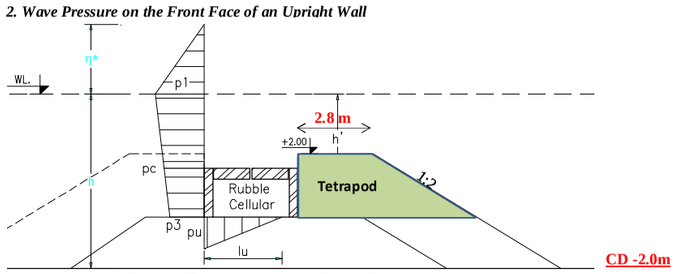
1. Input data:

- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	2.0
- Bottom Upright Wall Level (CDL):	-0.2
- Bottom Width of Upright Wall (m):	2.5
- Back Fill Level (CDL):	2.2
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-2.0
- Significant Wave Height ($H_{1/3}$), m:	3.578
- H_{max}, m:	4.762
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	85.78





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^5\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	63.333
cos β:	0.449
H_D (m):	4.762
L (m):	85.78
HWL (CDL):	3.55
Sea bed Level (CDL):	-2.0
Crest Level (CDL):	2.0
h (m):	5.55
h' (m)	3.75
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	0.813
2 πh/L	0.407
λ	0.999

5.2. Wave pressure on the front face of an Upright wall

η* =	5.17
α_1 =	1.003
α_3 =	0.948
(1+cosβ)	1.449
$\alpha_1 \lambda \rho_0 H_D$	4.893
p_1 (t/m2) =	3.54
p_c (at crest level), (t/m2) =	3.47
p_3 (t/m2) =	3.36

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	7.51
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	8.58

Horizontal Effect (Passive Pressure)

Pp, t/m	11.41
M_{Pp}, t.m	8.37

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	6.56
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	8.58

Sliding	**S.F. (Normal)**	**0.70**
	S.F. (with back fill layer effect)	**1.50**

Overturning	Mu	0.00
	Mp	8.30
	Mtetrapod	8.37
	Mconc. (=W*t)	8.20
	S.F. (Normal)	**0.99**
	S.F. (with back fill layer effect)	**OK**

		30 years	
	CD1	+ 2.2	m
	CD2	+ 2	m
	CD3	-0.2	m
	HWL	+ **3.55**	m
Cellular	**a**	2.5	m
	h	2.2	m
	b	1	m
	t	0.20	m
Conc. Cover	**h_c**	0.50	m
	a_c	1.00	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.24	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	3.75	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.34	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.26	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	2.13	t/m
	ΣW	**6.56**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	2.8	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	12.48	m2
	Wtetrapod	**8.58**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.2	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	$Kp = \tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	10.37	
	Pp, t/m	**11.41**	
	yp, m	0.73	
	M_{Pp}, t.m	**8.37**	

Rubble Cell	x_{sc}	1.25	m
	M (Sc)	**8.20**	t.m/m

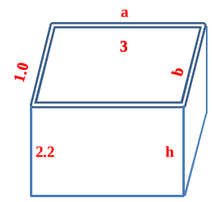
Wave	P	7.51	t/m
	U	0.00	t/m
	y_p	1.106	m
	x_u	2.500	m
	Mp	**8.30**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**8.30**	t.m/m

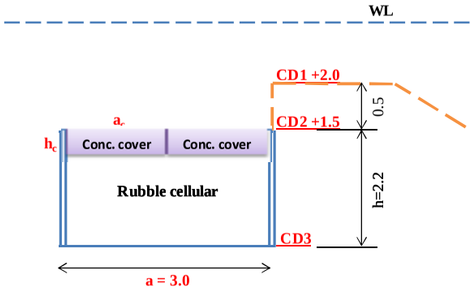
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*
Sand Protection Training Dike - Section for GL upto CD -3.0m

I. Wave Force under Wave Crest

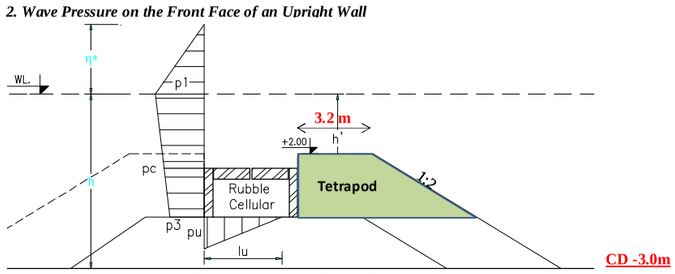
1. Input data:

- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	1.5
- Bottom Upright Wall Level (CDL):	-0.7
- Bottom Width of Upright Wall (m):	3.0
- Back Fill Level (CDL):	2.0
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-3.0
- Significant Wave Height ($H_{1/3}$), m:	4.08
- H_{max}, m:	5.365
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	90.82





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	60.793
cos β:	0.488
H_D (m):	5.365
L (m):	90.82
HWL (CDL):	3.55
Sea bed Level (CDL):	-3.0
Crest Level (CDL):	1.5
h (m):	6.55
h' (m)	4.25
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	0.906
2 πh/L	0.453
λ	0.999

5.2. Wave pressure on the front face of an Upright wall

η* =	5.98
α_1 =	0.983
α_3 =	0.939
(1+cosβ)	1.488
$\alpha_1 \lambda \rho_0 H_D$	5.400
p_1 (t/m2) =	4.02
p_c (at crest level), (t/m2) =	3.90
p_3 (t/m2) =	3.77

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	8.44
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	10.95

Horizontal Effect (Passive Pressure)

Pp, t/m	11.41
M_{Pp}, t.m	8.37

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	7.85
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	10.95

Sliding	**S.F. (Normal)**	**0.74**
	S.F. (with back fill layer effect)	**1.65**

Overturning	Mu	0.00
	Mp	9.33
	Mtetrapod	8.37
	Mconc. (=W*t)	11.77
	S.F. (Normal)	**1.26**
	S.F. (with back fill layer effect)	**12.19**

		30 years	
	CD1	+ 2	m
	CD2	+ 1.5	m
	CD3	-0.7	m
	HWL	**+ 3.55**	m
Cellular	**a**	3	m
	h	2.2	m
	b	1	m
	t	0.20	m
Conc. Cover	**h_c**	0.50	m
	a_c	1.25	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.44	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	4.36	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.43	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.56	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	2.63	t/m
	ΣW	**7.85**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	3.2	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	15.93	m2
	Wtetrapod	**10.95**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.2	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	$Kp = \tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	10.37	
	Pp, t/m	**11.41**	
	yp, m	0.73	
	M_{Pp}, t.m	**8.37**	

Rubble Cell	x_{sc}	1.50	m
	M (Sc)	**11.77**	t.m/m

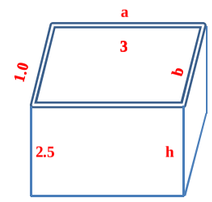
Wave	P	8.44	t/m
	U	0.00	t/m
	y_p	1.106	m
	x_u	3.000	m
	Mp	**9.33**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**9.33**	t.m/m

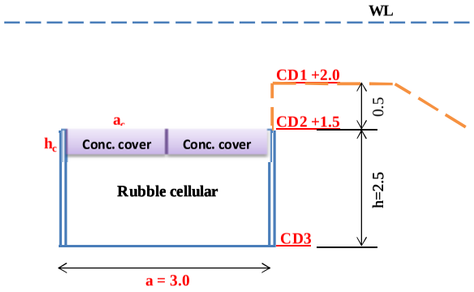
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*
Sand Protection Training Dike - Section for GL upto CD -4.0m

I. Wave Force under Wave Crest

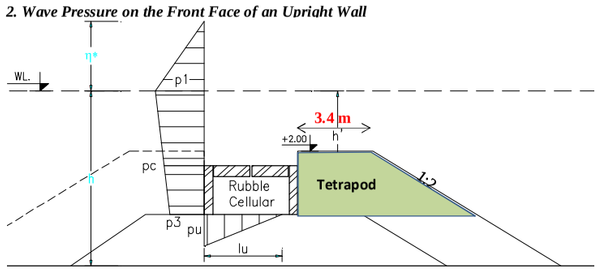
1. Input data:

- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	1.5
- Bottom Upright Wall Level (CDL):	-1.0
- Bottom Width of Upright Wall (m):	3.0
- Back Fill Level (CDL):	2.0
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-4.0
- Significant Wave Height ($H_{1/3}$), m:	4.636
- H_{max}, m:	6.035
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	96.05





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\ \_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	60.926
cos β:	0.486
H_D (m):	6.035
L (m):	96.05
HWL (CDL):	3.55
Sea bed Level (CDL):	-4.0
Crest Level (CDL):	1.5
h (m):	7.55
h' (m)	4.55
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	0.988
2 πh/L	0.494
λ	0.998

5.2. Wave pressure on the front face of an Upright wall

η* =	6.71
α_1 =	0.965
α_3 =	0.933
(1+cosβ)	1.486
$\alpha_1 \lambda \rho_0 H_D$	5.955
p_1 (t/m2) =	4.42
p_c (at crest level), (t/m2) =	4.29
p_3 (t/m2) =	4.13

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	10.53
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	13.20

Horizontal Effect (Passive Pressure)

Pp, t/m	14.73
M_{Pp}, t.m	12.28

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	8.91
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	13.20

Sliding	**S.F. (Normal)**	**0.68**
	S.F. (with back fill layer effect)	**1.55**

Overturning	Mu	0.00
	Mp	13.24
	Mtetrapod	12.28
	Mconc. (=W*t)	13.36
	S.F. (Normal)	**1.01**
	S.F. (with back fill layer effect)	**13.82**

		30 years	
	CD1	+ 2	m
	CD2	+ 1.5	m
	CD3	-1	m
	HWL	**+ 3.55**	m
Cellular	**a**	3	m
	h	2.5	m
	b	1	m
	t	0.20	m
Conc. Cover	**h_c**	0.50	m
	a_c	1.25	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.44	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	4.95	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.43	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.56	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	3.10	t/m
	ΣW	**8.91**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	3.4	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	19.20	m2
	Wtetrapod	**13.20**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.5	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	$Kp = \tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	11.78	
	Pp, t/m	**14.73**	
	yp, m	0.83	
	M_{Pp}, t.m	**12.28**	

Rubble Cell	x_{sc}	1.50	m
	M (Sc)	**13.36**	t.m/m

Wave	P	10.53	t/m
	U	0.00	t/m
	y_p	1.258	m
	x_u	3.000	m
	Mp	**13.24**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**13.24**	t.m/m

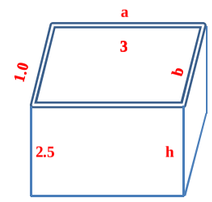
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*

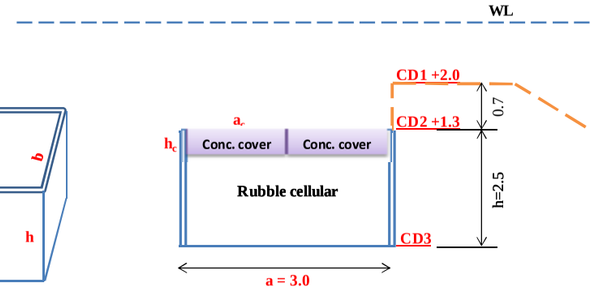
Sand Protection Training Dike - Section for GL upto CD -5.0m

I. Wave Force under Wave Crest

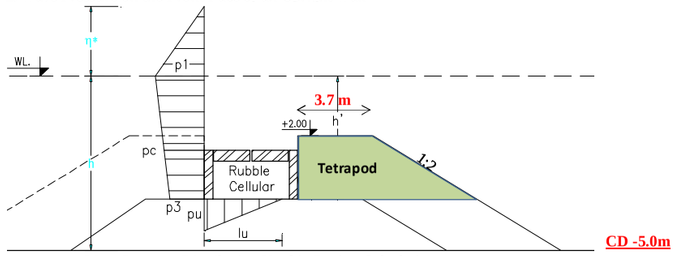
1. Input data:

- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	1.3
- Bottom Upright Wall Level (CDL):	-1.2
- Bottom Width of Upright Wall (m):	3.0
- Back Fill Level (CDL):	2.0
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-5.0
- Significant Wave Height ($H_{1/3}$), m:	4.96
- H_{max}, m:	6.615
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	100.31





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	60.947
cos β:	0.486
H_D (m):	6.615
L (m):	100.31
HWL (CDL):	3.55
Sea bed Level (CDL):	-5.0
Crest Level (CDL):	1.3
h (m):	8.55
h' (m)	4.75
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.071
2 πh/L	0.536
λ	0.996

5.2. Wave pressure on the front face of an Upright wall

η* =	7.34
α_1 =	0.946
α_3 =	0.929
(1+cosβ)	1.486
$\alpha_1 \lambda \rho_0 H_D$	6.385
p_1 (t/m2) =	4.74
p_c (at crest level), (t/m2) =	4.58
p_3 (t/m2) =	4.41

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	11.24
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	15.18

Horizontal Effect (Passive Pressure)

Pp, t/m	14.73
M_{Pp}, t.m	12.28

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	8.91
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	15.18

Sliding	**S.F. (Normal)**	**0.63**
	S.F. (with back fill layer effect)	**1.58**

Overturning	Mu	0.00
	Mp	14.14
	Mtetrapod	12.28
	Mconc. (=W*t)	13.36
	S.F. (Normal)	**0.94**
	S.F. (with back fill layer effect)	**7.17**

		30 years	
	CD1	+ 2	m
	CD2	+ 1.3	m
	CD3	-1.2	m
	HWL	**+ 3.55**	m
Cellular	**a**	3	m
	h	2.5	m
	b	1	m
	t	0.20	m
Conc. Cover	**h_c**	0.50	m
	a_c	1.25	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.44	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	4.95	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.43	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.56	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	3.10	t/m
	ΣW	**8.91**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	3.7	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	22.08	m2
	Wtetrapod	**15.18**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.5	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	Kp = $\tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	11.78	
	Pp, t/m	**14.73**	
	yp, m	0.83	
	M_{Pp}, t.m	**12.28**	

Rubble Cell	x_{sc}	1.50	m
	M (Sc)	**13.36**	t.m/m

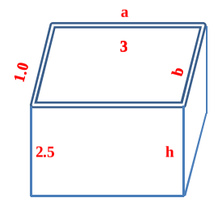
Wave	P	11.24	t/m
	U	0.00	t/m
	y_p	1.258	m
	x_u	3.000	m
	Mp	**14.14**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**14.14**	t.m/m

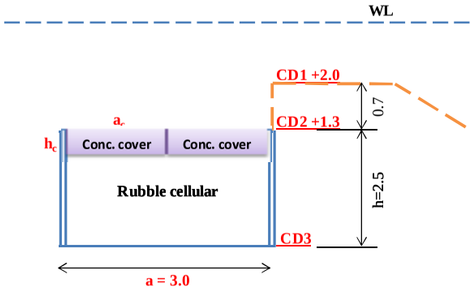
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*
Sand Protection Training Dike - Section for GL upto CD -6.0m

I. Wave Force under Wave Crest

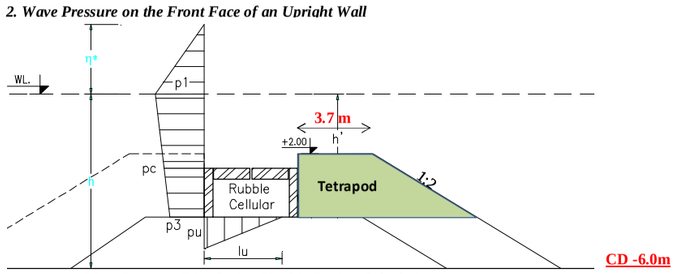
1. Input data:

- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	1.3
- Bottom Upright Wall Level (CDL):	-1.2
- Bottom Width of Upright Wall (m):	3.0
- Back Fill Level (CDL):	2.0
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-6.0
- Significant Wave Height ($H_{1/3}$), m:	5.01
- H_{max}, m:	7.308
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	105.13





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	60.77
cos β:	0.488
H_D (m):	7.308
L (m):	105.13
HWL (CDL):	3.55
Sea bed Level (CDL):	-6.0
Crest Level (CDL):	1.3
h (m):	9.55
h' (m)	4.75
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.142
2 πh/L	0.571
λ	0.991

5.2. Wave pressure on the front face of an Upright wall

η* =	8.09
α_1 =	0.930
α_3 =	0.929
(1+cosβ)	1.488
$\alpha_1 \lambda \rho_0 H_D$	6.902
p_1 (t/m2) =	5.14
p_c (at crest level), (t/m2) =	4.96
p_3 (t/m2) =	4.77

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	12.17
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	15.18

Horizontal Effect (Passive Pressure)

Pp, t/m	14.73
M_{Pp}, t.m	12.28

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	8.91
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	15.18

Sliding	**S.F. (Normal)**	**0.59**
	S.F. (with back fill layer effect)	**1.46**

Overturning	Mu	0.00
	Mp	15.31
	Mtetrapod	12.28
	Mconc. (=W*t)	13.36
	S.F. (Normal)	**0.87**
	S.F. (with back fill layer effect)	**4.41**

		30 years	
	CD1	+ 2	m
	CD2	+ 1.3	m
	CD3	-1.2	m
	HWL	**+ 3.55**	m
Cellular	**a**	3	m
	h	2.5	m
	b	1	m
	t	0.20	m
Conc. Cover	**h_c**	0.50	m
	a_c	1.25	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.44	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	4.95	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.43	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.56	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	3.10	t/m
	ΣW	**8.91**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	3.7	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	22.08	m2
	Wtetrapod	**15.18**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.5	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	Kp = $\tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	11.78	
	Pp, t/m	**14.73**	
	yp, m	0.83	
	M_{Pp}, t.m	**12.28**	

Rubble Cell	x_{sc}	1.50	m
	M (Sc)	**13.36**	t.m/m

Wave	P	12.17	t/m
	U	0.00	t/m
	y_p	1.258	m
	x_u	3.000	m
	Mp	**15.31**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**15.31**	t.m/m

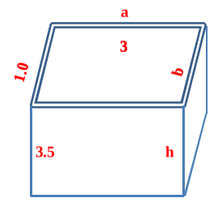
STABILITY CALCULATION DUE TO WAVE FORCE ***(Clause 5.5.2 - OCDI)*** **CASE A-1 Phu kin Tetrapod qua mai**

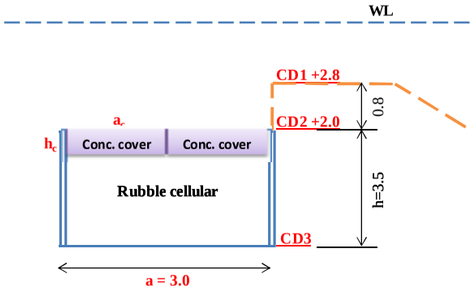
Sand Protection Training Dike - Section for GL upto CD -7.0m

I. Wave Force under Wave Crest

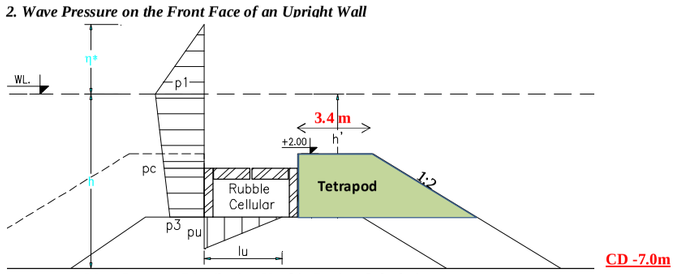
1. Input data:

- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	2.0
- Bottom Upright Wall Level (CDL):	-1.5
- Bottom Width of Upright Wall (m):	3.0
- Back Fill Level (CDL):	2.8
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-7.0
- Significant Wave Height ($H_{1/3}$), m:	5.067
- H_{max}, m:	7.931
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	109.23





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	60.21
cos β:	0.497
H_D (m):	7.931
L (m):	109.23
HWL (CDL):	3.55
Sea bed Level (CDL):	-7.0
Crest Level (CDL):	2.0
h (m):	10.55
h' (m)	5.05
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.214
2 πh/L	0.607
λ	0.989

5.2. Wave pressure on the front face of an Upright wall

η* =	8.80
α_1 =	0.913
α_3 =	0.924
(1+cosβ)	1.497
$\alpha_1 \lambda \rho_0 H_D$	7.335
p_1 (t/m2) =	5.49
p_c (at crest level), (t/m2) =	5.36
p_3 (t/m2) =	5.07

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	18.26
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	22.76

Horizontal Effect (Passive Pressure)

Pp, t/m	28.87
M_{Pp}, t.m	33.68

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	12.43
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	22.76

Sliding	**S.F. (Normal)**	**0.54**
	S.F. (with back fill layer effect)	**1.42**

Overturning	Mu	0.00
	Mp	32.24
	Mtetrapod	33.68
	Mconc. (=W*t)	18.65
	S.F. (Normal)	**0.58**
	S.F. (with back fill layer effect)	**OK**

		30 years	
	CD1	+ 2.8	m
	CD2	+ 2	m
	CD3	-1.5	m
	HWL	**+ 3.55**	m
Cellular	**a**	3	m
	h	3.5	m
	b	1	m
	t	0.20	m
Conc. Cover	**h_c**	0.50	m
	a_c	1.25	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.44	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	6.93	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.43	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.56	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	4.64	t/m
	ΣW	**12.43**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	3.4	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	33.11	m2
	Wtetrapod	**22.76**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	3.5	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	$Kp = \tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	16.50	
	Pp, t/m	**28.87**	
	yp, m	1.17	
	M_{Pp}, t.m	**33.68**	

Rubble Cell	x_{sc}	1.50	m
	M (Sc)	**18.65**	t.m/m

Wave	P	18.26	t/m
	U	0.00	t/m
	y_p	1.766	m
	x_u	3.000	m
	Mp	**32.24**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**32.24**	t.m/m

7 STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - CASE A-2 (HWL)

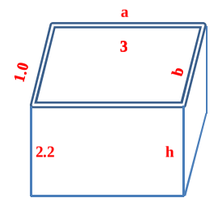
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*

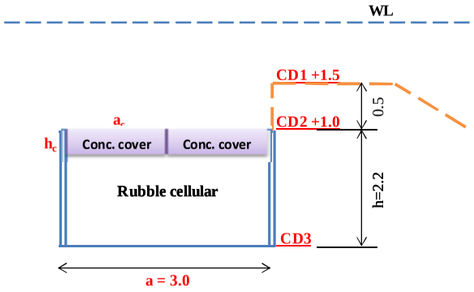
Sand Protection Training Dike - Section for GL upto CD -3.0m

I. Wave Force under Wave Crest

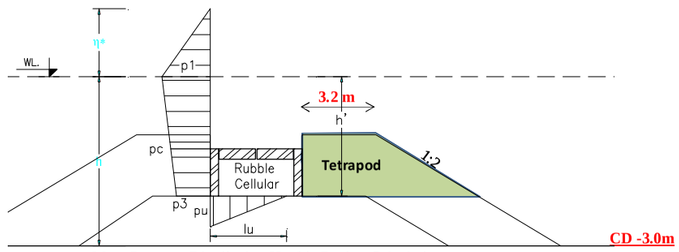
1. Input data:

- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	1.0
- Bottom Upright Wall Level (CDL):	-1.2
- Bottom Width of Upright Wall (m):	3.0
- Back Fill Level (CDL):	1.5
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-3.0
- Significant Wave Height ($H_{1/3}$), m:	4.08
- H_{max}, m:	5.365
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	90.82





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\ \_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	60.793
cos β:	0.488
H_D (m):	5.365
L (m):	90.82
HWL (CDL):	3.55
Sea bed Level (CDL):	-3.0
Crest Level (CDL):	1.0
h (m):	6.55
h' (m)	4.75
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	0.906
2 πh/L	0.453
λ	1.000

5.2. Wave pressure on the front face of an Upright wall

η* =	5.99
α_1 =	0.983
α_3 =	0.931
(1+cosβ)	1.488
$\alpha_1 \lambda \rho_0 H_D$	5.404
p_1 (t/m2) =	4.02
p_c (at crest level), (t/m2) =	3.87
p_3 (t/m2) =	3.74

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	8.38
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	10.95

Horizontal Effect (Passive Pressure)

Pp, t/m	11.41
M_{Pp}, t.m	8.37

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	7.85
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	10.95

Sliding	**S.F. (Normal)**	**0.75**
	S.F. (with back fill layer effect)	**1.66**

Overturning	Mu	0.00
	Mp	9.27
	Mtetrapod	8.37
	Mconc. (=W*t)	11.77
	S.F. (Normal)	**1.27**
	S.F. (with back fill layer effect)	**13.04**

		30 years	
	CD1	+ 1.5	m
	CD2	+ 1	m
	CD3	-1.20	m
	HWL	**+ 3.55**	m
Cellular	**a**	3	m
	h	2.2	m
	b	1	m
	t	0.20	m
Conc. Cover	**h_c**	0.50	m
	a_c	1.25	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.44	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	4.36	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.43	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.56	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	2.63	t/m
	ΣW	**7.85**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	3.2	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	15.93	m2
	Wtetrapod	**10.95**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.2	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	Kp = $\tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	10.37	
	Pp, t/m	**11.41**	
	yp, m	0.73	
	M_{Pp}, t.m	**8.37**	

Rubble Cell	x_{sc}	1.50	m
	M (Sc)	**11.77**	t.m/m

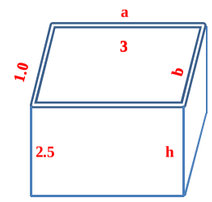
Wave	P	8.38	t/m
	U	0.00	t/m
	y_p	1.106	m
	x_u	3.000	m
	Mp	**9.27**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**9.27**	t.m/m

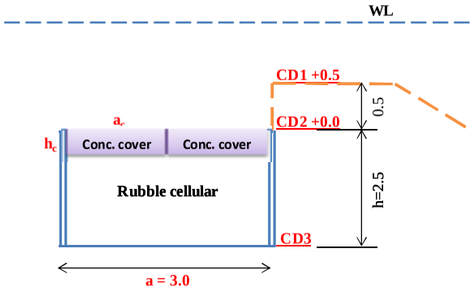
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*
Sand Protection Training Dike - Section for GL upto CD -4.0m

I. Wave Force under Wave Crest

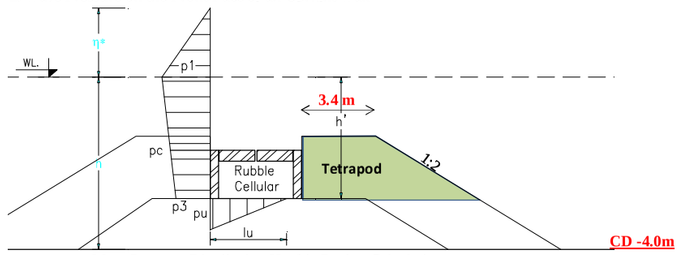
1. Input data:

- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	0.0
- Bottom Upright Wall Level (CDL):	-2.5
- Bottom Width of Upright Wall (m):	3.0
- Back Fill Level (CDL):	0.5
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-4.0
- Significant Wave Height ($H_{1/3}$), m:	4.636
- H_{max}, m:	6.035
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	96.05





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	60.926
cos β:	0.486
H_D (m):	6.035
L (m):	96.05
HWL (CDL):	3.55
Sea bed Level (CDL):	-4.0
Crest Level (CDL):	0.0
h (m):	7.55
h' (m)	6.05
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	0.988
2 πh/L	0.494
λ	1.000

5.2. Wave pressure on the front face of an Upright wall

η* =	6.73
α_1 =	0.965
α_3 =	0.911
(1+cosβ)	1.486
$\alpha_1 \lambda \rho_0 H_D$	5.968
p_1 (t/m2) =	4.43
p_c (at crest level), (t/m2) =	4.20
p_3 (t/m2) =	4.04

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	10.30
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	13.20

Horizontal Effect (Passive Pressure)

Pp, t/m	14.73
M_{Pp}, t.m	12.28

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	8.91
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	13.20

Sliding	**S.F. (Normal)**	**0.69**
	S.F. (with back fill layer effect)	**1.59**

Overturning	Mu	0.00
	Mp	12.97
	Mtetrapod	12.28
	Mconc. (=W*t)	13.36
	S.F. (Normal)	**1.03**
	S.F. (with back fill layer effect)	**19.37**

		30 years	
	CD1	+ 0.5	m
	CD2	+ 0	m
	CD3	-2.5	m
	HWL	**+ 3.55**	m
Cellular	**a**	3	m
	h	2.5	m
	b	1	m
	t	0.20	m
Conc. Cover	**h_c**	0.50	m
	a_c	1.25	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.44	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	4.95	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.43	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.56	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	3.10	t/m
	ΣW	**8.91**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	3.4	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	19.20	m2
	Wtetrapod	**13.20**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.5	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	$Kp = \tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	11.78	
	Pp, t/m	**14.73**	
	yp, m	0.83	
	M_{Pp}, t.m	**12.28**	

Rubble Cell	x_{sc}	1.50	m
	M (Sc)	**13.36**	t.m/m

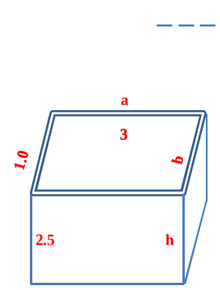
Wave	P	10.30	t/m
	U	0.00	t/m
	y_p	1.258	m
	x_u	3.000	m
	Mp	**12.97**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**12.97**	t.m/m

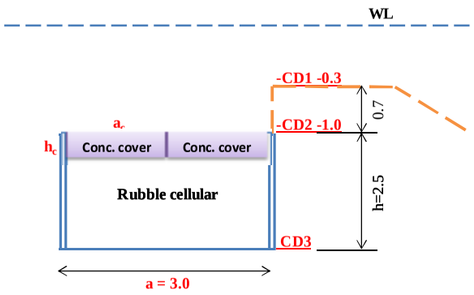
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*
Sand Protection Training Dike - Section for GL upto CD -5.0m

I. Wave Force under Wave Crest

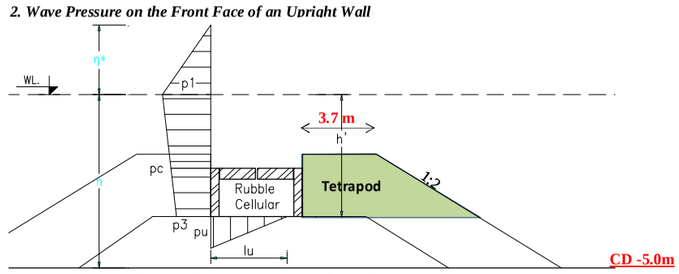
1. Input data:

- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	-1.0
- Bottom Upright Wall Level (CDL):	-3.5
- Bottom Width of Upright Wall (m):	3.0
- Back Fill Level (CDL):	-0.3
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-5.0
- Significant Wave Height ($H_{1/3}$), m:	4.96
- H_{max}, m:	6.615
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	100.31





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^5\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	60.947
cos β:	0.486
H_D (m):	6.615
L (m):	100.31
HWL (CDL):	3.55
Sea bed Level (CDL):	-5.0
Crest Level (CDL):	-1.0
h (m):	8.55
h' (m)	7.05
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.071
2 πh/L	0.536
λ	1.000

5.2. Wave pressure on the front face of an Upright wall

η* =	7.37
α_1 =	0.946
α_3 =	0.894
(1+cosβ)	1.486
$\alpha_1 \lambda \rho_0 H_D$	6.413
p_1 (t/m2) =	4.76
p_c (at crest level), (t/m2) =	4.44
p_3 (t/m2) =	4.26

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	10.87
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	15.18

Horizontal Effect (Passive Pressure)

Pp, t/m	14.73
M_{Pp}, t.m	12.28

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	8.91
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	15.18

Sliding	**S.F. (Normal)**	**0.66**
	S.F. (with back fill layer effect)	**1.63**

Overturning	Mu	0.00
	Mp	13.69
	Mtetrapod	12.28
	Mconc. (=W*t)	13.36
	S.F. (Normal)	**0.98**
	S.F. (with back fill layer effect)	**9.48**

		30 years	
	CD1	-0.3	m
	CD2	-1	m
	CD3	-3.5	m
	HWL	+ **3.55**	m
Cellular	**a**	3	m
	h	2.5	m
	b	1	m
	t	0.20	m
Conc. Cover	**h_c**	0.50	m
	a_c	1.25	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.44	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	4.95	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.43	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.56	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	3.10	t/m
	ΣW	**8.91**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	3.7	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	22.08	m2
	Wtetrapod	**15.18**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.5	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	Kp = $\tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	11.78	
	Pp, t/m	**14.73**	
	yp, m	0.83	
	M_{Pp}, t.m	**12.28**	

Rubble Cell	x_{sc}	1.50	m
	M (Sc)	**13.36**	t.m/m

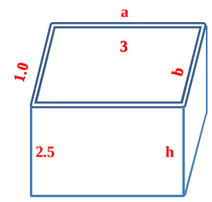
Wave	P	10.87	t/m
	U	0.00	t/m
	y_p	1.259	m
	x_u	3.000	m
	Mp	**13.69**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**13.69**	t.m/m

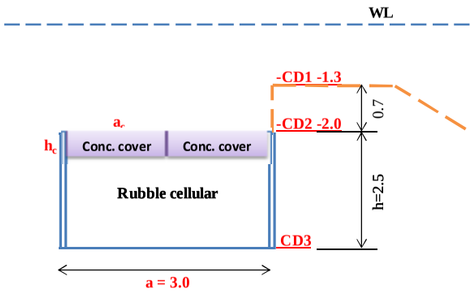
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*
Sand Protection Training Dike - Section for GL upto CD -6.0m

I. Wave Force under Wave Crest

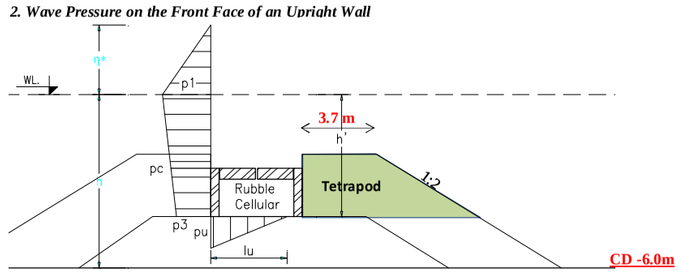
1. Input data:

- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	-2.0
- Bottom Upright Wall Level (CDL):	-4.5
- Bottom Width of Upright Wall (m):	3.0
- Back Fill Level (CDL):	-1.3
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-6.0
- Significant Wave Height ($H_{1/3}$), m:	5.01
- H_{max}, m:	7.308
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	105.13





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^5\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	60.77
cos β:	0.488
H_D (m):	7.308
L (m):	105.13
HWL (CDL):	3.55
Sea bed Level (CDL):	-6.0
Crest Level (CDL):	-2.0
h (m):	9.55
h' (m)	8.05
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.142
2 πh/L	0.571
λ	1.000

5.2. Wave pressure on the front face of an Upright wall

η* =	8.16
α_1 =	0.930
α_3 =	0.879
(1+cosβ)	1.488
$\alpha_1 \lambda \rho_0 H_D$	6.963
p_1 (t/m2) =	5.18
p_c (at crest level), (t/m2) =	4.75
p_3 (t/m2) =	4.56

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	11.63
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	15.18

Horizontal Effect (Passive Pressure)

Pp, t/m	14.73
M_{Pp}, t.m	12.28

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	8.91
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	15.18

Sliding	**S.F. (Normal)**	**0.61**
	S.F. (with back fill layer effect)	**1.53**

Overturning	Mu	0.00
	Mp	14.64
	Mtetrapod	12.28
	Mconc. (=W*t)	13.36
	S.F. (Normal)	**0.91**
	S.F. (with back fill layer effect)	**5.65**

		30 years	
	CD1	-1.3	m
	CD2	-2	m
	CD3	-4.5	m
	HWL	**+ 3.55**	m
Cellular	**a**	3	m
	h	2.5	m
	b	1	m
	t	0.20	m
Conc. Cover	**h_c**	0.50	m
	a_c	1.25	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.44	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	4.95	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.43	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.56	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	3.10	t/m
	ΣW	**8.91**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	3.7	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	22.08	m2
	Wtetrapod	**15.18**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.5	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	Kp = $\tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	11.78	
	Pp, t/m	**14.73**	
	yp, m	0.83	
	M_{Pp}, t.m	**12.28**	

Rubble Cell	x_{sc}	1.50	m
	M (Sc)	**13.36**	t.m/m

Wave	P	11.63	t/m
	U	0.00	t/m
	y_p	1.259	m
	x_u	3.000	m
	Mp	**14.64**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**14.64**	t.m/m

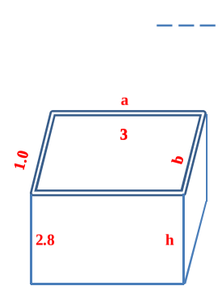
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*

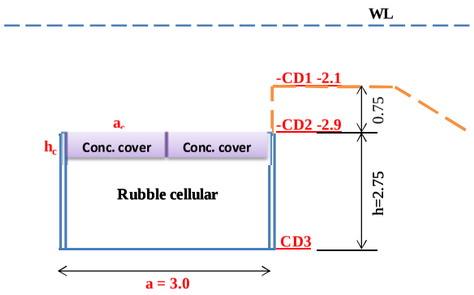
Sand Protection Training Dike - Section for GL upto CD -7.0m

I. Wave Force under Wave Crest

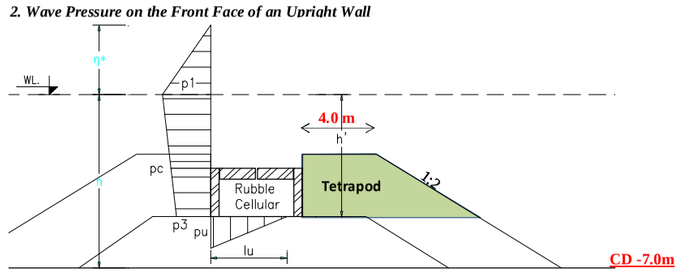
1. Input data:

- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	-2.9
- Bottom Upright Wall Level (CDL):	-5.6
- Bottom Width of Upright Wall (m):	3.0
- Back Fill Level (CDL):	-2.1
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-7.0
- Significant Wave Height ($H_{1/3}$), m:	5.067
- H_{max}, m:	7.931
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	109.23





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^5\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\ \_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	60.21
cos β:	0.497
H_D (m):	7.931
L (m):	109.23
HWL (CDL):	3.55
Sea bed Level (CDL):	-7.0
Crest Level (CDL):	-2.9
h (m):	10.55
h' (m)	9.15
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.214
2 πh/L	0.607
λ	1.000

5.2. Wave pressure on the front face of an Upright wall

η* =	8.90
α_1 =	0.913
α_3 =	0.862
(1+cosβ)	1.497
$\alpha_1 \lambda \rho_0 H_D$	7.420
p_1 (t/m2) =	5.55
p_c (at crest level), (t/m2) =	5.02
p_3 (t/m2) =	4.78

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	13.48
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	18.05

Horizontal Effect (Passive Pressure)

Pp, t/m	17.82
M_{Pp}, t.m	16.34

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	9.79
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	18.05

Sliding	**S.F. (Normal)**	**0.58**
	S.F. (with back fill layer effect)	**1.52**

Overturning	Mu	0.00
	Mp	18.68
	Mtetrapod	16.34
	Mconc. (=W*t)	14.68
	S.F. (Normal)	**0.79**
	S.F. (with back fill layer effect)	**6.28**

		30 years	
	CD1	-2.1	m
	CD2	-2.85	m
	CD3	-5.6	m
	HWL	+ **3.55**	m
Cellular	a	3	m
	h	2.75	m
	b	1	m
	t	0.20	m
Conc. Cover	h_c	0.50	m
	a_c	1.25	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.44	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	5.45	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.43	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.56	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	3.48	t/m
	ΣW	**9.79**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	4	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	26.25	m2
	Wtetrapod	**18.05**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.8	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	$Kp = \tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	12.96	
	Pp, t/m	**17.82**	
	yp, m	0.92	
	M_{Pp}, t.m	**16.34**	

Rubble Cell	x_{sc}	1.50	m
	M (Sc)	**14.68**	t.m/m

Wave	P	13.48	t/m
	U	0.00	t/m
	y_p	1.386	m
	x_u	3.000	m
	Mp	**18.68**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**18.68**	t.m/m

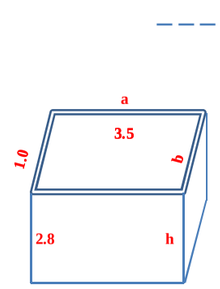
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*

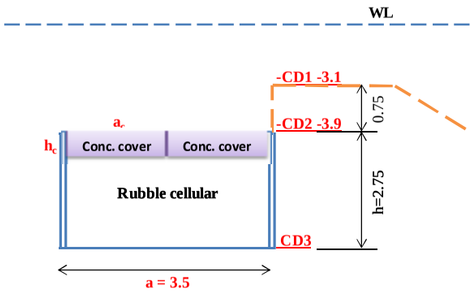
Sand Protection Training Dike - Section for GL upto CD -8.0m

I. Wave Force under Wave Crest

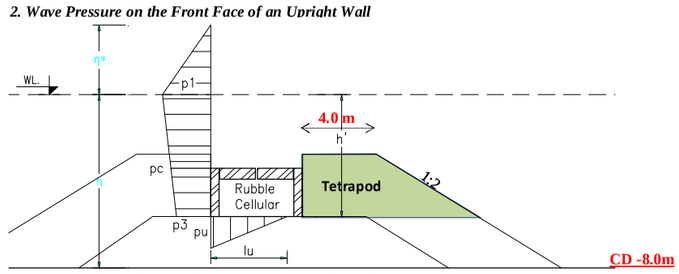
1. Input data:

- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	-3.9
- Bottom Upright Wall Level (CDL):	-6.6
- Bottom Width of Upright Wall (m):	3.5
- Back Fill Level (CDL):	-3.1
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-8.0
- Significant Wave Height ($H_{1/3}$), m:	5.096
- H_{max}, m:	8.44
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	112.43





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^5\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\ \_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	60.17
cos β:	0.497
H_D (m):	8.44
L (m):	112.43
HWL (CDL):	3.55
Sea bed Level (CDL):	-8.0
Crest Level (CDL):	-3.9
h (m):	11.55
h' (m)	10.15
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.291
2 πh/L	0.645
λ	1.000

5.2. Wave pressure on the front face of an Upright wall

η* =	9.48
α_1 =	0.895
α_3 =	0.844
(1+cosβ)	1.497
$\alpha_1 \lambda \rho_0 H_D$	7.743
p_1 (t/m2) =	5.80
p_c (at crest level), (t/m2) =	5.14
p_3 (t/m2) =	4.89

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	13.79
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	18.05

Horizontal Effect (Passive Pressure)

Pp, t/m	17.82
M_{Pp}, t.m	16.34

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	11.39
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	18.05

Sliding	**S.F. (Normal)**	**0.66**
	S.F. (with back fill layer effect)	**1.58**

Overturning	Mu	0.00
	Mp	19.12
	Mtetrapod	16.34
	Mconc. (=W*t)	19.92
	S.F. (Normal)	**1.04**
	S.F. (with back fill layer effect)	**7.16**

		30 years	
	CD1	-3.1	m
	CD2	-3.85	m
	CD3	-6.6	m
	HWL	+ **3.55**	m
Cellular	**a**	3.5	m
	h	2.75	m
	b	1	m
	t	0.20	m
Conc. Cover	**h_c**	0.50	m
	a_c	1.50	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.64	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	6.20	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.52	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.86	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	4.15	t/m
	ΣW	**11.39**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	4	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	26.25	m2
	Wtetrapod	**18.05**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.8	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	$Kp = \tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	12.96	
	Pp, t/m	**17.82**	
	yp, m	0.92	
	M_{Pp}, t.m	**16.34**	

Rubble Cell	x_{sc}	1.75	m
	M (Sc)	**19.92**	t.m/m

Wave	P	13.79	t/m
	U	0.00	t/m
	y_p	1.386	m
	x_u	3.500	m
	Mp	**19.12**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**19.12**	t.m/m

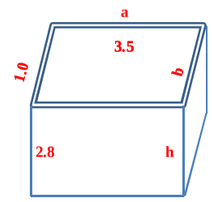
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*

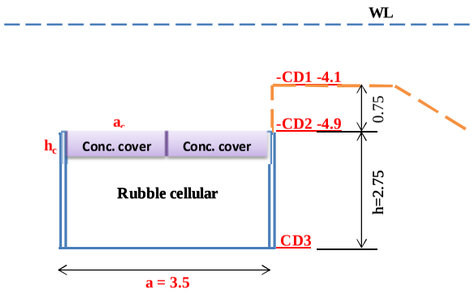
Sand Protection Training Dike - Section for GL upto CD -9.0m

I. Wave Force under Wave Crest

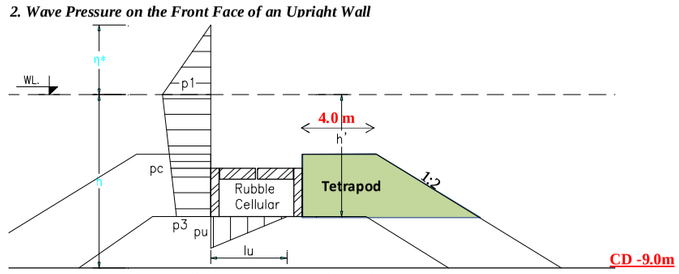
1. Input data:

- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	-4.9
- Bottom Upright Wall Level (CDL):	-7.6
- Bottom Width of Upright Wall (m):	3.5
- Back Fill Level (CDL):	-4.1
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-9.0
- Significant Wave Height ($H_{1/3}$), m:	5.143
- H_{max}, m:	8.522
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	112.94





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^5\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\ \_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	59.97
cos β:	0.500
H_D (m):	8.522
L (m):	112.94
HWL (CDL):	3.55
Sea bed Level (CDL):	-9.0
Crest Level (CDL):	-4.9
h (m):	12.55
h' (m)	11.15
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.396
2 πh/L	0.698
λ	1.000

5.2. Wave pressure on the front face of an Upright wall

η* =	9.59
α_1 =	0.871
α_3 =	0.820
(1+cosβ)	1.500
$\alpha_1 \lambda \rho_0 H_D$	7.609
p_1 (t/m2) =	5.71
p_c (at crest level), (t/m2) =	4.93
p_3 (t/m2) =	4.68

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	13.22
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	18.05

Horizontal Effect (Passive Pressure)

Pp, t/m	17.82
M_{Pp}, t.m	16.34

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	11.39
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	18.05

Sliding	**S.F. (Normal)**	**0.69**
	S.F. (with back fill layer effect)	**1.64**

Overturning	Mu	0.00
	Mp	18.34
	Mtetrapod	16.34
	Mconc. (=W*t)	19.92
	S.F. (Normal)	**1.09**
	S.F. (with back fill layer effect)	**9.95**

		30 years	
	CD1	-4.1	m
	CD2	-4.85	m
	CD3	-7.6	m
	HWL	**+ 3.55**	m
Cellular	**a**	3.5	m
	h	2.75	m
	b	1	m
	t	0.20	m
Conc. Cover	**h_c**	0.50	m
	a_c	1.50	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.64	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	6.20	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.52	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.86	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	4.15	t/m
	ΣW	**11.39**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	4	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	26.25	m2
	Wtetrapod	**18.05**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.8	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	$Kp = \tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	12.96	
	Pp, t/m	**17.82**	
	yp, m	0.92	
	M_{Pp}, t.m	**16.34**	

Rubble Cell	x_{sc}	1.75	m
	M (Sc)	**19.92**	t.m/m

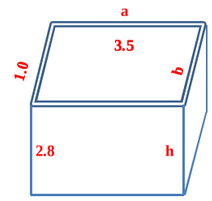
Wave	P	13.22	t/m
	U	0.00	t/m
	y_p	1.387	m
	x_u	3.500	m
	Mp	**18.34**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**18.34**	t.m/m

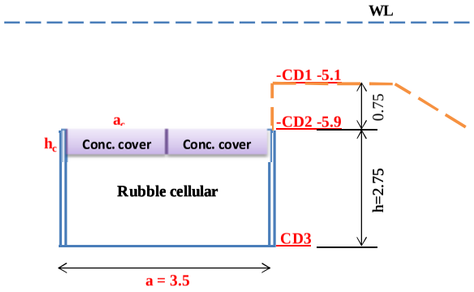
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*
Sand Protection Training Dike - Section for GL upto CD -10.0m

I. Wave Force under Wave Crest

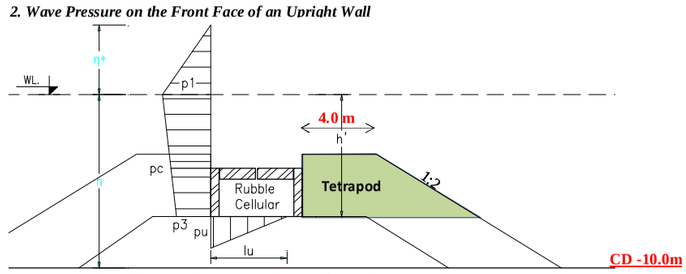
1. Input data:

- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	-5.9
- Bottom Upright Wall Level (CDL):	-8.6
- Bottom Width of Upright Wall (m):	3.5
- Back Fill Level (CDL):	-5.1
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-10.0
- Significant Wave Height ($H_{1/3}$), m:	5.058
- H_{max}, m:	8.629
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	113.60





2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^5\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\ \_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	60.12
cos β:	0.498
H_D (m):	8.629
L (m):	113.60
HWL (CDL):	3.55
Sea bed Level (CDL):	-10.0
Crest Level (CDL):	-5.9
h (m):	13.55
h' (m)	12.15
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.499
2 πh/L	0.749
λ	1.000

5.2. Wave pressure on the front face of an Upright wall

η* =	9.70
α_1 =	0.848
α_3 =	0.796
(1+cosβ)	1.498
$\alpha_1 \lambda \rho_0 H_D$	7.503
p_1 (t/m2) =	5.62
p_c (at crest level), (t/m2) =	4.73
p_3 (t/m2) =	4.48

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	12.66
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	18.05

Horizontal Effect (Passive Pressure)

Pp, t/m	17.82
M_{Pp}, t.m	16.34

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	11.39
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	18.05

Sliding	**S.F. (Normal)**	**0.72**
	S.F. (with back fill layer effect)	**1.72**

Overturning	Mu	0.00
	Mp	17.57
	Mtetrapod	16.34
	Mconc. (=W*t)	19.92
	S.F. (Normal)	**1.13**
	S.F. (with back fill layer effect)	**16.12**

		30 years	
	CD1	-5.1	m
	CD2	-5.85	m
	CD3	-8.6	m
	HWL	**+ 3.55**	m
Cellular	**a**	3.5	m
	h	2.75	m
	b	1	m
	t	0.20	m
Conc. Cover	**h_c**	0.50	m
	a_c	1.50	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.64	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	6.20	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.52	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.86	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	4.15	t/m
	ΣW	**11.39**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	4	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	26.25	m2
	Wtetrapod	**18.05**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.8	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	$Kp = \tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	12.96	
	Pp, t/m	**17.82**	
	yp, m	0.92	
	M_{Pp}, t.m	**16.34**	

Rubble Cell	x_{sc}	1.75	m
	M (Sc)	**19.92**	t.m/m

Wave	P	12.66	t/m
	U	0.00	t/m
	y_p	1.388	m
	x_u	3.500	m
	Mp	**17.57**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**17.57**	t.m/m

8 STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - CASE B-1 (HWL)

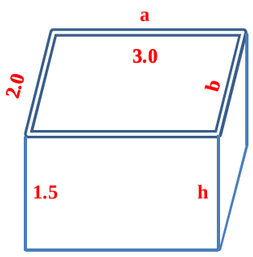
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*

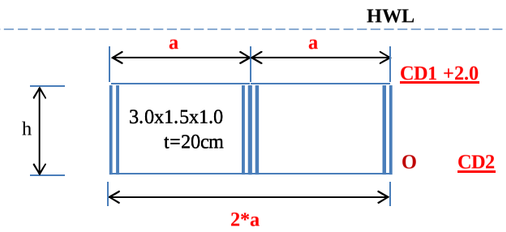
Sand Protection Training Dike - Section for GL upto CD 0.0m

I. Wave Force under Wave Crest

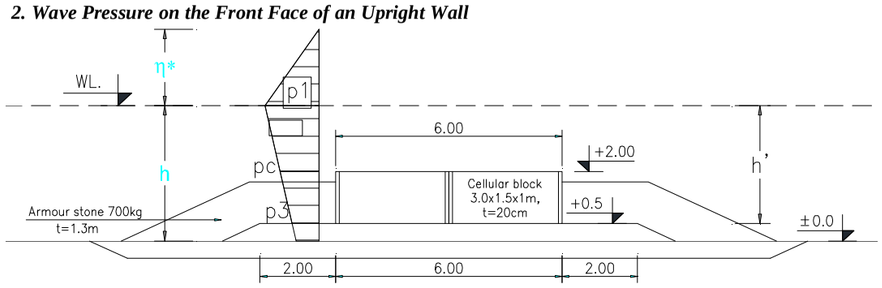
1. Input data:

- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	2.0
- Bottom Upright Wall Level (CDL):	0.5
- Bottom Width of Upright Wall (m):	6.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	0.0
- Significant Wave Height ($H_{1/3}$), m:	2.665
- H_{max}, m:	3.821
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	77.14





2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos b)\, l\, a_1 r_0 g H_D$

At toe of upright wall: $p_3 = p_u = a_3 p_1$

$$l = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad h^* = 0.75(1+\cos b)\, l\, H_D$$

$$a_1 = 0.6+\frac{1}{2}\left[\frac{4ph/L}{\sinh\left(\frac{4ph}{L}\right)}\right]^2 \qquad a_3 = 1+\frac{h'}{h^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	68.52
cos β:	0.366
H_D (m):	3.821
L (m):	77.14
HWL (CDL):	3.55
Sea bed Level (CDL):	0.0
Crest Level (CDL):	2.0
h (m):	3.6
h' (m)	3.05
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	0.578
2 πh/L	0.289
λ	1.000 *Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	3.92
α_1 =	1.048
α_3 =	0.965
(1+cosβ)	1.366
$\alpha_1 \lambda \rho_0 H_D$	4.104
p_1 (t/m2) =	2.80
p_c (at crest level), (t/m2) =	2.75
p_3 (t/m2) =	2.71

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ bottom\ Elev.}$ (t/m) =	4.09

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	9.99

Sliding	**S.F. at CD2 Elev.**	**1.95**

Overturning	$Mp_{at\ O}$	3.09
	$M_{conc.\ cell.\ at\ O}$ (=W*t)	29.96
	S.F. at O	**9.70**

		30 years	
	CD1	+ 2	m
	CD2	0.5	m
	HWL	**+ 3.55**	m
	a	3	m
	h	1.5	m
	b	2.00	m
	t	0.20	m
	$S_{conc.\ cell}$ (1 cell.)	1.84	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	3.80	t/m
	$S_{rubber\ filling}$ (1 cell.)	4.16	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	6.19	t/m
Upper Layer	Nos. of cellular block	2.00	unit
	x_O	3.00	m
	M_O	29.96	tm/m
Wave	$P_{up\ to\ bottom\ Elev.}$	4.09	t/m
	$y_{p\ upto\ bottom\ Elev.}$	0.754	m
	$Mp_{at\ O}$	3.09	t.m/m

STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*

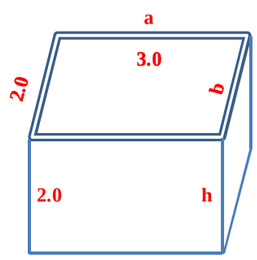
Sand Protection Training Dike - Section for GL upto CD -1.0m

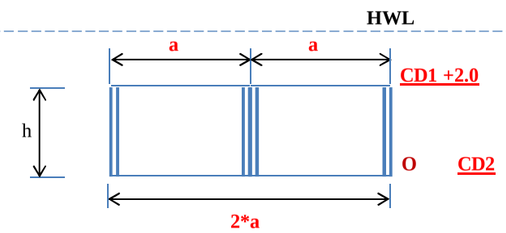
I. Wave Force under Wave Crest

1. Input data:

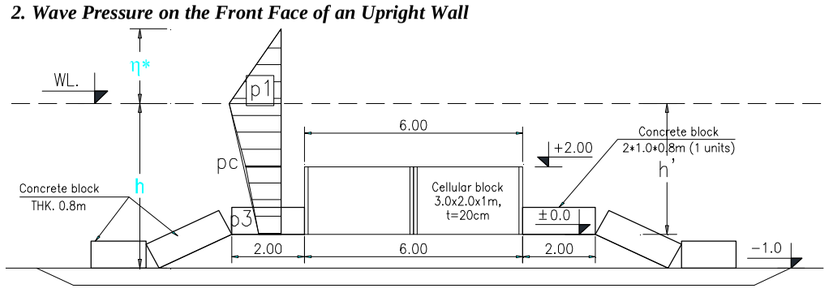
- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	2.0
- Bottom Upright Wall Level (CDL):	0.0
- Bottom Width of Upright Wall (m):	6.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-1.0
- Significant Wave Height ($H_{1/3}$), m:	3.084
- H_{max}, m:	4.234
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	81.06

Bellow sketch for reference only





2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos b)\, l\, a_1 r_0 g H_D$

At toe of upright wall: $p_3 = p_u = a_3 p_1$

$$l = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad h^* = 0.75(1+\cos b)\, l\, H_D$$

$$a_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad a_3 = 1+\frac{h'}{h^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	68.35
cos β:	0.369
H_D (m):	4.234
L (m):	81.06
HWL (CDL):	3.55
Sea bed Level (CDL):	-1.0
Crest Level (CDL):	2.0
h (m):	4.6
h' (m)	3.55
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	0.705
2 πh/L	0.353
λ	1.000 *Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	4.35
α_1 =	1.025
α_3 =	0.954
(1+cosβ)	1.369
$\alpha_1 \lambda \rho_0 H_D$	4.447
p_1 (t/m2) =	3.04
p_c (at crest level), (t/m2) =	2.98
p_3 (t/m2) =	2.90

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ bottom\ Elev.}$ (t/m) =	5.89

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	13.32

Sliding	**S.F. at CD2 Elev.**	**1.81**

Overturning	$Mp_{at\ O}$	5.93
	$M_{conc.\ cell.\ at\ O}$ (=W*t)	59.92
	S.F. at O	**10.10**

		30 years	
	CD1	+ 2	m
	CD2	0	m
	HWL	**+ 3.55**	m
	a	3	m
	h	2	m
	b	2.00	m
	t	0.20	m
	$S_{conc.\ cell}$ (1 cell.)	1.84	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	5.06	t/m
	$S_{rubber\ filling}$ (1 cell.)	4.16	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	8.26	t/m
Upper Layer	Nos. of cellular block	2.00	unit
	x_O	4.50	m
	M_O	59.92	tm/m
Wave	$P_{up\ to\ bottom\ Elev.}$	5.89	t/m
	$y_{p\ upto\ bottom\ Elev.}$	1.008	m
	$Mp_{at\ O}$	5.93	t.m/m

STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*

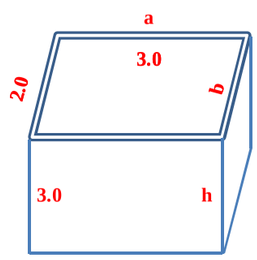
Sand Protection Training Dike - Section for GL upto CD -2.0m

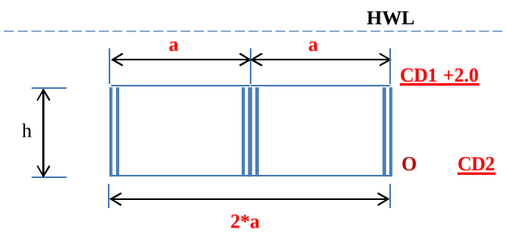
I. Wave Force under Wave Crest

1. Input data:

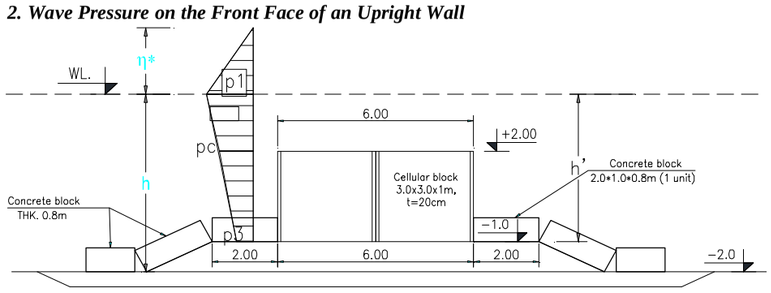
- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	2.0
- Bottom Upright Wall Level (CDL):	-1.0
- Bottom Width of Upright Wall (m):	6.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-2.0
- Significant Wave Height ($H_{1/3}$), m:	3.578
- H_{max}, m:	4.762
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	85.78

Bellow sketch for reference only





2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos b)\, l\, a_1 r_0 g H_D$

At toe of upright wall: $p_3 = p_u = a_3 p_1$

$$l = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad h^* = 0.75(1+\cos b)\, l\, H_D$$

$$a_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad a_3 = 1+\frac{h'}{h^*}(if\_h' \le 0)$$

		30 years	
	CD1	+ 2	m
	CD2	-1	m
	HWL	**+ 3.55**	m
	a	3.0	m
	h	3.0	m
	b	2.0	m
	t	0.2	m
	$S_{conc.\ cell}$ (1 cell.)	1.84	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	7.59	t/m
	$S_{rubber\ filling}$ (1 cell.)	4.16	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	12.38	t/m
Upper Layer	Nos. of cellular block	2.00	unit
	x_O	4.50	m
	M_O	89.88	tm/m
Wave	$P_{up\ to\ bottom\ Elev.}$	10.19	t/m
	$y_{p\ upto\ bottom\ Elev.}$	1.516	m
	$Mp_{at\ O}$	15.45	t.m/m

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years	
β (deg) =	63.333	
cos β:	0.449	
H_D (m):	4.762	
L (m):	85.78	
HWL (CDL):	3.55	
Sea bed Level (CDL):	-2.0	
Crest Level (CDL):	2.0	
h (m):	5.6	
h' (m)	4.55	
ρ_0 (t/m3):	1.025	
g (m/s2):	9.81	
4 πh/L	0.813	
2 πh/L	0.407	
λ	1.000	*Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	5.17
α_1 =	1.003
α_3 =	0.937
(1+cosβ)	1.449
$\alpha_1 \lambda \rho_0 H_D$	4.896
p_1 (t/m2) =	3.55
p_c (at crest level), (t/m2) =	3.47
p_3 (t/m2) =	3.32

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ bottom\ Elev.}$ (t/m) =	10.19

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	19.97

Sliding	**S.F. at CD2 Elev.**	**1.6**

Overturning	$Mp_{at\ O}$	15.45
	$M_{conc.\ cell.\ at\ O}$ (=W*t)	89.88
	S.F. at O	**5.82**

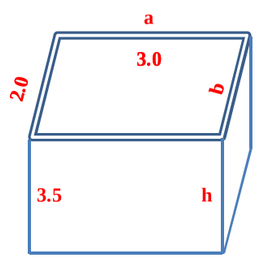
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*

Sand Protection Training Dike - Section for GL upto CD -2.0m - From Sta. 1+750~2+950

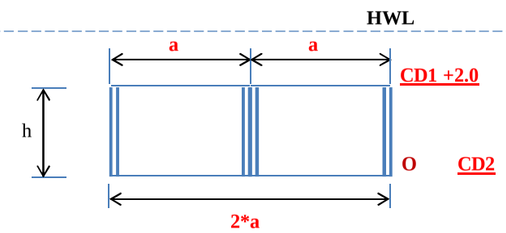
I. Wave Force under Wave Crest

1. Input data:

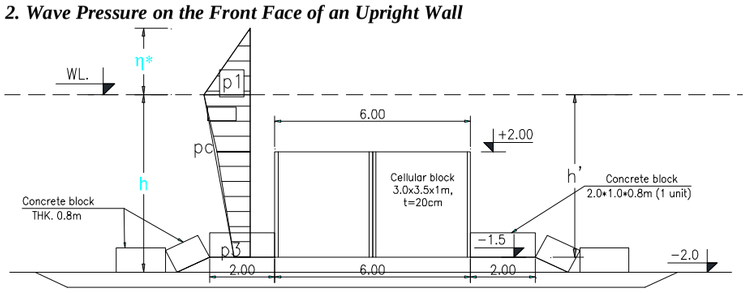
- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	2.0
- Bottom Upright Wall Level (CDL):	-1.5
- Bottom Width of Upright Wall (m):	6.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-2.0
- Significant Wave Height ($H_{1/3}$), m:	3.578
- H_{max}, m:	4.762
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	85.78



Bellow sketch for reference only



2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos b)\, l\, a_1 r_0 g H_D$

At toe of upright wall: $p_3 = p_u = a_3 p_1$

$$l = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad h^* = 0.75(1+\cos b)\, l\, H_D$$

$$a_1 = 0.6+\frac{1}{2}\left[\frac{4ph/L}{\sinh\left(\frac{4ph}{L}\right)}\right]^2 \qquad a_3 = 1+\frac{h'}{h^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years	
β (deg) =	63.333	
cos β:	0.449	
H_D (m):	4.762	
L (m):	85.78	
HWL (CDL):	3.55	
Sea bed Level (CDL):	-2.0	
Crest Level (CDL):	2.0	
h (m):	5.6	
h' (m)	5.05	
ρ_0 (t/m3):	1.025	
g (m/s2):	9.81	
4 πh/L	0.813	
2 πh/L	0.407	
λ	1.000	*Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	5.17
α_1 =	1.003
α_3 =	0.930
(1+cosβ)	1.449
$\alpha_1 \lambda \rho_0 H_D$	4.896
p_1 (t/m2) =	3.55
p_c (at crest level), (t/m2) =	3.47
p_3 (t/m2) =	3.30

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ bottom\ Elev.}$ (t/m) =	11.84

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	23.30

Sliding	**S.F. at CD2 Elev.**	**1.6**

Overturning	$Mp_{at\ O}$	20.98
	$M_{conc.\ cell.\ at\ O}$ (=W*t)	104.86
	S.F. at O	**5.00**

		30 years	
	CD1	+ 2	m
	CD2	-1.5	m
	HWL	**+ 3.55**	m
	a	3	m
	h	3.5	m
	b	2.00	m
	t	0.20	m
	$S_{conc.\ cell}$ (1 cell.)	1.84	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	8.86	t/m
	$S_{rubber\ filling}$ (1 cell.)	4.16	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	14.45	t/m
Upper Layer	Nos. of cellular block	2.00	unit
	x_O	4.50	m
	M_O	104.86	tm/m
Wave	$P_{up\ to\ bottom\ Elev.}$	11.84	t/m
	$y_{p\ upto\ bottom\ Elev.}$	1.771	m
	$Mp_{at\ O}$	20.98	t.m/m

STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*

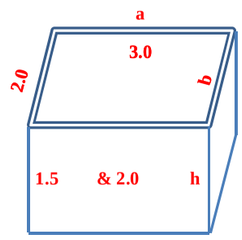
Sand Protection Training Dike - Section for GL upto CD -3.0m

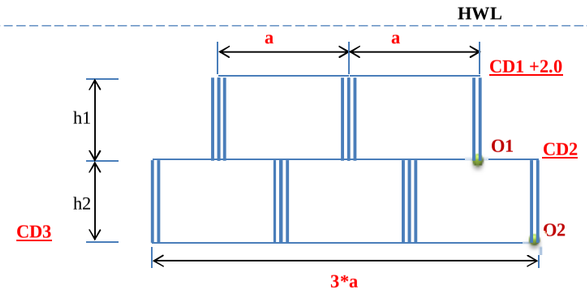
I. Wave Force under Wave Crest

1. Input data:

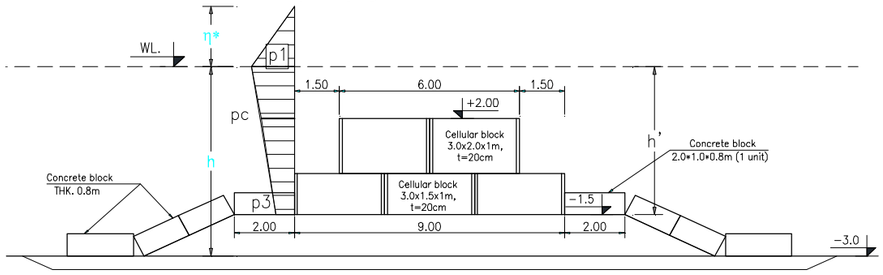
- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	2.0
- Bottom Upright Wall Level (CDL):	-1.5
- Bottom Width of Upright Wall (m):	9.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-3.0
- Significant Wave Height ($H_{1/3}$), m:	4.08
- H_{max}, m:	5.365
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	90.82

Bellow sketch for reference only





2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos b)\, l\, a_1\, r_0 g H_D$

At toe of upright wall: $p_3 = p_u = a_3 p_1$

$$l = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad h^* = 0.75(1+\cos b)\, l\, H_D$$

$$a_1 = 0.6+\frac{1}{2}\left[\frac{4ph/L}{\sinh\left(\frac{4ph}{L}\right)}\right]^2 \qquad a_3 = 1+\frac{h'}{h^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years	
β (deg) =	60.793	
cos β:	0.488	
H_D (m):	5.365	
L (m):	90.82	
HWL (CDL):	3.55	
Sea bed Level (CDL):	-2.5	
Crest Level (CDL):	2.0	
h (m):	6.05	
h' (m)	5.05	
ρ_0 (t/m3):	1.025	
g (m/s2):	9.81	
4 πh/L	0.837	
2 πh/L	0.419	
λ	1.000	*Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	5.99
α_1 =	0.998
α_3 =	0.932
(1+cosβ)	1.488
$\alpha_1 \lambda \rho_0 H_D$	5.488
p_1 (t/m2) =	4.08
p_c (at crest level), (t/m2) =	4.00
p_{O1} (at CD2 level), (t/m2) =	3.89
p_3 (t/m2) =	3.80

5.3. Total wave pressure on Upright Wall

P up to CD2 Elev. (t/m) =	7.69
P up to bottom Elev. (t/m) =	13.65

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
W1con. cell. (total), t/m	13.32
W2con. cell. (total), t/m	14.98

Sliding	**S.F. at CD2 Elev.**	**1.38**
	S.F. at CD3 Elev.	**1.66**

Overturning	$Mp_{at\ O1}$	7.75
	$M_{conc.\ cell.\ at\ O1}$ (=W*t)	59.92
	S.F. at O1	**7.73**
	$Mp_{at\ O2}$	24.17
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	168.77
	S.F. at O2	**6.98**

	30 years	
CD1	+ 2	m
CD2	+ 0	m
CD3	-1.50	m
HWL	**+ 3.55**	m
a	3	m
h1	2	m
h2	1.5	m
b	2.00	m
t	0.20	m
$S_{conc.\ cell}$ (1 cell.)	1.84	m2
$\gamma_{conc.}$	2.4	t/m3
$\gamma'_{conc.}$	1.375	t/m3
$W1_{conc.\ cell}$ (1 cell.)	5.06	t/m
$W2_{conc.\ cell}$ (1 cell.)	3.80	t/m
$S_{rubber\ filling}$ (1 cell.)	4.16	m2
$\gamma_{rubber\ stone}$	2.6	t/m3
$\gamma'_{rubber\ stone}$	1.575	t/m3
void ratio	37%	
$W1_{rubber\ filling}$ (1 cell.)	8.26	t/m
$W2_{rubber\ filling}$ (1 cell.)	6.19	t/m

Upper Layer	Nos. of cellular block	2.00	unit
	x_{O1}	4.50	m
	M_{O1}	59.92	tm/m
Lower Layer	Nos. of cellular block	3.00	unit
	x_{O2}	6.00	m
	M_{O2}	168.77	tm/m

Wave	P up to CD2 Elev.	7.69	t/m
	$y_{p\ upto\ CD2\ Elev.}$	1.01	
	$Mp_{at\ O1}$	7.75	t.m/m
	P up to bottom Elev.	13.65	t/m
	$y_{p\ upto\ bottom\ Elev.}$	1.771	m
	$Mp_{at\ O2}$	24.17	t.m/m

STABILITY CALCULATION DUE TO WAVE FORCE ***(Clause 5.5.2 - OCDI)***

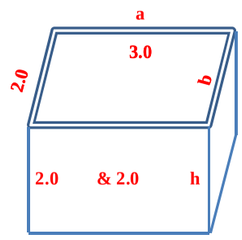
Sand Protection Training Dike - Section for GL upto CD -3.0m

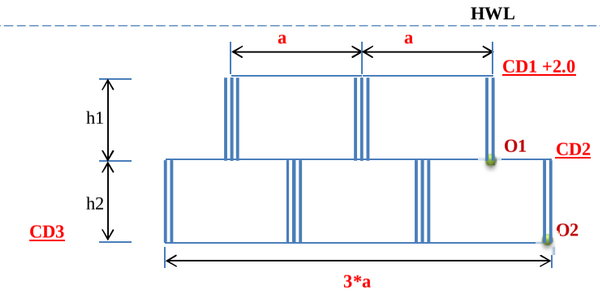
I. Wave Force under Wave Crest

1. Input data:

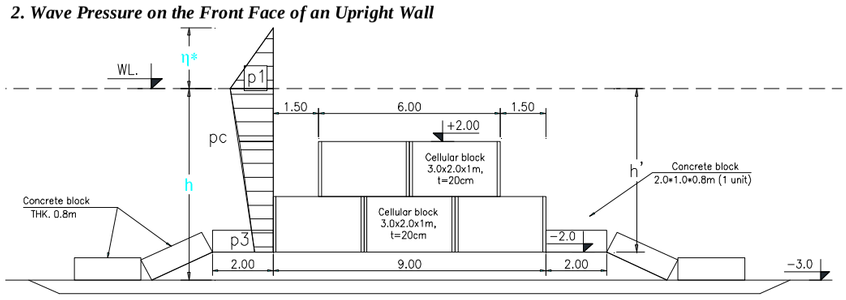
- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	2.0
- Bottom Upright Wall Level (CDL):	-2.0
- Bottom Width of Upright Wall (m):	9.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-3.0
- Significant Wave Height ($H_{1/3}$), m:	4.08
- H_{max}, m:	5.365
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	90.82

Bellow sketch for reference only





2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos b)\, l\, a_1\, r_0 g H_D$

At toe of upright wall: $p_3 = p_u = a_3 p_1$

$$l = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad h^* = 0.75(1+\cos b)\, l\, H_D$$

$$a_1 = 0.6+\frac{1}{2}\left[\frac{4ph/L}{\sinh\left(\frac{4ph}{L}\right)}\right]^2 \qquad a_3 = 1+\frac{h'}{h^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years	
β (deg) =	60.793	
cos β:	0.488	
H_D (m):	5.365	
L (m):	90.82	
HWL (CDL):	3.55	
Sea bed Level (CDL):	-3.0	
Crest Level (CDL):	2.0	
h (m):	6.55	
h' (m)	5.55	
ρ_0 (t/m3):	1.025	
g (m/s2):	9.81	
4 πh/L	0.906	
2 πh/L	0.453	
λ	1.000	*Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	5.99
α_1 =	0.983
α_3 =	0.920
(1+cosβ)	1.488
$\alpha_1 \lambda \rho_0 H_D$	5.405
p_1 (t/m2) =	4.02
p_c (at crest level), (t/m2) =	3.93
p_{O1} (at CD2 level), (t/m2) =	3.82
p_3 (t/m2) =	3.70

5.3. Total wave pressure on Upright Wall

P up to CD2 Elev. (t/m) =	7.51
P up to bottom Elev. (t/m) =	15.26

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
W1con. cell. (total), t/m	13.32
W2con. cell. (total), t/m	19.97

Sliding	**S.F. at CD2 Elev.**	**1.42**
	S.F. at CD3 Elev.	**1.74**

Overturning	Mp at O1	7.58
	$M_{conc.\ cell.\ at\ O1}$ (=W*t)	59.92
	S.F. at O1	**7.90**
	Mp at O2	30.95
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	199.73
	S.F. at O2	**6.45**

	30 years	
CD1	+ 2	m
CD2	+ 0	m
CD3	-+ 2	m
HWL	+ **3.55**	m
a	3	m
h1	2	m
h2	2	m
b	2.00	m
t	0.20	m
$S_{conc.\ cell}$ (1 cell.)	1.84	m2
$\gamma_{conc.}$	2.4	t/m3
$\gamma'_{conc.}$	1.375	t/m3
$W1_{conc.\ cell}$ (1 cell.)	5.06	t/m
$W2_{conc.\ cell}$ (1 cell.)	5.06	t/m
$S_{rubber\ filling}$ (1 cell.)	4.16	m2
$\gamma_{rubber\ stone}$	2.6	t/m3
$\gamma'_{rubber\ stone}$	1.575	t/m3
void ratio	37%	
$W1_{rubber\ filling}$ (1 cell.)	8.26	t/m
$W2_{rubber\ filling}$ (1 cell.)	8.26	t/m
Upper Layer: Nos. of cellular block	2.00	unit
Upper Layer: x_{O1}	4.50	m
Upper Layer: M_{O1}	59.92	tm/m
Lower Layer: Nos. of cellular block	3.00	unit
Lower Layer: x_{O2}	6.00	m
Lower Layer: M_{O2}	199.73	tm/m

Wave	P up to CD2 Elev.	7.51	t/m
	$y_{p\ upto\ CD2\ Elev.}$	1.01	
	Mp at O1	7.58	t.m/m
	P up to bottom Elev.	15.26	t/m
	$y_{p\ upto\ bottom\ Elev.}$	2.028	m
	Mp at O2	30.95	t.m/m

STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*

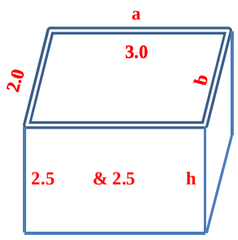
Sand Protection Training Dike - Section for GL upto CD -3.0m

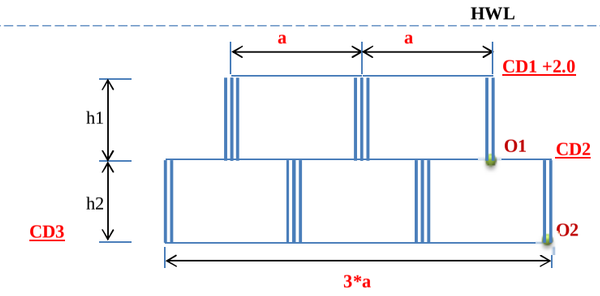
I. Wave Force under Wave Crest

1. Input data:

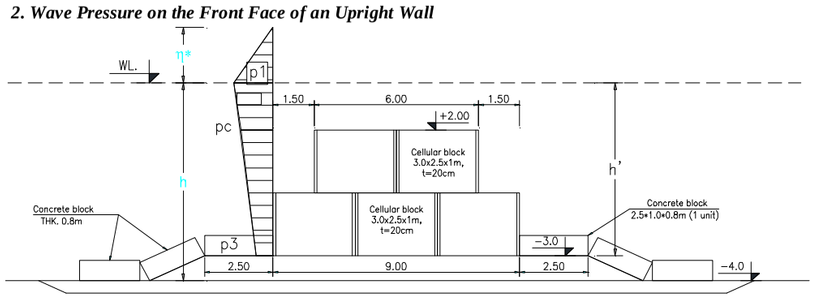
- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	2.0
- Bottom Upright Wall Level (CDL):	-3.0
- Bottom Width of Upright Wall (m):	9.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-4.0
- Significant Wave Height ($H_{1/3}$), m:	4.636
- H_{max}, m:	6.035
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	96.05

Bellow sketch for reference only





2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos b)\, l\, a_1\, r_0 g H_D$

At toe of upright wall: $p_3 = p_u = a_3 p_1$

$$l = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad h^* = 0.75(1+\cos b)\, l\, H_D$$

$$a_1 = 0.6+\frac{1}{2}\left[\frac{4ph/L}{\sinh\left(\frac{4ph}{L}\right)}\right]^2 \qquad a_3 = 1+\frac{h'}{h^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years	
β (deg) =	60.926	
cos β:	0.486	
H_D (m):	6.035	
L (m):	96.05	
HWL (CDL):	3.55	
Sea bed Level (CDL):	-4.0	
Crest Level (CDL):	2.0	
h (m):	7.55	
h' (m)	6.55	
ρ_0 (t/m3):	1.025	
g (m/s2):	9.81	
4 πh/L	0.988	
2 πh/L	0.494	
λ	1.000	*Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	6.73
α_1 =	0.965
α_3 =	0.904
(1+cosβ)	1.486
$\alpha_1 \lambda \rho_0 H_D$	5.968
p_1 (t/m2) =	4.43
p_c (at crest level), (t/m2) =	4.33
p_{O1} (at CD2 level), (t/m2) =	4.17
p_3 (t/m2) =	4.01

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ CD2\ Elev.}$ (t/m) =	10.22
$P_{up\ to\ bottom\ Elev.}$ (t/m) =	20.85

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
W1con. cell. (total), t/m	16.64
W2con. cell. (total), t/m	24.97

Sliding	**S.F. at CD2 Elev.**	**1.30**
	S.F. at CD3 Elev.	**1.60**

Overturning	$Mp_{at\ O1}$	12.91
	$M_{conc.\ cell.\ at\ O1}$ (=W*t)	74.90
	S.F. at O1	**5.80**
	$Mp_{at\ O2}$	53.01
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	249.67
	S.F. at O2	**4.71**

	30 years	
CD1	+ 2	m
CD2	-0.50	m
CD3	-3.00	m
HWL	**+ 3.55**	m
a	3	m
h1	2.5	m
h2	2.5	m
b	2.00	m
t	0.20	m
$S_{conc.\ cell}$ (1 cell.)	1.84	m2
$\gamma_{conc.}$	2.4	t/m3
$\gamma'_{conc.}$	1.375	t/m3
$W1_{conc.\ cell}$ (1 cell.)	6.33	t/m
$W2_{conc.\ cell}$ (1 cell.)	6.33	t/m
$S_{rubber\ filling}$ (1 cell.)	4.16	m2
$\gamma_{rubber\ stone}$	2.6	t/m3
$\gamma'_{rubber\ stone}$	1.575	t/m3
void ratio	37%	
$W1_{rubber\ filling}$ (1 cell.)	10.32	t/m
$W2_{rubber\ filling}$ (1 cell.)	10.32	t/m

Upper Layer	Nos. of cellular block	2.00	unit
	x_{O1}	4.50	m
	M_{O1}	74.90	tm/m
Lower Layer	Nos. of cellular block	3.00	unit
	x_{O2}	6.00	m
	M_{O2}	249.67	tm/m

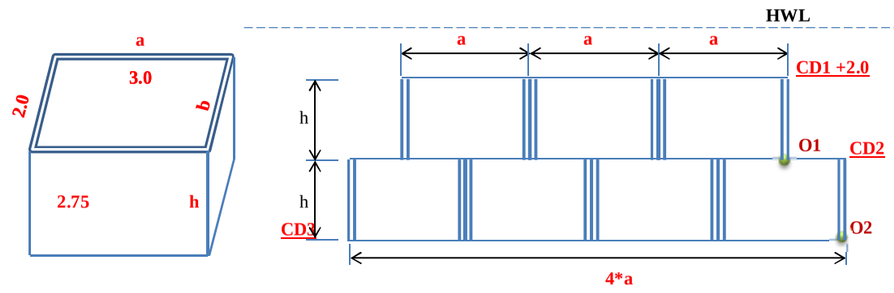
Wave	$P_{up\ to\ CD2\ Elev.}$	10.22	t/m
	$y_{p\ upto\ CD2\ Elev.}$	1.26	
	$Mp_{at\ O1}$	12.91	t.m/m
	$P_{up\ to\ bottom\ Elev.}$	20.85	t/m
	$y_{p\ upto\ bottom\ Elev.}$	2.542	m
	$Mp_{at\ O2}$	53.01	t.m/m

STABILITY CALCULATION DUE TO WAVE FORCE ***(Clause 5.5.2 - OCDI)***

Sand Protection Training Dike - Section for GL upto CD -5.0m

I. Wave Force under Wave Crest

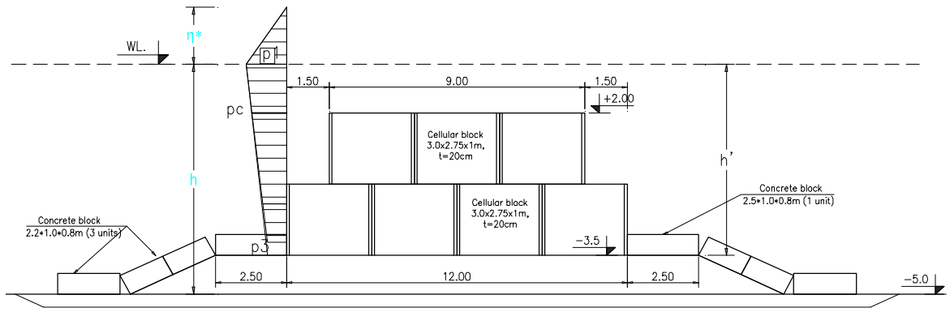
Bellow sketch for reference only



1. Input data:

- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	2.0
- Bottom Upright Wall Level (CDL):	-3.5
- Bottom Width of Upright Wall (m):	12.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-5.0
- Significant Wave Height ($H_{1/3}$), m:	4.96
- H_{max}, m:	6.615
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	100.31

2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos b)\, l\, a_1\, r_0 g H_D$

At toe of upright wall: $p_3 = p_u = a_3 p_1$

$$l = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad h^* = 0.75(1+\cos b)\, l\, H_D$$

$$a_1 = 0.6+\frac{1}{2}\left[\frac{4p\,h/L}{\sinh\left(\frac{4p\,h}{L}\right)}\right]^2 \qquad a_3 = 1+\frac{h'}{h^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years	
β (deg) =	60.947	
cos β:	0.486	
H_D (m):	6.615	
L (m):	100.31	
HWL (CDL):	3.55	
Sea bed Level (CDL):	-5.0	
Crest Level (CDL):	2.0	
h (m):	8.55	
h' (m)	7.05	
ρ_0 (t/m3):	1.025	
g (m/s2):	9.81	
4 πh/L	1.071	
2 πh/L	0.536	
λ	1.000	*Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	7.37
α_1 =	0.946
α_3 =	0.894
(1+cosβ)	1.486
$\alpha_1 \lambda \rho_0 H_D$	6.413
p_1 (t/m2) =	4.76
p_c (at crest level), (t/m2) =	4.65
p_{O1} (at CD2 level), (t/m2) =	4.46
p_3 (t/m2) =	4.26

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ CD2\ Elev.}$ (t/m) =	11.99
$P_{up\ to\ bottom\ Elev.}$ (t/m) =	24.51

II. Safety Factor

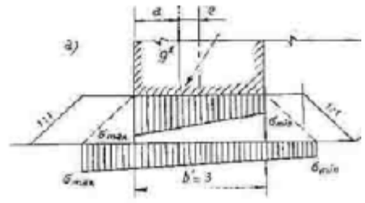
μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	64.08

Sliding	**S.F. at CD2 Elev.**	**1.83**
	S.F. at CD3 Elev.	**2.09**

Overturning	$Mp_{at\ O1}$	16.66
	$M_{conc.\ cell.\ at\ O1}$ (=W*t)	123.58
	S.F. at O1	**7.42**
	$Mp_{at\ O2}$	68.66
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	384.49
	S.F. at O2	**5.60**

		30 years	
	CD1	+ 2	m
	CD2	-0.8	m
	CD3	-3.5	m
	HWL	+ **3.55**	m
	a	3	m
	h	2.75	m
	b	2.00	m
	t	0.20	m
	$S_{conc.\ cell}$ (1 cell.)	1.84	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	6.96	t/m
	$S_{rubber\ filling}$ (1 cell.)	4.16	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	11.35	t/m
Upper Layer	Nos. of cellular block	3.00	unit
	x_{O1}	4.50	m
	M_{O1}	123.58	tm/m
Lower Layer	Nos. of cellular block	4.00	unit
	x_{O2}	6.00	m
	M_{O2}	384.49	tm/m
Wave	$P_{up\ to\ CD2\ Elev.}$	11.99	t/m
	$y_{p\ upto\ CD2\ Elev.}$	1.39	
	$Mp_{at\ O1}$	16.66	t.m/m
	$P_{up\ to\ bottom\ Elev.}$	24.51	t/m
	$y_{p\ upto\ bottom\ Elev.}$	2.801	m
	$Mp_{at\ O2}$	68.66	t.m/m

Bearing capacity of soft soil under foundation



a = 4.93 m

b = 12 m

b/3 = 4 m

Checking condition a ≥ b/3: **OK**

e = 1.07 m

–(–) ruberstone = 6.0 kg/cm²

σ_{max} = 8.20 t/m² = 0.82 kg/cm² **OK**

σ_{min} = 2.48 t/m² = 0.25 kg/cm² **OK**

—— soft soil = 2.0 kg/cm²

b' = 12 m

hn = 1.5 m

γ'^{tc}_{k} 1.575 t/m3

σ'_{max} = 8.92 t/m² = 0.89 kg/cm² **OK**

σ'_{min} = 4.35 t/m² = 0.43 kg/cm² **OK**

9 STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - CASE B-2 (HWL)

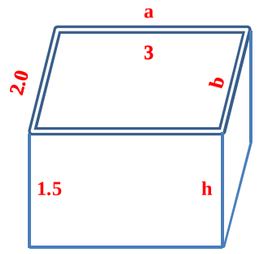
D. STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - Section for GL upto CD 0.0m

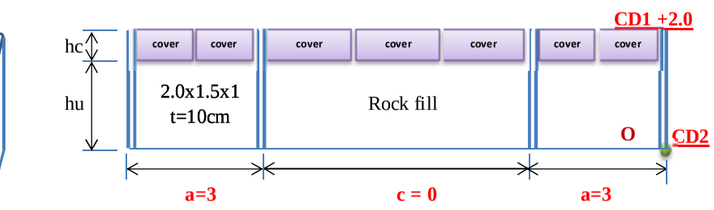
(Clause 5.5.2 - OCDI)

I. Wave Force under Wave Crest

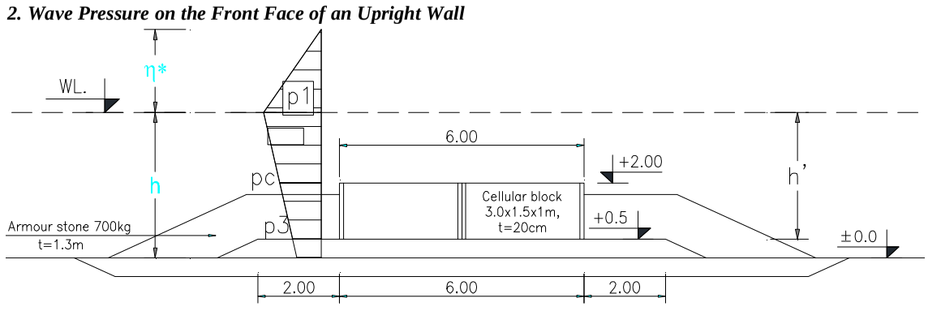
1. Input data:

- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	2.0
- Bottom Upright Wall Level (CDL):	0.5
- Bottom Width of Upright Wall (m):	6.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	0.0
- Significant Wave Height ($H_{1/3}$), m:	2.665
- H_{max}, m:	3.821
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	77.14





2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^5\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30	
β (deg) =	68.52	
cos β:	0.366	
H_D (m):	3.821	
L (m):	77.14	
HWL (CDL):	3.55	
Sea bed Level (CDL):	0.0	
Crest Level (CDL):	2.0	
h (m):	3.55	
h' (m)	3.05	
ρ_0 (t/m3):	1.025	
g (m/s2):	9.81	
4 πh/L	0.578	
2 πh/L	0.289	
λ	1.000	*Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	3.92
α_1 =	1.048
α_3 =	0.965
(1+cosβ)	1.366
$\alpha_1 \lambda \rho_0 H_D$	4.104
p_1 (t/m2) =	2.80
p_c (at crest level), (t/m2) =	2.75
p_3 (t/m2) =	2.71

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ bottom\ Elev.}$ (t/m) =	4.09

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	7.92
Wconc. cover (total), t/m	3.58
$W_{core\ ruble\ at\ bottom}$, t/m	0.00

Sliding	**S.F. at bottom Elev.**	**2.25**

Overturning	$Mp_{at\ O}$	3.08
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	55.09
	S.F. at O	**17.89**

	30 years		
CD1	+ 2	m	
CD2	+ 0.5	m	
HWL	**+ 3.55**	m	
a	3	m	
h	1.5	m	
hu	1.00	m	
b	2.00	m	
t	0.20	m	
c	0.00	m	
hc	0.50	m	
$a_{c\ side}$	2.6	m	
$a_{c\ center}$	0.00	m	
$S_{conc.\ cell}$ (1 cell.)	1.84	m2	
$\gamma_{conc.}$	2.4	t/m3	
$\gamma'_{conc.}$	1.375	t/m3	
$W_{conc.\ cell}$ (1 cell.)	3.80	t/cell.	
$S_{rubber\ filling}$ (1 cell.)	4.16	m2	
$\gamma_{rubber\ stone}$	2.6	t/m3	
$\gamma'_{rubber\ stone}$	1.575	t/m3	
void ratio	37%		
$W_{rubber\ filling}$ (1 cell.)	4.13	t/cell.	
$W_{conc.\ cover\ side}$	1.79	t/m	
$W_{conc.\ cover\ center}$	0.00	t/m	
$W_{core\ ruble\ at\ bottom}$	0.00	t/m	
Upper Layer: Nos. of cellular block	2.00	unit	
Upper Layer: x_{O1}	3.00	m	
Upper Layer: M_{O1}	55.09	tm/m	
Wave: $P_{up\ to\ bottom\ Elev.}$	4.09	t/m	
Wave: $y_{p\ upto\ bottom\ Elev.}$	0.752	m	
Wave: $Mp_{at\ O2}$	3.08	t.m/m	

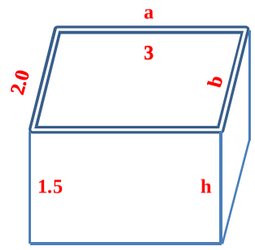
E. STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - Section for GL upto CD -1.0m

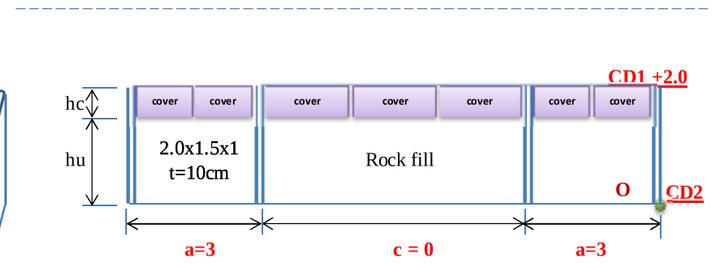
(Clause 5.5.2 - OCDI)

I. Wave Force under Wave Crest

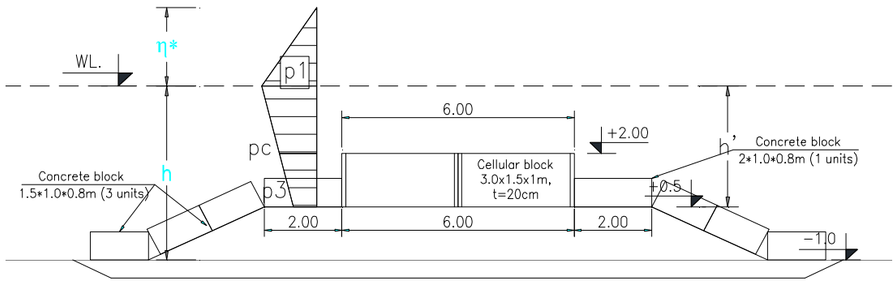
1. Input data:

- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	2.0
- Bottom Upright Wall Level (CDL):	0.5
- Bottom Width of Upright Wall (m):	6.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-1.0
- Significant Wave Height ($H_{1/3}$), m:	3.084
- H_{max}, m:	4.234
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	81.06





2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30	
β (deg) =	68.35	
cos β:	0.369	
H_D (m):	4.234	
L (m):	81.06	
HWL (CDL):	3.55	
Sea bed Level (CDL):	-1.0	
Crest Level (CDL):	2.0	
h (m):	4.55	
h' (m)	3.05	
ρ_0 (t/m3):	1.025	
g (m/s2):	9.81	
4 πh/L	0.705	
2 πh/L	0.353	
λ	1.000	*Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	4.35
α_1 =	1.025
α_3 =	0.960
(1+cosβ)	1.369
$\alpha_1 \lambda \rho_0 H_D$	4.447
p_1 (t/m2) =	3.04
p_c (at crest level), (t/m2) =	2.98
p_3 (t/m2) =	2.92

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ bottom\ Elev.}$ (t/m) =	4.43

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	7.92
Wconc. cover (total), t/m	3.58
$W_{core\ ruble\ at\ bottom}$, t/m	0.00

Sliding	**S.F. at bottom Elev.**	**2.08**

Overturning	$Mp_{at\ O}$	3.33
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	55.09
	S.F. at O	**16.53**

	30 years		
CD1	+ 2	m	
CD2	+ 0.5	m	
HWL	**+ 3.55**	m	
a	3	m	
h	1.5	m	
hu	1.00	m	
b	2.00	m	
t	0.20	m	
c	0.00	m	
hc	0.50	m	
$a_{c\ side}$	2.6	m	
$a_{c\ center}$	0.00	m	
$S_{conc.\ cell}$ (1 cell.)	1.84	m2	
$\gamma_{conc.}$	2.4	t/m3	
$\gamma'_{conc.}$	1.375	t/m3	
$W_{conc.\ cell}$ (1 cell.)	3.80	t/cell.	
$S_{rubber\ filling}$ (1 cell.)	4.16	m2	
$\gamma_{rubber\ stone}$	2.6	t/m3	
$\gamma'_{rubber\ stone}$	1.575	t/m3	
void ratio	37%		
$W_{rubber\ filling}$ (1 cell.)	4.13	t/cell.	
$W_{conc.\ cover\ side}$	1.79	t/m	
$W_{conc.\ cover\ center}$	0.00	t/m	
$W_{core\ ruble\ at\ bottom}$	0.00	t/m	
Upper Layer: Nos. of cellular block	2.00	unit	
Upper Layer: x_{O1}	3.00	m	
Upper Layer: M_{O1}	55.09	tm/m	
Wave: $P_{up\ to\ bottom\ Elev.}$	4.43	t/m	
Wave: $y_{p\ upto\ bottom\ Elev.}$	0.753	m	
Wave: $Mp_{at\ O2}$	3.33	t.m/m	

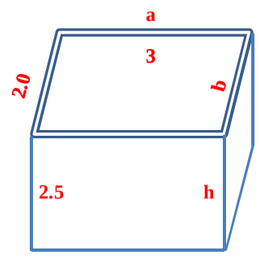
F. STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - Section for GL upto CD -2.0m

(Clause 5.5.2 - OCDI)

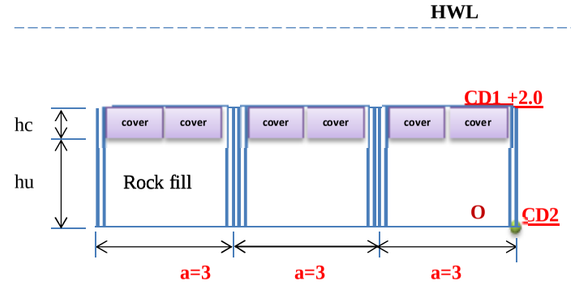
I. Wave Force under Wave Crest

1. Input data:

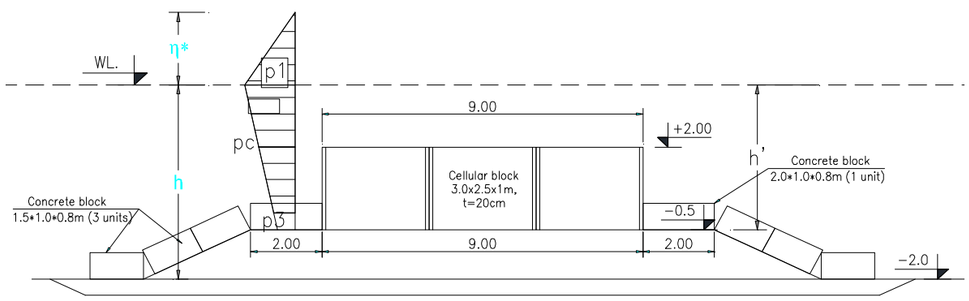
- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	2.0
- Bottom Upright Wall Level (CDL):	-0.5
- Bottom Width of Upright Wall (m):	9.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-2.0
- Significant Wave Height ($H_{1/3}$), m:	3.578
- H_{max}, m:	4.762
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	85.78



Sketch of detail of super structure



2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30
β (deg) =	63.333
cos β:	0.449
H_D (m):	4.762
L (m):	85.78
HWL (CDL):	3.55
Sea bed Level (CDL):	-2.0
Crest Level (CDL):	2.0
h (m):	5.55
h' (m)	4.05
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	0.813
2 πh/L	0.407
λ	1.000 *Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	5.17
α_1 =	1.003
α_3 =	0.944
(1+cosβ)	1.449
$\alpha_1 \lambda \rho_0 H_D$	4.896
p_1 (t/m2) =	3.55
p_c (at crest level), (t/m2) =	3.47
p_3 (t/m2) =	3.35

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ bottom\ Elev.}$ (t/m) =	8.52

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	21.87
Wconc. cover (total), t/m	5.36

Sliding	**S.F. at bottom Elev.**	**2.56**

Overturning	$Mp_{at\ O}$	10.71
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	220.97
	S.F. at O	**20.62**

	30 years	
CD1	+ 2	m
CD2	-0.5	m
HWL	**+ 3.55**	m
a	3	m
h	2.5	m
hu	2.00	m
b	2.00	m
t	0.20	m
hc	0.50	m
a_{inside}	2.6	m
$S_{conc.\ cell}$ (1 cell.)	1.84	m2
$\gamma_{conc.}$	2.4	t/m3
$\gamma'_{conc.}$	1.375	t/m3
$W_{conc.\ cell}$ (1 cell.)	**6.33**	t/cell.
$S_{rubber\ filling}$ (1 cell.)	4.16	m2
$\gamma_{rubber\ stone}$	2.6	t/m3
$\gamma'_{rubber\ stone}$	1.575	t/m3
void ratio	37%	
$W_{rubber\ filling}$ (1 cell.)	**8.26**	t/cell.
$W_{conc.\ cover\ side}$	1.79	t/m

Upper Layer	Nos. of cellular block	3.00	unit
	x_{O1}	4.50	m
	M_{O1}	220.97	tm/m

Wave	$P_{up\ to\ bottom\ Elev.}$	8.52	t/m
	$y_{p\ upto\ bottom\ Elev.}$	1.258	m
	$Mp_{at\ O2}$	10.71	t.m/m

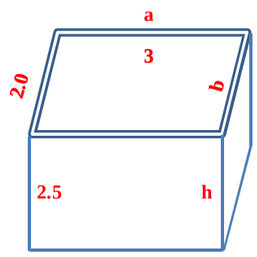
G. STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - Section for GL upto CD -3.0m

(Clause 5.5.2 - OCDI)

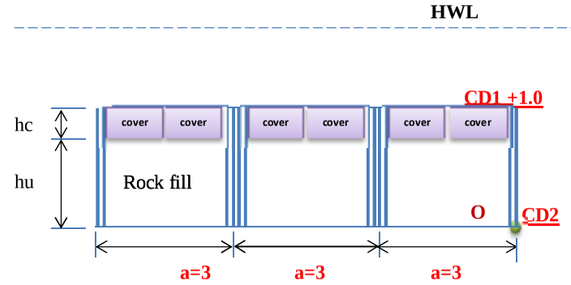
I. Wave Force under Wave Crest

1. Input data:

- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	1.0
- Bottom Upright Wall Level (CDL):	-1.5
- Bottom Width of Upright Wall (m):	9.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-3.0
- Significant Wave Height ($H_{1/3}$), m:	4.08
- H_{max}, m:	5.365
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	90.82

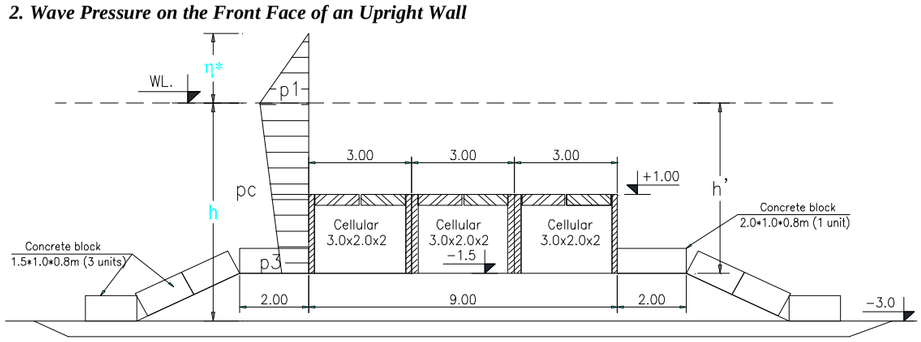


Sketch of detail of super structure



	30 years	
CD1	+ 1	m
CD2	-1.5	m
HWL	**+ 3.55**	m
a	3	m
h	2.5	m
hu	2.00	m
b	2.00	m
t	0.20	m
hc	0.50	m
a_{inside}	2.6	m
$S_{conc.\ cell}$ (1 cell.)	1.84	m2
$\gamma_{conc.}$	2.4	t/m3
$\gamma'_{conc.}$	1.375	t/m3
$W_{conc.\ cell}$ (1 cell.)	**6.33**	t/cell.
$S_{rubber\ filling}$ (1 cell.)	4.16	m2
$\gamma_{rubber\ stone}$	2.6	t/m3
$\gamma'_{rubber\ stone}$	1.575	t/m3
void ratio	37%	
$W_{rubber\ filling}$ (1 cell.)	**8.26**	t/cell.
$W_{conc.\ cover\ side}$	1.79	t/m

2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30	
β (deg) =	60.793	
cos β:	0.488	
H_D (m):	5.365	
L (m):	90.82	
HWL (CDL):	3.55	
Sea bed Level (CDL):	-3.0	
Crest Level (CDL):	1.0	
h (m):	6.55	
h' (m)	5.05	
ρ_0 (t/m3):	1.025	
g (m/s2):	9.81	
4 πh/L	0.906	
2 πh/L	0.453	
λ	1.000	*Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	5.99
α_1 =	0.983
α_3 =	0.927
(1+cosβ)	1.488
$\alpha_1 \lambda \rho_0 H_D$	5.405
p_1 (t/m2) =	4.02
p_c (at crest level), (t/m2) =	3.87
p_3 (t/m2) =	3.73

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ bottom\ Elev.}$ (t/m) =	9.50

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	21.87
Wconc. cover (total), t/m	5.36

Sliding	**S.F. at bottom Elev.**	**2.29**

Overturning	$Mp_{at\ O}$	11.95
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	220.97
	S.F. at O	**18.49**

Upper Layer	Nos. of cellular block	3.00	unit
	x_{O1}	4.50	m
	M_{O1}	220.97	tm/m

Wave	$P_{up\ to\ bottom\ Elev.}$	9.50	t/m
	$y_{p\ upto\ bottom\ Elev.}$	1.258	m
	$Mp_{at\ O2}$	11.95	t.m/m

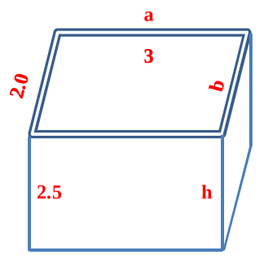
G. STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - Section for GL upto CD -3.0m

(Clause 5.5.2 - OCDI)

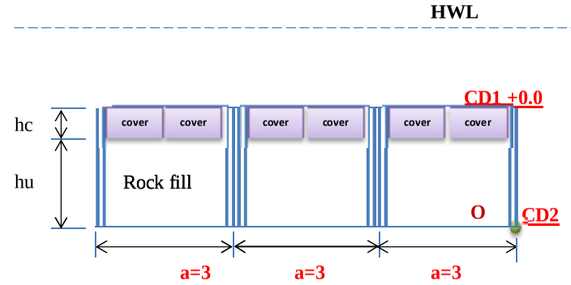
I. Wave Force under Wave Crest

1. Input data:

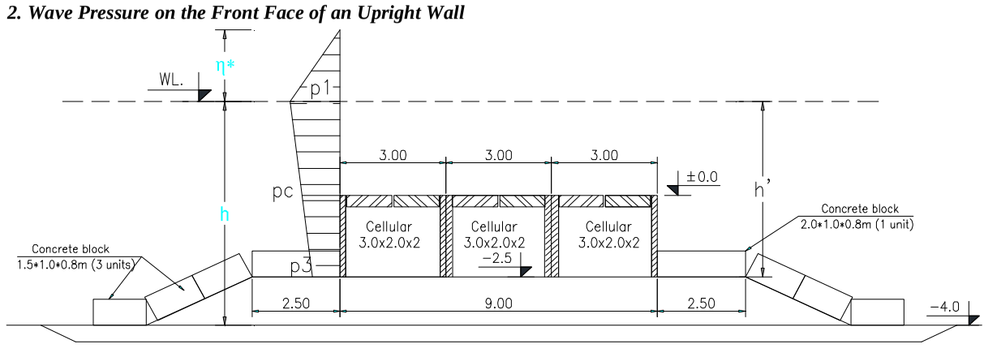
- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**0.43**
- Crest Level (CDL):	0.0
- Bottom Upright Wall Level (CDL):	-2.5
- Bottom Width of Upright Wall (m):	9.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-4.0
- Significant Wave Height ($H_{1/3}$), m:	4.636
- H_{max}, m:	6.035
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	96.05



Sketch of detail of super structure



2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30	
β (deg) =	60.926	
cos β:	0.486	
H_D (m):	6.035	
L (m):	96.05	
HWL (CDL):	0.43	
Sea bed Level (CDL):	-4.0	
Crest Level (CDL):	0.0	
h (m):	4.43	
h' (m)	2.93	
ρ_0 (t/m3):	1.025	
g (m/s2):	9.81	
4 πh/L	0.580	
2 πh/L	0.290	
λ	1.000	*Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	6.73
α_1 =	1.048
α_3 =	0.973
(1+cosβ)	1.486
$\alpha_1 \lambda \rho_0 H_D$	6.480
p_1 (t/m2) =	4.81
p_c (at crest level), (t/m2) =	4.80
p_3 (t/m2) =	4.69

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ bottom\ Elev.}$ (t/m) =	11.85

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	21.87
Wconc. cover (total), t/m	5.36

Sliding	**S.F. at bottom Elev.**	**1.84**

Overturning	$Mp_{at\ O}$	14.87
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	220.97
	S.F. at O	**14.86**

	30 years	
CD1	+ 0	m
CD2	-2.5	m
HWL	**+ 0.43**	m
a	3	m
h	2.5	m
hu	2.00	m
b	2.00	m
t	0.20	m
hc	0.50	m
a_{inside}	2.6	m
$S_{conc.\ cell}$ (1 cell.)	1.84	m2
$\gamma_{conc.}$	2.4	t/m3
$\gamma'_{conc.}$	1.375	t/m3
$W_{conc.\ cell}$ (1 cell.)	**6.33**	t/cell.
$S_{rubber\ filling}$ (1 cell.)	4.16	m2
$\gamma_{rubber\ stone}$	2.6	t/m3
$\gamma'_{rubber\ stone}$	1.575	t/m3
void ratio	37%	
$W_{rubber\ filling}$ (1 cell.)	**8.26**	t/cell.
$W_{conc.\ cover\ side}$	1.79	t/m

Upper Layer	Nos. of cellular block	3.00	unit
	x_{O1}	4.50	m
	M_{O1}	220.97	tm/m

Wave	$P_{up\ to\ bottom\ Elev.}$	11.85	t/m
	$y_{p\ upto\ bottom\ Elev.}$	1.255	m
	$Mp_{at\ O2}$	14.87	t.m/m

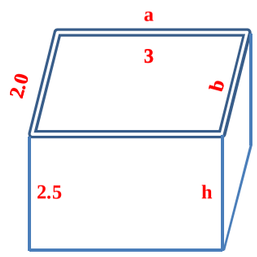
G. STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - Section for GL upto CD -3.0m

(Clause 5.5.2 - OCDI)

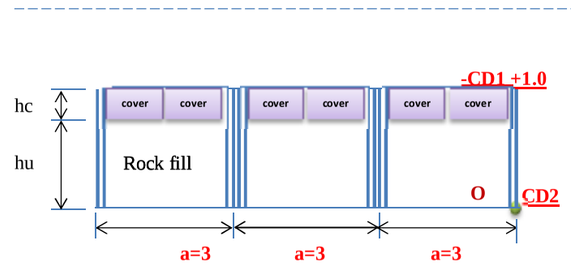
I. Wave Force under Wave Crest

1. Input data:

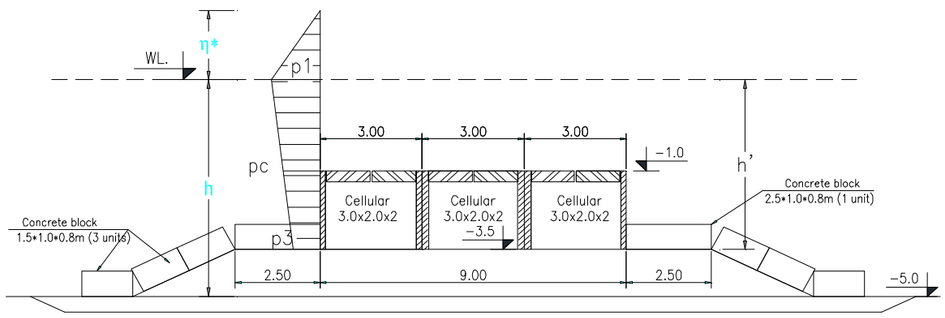
- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	-1.0
- Bottom Upright Wall Level (CDL):	-3.5
- Bottom Width of Upright Wall (m):	9.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-5.0
- Significant Wave Height ($H_{1/3}$), m:	4.96
- H_{max}, m:	6.615
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	100.31



Sketch of detail of super structure



2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30
β (deg) =	60.947
cos β:	0.486
H_D (m):	6.615
L (m):	100.31
HWL (CDL):	3.55
Sea bed Level (CDL):	-5.0
Crest Level (CDL):	-1.0
h (m):	8.55
h' (m)	7.05
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.071
2 πh/L	0.536
λ	1.000 *Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	7.37
α_1 =	0.946
α_3 =	0.894
(1+cosβ)	1.486
α_1 λ ρ_0 H_D	6.413
p_1 (t/m2) =	4.76
p_c (at crest level), (t/m2) =	4.44
p_3 (t/m2) =	4.26

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ bottom\ Elev.}$ (t/m) =	10.87

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	21.87
Wconc. cover (total), t/m	5.36

Sliding	**S.F. at bottom Elev.**	**2.00**

Overturning	$Mp_{at\ O}$	13.69
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	220.97
	S.F. at O	**16.15**

	30 years	
CD1	-1	m
CD2	-3.5	m
HWL	**+ 3.55**	m
a	3	m
h	2.5	m
hu	2.00	m
b	2.00	m
t	0.20	m
hc	0.50	m
a_{inside}	2.6	m
$S_{conc.\ cell}$ (1 cell.)	1.84	m2
$\gamma_{conc.}$	2.4	t/m3
$\gamma'_{conc.}$	1.375	t/m3
$W_{conc.\ cell}$ (1 cell.)	**6.33**	t/cell.
$S_{rubber\ filling}$ (1 cell.)	4.16	m2
$\gamma_{rubber\ stone}$	2.6	t/m3
$\gamma'_{rubber\ stone}$	1.575	t/m3
void ratio	37%	
$W_{rubber\ filling}$ (1 cell.)	**8.26**	t/cell.
$W_{conc.\ cover\ side}$	1.79	t/m

Upper Layer	Nos. of cellular block	3.00	unit
	x_{O1}	4.50	m
	M_{O1}	220.97	tm/m

Wave	$P_{up\ to\ bottom\ Elev.}$	10.87	t/m
	$y_{p\ upto\ bottom\ Elev.}$	1.259	m
	$Mp_{at\ O2}$	13.69	t.m/m

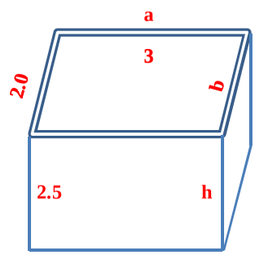
G. STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - Section for GL upto CD -3.0m

(Clause 5.5.2 - OCDI)

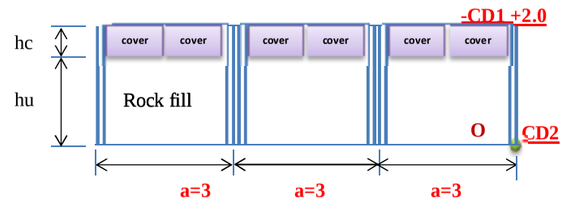
I. Wave Force under Wave Crest

1. Input data:

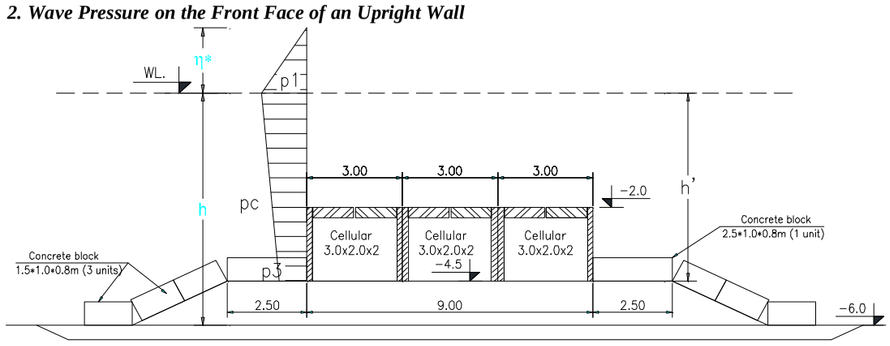
- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	-2.0
- Bottom Upright Wall Level (CDL):	-4.5
- Bottom Width of Upright Wall (m):	9.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-6.0
- Significant Wave Height ($H_{1/3}$), m:	5.01
- H_{max}, m:	7.308
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	105.13



Sketch of detail of super structure



2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30
β (deg) =	60.772
cos β:	0.488
H_D (m):	7.308
L (m):	105.13
HWL (CDL):	3.55
Sea bed Level (CDL):	-6.0
Crest Level (CDL):	-2.0
h (m):	9.55
h' (m)	8.05
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.142
2 πh/L	0.571
λ	1.000 *Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	8.16
α_1 =	0.930
α_3 =	0.879
(1+cosβ)	1.488
$\alpha_1 \lambda \rho_0 H_D$	6.963
p_1 (t/m2) =	5.18
p_c (at crest level), (t/m2) =	4.75
p_3 (t/m2) =	4.56

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ bottom\ Elev.}$ (t/m) =	11.63

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	21.87
Wconc. cover (total), t/m	5.36

Sliding	**S.F. at bottom Elev.**	**1.87**

Overturning	$Mp_{at\ O}$	14.64
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	220.97
	S.F. at O	**15.09**

	30 years	
CD1	-2	m
CD2	-4.5	m
HWL	**+ 3.55**	m
a	3	m
h	2.5	m
hu	2.00	m
b	2.00	m
t	0.20	m
hc	0.50	m
a_{inside}	2.6	m
$S_{conc.\ cell}$ (1 cell.)	1.84	m2
$\gamma_{conc.}$	2.4	t/m3
$\gamma'_{conc.}$	1.375	t/m3
$W_{conc.\ cell}$ (1 cell.)	**6.33**	t/cell.
$S_{rubber\ filling}$ (1 cell.)	4.16	m2
$\gamma_{rubber\ stone}$	2.6	t/m3
$\gamma'_{rubber\ stone}$	1.575	t/m3
void ratio	37%	
$W_{rubber\ filling}$ (1 cell.)	**8.26**	t/cell.
$W_{conc.\ cover\ side}$	1.79	t/m

Upper Layer	Nos. of cellular block	3.00	unit
	x_{O1}	4.50	m
	M_{O1}	220.97	tm/m

Wave	$P_{up\ to\ bottom\ Elev.}$	11.63	t/m
	$y_{p\ upto\ bottom\ Elev.}$	1.259	m
	$Mp_{at\ O2}$	14.64	t.m/m

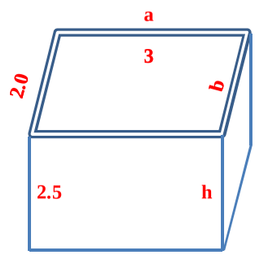
G. STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - Section for GL upto CD -3.0m

(Clause 5.5.2 - OCDI)

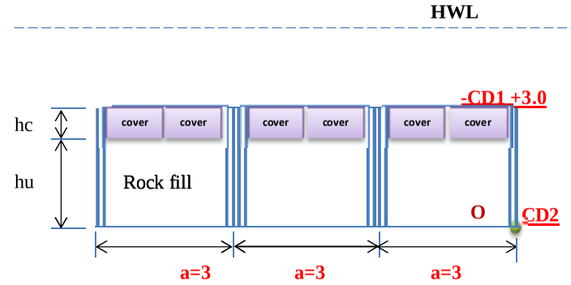
I. Wave Force under Wave Crest

1. Input data:

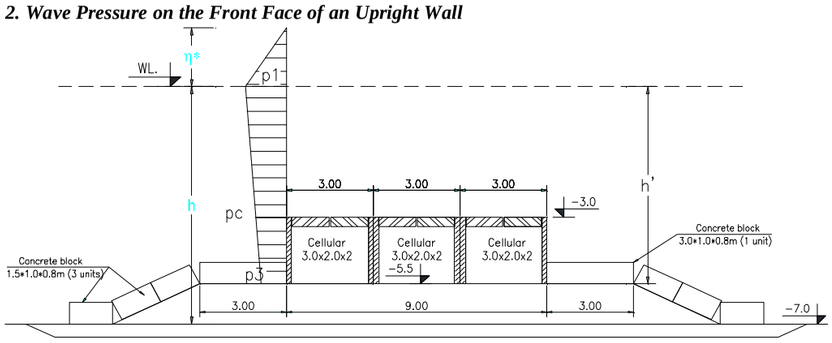
- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	-3.0
- Bottom Upright Wall Level (CDL):	-5.5
- Bottom Width of Upright Wall (m):	9.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-7.0
- Significant Wave Height ($H_{1/3}$), m:	5.067
- H_{max}, m:	7.931
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	109.23



Sketch of detail of super structure



2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30
β (deg) =	60.21
cos β:	0.497
H_D (m):	7.931
L (m):	109.23
HWL (CDL):	3.55
Sea bed Level (CDL):	-7.0
Crest Level (CDL):	-3.0
h (m):	10.55
h' (m)	9.05
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.214
2 πh/L	0.607
λ	1.000 *Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	8.90
α_1 =	0.913
α_3 =	0.863
(1+cosβ)	1.497
α_1 λ ρ_0 H_D	7.421
p_1 (t/m2) =	5.55
p_c (at crest level), (t/m2) =	5.00
p_3 (t/m2) =	4.79

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ bottom\ Elev.}$ (t/m) =	12.25

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	21.87
Wconc. cover (total), t/m	5.36

Sliding	**S.F. at bottom Elev.**	**1.78**

Overturning	$Mp_{at\ O}$	15.42
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	220.97
	S.F. at O	**14.33**

	30 years	
CD1	-3	m
CD2	-5.5	m
HWL	**+ 3.55**	m
a	3	m
h	2.5	m
hu	2.00	m
b	2.00	m
t	0.20	m
hc	0.50	m
a_{inside}	2.6	m
$S_{conc.\ cell}$ (1 cell.)	1.84	m2
$\gamma_{conc.}$	2.4	t/m3
$\gamma'_{conc.}$	1.375	t/m3
$W_{conc.\ cell}$ (1 cell.)	**6.33**	t/cell.
$S_{rubber\ filling}$ (1 cell.)	4.16	m2
$\gamma_{rubber\ stone}$	2.6	t/m3
$\gamma'_{rubber\ stone}$	1.575	t/m3
void ratio	37%	
$W_{rubber\ filling}$ (1 cell.)	**8.26**	t/cell.
$W_{conc.\ cover\ side}$	1.79	t/m

Upper Layer	Nos. of cellular block	3.00	unit
	x_{O1}	4.50	m
	M_{O1}	220.97	tm/m

Wave	$P_{up\ to\ bottom\ Elev.}$	12.25	t/m
	$y_{p\ upto\ bottom\ Elev.}$	1.259	m
	$Mp_{at\ O2}$	15.42	t.m/m

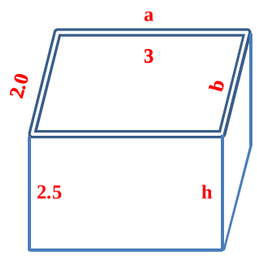
G. STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - Section for GL upto CD -3.0m

(Clause 5.5.2 - OCDI)

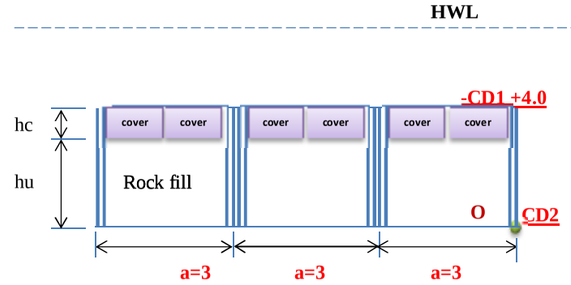
I. Wave Force under Wave Crest

1. Input data:

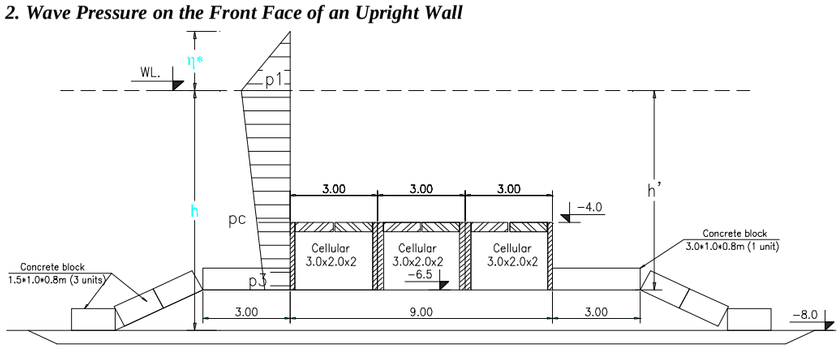
- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	-4.0
- Bottom Upright Wall Level (CDL):	-6.5
- Bottom Width of Upright Wall (m):	9.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-8.0
- Significant Wave Height ($H_{1/3}$), m:	5.096
- H_{max}, m:	8.44
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	112.43



Sketch of detail of super structure



2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30
β (deg) =	60.174
cos β:	0.497
H_D (m):	8.44
L (m):	112.43
HWL (CDL):	3.55
Sea bed Level (CDL):	-8.0
Crest Level (CDL):	-4.0
h (m):	11.55
h' (m)	10.05
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.291
2 πh/L	0.645
λ	1.000 *Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	9.48
α_1 =	0.895
α_3 =	0.846
(1+cosβ)	1.497
α_1 λ ρ_0 H_D	7.743
p_1 (t/m2) =	5.80
p_c (at crest level), (t/m2) =	5.12
p_3 (t/m2) =	4.90

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ bottom\ Elev.}$ (t/m) =	12.53

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	21.87
Wconc. cover (total), t/m	5.36

Sliding	**S.F. at bottom Elev.**	**1.74**

Overturning	$Mp_{at\ O}$	15.78
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	220.97
	S.F. at O	**14.00**

	30 years	
CD1	-4	m
CD2	-6.5	m
HWL	**+ 3.55**	m
a	3	m
h	2.5	m
hu	2.00	m
b	2.00	m
t	0.20	m
hc	0.50	m
a_{inside}	2.6	m
$S_{conc.\ cell}$ (1 cell.)	1.84	m2
$\gamma_{conc.}$	2.4	t/m3
$\gamma'_{conc.}$	1.375	t/m3
$W_{conc.\ cell}$ (1 cell.)	**6.33**	t/cell.
$S_{rubber\ filling}$ (1 cell.)	4.16	m2
$\gamma_{rubber\ stone}$	2.6	t/m3
$\gamma'_{rubber\ stone}$	1.575	t/m3
void ratio	37%	
$W_{rubber\ filling}$ (1 cell.)	**8.26**	t/cell.
$W_{conc.\ cover\ side}$	1.79	t/m

Upper Layer	Nos. of cellular block	3.00	unit
	x_{O1}	4.50	m
	M_{O1}	220.97	tm/m

Wave	$P_{up\ to\ bottom\ Elev.}$	12.53	t/m
	$y_{p\ upto\ bottom\ Elev.}$	1.259	m
	$Mp_{at\ O2}$	15.78	t.m/m

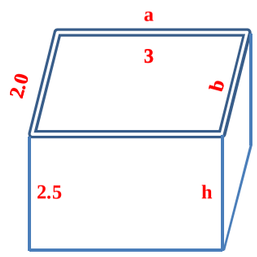
G. STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - Section for GL upto CD -3.0m

(Clause 5.5.2 - OCDI)

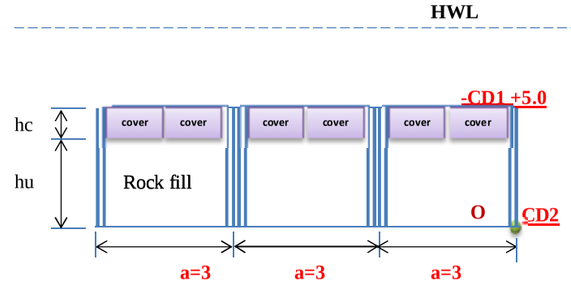
I. Wave Force under Wave Crest

1. Input data:

- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	-5.0
- Bottom Upright Wall Level (CDL):	-7.5
- Bottom Width of Upright Wall (m):	9.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-9.0
- Significant Wave Height ($H_{1/3}$), m:	5.143
- H_{max}, m:	8.522
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	112.94

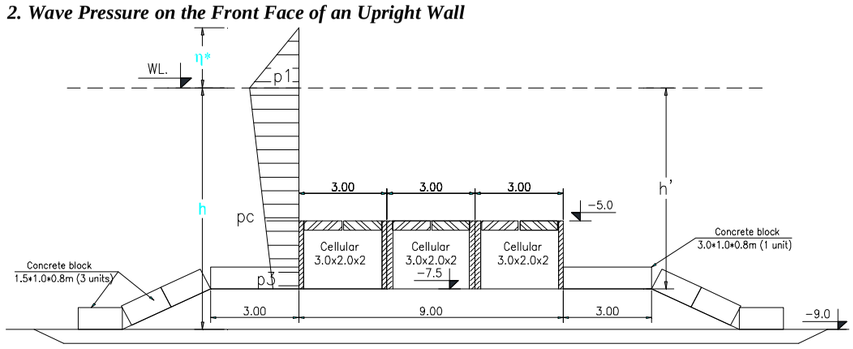


Sketch of detail of super structure



	30 years	
CD1	-5	m
CD2	-7.5	m
HWL	**+ 3.55**	m
a	3	m
h	2.5	m
hu	2.00	m
b	2.00	m
t	0.20	m
hc	0.50	m
a_{inside}	2.6	m
$S_{conc.\ cell}$ (1 cell.)	1.84	m2
$\gamma_{conc.}$	2.4	t/m3
$\gamma'_{conc.}$	1.375	t/m3
$W_{conc.\ cell}$ (1 cell.)	**6.33**	t/cell.
$S_{rubber\ filling}$ (1 cell.)	4.16	m2
$\gamma_{rubber\ stone}$	2.6	t/m3
$\gamma'_{rubber\ stone}$	1.575	t/m3
void ratio	37%	
$W_{rubber\ filling}$ (1 cell.)	**8.26**	t/cell.
$W_{conc.\ cover\ side}$	1.79	t/m

2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\ \_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30	
β (deg) =	59.967	
cos β:	0.500	
H_D (m):	8.522	
L (m):	112.94	
HWL (CDL):	3.55	
Sea bed Level (CDL):	-9.0	
Crest Level (CDL):	-5.0	
h (m):	12.55	
h' (m)	11.05	
ρ_0 (t/m3):	1.025	
g (m/s2):	9.81	
4 πh/L	1.396	
2 πh/L	0.698	
λ	1.000	*Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	9.59
α_1 =	0.871
α_3 =	0.822
(1+cosβ)	1.500
α_1 λ ρ_0 H_D	7.609
p_1 (t/m2) =	5.71
p_c (at crest level), (t/m2) =	4.92
p_3 (t/m2) =	4.69

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ bottom\ Elev.}$ (t/m) =	12.02

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	21.87
Wconc. cover (total), t/m	5.36

Sliding	**S.F. at bottom Elev.**	**1.8**

Overturning	$Mp_{at\ O}$	15.14
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	220.97
	S.F. at O	**14.60**

Upper Layer	Nos. of cellular block	3.00	unit
	x_{O1}	4.50	m
	M_{O1}	220.97	tm/m

Wave	$P_{up\ to\ bottom\ Elev.}$	12.02	t/m
	$y_{p\ upto\ bottom\ Elev.}$	1.260	m
	$Mp_{at\ O2}$	15.14	t.m/m

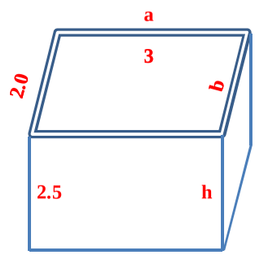
G. STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - Section for GL upto CD -3.0m

(Clause 5.5.2 - OCDI)

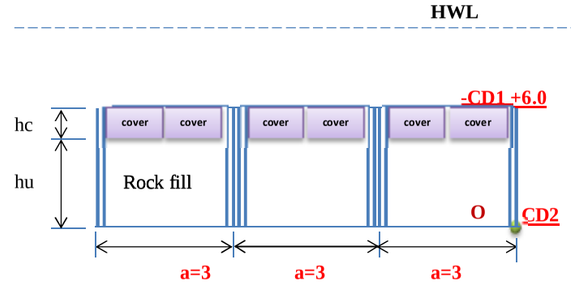
I. Wave Force under Wave Crest

1. Input data:

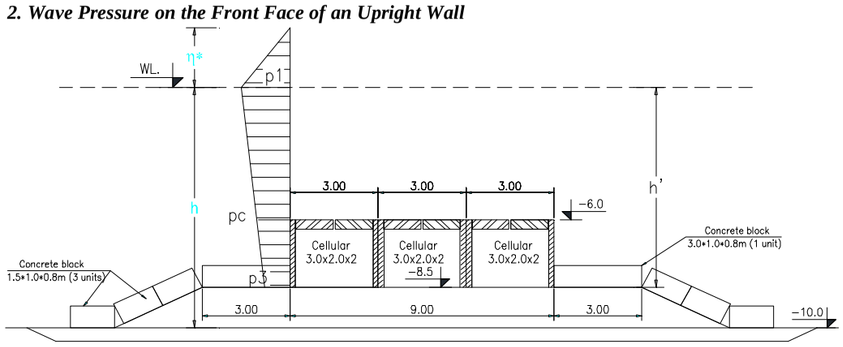
- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	-6.0
- Bottom Upright Wall Level (CDL):	-8.5
- Bottom Width of Upright Wall (m):	9.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-10.0
- Significant Wave Height ($H_{1/3}$), m:	5.058
- H_{max}, m:	8.629
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	113.60



Sketch of detail of super structure



2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30
β (deg) =	60.118
cos β:	0.498
H_D (m):	8.629
L (m):	113.60
HWL (CDL):	3.55
Sea bed Level (CDL):	-10.0
Crest Level (CDL):	-6.0
h (m):	13.55
h' (m)	12.05
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.499
2 πh/L	0.749
λ	1.000 *Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	9.70
α_1 =	0.848
α_3 =	0.798
(1+cosβ)	1.498
α_1 λ ρ_0 H_D	7.504
p_1 (t/m2) =	5.62
p_c (at crest level), (t/m2) =	4.72
p_3 (t/m2) =	4.48

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ bottom\ Elev.}$ (t/m) =	11.51

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	21.87
Wconc. cover (total), t/m	5.36

Sliding	**S.F. at bottom Elev.**	**1.89**

Overturning	$Mp_{at\ O}$	14.51
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	220.97
	S.F. at O	**15.23**

	30 years	
CD1	-6	m
CD2	-8.5	m
HWL	**+ 3.55**	m
a	3	m
h	2.5	m
hu	2.00	m
b	2.00	m
t	0.20	m
hc	0.50	m
a_{inside}	2.6	m
$S_{conc.\ cell}$ (1 cell.)	1.84	m2
$\gamma_{conc.}$	2.4	t/m3
$\gamma'_{conc.}$	1.375	t/m3
$W_{conc.\ cell}$ (1 cell.)	**6.33**	t/cell.
$S_{rubber\ filling}$ (1 cell.)	4.16	m2
$\gamma_{rubber\ stone}$	2.6	t/m3
$\gamma'_{rubber\ stone}$	1.575	t/m3
void ratio	37%	
$W_{rubber\ filling}$ (1 cell.)	**8.26**	t/cell.
$W_{conc.\ cover\ side}$	1.79	t/m

Upper Layer	Nos. of cellular block	3.00	unit
	x_{O1}	4.50	m
	M_{O1}	220.97	tm/m

Wave	$P_{up\ to\ bottom\ Elev.}$	11.51	t/m
	$y_{p\ upto\ bottom\ Elev.}$	1.261	m
	$Mp_{at\ O2}$	14.51	t.m/m

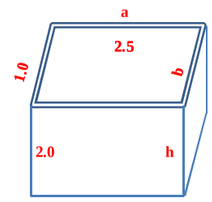
10 STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - CASE A-1 (LWL)

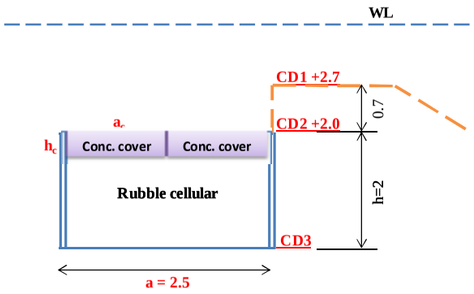
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*
Sand Protection Training Dike - Section for GL upto CD 0.0m

I. Wave Force under Wave Crest

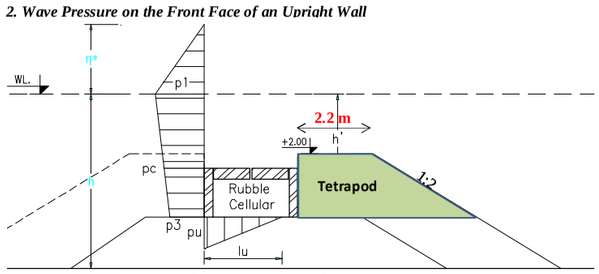
1. Input data:

- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**0.43**
- Crest Level (CDL):	2.0
- Bottom Upright Wall Level (CDL):	0.0
- Bottom Width of Upright Wall (m):	2.5
- Back Fill Level (CDL):	2.7
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	0.0
- Significant Wave Height ($H_{1/3}$), m:	0.93
- H_{max}, m:	3.14
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	70.13





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\ \_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	32.35
cos β:	0.845
H_D (m):	3.14
L (m):	70.13
LWL (CDL):	0.43
Sea bed Level (CDL):	0.0
Crest Level (CDL):	2.0
h (m):	0.43
h' (m)	0.43
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	0.077
2 πh/L	0.039
λ	1.000

5.2. Wave pressure on the front face of an Upright wall

η* =	4.34
α_1 =	1.099
α_3 =	0.999
(1+cosβ)	1.845
$\alpha_1 \lambda \rho_0 H_D$	3.537
p_1 (t/m2) =	3.26
p_c (at crest level), (t/m2) =	3.27
p_3 (t/m2) =	3.26

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	6.53
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	9.10

Horizontal Effect (Passive Pressure)

Pp, t/m	9.43
M_{Pp}, t.m	6.29

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	5.97
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	9.10

Sliding	**S.F. (Normal)**	**0.73**
	S.F. (with back fill layer effect)	**1.71**
Overturning	Mu	0.00
	Mp	6.54
	Mtetrapod	6.29
	Mconc. (=W*t)	7.47
	S.F. (Normal)	**1.14**
	S.F. (with back fill layer effect)	**29.82**

		30 years	
	CD1	+ 2.7	m
	CD2	+ 2	m
	CD3	0	m
	LWL	**+ 0.43**	m
Cellular	**a**	2.5	m
	h	2	m
	b	1	m
	t	0.20	m
Conc. Cover	**h_c**	0.50	m
	a_c	1.00	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.24	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	3.41	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.34	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.26	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	1.88	t/m
	ΣW	**5.97**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	2.2	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	13.23	m2
	Wtetrapod	**9.10**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.0	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	$Kp = \tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	9.43	
	Pp, t/m	**9.43**	
	yp, m	0.67	
	M_{Pp}, t.m	**6.29**	

Rubble Cell	x_{sc}	1.25	m
	M (Sc)	**7.47**	t.m/m

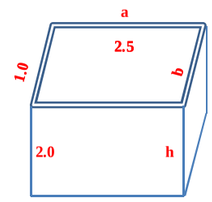
Wave	P	6.53	t/m
	U	0.00	t/m
	y_p	1.001	m
	x_u	2.500	m
	Mp	**6.54**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**6.54**	t.m/m

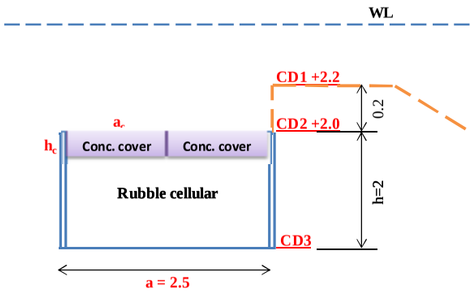
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*
Sand Protection Training Dike - Section for GL upto CD -1.0m

I. Wave Force under Wave Crest

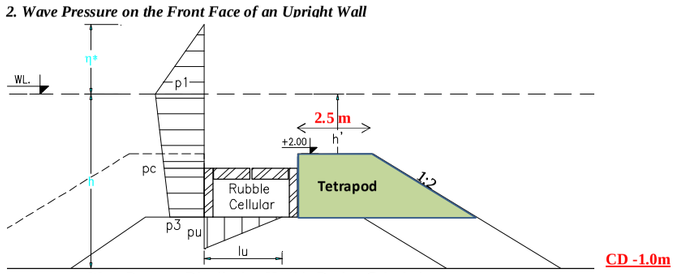
1. Input data:

- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**3.55**
- Crest Level (CDL):	2.0
- Bottom Upright Wall Level (CDL):	0.0
- Bottom Width of Upright Wall (m):	2.5
- Back Fill Level (CDL):	2.2
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-1.0
- Significant Wave Height ($H_{1/3}$), m:	1.48
- H_{max}, m:	3.727
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	76.21





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	57.021
cos β:	0.544
H_D (m):	3.727
L (m):	76.21
LWL (CDL):	3.55
Sea bed Level (CDL):	-1.0
Crest Level (CDL):	2.0
h (m):	4.55
h' (m)	3.55
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	0.750
2 πh/L	0.375
λ	1.000

5.2. Wave pressure on the front face of an Upright wall

η* =	4.32
α_1 =	1.016
α_3 =	0.948
(1+cosβ)	1.544
$\alpha_1 \lambda \rho_0 H_D$	3.881
p_1 (t/m2) =	3.00
p_c (at crest level), (t/m2) =	2.93
p_3 (t/m2) =	2.84

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	5.77
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	7.11

Horizontal Effect (Passive Pressure)

Pp, t/m	9.43
M_{Pp}, t.m	6.29

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	5.97
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	7.11

Sliding	**S.F. (Normal)**	**0.83**
	S.F. (with back fill layer effect)	**1.69**

Overturning	Mu	0.00
	Mp	5.80
	Mtetrapod	6.29
	Mconc. (=W*t)	7.47
	S.F. (Normal)	**1.29**
	S.F. (with back fill layer effect)	**OK**

		30 years	
	CD1	+ 2.2	m
	CD2	+ 2	m
	CD3	0	m
	LWL	**+ 3.55**	m
Cellular	**a**	2.5	m
	h	2	m
	b	1	m
	t	0.20	m
Conc. Cover	**h_c**	0.50	m
	a_c	1.00	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.24	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	3.41	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.34	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.26	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	1.88	t/m
	ΣW	**5.97**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	2.5	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	10.34	m2
	Wtetrapod	**7.11**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.0	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	Kp = $\tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	9.43	
	Pp, t/m	**9.43**	
	yp, m	0.67	
	M_{Pp}, t.m	**6.29**	

Rubble Cell	x_{sc}	1.25	m
	M (Sc)	**7.47**	t.m/m

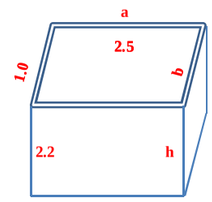
Wave	P	5.77	t/m
	U	0.00	t/m
	y_p	1.005	m
	x_u	2.500	m
	Mp	**5.80**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**5.80**	t.m/m

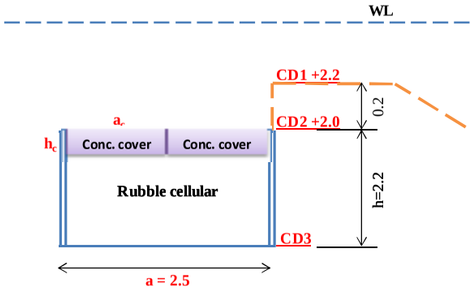
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*
Sand Protection Training Dike - Section for GL upto CD -2.0m

I. Wave Force under Wave Crest

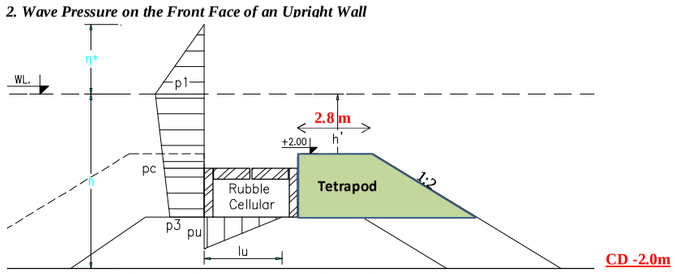
1. Input data:

- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**3.55**
- Crest Level (CDL):	2.0
- Bottom Upright Wall Level (CDL):	-0.2
- Bottom Width of Upright Wall (m):	2.5
- Back Fill Level (CDL):	2.2
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-2.0
- Significant Wave Height ($H_{1/3}$), m:	1.952
- H_{max}, m:	2.87
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	67.12





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^5\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	65.468
cos β:	0.415
H_D (m):	2.87
L (m):	67.12
LWL (CDL):	3.55
Sea bed Level (CDL):	-2.0
Crest Level (CDL):	2.0
h (m):	5.55
h' (m)	3.75
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.039
2 πh/L	0.520
λ	0.999

5.2. Wave pressure on the front face of an Upright wall

η* =	3.04
α_1 =	0.953
α_3 =	0.918
(1+cosβ)	1.415
$\alpha_1 \lambda \rho_0 H_D$	2.801
p_1 (t/m2) =	1.98
p_c (at crest level), (t/m2) =	1.92
p_3 (t/m2) =	1.82

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	4.11
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	8.58

Horizontal Effect (Passive Pressure)

Pp, t/m	11.41
M_{Pp}, t.m	8.37

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	6.56
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	8.58

Sliding	**S.F. (Normal)**	**1.28**
	S.F. (with back fill layer effect)	**2.74**

Overturning	Mu	0.00
	Mp	4.56
	Mtetrapod	8.37
	Mconc. (=W*t)	8.20
	S.F. (Normal)	**1.80**
	S.F. (with back fill layer effect)	**OK**

		30 years	
	CD1	+ 2.2	m
	CD2	+ 2	m
	CD3	-0.2	m
	LWL	+ **3.55**	m
Cellular	**a**	2.5	m
	h	2.2	m
	b	1	m
	t	0.20	m
Conc. Cover	**h_c**	0.50	m
	a_c	1.00	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.24	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	3.75	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.34	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.26	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	2.13	t/m
	ΣW	**6.56**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	2.8	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	12.48	m2
	Wtetrapod	**8.58**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.2	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	$Kp = \tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	10.37	
	Pp, t/m	**11.41**	
	yp, m	0.73	
	M_{Pp}, t.m	**8.37**	

Rubble Cell	x_{sc}	1.25	m
	M (Sc)	**8.20**	t.m/m

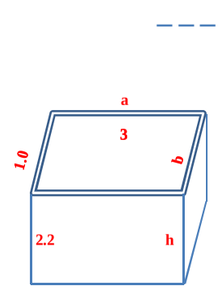
Wave	P	4.11	t/m
	U	0.00	t/m
	y_p	1.109	m
	x_u	2.500	m
	Mp	**4.56**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**4.56**	t.m/m

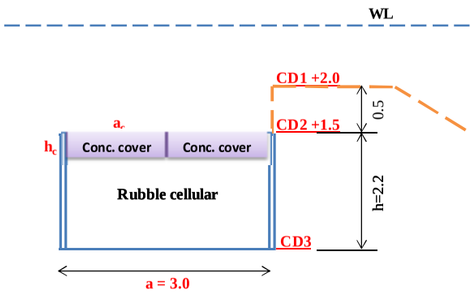
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*
Sand Protection Training Dike - Section for GL upto CD -3.0m

I. Wave Force under Wave Crest

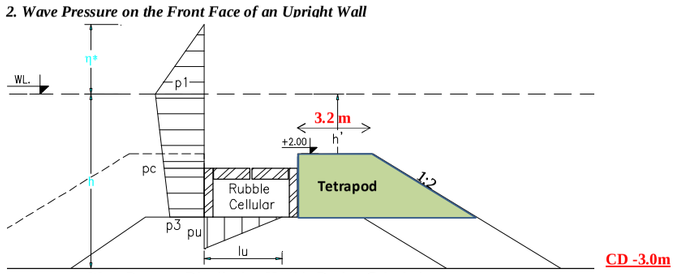
1. Input data:

- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**3.55**
- Crest Level (CDL):	1.5
- Bottom Upright Wall Level (CDL):	-0.7
- Bottom Width of Upright Wall (m):	3.0
- Back Fill Level (CDL):	2.0
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-3.0
- Significant Wave Height ($H_{1/3}$), m:	2.427
- H_{max}, m:	3.343
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	72.30





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	61.332
cos β:	0.480
H_D (m):	3.343
L (m):	72.30
LWL (CDL):	3.55
Sea bed Level (CDL):	-3.0
Crest Level (CDL):	1.5
h (m):	6.55
h' (m)	4.25
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.138
2 πh/L	0.569
λ	0.999

5.2. Wave pressure on the front face of an Upright wall

η* =	3.70
α_1 =	0.930
α_3 =	0.907
(1+cosβ)	1.480
$\alpha_1 \lambda \rho_0 H_D$	3.183
p_1 (t/m2) =	2.35
p_c (at crest level), (t/m2) =	2.25
p_3 (t/m2) =	2.14

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	4.83
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	10.95

Horizontal Effect (Passive Pressure)

Pp, t/m	11.41
M_{Pp}, t.m	8.37

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	7.85
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	10.95

Sliding	**S.F. (Normal)**	**1.30**
	S.F. (with back fill layer effect)	**2.89**

Overturning	Mu	0.00
	Mp	5.35
	Mtetrapod	8.37
	Mconc. (=W*t)	11.77
	S.F. (Normal)	**2.20**
	S.F. (with back fill layer effect)	**OK**

		30 years	
	CD1	+ 2	m
	CD2	+ 1.5	m
	CD3	-0.7	m
	LWL	**+ 3.55**	m
Cellular	**a**	3	m
	h	2.2	m
	b	1	m
	t	0.20	m
Conc. Cover	**h_c**	0.50	m
	a_c	1.25	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.44	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	4.36	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.43	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.56	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	2.63	t/m
	ΣW	**7.85**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	3.2	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	15.93	m2
	Wtetrapod	**10.95**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.2	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	$Kp = \tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	10.37	
	Pp, t/m	**11.41**	
	yp, m	0.73	
	M_{Pp}, t.m	**8.37**	

Rubble Cell	x_{sc}	1.50	m
	M (Sc)	**11.77**	t.m/m

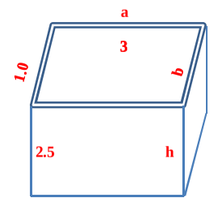
Wave	P	4.83	t/m
	U	0.00	t/m
	y_p	1.109	m
	x_u	3.000	m
	Mp	**5.35**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**5.35**	t.m/m

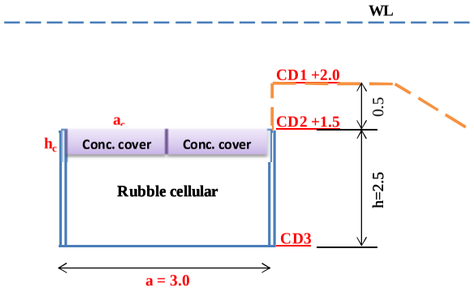
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*
Sand Protection Training Dike - Section for GL upto CD -4.0m

I. Wave Force under Wave Crest

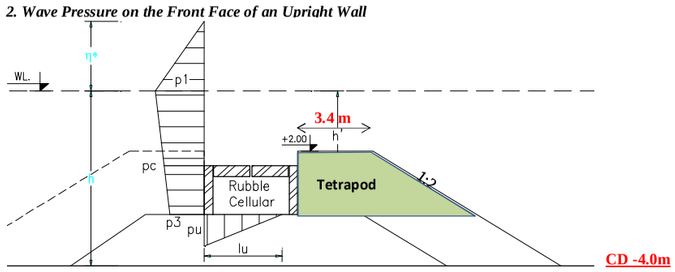
1. Input data:

- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**3.55**
- Crest Level (CDL):	1.5
- Bottom Upright Wall Level (CDL):	-1.0
- Bottom Width of Upright Wall (m):	3.0
- Back Fill Level (CDL):	2.0
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-4.0
- Significant Wave Height ($H_{1/3}$), m:	2.985
- H_{max}, m:	4.012
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	78.98





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\ \_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	60.936
cos β:	0.486
H_D (m):	4.012
L (m):	78.98
LWL (CDL):	3.55
Sea bed Level (CDL):	-4.0
Crest Level (CDL):	1.5
h (m):	7.55
h' (m)	4.55
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.201
2 πh/L	0.601
λ	0.997

5.2. Wave pressure on the front face of an Upright wall

η* =	4.46
α_1 =	0.916
α_3 =	0.906
(1+cosβ)	1.486
$\alpha_1 \lambda \rho_0 H_D$	3.755
p_1 (t/m2) =	2.79
p_c (at crest level), (t/m2) =	2.67
p_3 (t/m2) =	2.53

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	6.50
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	13.20

Horizontal Effect (Passive Pressure)

Pp, t/m	14.73
M_{Pp}, t.m	12.28

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	8.91
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	13.20

Sliding	**S.F. (Normal)**	**1.10**
	S.F. (with back fill layer effect)	**2.52**

Overturning	Mu	0.00
	Mp	8.19
	Mtetrapod	12.28
	Mconc. (=W*t)	13.36
	S.F. (Normal)	**1.63**
	S.F. (with back fill layer effect)	**OK**

		30 years	
	CD1	+ 2	m
	CD2	+ 1.5	m
	CD3	-1	m
	LWL	**+ 3.55**	m
Cellular	**a**	3	m
	h	2.5	m
	b	1	m
	t	0.20	m
Conc. Cover	**h_c**	0.50	m
	a_c	1.25	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.44	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	4.95	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.43	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.56	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	3.10	t/m
	ΣW	**8.91**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	3.4	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	19.20	m2
	Wtetrapod	**13.20**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.5	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	$Kp = \tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	11.78	
	Pp, t/m	**14.73**	
	yp, m	0.83	
	M_{Pp}, t.m	**12.28**	

Rubble Cell	x_{sc}	1.50	m
	M (Sc)	**13.36**	t.m/m

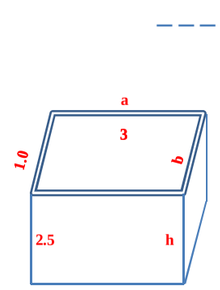
Wave	P	6.50	t/m
	U	0.00	t/m
	y_p	1.262	m
	x_u	3.000	m
	Mp	**8.19**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**8.19**	t.m/m

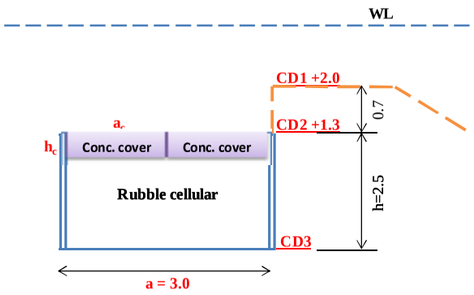
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*
Sand Protection Training Dike - Section for GL upto CD -5.0m

I. Wave Force under Wave Crest

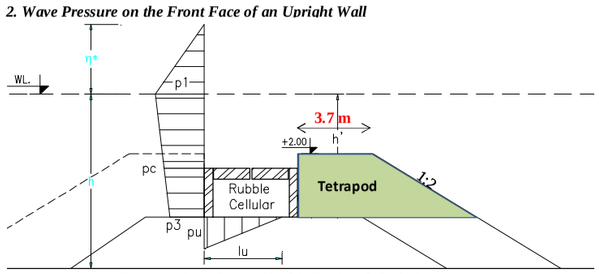
1. Input data:

- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**3.55**
- Crest Level (CDL):	1.3
- Bottom Upright Wall Level (CDL):	-1.2
- Bottom Width of Upright Wall (m):	3.0
- Back Fill Level (CDL):	2.0
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-5.0
- Significant Wave Height ($H_{1/3}$), m:	3.457
- H_{max}, m:	4.595
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	84.32





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	60.681
cos β:	0.490
H_D (m):	4.595
L (m):	84.32
LWL (CDL):	3.55
Sea bed Level (CDL):	-5.0
Crest Level (CDL):	1.3
h (m):	8.55
h' (m)	4.75
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.274
2 πh/L	0.637
λ	0.994

5.2. Wave pressure on the front face of an Upright wall

η* =	5.11
α_1 =	0.899
α_3 =	0.904
(1+cosβ)	1.490
$\alpha_1 \lambda \rho_0 H_D$	4.210
p_1 (t/m2) =	3.14
p_c (at crest level), (t/m2) =	2.99
p_3 (t/m2) =	2.83

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	7.28
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	15.18

Horizontal Effect (Passive Pressure)

Pp, t/m	14.73
M_{Pp}, t.m	12.28

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	8.91
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	15.18

Sliding	**S.F. (Normal)**	**0.98**
	S.F. (with back fill layer effect)	**2.44**

Overturning	Mu	0.00
	Mp	9.19
	Mtetrapod	12.28
	Mconc. (=W*t)	13.36
	S.F. (Normal)	**1.45**
	S.F. (with back fill layer effect)	**OK**

		30 years	
	CD1	+ 2	m
	CD2	+ 1.3	m
	CD3	-1.2	m
	LWL	**+ 3.55**	m
Cellular	**a**	3	m
	h	2.5	m
	b	1	m
	t	0.20	m
Conc. Cover	**h_c**	0.50	m
	a_c	1.25	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.44	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	4.95	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.43	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.56	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	3.10	t/m
	ΣW	**8.91**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	3.7	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	22.08	m2
	Wtetrapod	**15.18**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.5	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	$Kp = \tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	11.78	
	Pp, t/m	**14.73**	
	yp, m	0.83	
	M_{Pp}, t.m	**12.28**	

Rubble Cell	x_{sc}	1.50	m
	M (Sc)	**13.36**	t.m/m

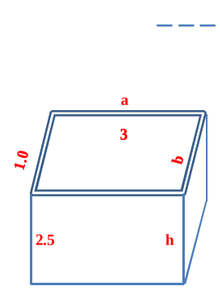
Wave	P	7.28	t/m
	U	0.00	t/m
	y_p	1.261	m
	x_u	3.000	m
	Mp	**9.19**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**9.19**	t.m/m

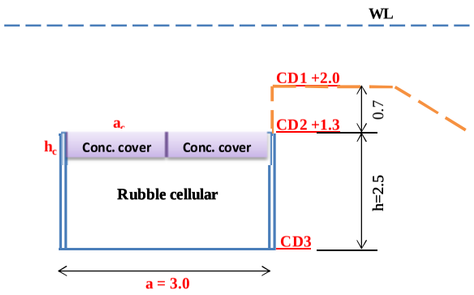
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*
Sand Protection Training Dike - Section for GL upto CD -6.0m

I. Wave Force under Wave Crest

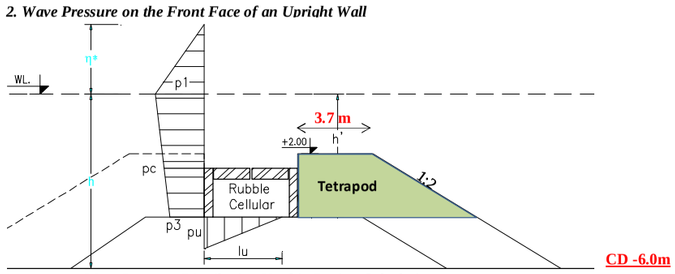
1. Input data:

- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**3.55**
- Crest Level (CDL):	1.3
- Bottom Upright Wall Level (CDL):	-1.2
- Bottom Width of Upright Wall (m):	3.0
- Back Fill Level (CDL):	2.0
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-6.0
- Significant Wave Height ($H_{1/3}$), m:	4.036
- H_{max}, m:	5.296
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	88.23





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^5\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\ \_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	60.37
cos β:	0.494
H_D (m):	5.296
L (m):	88.23
LWL (CDL):	3.55
Sea bed Level (CDL):	-6.0
Crest Level (CDL):	1.3
h (m):	9.55
h' (m)	4.75
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.360
2 πh/L	0.680
λ	0.989

5.2. Wave pressure on the front face of an Upright wall

η* =	5.87
α_1 =	0.879
α_3 =	0.904
(1+cosβ)	1.494
$\alpha_1 \lambda \rho_0 H_D$	4.719
p_1 (t/m2) =	3.53
p_c (at crest level), (t/m2) =	3.36
p_3 (t/m2) =	3.19

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	8.19
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	15.18

Horizontal Effect (Passive Pressure)

Pp, t/m	14.73
M_{Pp}, t.m	12.28

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	8.91
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	15.18

Sliding	**S.F. (Normal)**	**0.87**
	S.F. (with back fill layer effect)	**2.17**

Overturning	Mu	0.00
	Mp	10.33
	Mtetrapod	12.28
	Mconc. (=W*t)	13.36
	S.F. (Normal)	**1.29**
	S.F. (with back fill layer effect)	**OK**

		30 years	
	CD1	+ 2	m
	CD2	+ 1.3	m
	CD3	-1.2	m
	LWL	**+ 3.55**	m
Cellular	**a**	3	m
	h	2.5	m
	b	1	m
	t	0.20	m
Conc. Cover	**h_c**	0.50	m
	a_c	1.25	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.44	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	4.95	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.43	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.56	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	3.10	t/m
	ΣW	**8.91**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	3.7	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	22.08	m2
	Wtetrapod	**15.18**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.5	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	Kp = $\tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	11.78	
	Pp, t/m	**14.73**	
	yp, m	0.83	
	M_{Pp}, t.m	**12.28**	

Rubble Cell	x_{sc}	1.50	m
	M (Sc)	**13.36**	t.m/m

Wave	P	8.19	t/m
	U	0.00	t/m
	y_p	1.261	m
	x_u	3.000	m
	Mp	**10.33**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**10.33**	t.m/m

11 STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - CASE A-2 (LWL)

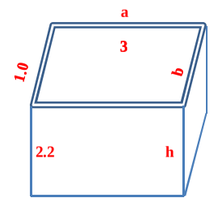
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*

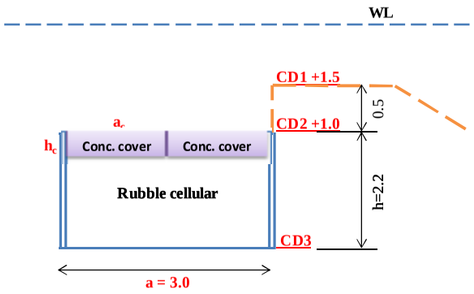
Sand Protection Training Dike - Section for GL upto CD -3.0m

I. Wave Force under Wave Crest

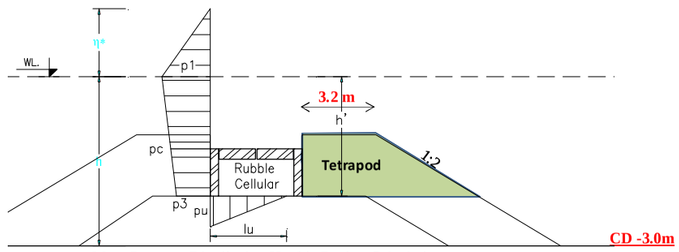
1. Input data:

- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**3.55**
- Crest Level (CDL):	1.0
- Bottom Upright Wall Level (CDL):	-1.2
- Bottom Width of Upright Wall (m):	3.0
- Back Fill Level (CDL):	1.5
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-3.0
- Significant Wave Height ($H_{1/3}$), m:	2.427
- H_{max}, m:	3.343
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	72.30





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	61.332
cos β:	0.480
H_D (m):	3.343
L (m):	72.30
LWL (CDL):	3.55
Sea bed Level (CDL):	-3.0
Crest Level (CDL):	1.0
h (m):	6.55
h' (m)	4.75
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.138
2 πh/L	0.569
λ	1.000

5.2. Wave pressure on the front face of an Upright wall

η* =	3.71
α_1 =	0.930
α_3 =	0.897
(1+cosβ)	1.480
$\alpha_1 \lambda \rho_0 H_D$	3.186
p_1 (t/m2) =	2.36
p_c (at crest level), (t/m2) =	2.23
p_3 (t/m2) =	2.11

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	4.77
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	10.95

Horizontal Effect (Passive Pressure)

Pp, t/m	11.41
M_{Pp}, t.m	8.37

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	7.85
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	10.95

Sliding	**S.F. (Normal)**	**1.31**
	S.F. (with back fill layer effect)	**2.92**

Overturning	Mu	0.00
	Mp	5.30
	Mtetrapod	8.37
	Mconc. (=W*t)	11.77
	S.F. (Normal)	**2.22**
	S.F. (with back fill layer effect)	**OK**

		30 years	
	CD1	+ 1.5	m
	CD2	+ 1	m
	CD3	-1.20	m
	LWL	**+ 3.55**	m
Cellular	**a**	3	m
	h	2.2	m
	b	1	m
	t	0.20	m
Conc. Cover	**h_c**	0.50	m
	a_c	1.25	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.44	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	4.36	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.43	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.56	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	2.63	t/m
	ΣW	**7.85**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	3.2	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	15.93	m2
	Wtetrapod	**10.95**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.2	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	Kp = $\tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	10.37	
	Pp, t/m	**11.41**	
	yp, m	0.73	
	M_{Pp}, t.m	**8.37**	

Rubble Cell	x_{sc}	1.50	m
	M (Sc)	**11.77**	t.m/m

Wave	P	4.77	t/m
	U	0.00	t/m
	y_p	1.110	m
	x_u	3.000	m
	Mp	**5.30**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**5.30**	t.m/m

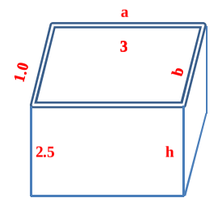
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*

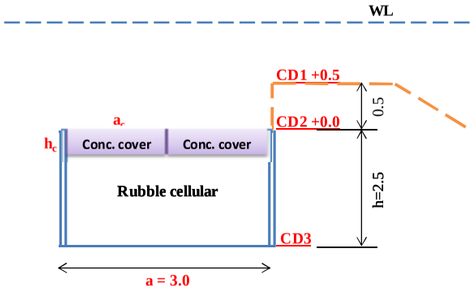
Sand Protection Training Dike - Section for GL upto CD -4.0m

I. Wave Force under Wave Crest

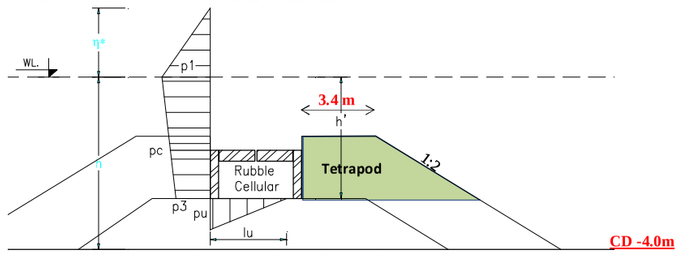
1. Input data:

- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**3.55**
- Crest Level (CDL):	0.0
- Bottom Upright Wall Level (CDL):	-2.5
- Bottom Width of Upright Wall (m):	3.0
- Back Fill Level (CDL):	0.5
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-4.0
- Significant Wave Height ($H_{1/3}$), m:	2.985
- H_{max}, m:	4.012
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	78.98





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^5\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	60.936
cos β:	0.486
H_D (m):	4.012
L (m):	78.98
LWL (CDL):	3.55
Sea bed Level (CDL):	-4.0
Crest Level (CDL):	0.0
h (m):	7.55
h' (m)	6.05
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.201
2 πh/L	0.601
λ	1.000

5.2. Wave pressure on the front face of an Upright wall

η* =	4.47
α_1 =	0.916
α_3 =	0.874
(1+cosβ)	1.486
$\alpha_1 \lambda \rho_0 H_D$	3.765
p_1 (t/m2) =	2.80
p_c (at crest level), (t/m2) =	2.59
p_3 (t/m2) =	2.45

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	6.30
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	13.20

Horizontal Effect (Passive Pressure)

Pp, t/m	14.73
M_{Pp}, t.m	12.28

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	8.91
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	13.20

Sliding	**S.F. (Normal)**	**1.13**
	S.F. (with back fill layer effect)	**2.60**

Overturning	Mu	0.00
	Mp	7.95
	Mtetrapod	12.28
	Mconc. (=W*t)	13.36
	S.F. (Normal)	**1.68**
	S.F. (with back fill layer effect)	**OK**

		30 years	
	CD1	+ 0.5	m
	CD2	+ 0	m
	CD3	-2.5	m
	LWL	+ **3.55**	m
Cellular	**a**	3	m
	h	2.5	m
	b	1	m
	t	0.20	m
Conc. Cover	**h_c**	0.50	m
	a_c	1.25	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.44	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	4.95	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.43	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.56	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	3.10	t/m
	ΣW	**8.91**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	3.4	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	19.20	m2
	Wtetrapod	**13.20**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.5	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	Kp = $\tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	11.78	
	Pp, t/m	**14.73**	
	yp, m	0.83	
	M_{Pp}, t.m	**12.28**	

Rubble Cell	x_{sc}	1.50	m
	M (Sc)	**13.36**	t.m/m

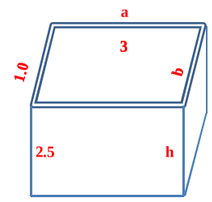
Wave	P	6.30	t/m
	U	0.00	t/m
	y_p	1.262	m
	x_u	3.000	m
	Mp	**7.95**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**7.95**	t.m/m

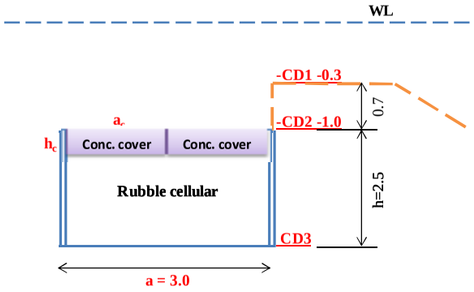
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*
Sand Protection Training Dike - Section for GL upto CD -5.0m

I. Wave Force under Wave Crest

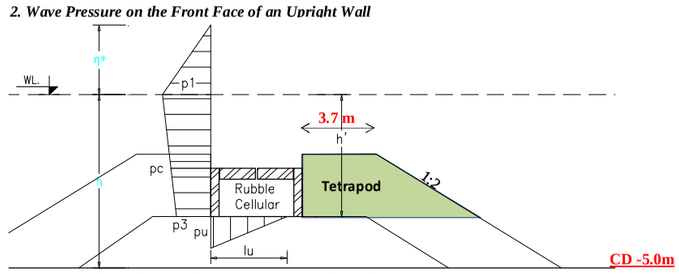
1. Input data:

- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**3.55**
- Crest Level (CDL):	-1.0
- Bottom Upright Wall Level (CDL):	-3.5
- Bottom Width of Upright Wall (m):	3.0
- Back Fill Level (CDL):	-0.3
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-5.0
- Significant Wave Height ($H_{1/3}$), m:	3.457
- H_{max}, m:	4.595
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	84.32





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^5\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	60.681
cos β:	0.490
H_D (m):	4.595
L (m):	84.32
LWL (CDL):	3.55
Sea bed Level (CDL):	-5.0
Crest Level (CDL):	-1.0
h (m):	8.55
h' (m)	7.05
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.274
2 πh/L	0.637
λ	1.000

5.2. Wave pressure on the front face of an Upright wall

η* =	5.13
α_1 =	0.899
α_3 =	0.857
(1+cosβ)	1.490
$\alpha_1 \lambda \rho_0 H_D$	4.233
p_1 (t/m2) =	3.15
p_c (at crest level), (t/m2) =	2.86
p_3 (t/m2) =	2.70

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	6.96
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	15.18

Horizontal Effect (Passive Pressure)

Pp, t/m	14.73
M_{Pp}, t.m	12.28

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	8.91
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	15.18

Sliding	**S.F. (Normal)**	**1.02**
	S.F. (with back fill layer effect)	**2.55**

Overturning	Mu	0.00
	Mp	8.78
	Mtetrapod	12.28
	Mconc. (=W*t)	13.36
	S.F. (Normal)	**1.52**
	S.F. (with back fill layer effect)	**OK**

		30 years	
	CD1	-0.3	m
	CD2	-1	m
	CD3	-3.5	m
	LWL	+ **3.55**	m
Cellular	a	3	m
	h	2.5	m
	b	1	m
	t	0.20	m
Conc. Cover	h_c	0.50	m
	a_c	1.25	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.44	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	4.95	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.43	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.56	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	3.10	t/m
	ΣW	**8.91**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	3.7	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	22.08	m2
	Wtetrapod	**15.18**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.5	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	$Kp = \tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	11.78	
	Pp, t/m	**14.73**	
	yp, m	0.83	
	M_{Pp}, t.m	**12.28**	

Rubble Cell	x_{sc}	1.50	m
	M (Sc)	**13.36**	t.m/m

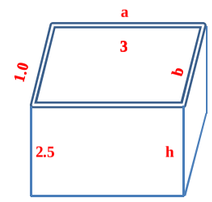
Wave	P	6.96	t/m
	U	0.00	t/m
	y_p	1.262	m
	x_u	3.000	m
	Mp	**8.78**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**8.78**	t.m/m

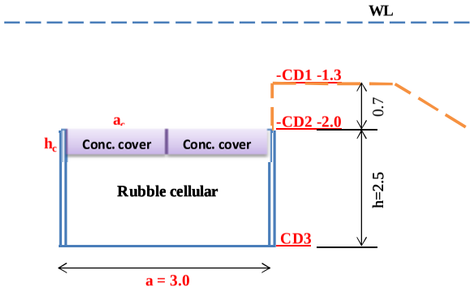
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*
Sand Protection Training Dike - Section for GL upto CD -6.0m

I. Wave Force under Wave Crest

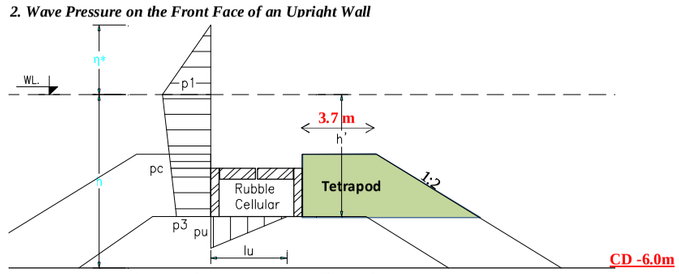
1. Input data:

- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**3.55**
- Crest Level (CDL):	-2.0
- Bottom Upright Wall Level (CDL):	-4.5
- Bottom Width of Upright Wall (m):	3.0
- Back Fill Level (CDL):	-1.3
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-6.0
- Significant Wave Height ($H_{1/3}$), m:	4.036
- H_{max}, m:	5.296
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	88.23





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	60.37
cos β:	0.494
H_D (m):	5.296
L (m):	88.23
LWL (CDL):	3.55
Sea bed Level (CDL):	-6.0
Crest Level (CDL):	-2.0
h (m):	9.55
h' (m)	8.05
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.360
2 πh/L	0.680
λ	1.000

5.2. Wave pressure on the front face of an Upright wall

η* =	5.94
α_1 =	0.879
α_3 =	0.837
(1+cosβ)	1.494
$\alpha_1 \lambda \rho_0 H_D$	4.773
p_1 (t/m2) =	3.57
p_c (at crest level), (t/m2) =	3.16
p_3 (t/m2) =	2.98

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	7.68
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	15.18

Horizontal Effect (Passive Pressure)

Pp, t/m	14.73
M_{Pp}, t.m	12.28

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	8.91
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	15.18

Sliding	**S.F. (Normal)**	**0.93**
	S.F. (with back fill layer effect)	**2.31**

Overturning	Mu	0.00
	Mp	9.70
	Mtetrapod	12.28
	Mconc. (=W*t)	13.36
	S.F. (Normal)	**1.38**
	S.F. (with back fill layer effect)	**OK**

		30 years	
	CD1	-1.3	m
	CD2	-2	m
	CD3	-4.5	m
	LWL	**+ 3.55**	m
Cellular	**a**	3	m
	h	2.5	m
	b	1	m
	t	0.20	m
Conc. Cover	**h_c**	0.50	m
	a_c	1.25	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.44	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	4.95	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.43	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.56	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	3.10	t/m
	ΣW	**8.91**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	3.7	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	22.08	m2
	Wtetrapod	**15.18**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.5	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	Kp = $\tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	11.78	
	Pp, t/m	**14.73**	
	yp, m	0.83	
	M_{Pp}, t.m	**12.28**	

Rubble Cell	x_{sc}	1.50	m
	M (Sc)	**13.36**	t.m/m

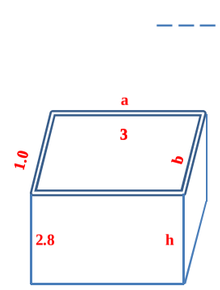
Wave	P	7.68	t/m
	U	0.00	t/m
	y_p	1.262	m
	x_u	3.000	m
	Mp	**9.70**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**9.70**	t.m/m

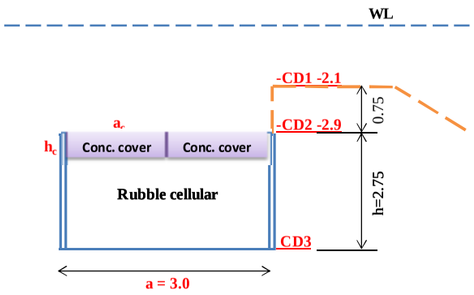
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*
Sand Protection Training Dike - Section for GL upto CD -7.0m

I. Wave Force under Wave Crest

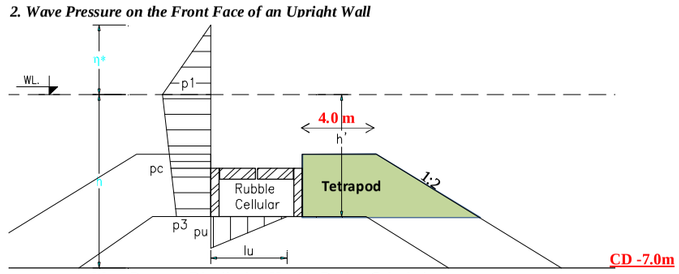
1. Input data:

- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**3.55**
- Crest Level (CDL):	-2.9
- Bottom Upright Wall Level (CDL):	-5.6
- Bottom Width of Upright Wall (m):	3.0
- Back Fill Level (CDL):	-2.1
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-7.0
- Significant Wave Height ($H_{1/3}$), m:	4.545
- H_{max}, m:	5.922
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	95.19





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\ \_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	59.65
cos β:	0.505
H_D (m):	5.922
L (m):	95.19
LWL (CDL):	3.55
Sea bed Level (CDL):	-7.0
Crest Level (CDL):	-2.9
h (m):	10.55
h' (m)	9.15
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.393
2 πh/L	0.696
λ	1.000

5.2. Wave pressure on the front face of an Upright wall

η* =	6.69
α_1 =	0.872
α_3 =	0.825
(1+cosβ)	1.505
$\alpha_1 \lambda \rho_0 H_D$	5.292
p_1 (t/m2) =	3.98
p_c (at crest level), (t/m2) =	3.50
p_3 (t/m2) =	3.29

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	9.33
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	18.05

Horizontal Effect (Passive Pressure)

Pp, t/m	17.82
M_{Pp}, t.m	16.34

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	9.79
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	18.05

Sliding	**S.F. (Normal)**	**0.84**
	S.F. (with back fill layer effect)	**2.19**

Overturning	Mu	0.00
	Mp	12.96
	Mtetrapod	16.34
	Mconc. (=W*t)	14.68
	S.F. (Normal)	**1.13**
	S.F. (with back fill layer effect)	**OK**

		30 years	
	CD1	-2.1	m
	CD2	-2.85	m
	CD3	-5.6	m
	LWL	**+ 3.55**	m
Cellular	**a**	3	m
	h	2.75	m
	b	1	m
	t	0.20	m
Conc. Cover	**h_c**	0.50	m
	a_c	1.25	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.44	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	5.45	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.43	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.56	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	3.48	t/m
	ΣW	**9.79**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	4	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	26.25	m2
	Wtetrapod	**18.05**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.8	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	$Kp = \tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	12.96	
	Pp, t/m	**17.82**	
	yp, m	0.92	
	M_{Pp}, t.m	**16.34**	

Rubble Cell	x_{sc}	1.50	m
	M (Sc)	**14.68**	t.m/m

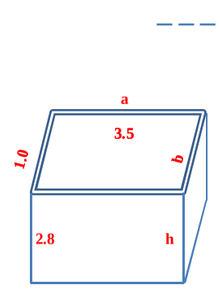
Wave	P	9.33	t/m
	U	0.00	t/m
	y_p	1.389	m
	x_u	3.000	m
	Mp	**12.96**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**12.96**	t.m/m

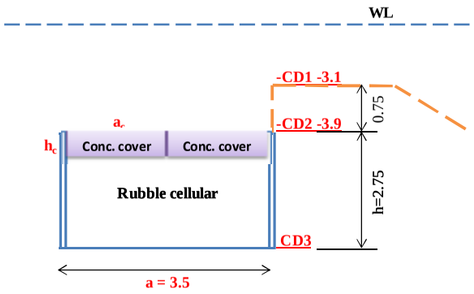
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*
Sand Protection Training Dike - Section for GL upto CD -8.0m

I. Wave Force under Wave Crest

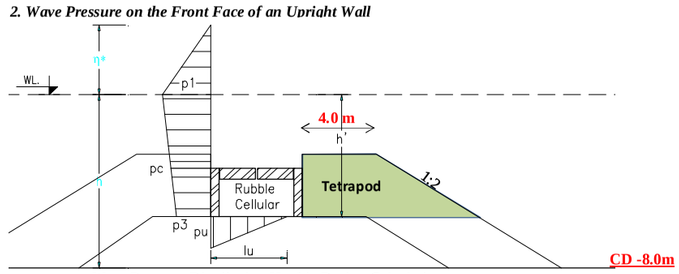
1. Input data:

- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**3.55**
- Crest Level (CDL):	-3.9
- Bottom Upright Wall Level (CDL):	-6.6
- Bottom Width of Upright Wall (m):	3.5
- Back Fill Level (CDL):	-3.1
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-8.0
- Significant Wave Height ($H_{1/3}$), m:	4.956
- H_{max}, m:	6.47
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	99.27





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^5\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\ \_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	59.60
cos β:	0.506
H_D (m):	6.47
L (m):	99.27
LWL (CDL):	3.55
Sea bed Level (CDL):	-8.0
Crest Level (CDL):	-3.9
h (m):	11.55
h' (m)	10.15
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.462
2 πh/L	0.731
λ	1.000

5.2. Wave pressure on the front face of an Upright wall

η* =	7.31
α_1 =	0.856
α_3 =	0.808
(1+cosβ)	1.506
$\alpha_1 \lambda \rho_0 H_D$	5.680
p_1 (t/m2) =	4.28
p_c (at crest level), (t/m2) =	3.68
p_3 (t/m2) =	3.46

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	9.81
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	18.05

Horizontal Effect (Passive Pressure)

Pp, t/m	17.82
M_{Pp}, t.m	16.34

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	11.39
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	18.05

Sliding	**S.F. (Normal)**	**0.93**
	S.F. (with back fill layer effect)	**2.22**

Overturning	Mu	0.00
	Mp	13.63
	Mtetrapod	16.34
	Mconc. (=W*t)	19.92
	S.F. (Normal)	**1.46**
	S.F. (with back fill layer effect)	**OK**

		30 years	
	CD1	-3.1	m
	CD2	-3.85	m
	CD3	-6.6	m
	LWL	**+ 3.55**	m
Cellular	**a**	3.5	m
	h	2.75	m
	b	1	m
	t	0.20	m
Conc. Cover	**h_c**	0.50	m
	a_c	1.50	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.64	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	6.20	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.52	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.86	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	4.15	t/m
	ΣW	**11.39**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	4	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	26.25	m2
	Wtetrapod	**18.05**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.8	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	$Kp = \tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	12.96	
	Pp, t/m	**17.82**	
	yp, m	0.92	
	M_{Pp}, t.m	**16.34**	

Rubble Cell	x_{sc}	1.75	m
	M (Sc)	**19.92**	t.m/m

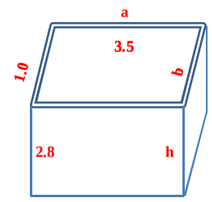
Wave	P	9.81	t/m
	U	0.00	t/m
	y_p	1.389	m
	x_u	3.500	m
	Mp	**13.63**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**13.63**	t.m/m

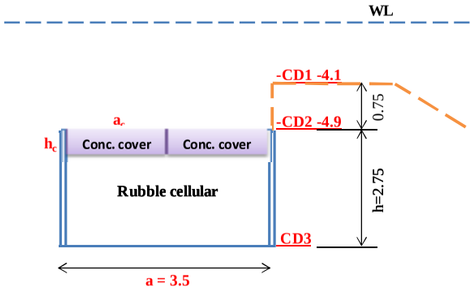
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*
Sand Protection Training Dike - Section for GL upto CD -9.0m

I. Wave Force under Wave Crest

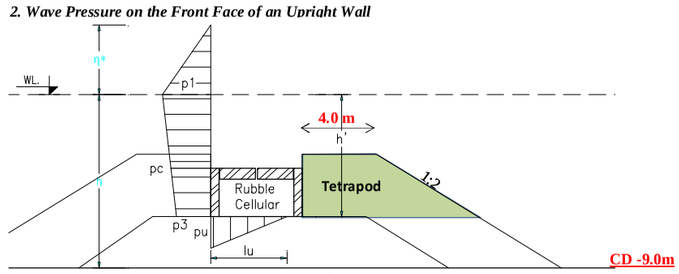
1. Input data:

- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**3.55**
- Crest Level (CDL):	-4.9
- Bottom Upright Wall Level (CDL):	-7.6
- Bottom Width of Upright Wall (m):	3.5
- Back Fill Level (CDL):	-4.1
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-9.0
- Significant Wave Height ($H_{1/3}$), m:	5.022
- H_{max}, m:	7.17
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	104.19





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\ \_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	59.43
cos β:	0.509
H_D (m):	7.17
L (m):	104.19
LWL (CDL):	3.55
Sea bed Level (CDL):	-9.0
Crest Level (CDL):	-4.9
h (m):	12.55
h' (m)	11.15
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.514
2 πh/L	0.757
λ	1.000

5.2. Wave pressure on the front face of an Upright wall

η* =	8.11
α_1 =	0.845
α_3 =	0.795
(1+cosβ)	1.509
$\alpha_1 \lambda \rho_0 H_D$	6.211
p_1 (t/m2) =	4.69
p_c (at crest level), (t/m2) =	3.96
p_3 (t/m2) =	3.72

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	10.57
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	18.05

Horizontal Effect (Passive Pressure)

Pp, t/m	17.82
M_{Pp}, t.m	16.34

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	11.39
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	18.05

Sliding	**S.F. (Normal)**	**0.86**
	S.F. (with back fill layer effect)	**2.06**

Overturning	Mu	0.00
	Mp	14.68
	Mtetrapod	16.34
	Mconc. (=W*t)	19.92
	S.F. (Normal)	**1.36**
	S.F. (with back fill layer effect)	**OK**

		30 years	
	CD1	-4.1	m
	CD2	-4.85	m
	CD3	-7.6	m
	LWL	+ **3.55**	m
Cellular	**a**	3.5	m
	h	2.75	m
	b	1	m
	t	0.20	m
Conc. Cover	**h_c**	0.50	m
	a_c	1.50	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.64	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	6.20	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.52	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.86	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	4.15	t/m
	ΣW	**11.39**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	4	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	26.25	m2
	Wtetrapod	**18.05**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.8	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	$Kp = \tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	12.96	
	Pp, t/m	**17.82**	
	yp, m	0.92	
	M_{Pp}, t.m	**16.34**	

Rubble Cell	x_{sc}	1.75	m
	M (Sc)	**19.92**	t.m/m

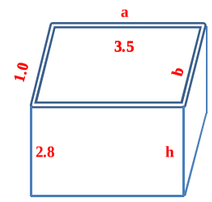
Wave	P	10.57	t/m
	U	0.00	t/m
	y_p	1.389	m
	x_u	3.500	m
	Mp	**14.68**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**14.68**	t.m/m

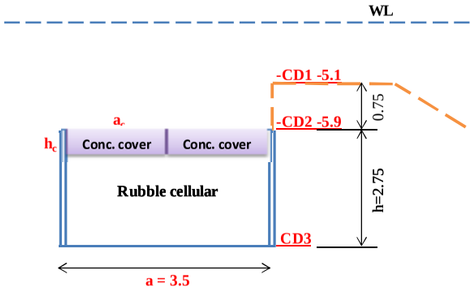
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*
Sand Protection Training Dike - Section for GL upto CD -10.0m

I. Wave Force under Wave Crest

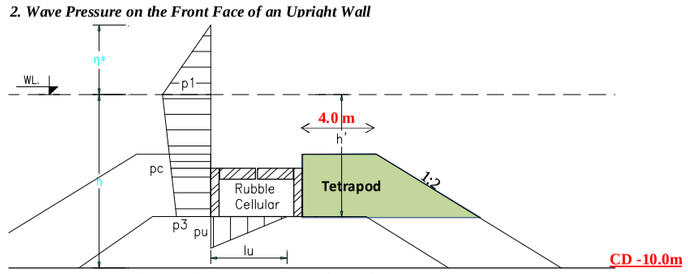
1. Input data:

- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**3.55**
- Crest Level (CDL):	-5.9
- Bottom Upright Wall Level (CDL):	-8.6
- Bottom Width of Upright Wall (m):	3.5
- Back Fill Level (CDL):	-5.1
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-10.0
- Significant Wave Height ($H_{1/3}$), m:	5.079
- H_{max}, m:	7.818
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	108.50





2. Wave Pressure on the Front Face of an Upriaht Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\ \_h' \le 0)$$

3. Uplift beneath Upright Wall

$$p_3 = p_u = \alpha_3 p_1 \qquad l_u = \min\left\{B, 0.2\frac{(\eta^*+h')}{|h'|}\right\}$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years
β (deg) =	59.72
cos β:	0.504
H_D (m):	7.818
L (m):	108.50
LWL (CDL):	3.55
Sea bed Level (CDL):	-10.0
Crest Level (CDL):	-5.9
h (m):	13.55
h' (m)	12.15
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.569
2 πh/L	0.785
λ	1.000

5.2. Wave pressure on the front face of an Upright wall

η* =	8.82
α_1 =	0.833
α_3 =	0.781
(1+cosβ)	1.504
$\alpha_1 \lambda \rho_0 H_D$	6.677
p_1 (t/m2) =	5.02
p_c (at crest level), (t/m2) =	4.17
p_3 (t/m2) =	3.92

5.3. Uplift beneath Upright Wall

p_u (t/m2) =	0.00
l_u (m) =	0.00

5.4. Total wave pressure on Upright Wall

P (t/m) =	11.12
U (t/m) =	0.00

II. Effect of Back Fill Tetrapod Block

Vertical Effect

ΣW (t) =	18.05

Horizontal Effect (Passive Pressure)

Pp, t/m	17.82
M_{Pp}, t.m	16.34

III. Safety Factor

μ (friction factor between rubble cellular & stone):	0.80
Wcon. (total), t/m	11.39
μ (friction factor between tetrapod & stone)	0.70
$W_{tetrapod}$, t/m	18.05

Sliding	**S.F. (Normal)**	**0.82**
	S.F. (with back fill layer effect)	**1.95**

Overturning	Mu	0.00
	Mp	15.45
	Mtetrapod	16.34
	Mconc. (=W*t)	19.92
	S.F. (Normal)	**1.29**
	S.F. (with back fill layer effect)	**OK**

		30 years	
	CD1	-5.1	m
	CD2	-5.85	m
	CD3	-8.6	m
	LWL	**+ 3.55**	m
Cellular	**a**	3.5	m
	h	2.75	m
	b	1	m
	t	0.20	m
Conc. Cover	**h_c**	0.50	m
	a_c	1.50	m
	b_c	0.50	m
	$S_{conc.\ cell}$ (1 cell.)	1.64	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	6.20	t/m
	$W_{conc.\ cover}$ (1 unit.)	0.52	t/m
	Nos. of cover block	2.00	
	$S_{rubber\ filling}$ (1 cell.)	1.86	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	4.15	t/m
	ΣW	**11.39**	t/m

Back fill beside conc. Block	*Vertical Effect*		
	$b_{back\ fill\ layer}$	4	m
	Slope	2	
	$\gamma_{Tetrapod}$	2.4	t/m3
	$\gamma'_{Tetrapod}$	1.375	t/m3
	void ratio	50%	
	Stetrapod	26.25	m2
	Wtetrapod	**18.05**	t/m
	Horizontal Effect (Passive Pressure)		
	H (m)	2.8	
	ϕ (deg)	40.0	
	γ'_s (t/m3)	1.03	
	$Kp = \tan^2(45^o+\phi/2)$	4.6	
	p_p (wet), t/m2	12.96	
	Pp, t/m	**17.82**	
	yp, m	0.92	
	M_{Pp}, t.m	**16.34**	

Rubble Cell	x_{sc}	1.75	m
	M (Sc)	**19.92**	t.m/m

Wave	P	11.12	t/m
	U	0.00	t/m
	y_p	1.389	m
	x_u	3.500	m
	Mp	**15.45**	t.m/m
	Mu	**0.00**	t.m/m
	M total	**15.45**	t.m/m

12 STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - CASE B-1 (LWL)

STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*

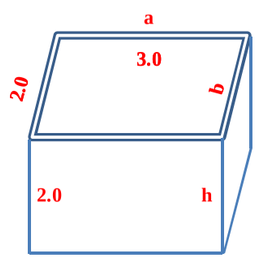
Sand Protection Training Dike - Section for GL upto CD -1.0m

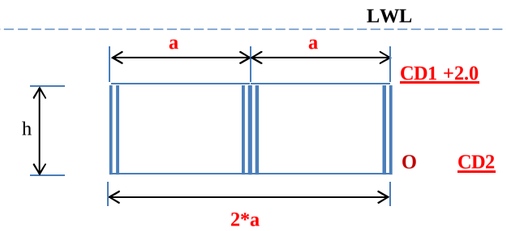
I. Wave Force under Wave Crest

1. Input data:

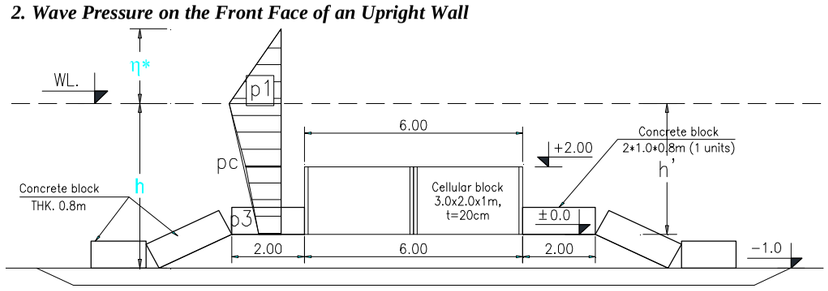
- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**0.43**
- Crest Level (CDL):	2.0
- Bottom Upright Wall Level (CDL):	0.0
- Bottom Width of Upright Wall (m):	6.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-1.0
- Significant Wave Height ($H_{1/3}$), m:	1.48
- H_{max}, m:	3.727
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	76.21

Bellow sketch for reference only





2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos b)\, l\, a_1 r_0 g H_D$

At toe of upright wall: $p_3 = p_u = a_3 p_1$

$$l = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad h^* = 0.75(1+\cos b)\, l\, H_D$$

$$a_1 = 0.6+\frac{1}{2}\left[\frac{4ph/L}{\sinh\left(\frac{4ph}{L}\right)}\right]^2 \qquad a_3 = 1+\frac{h'}{h^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years	
β (deg) =	57.02	
cos β:	0.544	
H_D (m):	3.727	
L (m):	76.21	
HWL (CDL):	0.43	
Sea bed Level (CDL):	-1.0	
Crest Level (CDL):	2.0	
h (m):	1.4	
h' (m)	0.43	
ρ_0 (t/m3):	1.025	
g (m/s2):	9.81	
4 πh/L	0.236	
2 πh/L	0.118	
λ	1.000	*Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	4.32
α_1 =	1.091
α_3 =	0.998
(1+cosβ)	1.544
$\alpha_1 \lambda \rho_0 H_D$	4.167
p_1 (t/m2) =	3.22
p_c (at crest level), (t/m2) =	3.24
p_3 (t/m2) =	3.21

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ bottom\ Elev.}$ (t/m) =	6.45

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	13.32

Sliding	**S.F. at CD2 Elev.**	**1.65**

Overturning	$Mp_{at\ O}$	6.46
	$M_{conc.\ cell.\ at\ O}$ (=W*t)	59.92
	S.F. at O	**9.28**

		30 years	
	CD1	+ 2	m
	CD2	0	m
	LWL	**+ 0.43**	m
	a	3	m
	h	2	m
	b	2.00	m
	t	0.20	m
	$S_{conc.\ cell}$ (1 cell.)	1.84	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	5.06	t/m
	$S_{rubber\ filling}$ (1 cell.)	4.16	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	8.26	t/m
Upper Layer	Nos. of cellular block	2.00	unit
	x_O	4.50	m
	M_O	59.92	tm/m
Wave	$P_{up\ to\ bottom\ Elev.}$	6.45	t/m
	$y_{p\ upto\ bottom\ Elev.}$	1.000	m
	$Mp_{at\ O}$	6.46	t.m/m

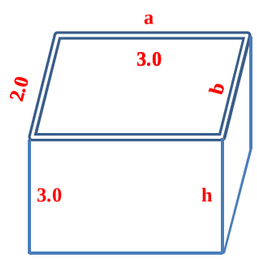
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*

Sand Protection Training Dike - Section for GL upto CD -2.0m

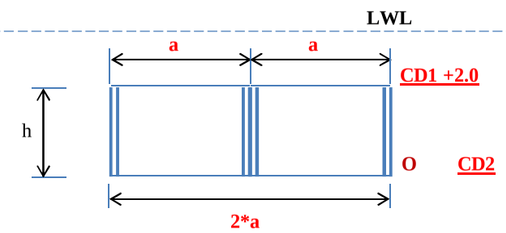
I. Wave Force under Wave Crest

1. Input data:

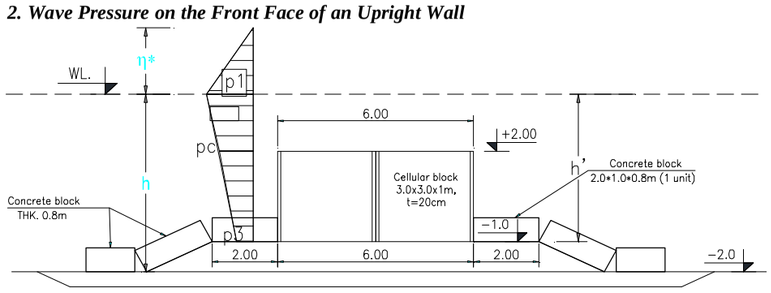
- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**0.43**
- Crest Level (CDL):	2.0
- Bottom Upright Wall Level (CDL):	-1.0
- Bottom Width of Upright Wall (m):	6.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-2.0
- Significant Wave Height ($H_{1/3}$), m:	1.952
- H_{max}, m:	2.87
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	67.12



Bellow sketch for reference only



2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos b)\, l\, a_1 r_0 g H_D$

At toe of upright wall: $p_3 = p_u = a_3 p_1$

$$l = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad h^* = 0.75(1+\cos b)\, l\, H_D$$

$$a_1 = 0.6+\frac{1}{2}\left[\frac{4p\,h/L}{\sinh\left(\frac{4p\,h}{L}\right)}\right]^2 \qquad a_3 = 1+\frac{h'}{h^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years	
β (deg) =	65.468	
cos β:	0.415	
H_D (m):	2.87	
L (m):	67.12	
HWL (CDL):	0.43	
Sea bed Level (CDL):	-2.0	
Crest Level (CDL):	2.0	
h (m):	2.4	
h' (m)	1.43	
ρ_0 (t/m3):	1.025	
g (m/s2):	9.81	
4 πh/L	0.455	
2 πh/L	0.227	
λ	1.000	*Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	3.05
α_1 =	1.067
α_3 =	0.985
(1+cosβ)	1.415
$\alpha_1 \lambda \rho_0 H_D$	3.139
p_1 (t/m2) =	2.22
p_c (at crest level), (t/m2) =	2.26
p_3 (t/m2) =	2.19

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ bottom\ Elev.}$ (t/m) =	6.67

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	19.97

Sliding	**S.F. at CD2 Elev.**	**2.4**

Overturning	$Mp_{at\ O}$	10.03
	$M_{conc.\ cell.\ at\ O}$ (=W*t)	89.88
	S.F. at O	**8.96**

		30 years	
	CD1	+ 2	m
	CD2	-1	m
	LWL	**+ 0.43**	m
	a	3.0	m
	h	3.0	m
	b	2.0	m
	t	0.2	m
	$S_{conc.\ cell}$ (1 cell.)	1.84	m2
	$\gamma_{conc.}$	2.4	t/m3
	$\gamma'_{conc.}$	1.375	t/m3
	$W_{conc.\ cell}$ (1 cell.)	7.59	t/m
	$S_{rubber\ filling}$ (1 cell.)	4.16	m2
	$\gamma_{rubber\ stone}$	2.6	t/m3
	$\gamma'_{rubber\ stone}$	1.575	t/m3
	void ratio	37%	
	$W_{rubber\ filling}$ (1 cell.)	12.38	t/m
Upper Layer	Nos. of cellular block	2.00	unit
	x_O	4.50	m
	M_O	89.88	tm/m
Wave	$P_{up\ to\ bottom\ Elev.}$	6.67	t/m
	$y_{p\ upto\ bottom\ Elev.}$	1.504	m
	$Mp_{at\ O}$	10.03	t.m/m

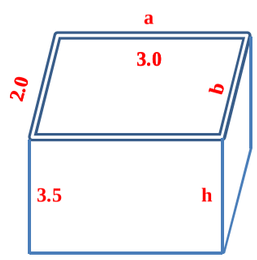
STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*

Sand Protection Training Dike - Section for GL upto CD -2.0m - From Sta. 1+750~2+950

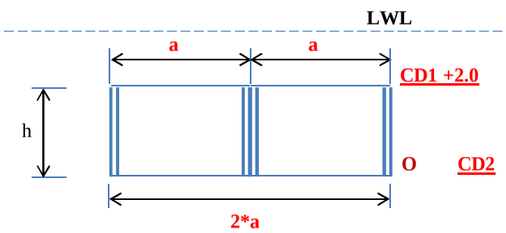
I. Wave Force under Wave Crest

1. Input data:

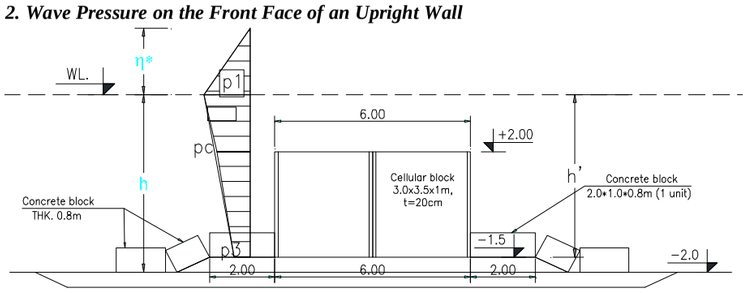
- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**0.43**
- Crest Level (CDL):	2.0
- Bottom Upright Wall Level (CDL):	-1.5
- Bottom Width of Upright Wall (m):	6.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-2.0
- Significant Wave Height ($H_{1/3}$), m:	1.952
- H_{max}, m:	2.87
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	67.12



Bellow sketch for reference only



2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos b)\, l\, a_1 r_0 g H_D$

At toe of upright wall: $p_3 = p_u = a_3 p_1$

$$l = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad h^* = 0.75(1+\cos b)\, l\, H_D$$

$$a_1 = 0.6+\frac{1}{2}\left[\frac{4p\,h/L}{\sinh\left(\frac{4p\,h}{L}\right)}\right]^2 \qquad a_3 = 1+\frac{h'}{h^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years	
β (deg) =	65.468	
cos β:	0.415	
H_D (m):	2.87	
L (m):	67.12	
HWL (CDL):	0.43	
Sea bed Level (CDL):	-2.0	
Crest Level (CDL):	2.0	
h (m):	2.4	
h' (m)	1.93	
ρ_0 (t/m3):	1.025	
g (m/s2):	9.81	
4 πh/L	0.455	
2 πh/L	0.227	
λ	1.000	*Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	3.05
α_1 =	1.067
α_3 =	0.980
(1+cosβ)	1.415
$\alpha_1 \lambda \rho_0 H_D$	3.139
p_1 (t/m2) =	2.22
p_c (at crest level), (t/m2) =	2.26
p_3 (t/m2) =	2.18

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ bottom\ Elev.}$ (t/m) =	7.76

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	23.30

Sliding	**S.F. at CD2 Elev.**	**2.4**

Overturning	$Mp_{at\ O}$	13.62
	$M_{conc.\ cell.\ at\ O}$ (=W*t)	104.86
	S.F. at O	**7.70**

	30 years	
CD1	+ 2	m
CD2	-1.5	m
LWL	+ **0.43**	m
a	3	m
h	3.5	m
b	2.00	m
t	0.20	m
$S_{conc.\ cell}$ (1 cell.)	1.84	m2
$\gamma_{conc.}$	2.4	t/m3
$\gamma'_{conc.}$	1.375	t/m3
$W_{conc.\ cell}$ (1 cell.)	8.86	t/m
$S_{rubber\ filling}$ (1 cell.)	4.16	m2
$\gamma_{rubber\ stone}$	2.6	t/m3
$\gamma'_{rubber\ stone}$	1.575	t/m3
void ratio	37%	
$W_{rubber\ filling}$ (1 cell.)	14.45	t/m
Upper Layer: Nos. of cellular block	2.00	unit
Upper Layer: x_O	4.50	m
Upper Layer: M_O	104.86	tm/m
Wave: $P_{up\ to\ bottom\ Elev.}$	7.76	t/m
Wave: $y_{p\ upto\ bottom\ Elev.}$	1.756	m
Wave: $Mp_{at\ O}$	13.62	t.m/m

STABILITY CALCULATION DUE TO WAVE FORCE ***(Clause 5.5.2 - OCDI)***

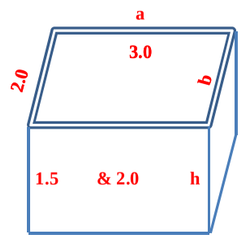
Sand Protection Training Dike - Section for GL upto CD -3.0m

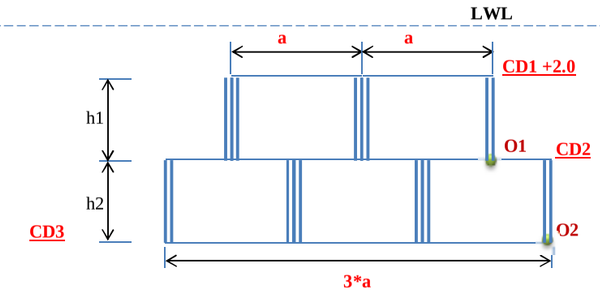
I. Wave Force under Wave Crest

1. Input data:

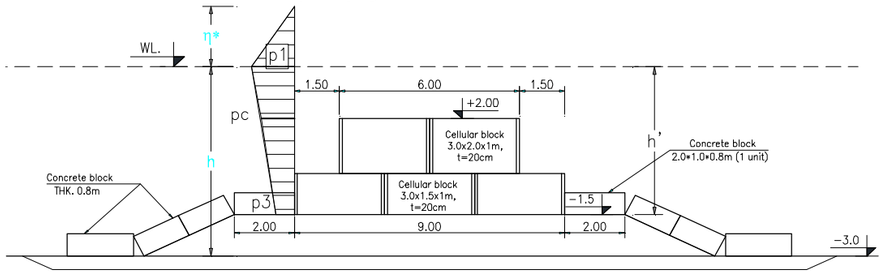
- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**0.43**
- Crest Level (CDL):	2.0
- Bottom Upright Wall Level (CDL):	-1.5
- Bottom Width of Upright Wall (m):	9.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-3.0
- Significant Wave Height ($H_{1/3}$), m:	2.427
- H_{max}, m:	3.343
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	72.30

Bellow sketch for reference only





2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos b)\, l\, a_1\, r_0 g H_D$

At toe of upright wall: $p_3 = p_u = a_3 p_1$

$$l = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad h^* = 0.75(1+\cos b)\, l\, H_D$$

$$a_1 = 0.6+\frac{1}{2}\left[\frac{4ph/L}{\sinh\left(\frac{4ph}{L}\right)}\right]^2 \qquad a_3 = 1+\frac{h'}{h^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years	
β (deg) =	61.332	
cos β:	0.480	
H_D (m):	3.343	
L (m):	72.30	
HWL (CDL):	0.43	
Sea bed Level (CDL):	-2.5	
Crest Level (CDL):	2.0	
h (m):	2.93	
h' (m)	1.93	
ρ_0 (t/m3):	1.025	
g (m/s2):	9.81	
4 πh/L	0.509	
2 πh/L	0.255	
λ	1.000	*Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	3.71
α_1 =	1.059
α_3 =	0.979
(1+cosβ)	1.480
$\alpha_1 \lambda \rho_0 H_D$	3.628
p_1 (t/m2) =	2.68
p_c (at crest level), (t/m2) =	2.73
p_{O1} (at CD2 level), (t/m2) =	2.67
p_3 (t/m2) =	2.63

5.3. Total wave pressure on Upright Wall

P up to CD2 Elev. (t/m) =	5.30
P up to bottom Elev. (t/m) =	9.38

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
W1con. cell. (total), t/m	13.32
W2con. cell. (total), t/m	14.98

Sliding	**S.F. at CD2 Elev.**	**2.01**
	S.F. at CD3 Elev.	**2.41**

Overturning	$Mp_{at\ O1}$	5.31
	$M_{conc.\ cell.\ at\ O1}$ (=W*t)	59.92
	S.F. at O1	**11.29**
	$Mp_{at\ O2}$	16.47
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	168.77
	S.F. at O2	**10.25**

	30 years	
CD1	+ 2	m
CD2	+ 0	m
CD3	-1.50	m
LWL	**+ 0.43**	m
a	3	m
h1	2	m
h2	1.5	m
b	2.00	m
t	0.20	m
$S_{conc.\ cell}$ (1 cell.)	1.84	m2
$\gamma_{conc.}$	2.4	t/m3
$\gamma'_{conc.}$	1.375	t/m3
$W1_{conc.\ cell}$ (1 cell.)	5.06	t/m
$W2_{conc.\ cell}$ (1 cell.)	3.80	t/m
$S_{rubber\ filling}$ (1 cell.)	4.16	m2
$\gamma_{rubber\ stone}$	2.6	t/m3
$\gamma'_{rubber\ stone}$	1.575	t/m3
void ratio	37%	
$W1_{rubber\ filling}$ (1 cell.)	8.26	t/m
$W2_{rubber\ filling}$ (1 cell.)	6.19	t/m
Upper Layer: Nos. of cellular block	2.00	unit
Upper Layer: x_{O1}	4.50	m
Upper Layer: M_{O1}	59.92	tm/m
Lower Layer: Nos. of cellular block	3.00	unit
Lower Layer: x_{O2}	6.00	m
Lower Layer: M_{O2}	168.77	tm/m

Wave	P up to CD2 Elev.	5.30	t/m
	$y_{p\ upto\ CD2\ Elev.}$	1.00	
	$Mp_{at\ O1}$	5.31	t.m/m
	P up to bottom Elev.	9.38	t/m
	$y_{p\ upto\ bottom\ Elev.}$	1.756	m
	$Mp_{at\ O2}$	16.47	t.m/m

STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*

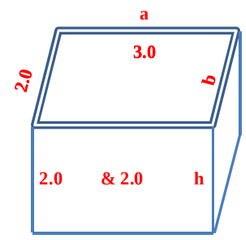
Sand Protection Training Dike - Section for GL upto CD -3.0m

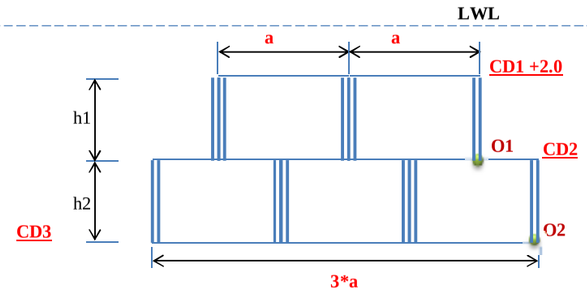
I. Wave Force under Wave Crest

1. Input data:

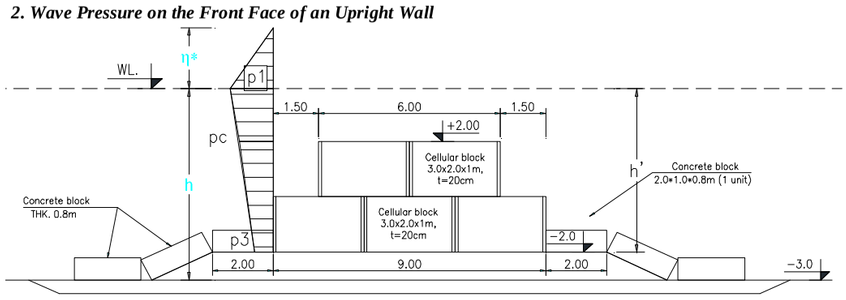
- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**0.43**
- Crest Level (CDL):	2.0
- Bottom Upright Wall Level (CDL):	-2.0
- Bottom Width of Upright Wall (m):	9.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-3.0
- Significant Wave Height ($H_{1/3}$), m:	2.427
- H_{max}, m:	3.343
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	72.30

Bellow sketch for reference only





2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos b)\, l\, a_1\, r_0 g H_D$

At toe of upright wall: $p_3 = p_u = a_3 p_1$

$$l = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad h^* = 0.75(1+\cos b)\, l\, H_D$$

$$a_1 = 0.6+\frac{1}{2}\left[\frac{4ph/L}{\sinh\left(\frac{4ph}{L}\right)}\right]^2 \qquad a_3 = 1+\frac{h'}{h^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years	
β (deg) =	61.332	
cos β:	0.480	
H_D (m):	3.343	
L (m):	72.30	
HWL (CDL):	0.43	
Sea bed Level (CDL):	-3.0	
Crest Level (CDL):	2.0	
h (m):	3.43	
h' (m)	2.43	
ρ_0 (t/m3):	1.025	
g (m/s2):	9.81	
4 πh/L	0.596	
2 πh/L	0.298	
λ	1.000	*Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	3.71
α_1 =	1.045
α_3 =	0.970
(1+cosβ)	1.480
$\alpha_1 \lambda \rho_0 H_D$	3.580
p_1 (t/m2) =	2.65
p_c (at crest level), (t/m2) =	2.70
p_{O1} (at CD2 level), (t/m2) =	2.63
p_3 (t/m2) =	2.57

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ CD2\ Elev.}$ (t/m) =	5.20
$P_{up\ to\ bottom\ Elev.}$ (t/m) =	10.54

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
W1con. cell. (total), t/m	13.32
W2con. cell. (total), t/m	19.97

Sliding	**S.F. at CD2 Elev.**	**2.05**
	S.F. at CD3 Elev.	**2.53**

Overturning	$Mp_{at\ O1}$	5.21
	$M_{conc.\ cell.\ at\ O1}$ (=W*t)	59.92
	S.F. at O1	**11.51**
	$Mp_{at\ O2}$	21.18
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	199.73
	S.F. at O2	**9.43**

	30 years	
CD1	+ 2	m
CD2	+ 0	m
CD3	-+ 2	m
LWL	**+ 0.43**	m
a	3	m
h1	2	m
h2	2	m
b	2.00	m
t	0.20	m
$S_{conc.\ cell}$ (1 cell.)	1.84	m2
$\gamma_{conc.}$	2.4	t/m3
$\gamma'_{conc.}$	1.375	t/m3
$W1_{conc.\ cell}$ (1 cell.)	5.06	t/m
$W2_{conc.\ cell}$ (1 cell.)	5.06	t/m
$S_{rubber\ filling}$ (1 cell.)	4.16	m2
$\gamma_{rubber\ stone}$	2.6	t/m3
$\gamma'_{rubber\ stone}$	1.575	t/m3
void ratio	37%	
$W1_{rubber\ filling}$ (1 cell.)	8.26	t/m
$W2_{rubber\ filling}$ (1 cell.)	8.26	t/m

Upper Layer	Nos. of cellular block	2.00	unit
	x_{O1}	4.50	m
	M_{O1}	59.92	tm/m
Lower Layer	Nos. of cellular block	3.00	unit
	x_{O2}	6.00	m
	M_{O2}	199.73	tm/m

Wave	$P_{up\ to\ CD2\ Elev.}$	5.20	t/m
	$y_{p\ upto\ CD2\ Elev.}$	1.00	
	$Mp_{at\ O1}$	5.21	t.m/m
	$P_{up\ to\ bottom\ Elev.}$	10.54	t/m
	$y_{p\ upto\ bottom\ Elev.}$	2.010	m
	$Mp_{at\ O2}$	21.18	t.m/m

STABILITY CALCULATION DUE TO WAVE FORCE *(Clause 5.5.2 - OCDI)*

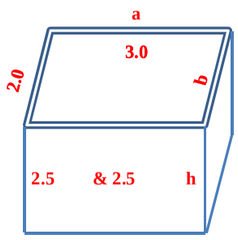
Sand Protection Training Dike - Section for GL upto CD -3.0m

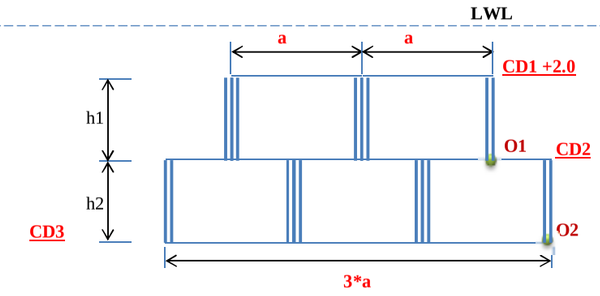
I. Wave Force under Wave Crest

1. Input data:

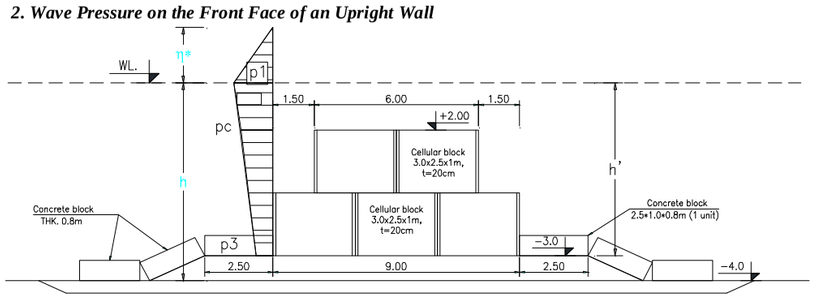
- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**0.43**
- Crest Level (CDL):	2.0
- Bottom Upright Wall Level (CDL):	-3.0
- Bottom Width of Upright Wall (m):	9.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-4.0
- Significant Wave Height ($H_{1/3}$), m:	2.985
- H_{max}, m:	4.012
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	78.98

Bellow sketch for reference only





2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos b)\, l\, a_1\, r_0 g H_D$

At toe of upright wall: $p_3 = p_u = a_3 p_1$

$$l = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad h^* = 0.75(1+\cos b)\, l\, H_D$$

$$a_1 = 0.6+\frac{1}{2}\left[\frac{4ph/L}{\sinh\left(\frac{4ph}{L}\right)}\right]^2 \qquad a_3 = 1+\frac{h'}{h^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years	
β (deg) =	60.936	
cos β:	0.486	
H_D (m):	4.012	
L (m):	78.98	
HWL (CDL):	0.43	
Sea bed Level (CDL):	-4.0	
Crest Level (CDL):	2.0	
h (m):	4.43	
h' (m)	3.43	
ρ_0 (t/m3):	1.025	
g (m/s2):	9.81	
4 πh/L	0.705	
2 πh/L	0.352	
λ	1.000	*Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	4.47
α_1 =	1.025
α_3 =	0.954
(1+cosβ)	1.486
$\alpha_1 \lambda \rho_0 H_D$	4.214
p_1 (t/m2) =	3.13
p_c (at crest level), (t/m2) =	3.20
p_{O1} (at CD2 level), (t/m2) =	3.09
p_3 (t/m2) =	2.99

5.3. Total wave pressure on Upright Wall

P up to CD2 Elev. (t/m) =	7.60
P up to bottom Elev. (t/m) =	15.46

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
W1con. cell. (total), t/m	16.64
W2con. cell. (total), t/m	24.97

Sliding	**S.F. at CD2 Elev.**	**1.75**
	S.F. at CD3 Elev.	**2.15**

Overturning	$Mp_{at\ O1}$	9.52
	$M_{conc.\ cell.\ at\ O1}$ (=W*t)	74.90
	S.F. at O1	**7.87**
	$Mp_{at\ O2}$	38.95
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	249.67
	S.F. at O2	**6.41**

	30 years	
CD1	+ 2	m
CD2	-0.50	m
CD3	-3.00	m
LWL	**+ 0.43**	m
a	3	m
h1	2.5	m
h2	2.5	m
b	2.00	m
t	0.20	m
$S_{conc.\ cell}$ (1 cell.)	1.84	m2
$\gamma_{conc.}$	2.4	t/m3
$\gamma'_{conc.}$	1.375	t/m3
$W1_{conc.\ cell}$ (1 cell.)	6.33	t/m
$W2_{conc.\ cell}$ (1 cell.)	6.33	t/m
$S_{rubber\ filling}$ (1 cell.)	4.16	m2
$\gamma_{rubber\ stone}$	2.6	t/m3
$\gamma'_{rubber\ stone}$	1.575	t/m3
void ratio	37%	
$W1_{rubber\ filling}$ (1 cell.)	10.32	t/m
$W2_{rubber\ filling}$ (1 cell.)	10.32	t/m
Upper Layer: Nos. of cellular block	2.00	unit
Upper Layer: x_{O1}	4.50	m
Upper Layer: M_{O1}	74.90	tm/m
Lower Layer: Nos. of cellular block	3.00	unit
Lower Layer: x_{O2}	6.00	m
Lower Layer: M_{O2}	249.67	tm/m

Wave	P up to CD2 Elev.	7.60	t/m
	$y_{p\ upto\ CD2\ Elev.}$	1.25	
	$Mp_{at\ O1}$	9.52	t.m/m
	P up to bottom Elev.	15.46	t/m
	$y_{p\ upto\ bottom\ Elev.}$	2.519	m
	$Mp_{at\ O2}$	38.95	t.m/m

STABILITY CALCULATION DUE TO WAVE FORCE ***(Clause 5.5.2 - OCDI)***

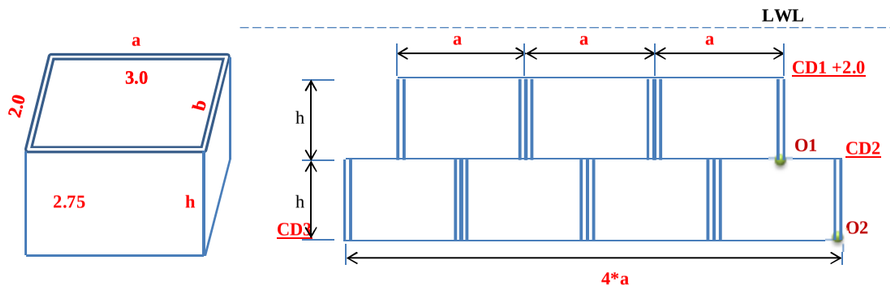
Sand Protection Training Dike - Section for GL upto CD -5.0m

I. Wave Force under Wave Crest

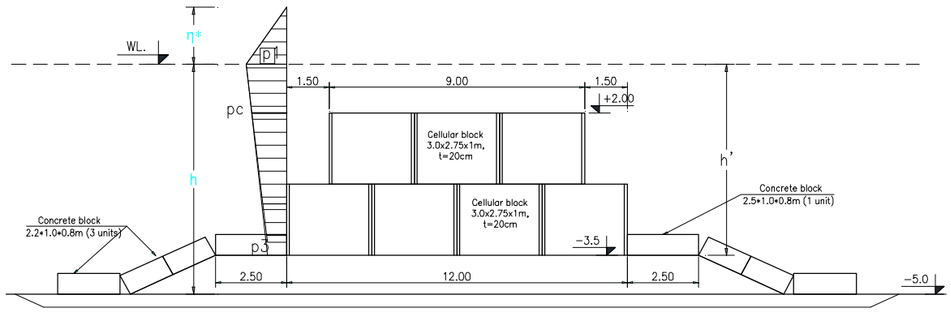
1. Input data:

- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**0.43**
- Crest Level (CDL):	2.0
- Bottom Upright Wall Level (CDL):	-3.5
- Bottom Width of Upright Wall (m):	12.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-5.0
- Significant Wave Height ($H_{1/3}$), m:	3.457
- H_{max}, m:	4.595
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	84.32

Bellow sketch for reference only



2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos b)\, l\, a_1\, r_0 g H_D$

At toe of upright wall: $p_3 = p_u = a_3 p_1$

$$l = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad h^* = 0.75(1+\cos b)\, l\, H_D$$

$$a_1 = 0.6+\frac{1}{2}\left[\frac{4p\,h/L}{\sinh\left(\frac{4p\,h}{L}\right)}\right]^2 \qquad a_3 = 1+\frac{h'}{h^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30 years	
β (deg) =	60.681	
cos β:	0.490	
H_D (m):	4.595	
L (m):	84.32	
HWL (CDL):	0.43	
Sea bed Level (CDL):	-5.0	
Crest Level (CDL):	2.0	
h (m):	5.43	
h' (m)	3.93	
ρ_0 (t/m3):	1.025	
g (m/s2):	9.81	
4 πh/L	0.809	
2 πh/L	0.405	
λ	1.000	*Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	5.13
α_1 =	1.004
α_3 =	0.945
(1+cosβ)	1.490
$\alpha_1 \lambda \rho_0 H_D$	4.728
p_1 (t/m2) =	3.52
p_c (at crest level), (t/m2) =	3.60
p_{O1} (at CD2 level), (t/m2) =	3.46
p_3 (t/m2) =	3.33

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ CD2\ Elev.}$ (t/m) =	9.33
$P_{up\ to\ bottom\ Elev.}$ (t/m) =	19.05

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	64.08

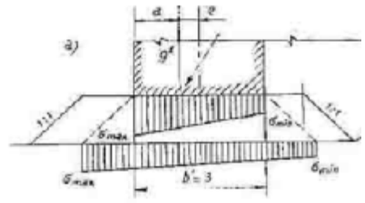
Sliding	**S.F. at CD2 Elev.**	**2.35**
	S.F. at CD3 Elev.	**2.69**

Overturning	$M_{p\ at\ O1}$	12.87
	$M_{conc.\ cell.\ at\ O1}$ (=W*t)	123.58
	S.F. at O1	**9.60**
	$M_{p\ at\ O2}$	52.87
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	384.49
	S.F. at O2	**7.27**

	30 years	
CD1	+ 2	m
CD2	-0.8	m
CD3	-3.5	m
LWL	+ **0.43**	m
a	3	m
h	2.75	m
b	2.00	m
t	0.20	m
$S_{conc.\ cell}$ (1 cell.)	1.84	m2
$\gamma_{conc.}$	2.4	t/m3
$\gamma'_{conc.}$	1.375	t/m3
$W_{conc.\ cell}$ (1 cell.)	6.96	t/m
$S_{rubber\ filling}$ (1 cell.)	4.16	m2
$\gamma_{rubber\ stone}$	2.6	t/m3
$\gamma'_{rubber\ stone}$	1.575	t/m3
void ratio	37%	
$W_{rubber\ filling}$ (1 cell.)	11.35	t/m
Upper Layer: Nos. of cellular block	3.00	unit
Upper Layer: x_{O1}	4.50	m
Upper Layer: M_{O1}	123.58	tm/m
Lower Layer: Nos. of cellular block	4.00	unit
Lower Layer: x_{O2}	6.00	m
Lower Layer: M_{O2}	384.49	tm/m

Wave	$P_{up\ to\ CD2\ Elev.}$	9.33	t/m
	$y_{p\ upto\ CD2\ Elev.}$	1.38	
	$Mp_{\ at\ O1}$	12.87	t.m/m
	$P_{up\ to\ bottom\ Elev.}$	19.05	t/m
	$y_{p\ upto\ bottom\ Elev.}$	2.776	m
	$Mp_{\ at\ O2}$	52.87	t.m/m

Bearing capacity of soft soil under foundation



a = 5.17 m
b = 12 m
b/3 = 4 m
Checking condition a ≥ b/3: **OK**
e = 0.83 m

–(–) ruberstone = 6.0 kg/cm²

σ_{max} = 7.54 t/m² = 0.75 kg/cm² **OK**
σ_{min} = 3.14 t/m² = 0.31 kg/cm² **OK**

—— soft soil = 2.0 kg/cm²

b' = 12 m
hn = 1.5 m
γ'^{tc}_{k} 1.575 t/m3

σ'_{max} = 8.40 t/m² = 0.84 kg/cm² **OK**
σ'_{min} = 4.87 t/m² = 0.49 kg/cm² **OK**

13 STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - CASE B-2 (LWL)

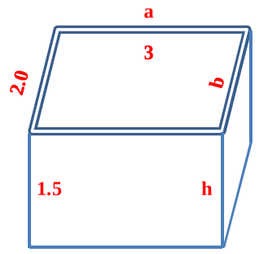
D. STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - Section for GL upto CD 0.0m

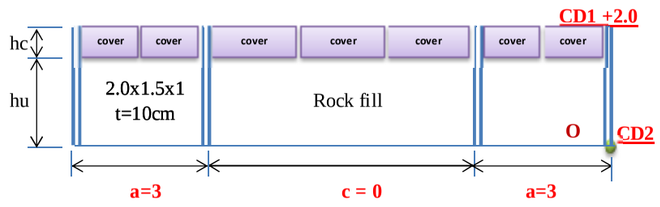
(Clause 5.5.2 - OCDI)

I. Wave Force under Wave Crest

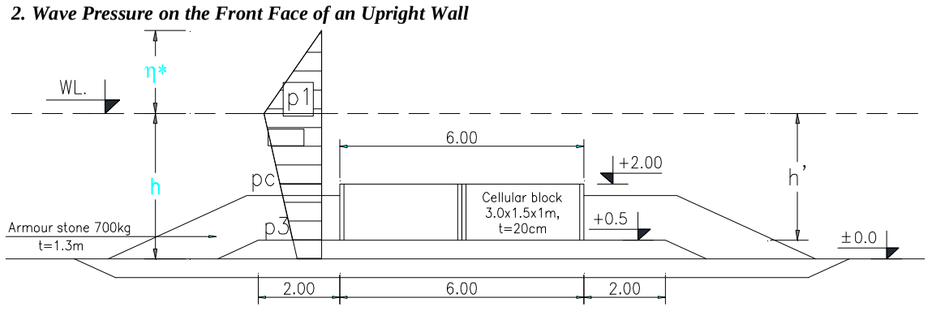
1. Input data:

- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**0.43**
- Crest Level (CDL):	2.0
- Bottom Upright Wall Level (CDL):	0.5
- Bottom Width of Upright Wall (m):	6.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	0.0
- Significant Wave Height ($H_{1/3}$), m:	0.93
- H_{max}, m:	3.14
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	70.13





2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30	
β (deg) =	32.35	
cos β:	0.845	
H_D (m):	3.14	
L (m):	70.13	
LWL (CDL):	0.43	
Sea bed Level (CDL):	0.0	
Crest Level (CDL):	2.0	
h (m):	0.43	
h' (m)	-0.07	
ρ_0 (t/m3):	1.025	
g (m/s2):	9.81	
4 πh/L	0.077	
2 πh/L	0.039	
λ	1.000	*Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	4.34
α_1 =	1.099
α_3 =	0.984
(1+cosβ)	1.845
$\alpha_1 \lambda \rho_0 H_D$	3.537
p_1 (t/m2) =	3.26
p_c (at crest level), (t/m2) =	2.08
p_3 (t/m2) =	3.21

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ bottom\ Elev.}$ (t/m) =	3.97

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	7.92
Wconc. cover (total), t/m	3.58
$W_{core\ ruble\ at\ bottom}$, t/m	0.00

Sliding	**S.F. at bottom Elev.**	**2.32**

Overturning	$Mp_{at\ O}$	2.77
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	55.09
	S.F. at O	**19.91**

	30 years		
CD1	+ 2	m	
CD2	+ 0.5	m	
LWL	**+ 0.43**	m	
a	3	m	
h	1.5	m	
hu	1.00	m	
b	2.00	m	
t	0.20	m	
c	0.00	m	
hc	0.50	m	
$a_{c\ side}$	2.6	m	
$a_{c\ center}$	0.00	m	
$S_{conc.\ cell}$ (1 cell.)	1.84	m2	
$\gamma_{conc.}$	2.4	t/m3	
$\gamma'_{conc.}$	1.375	t/m3	
$W_{conc.\ cell}$ (1 cell.)	3.80	t/cell.	
$S_{rubber\ filling}$ (1 cell.)	4.16	m2	
$\gamma_{rubber\ stone}$	2.6	t/m3	
$\gamma'_{rubber\ stone}$	1.575	t/m3	
void ratio	37%		
$W_{rubber\ filling}$ (1 cell.)	4.13	t/cell.	
$W_{conc.\ cover\ side}$	1.79	t/m	
$W_{conc.\ cover\ center}$	0.00	t/m	
$W_{core\ ruble\ at\ bottom}$	0.00	t/m	
Upper Layer	Nos. of cellular block	2.00	unit
	x_{O1}	3.00	m
	M_{O1}	55.09	tm/m

Wave	$P_{up\ to\ bottom\ Elev.}$	3.97	t/m
	$y_{p\ upto\ bottom\ Elev.}$	0.697	m
	$Mp_{at\ O2}$	2.77	t.m/m

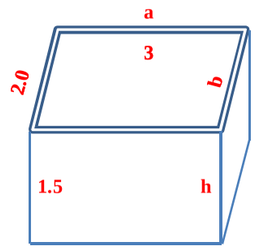
E. STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - Section for GL upto CD -1.0m

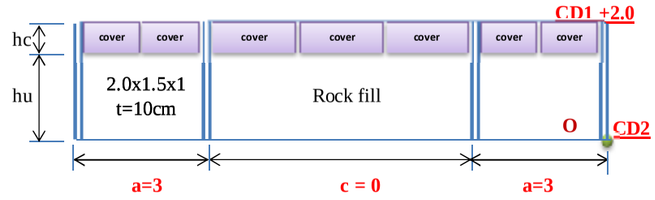
(Clause 5.5.2 - OCDI)

I. Wave Force under Wave Crest

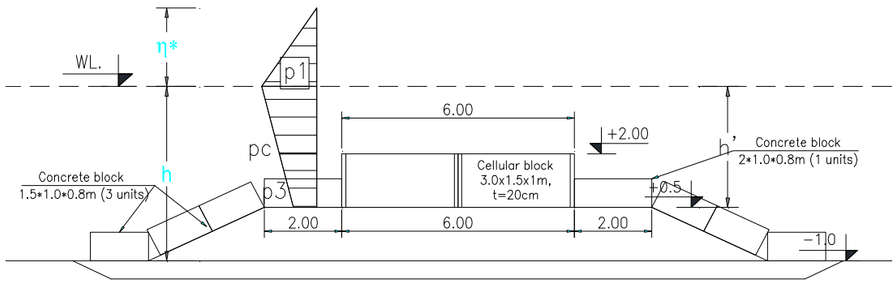
1. Input data:

- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**0.43**
- Crest Level (CDL):	2.0
- Bottom Upright Wall Level (CDL):	0.5
- Bottom Width of Upright Wall (m):	6.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-1.0
- Significant Wave Height ($H_{1/3}$), m:	1.48
- H_{max}, m:	3.727
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	76.21





2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30	
β (deg) =	57.02	
cos β:	0.544	
H_D (m):	3.727	
L (m):	76.21	
LWL (CDL):	0.43	
Sea bed Level (CDL):	-1.0	
Crest Level (CDL):	2.0	
h (m):	1.43	
h' (m)	-0.07	
ρ_0 (t/m3):	1.025	
g (m/s2):	9.81	
4 πh/L	0.236	
2 πh/L	0.118	
λ	1.000	*Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	4.32
α_1 =	1.091
α_3 =	0.984
(1+cosβ)	1.544
$\alpha_1 \lambda \rho_0 H_D$	4.167
p_1 (t/m2) =	3.22
p_c (at crest level), (t/m2) =	2.05
p_3 (t/m2) =	3.17

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ bottom\ Elev.}$ (t/m) =	3.91

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	7.92
Wconc. cover (total), t/m	3.58
$W_{core\ ruble\ at\ bottom}$, t/m	0.00

Sliding	**S.F. at bottom Elev.**	**2.35**

Overturning	$Mp_{at\ O}$	2.72
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	55.09
	S.F. at O	**20.23**

	30 years		
CD1	+ 2	m	
CD2	+ 0.5	m	
LWL	+ **0.43**	m	
a	3	m	
h	1.5	m	
hu	1.00	m	
b	2.00	m	
t	0.20	m	
c	0.00	m	
hc	0.50	m	
$a_{c\ side}$	2.6	m	
$a_{c\ center}$	0.00	m	
$S_{conc.\ cell}$ (1 cell.)	1.84	m2	
$\gamma_{conc.}$	2.4	t/m3	
$\gamma'_{conc.}$	1.375	t/m3	
$W_{conc.\ cell}$ (1 cell.)	3.80	t/cell.	
$S_{rubber\ filling}$ (1 cell.)	4.16	m2	
$\gamma_{rubber\ stone}$	2.6	t/m3	
$\gamma'_{rubber\ stone}$	1.575	t/m3	
void ratio	37%		
$W_{rubber\ filling}$ (1 cell.)	4.13	t/cell.	
$W_{conc.\ cover\ side}$	1.79	t/m	
$W_{conc.\ cover\ center}$	0.00	t/m	
$W_{core\ ruble\ at\ bottom}$	0.00	t/m	
Upper Layer	Nos. of cellular block	2.00	unit
	x_{O1}	3.00	m
	M_{O1}	55.09	tm/m

Wave	$P_{up\ to\ bottom\ Elev.}$	3.91	t/m
	$y_{p\ upto\ bottom\ Elev.}$	0.696	m
	$Mp_{at\ O2}$	2.72	t.m/m

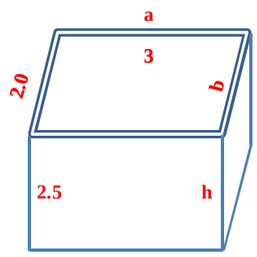
F. STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - Section for GL upto CD -2.0m

(Clause 5.5.2 - OCDI)

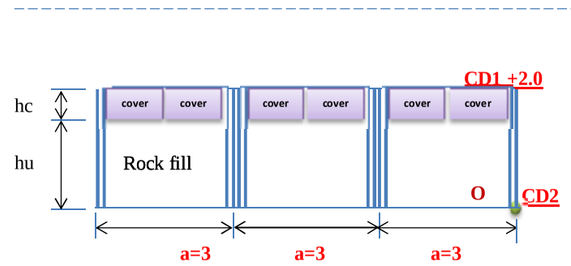
I. Wave Force under Wave Crest

1. Input data:

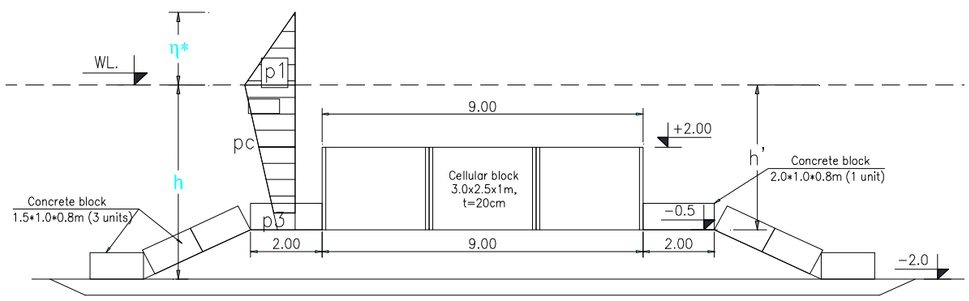
- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**0.43**
- Crest Level (CDL):	2.0
- Bottom Upright Wall Level (CDL):	-0.5
- Bottom Width of Upright Wall (m):	9.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-2.0
- Significant Wave Height ($H_{1/3}$), m:	1.952
- H_{max}, m:	2.87
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	67.12



Sketch of detail of super structure



2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30
β (deg) =	65.468
cos β:	0.415
H_D (m):	2.87
L (m):	67.12
LWL (CDL):	0.43
Sea bed Level (CDL):	-2.0
Crest Level (CDL):	2.0
h (m):	2.43
h' (m)	0.93
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	0.455
2 πh/L	0.227
λ	1.000 *Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	3.05
α_1 =	1.067
α_3 =	0.990
(1+cosβ)	1.415
α_1 λ ρ_0 H_D	3.139
p_1 (t/m2) =	2.22
p_c (at crest level), (t/m2) =	2.26
p_3 (t/m2) =	2.20

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ bottom\ Elev.}$ (t/m) =	5.57

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	21.87
Wconc. cover (total), t/m	5.36

Sliding	**S.F. at bottom Elev.**	**3.91**

Overturning	$Mp_{at\ O}$	6.99
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	220.97
	S.F. at O	**31.60**

	30 years
CD1	+ 2 m
CD2	-0.5 m
WL	**+ 0.43** m
a	3 m
h	2.5 m
hu	2.00 m
b	2.00 m
t	0.20 m
hc	0.50 m
a_{inside}	2.6 m
$S_{conc.\ cell}$ (1 cell.)	1.84 m2
$\gamma_{conc.}$	2.4 t/m3
$\gamma'_{conc.}$	1.375 t/m3
$W_{conc.\ cell}$ (1 cell.)	**6.33** t/cell.
$S_{rubber\ filling}$ (1 cell.)	4.16 m2
$\gamma_{rubber\ stone}$	2.6 t/m3
$\gamma'_{rubber\ stone}$	1.575 t/m3
void ratio	37%
$W_{rubber\ filling}$ (1 cell.)	**8.26** t/cell.
$W_{conc.\ cover\ side}$	1.79 t/m

Upper Layer	Nos. of cellular block	3.00	unit
	x_{O1}	4.50	m
	M_{O1}	220.97	tm/m

Wave	$P_{up\ to\ bottom\ Elev.}$	5.57	t/m
	$y_{p\ upto\ bottom\ Elev.}$	1.255	m
	$Mp_{at\ O2}$	6.99	t.m/m

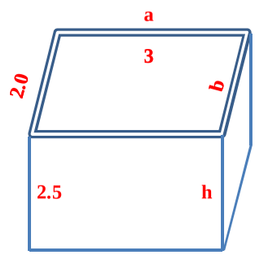
G. STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - Section for GL upto CD -3.0m

(Clause 5.5.2 - OCDI)

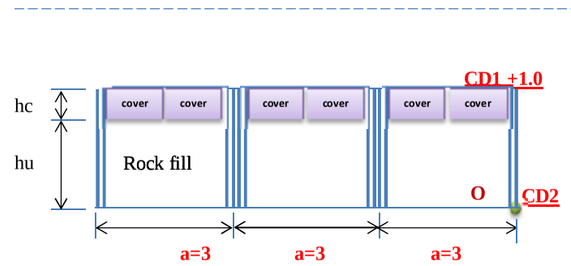
I. Wave Force under Wave Crest

1. Input data:

- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**0.43**
- Crest Level (CDL):	1.0
- Bottom Upright Wall Level (CDL):	-1.5
- Bottom Width of Upright Wall (m):	9.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-3.0
- Significant Wave Height ($H_{1/3}$), m:	2.427
- H_{max}, m:	3.343
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	72.30

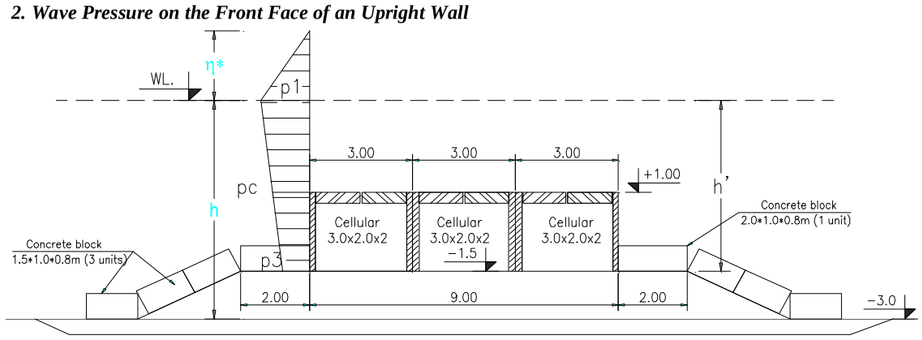


Sketch of detail of super structure



	30 years	
CD1	+ 1	m
CD2	-1.5	m
LWL	**+ 0.43**	m
a	3	m
h	2.5	m
hu	2.00	m
b	2.00	m
t	0.20	m
hc	0.50	m
a_{inside}	2.6	m
$S_{conc.\ cell}$ (1 cell.)	1.84	m2
$\gamma_{conc.}$	2.4	t/m3
$\gamma'_{conc.}$	1.375	t/m3
$W_{conc.\ cell}$ (1 cell.)	**6.33**	t/cell.
$S_{rubber\ filling}$ (1 cell.)	4.16	m2
$\gamma_{rubber\ stone}$	2.6	t/m3
$\gamma'_{rubber\ stone}$	1.575	t/m3
void ratio	37%	
$W_{rubber\ filling}$ (1 cell.)	**8.26**	t/cell.
$W_{conc.\ cover\ side}$	1.79	t/m

2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30	
β (deg) =	61.332	
cos β:	0.480	
H_D (m):	3.343	
L (m):	72.30	
LWL (CDL):	0.43	
Sea bed Level (CDL):	-3.0	
Crest Level (CDL):	1.0	
h (m):	3.43	
h' (m)	1.93	
ρ_0 (t/m3):	1.025	
g (m/s2):	9.81	
4 πh/L	0.596	
2 πh/L	0.298	
λ	1.000	*Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	3.71
α_1 =	1.045
α_3 =	0.976
(1+cosβ)	1.480
α_1 λ ρ_0 H_D	3.580
p_1 (t/m2) =	2.65
p_c (at crest level), (t/m2) =	2.67
p_3 (t/m2) =	2.58

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ bottom\ Elev.}$ (t/m) =	6.57

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	21.87
Wconc. cover (total), t/m	5.36

Sliding	**S.F. at bottom Elev.**	**3.32**

Overturning	$Mp_{at\ O}$	8.25
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	220.97
	S.F. at O	**26.78**

Upper Layer	Nos. of cellular block	3.00	unit
	x_{O1}	4.50	m
	M_{O1}	220.97	tm/m

Wave	$P_{up\ to\ bottom\ Elev.}$	6.57	t/m
	$y_{p\ upto\ bottom\ Elev.}$	1.257	m
	$Mp_{at\ O2}$	8.25	t.m/m

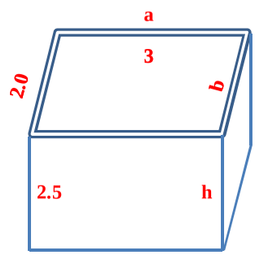
G. STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - Section for GL upto CD -3.0m

(Clause 5.5.2 - OCDI)

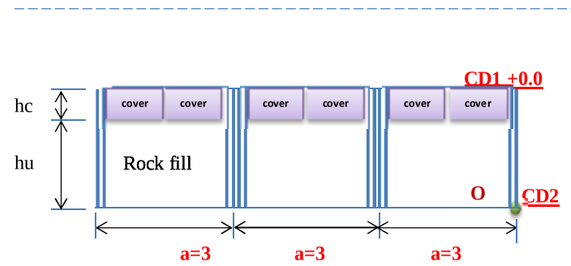
I. Wave Force under Wave Crest

1. Input data:

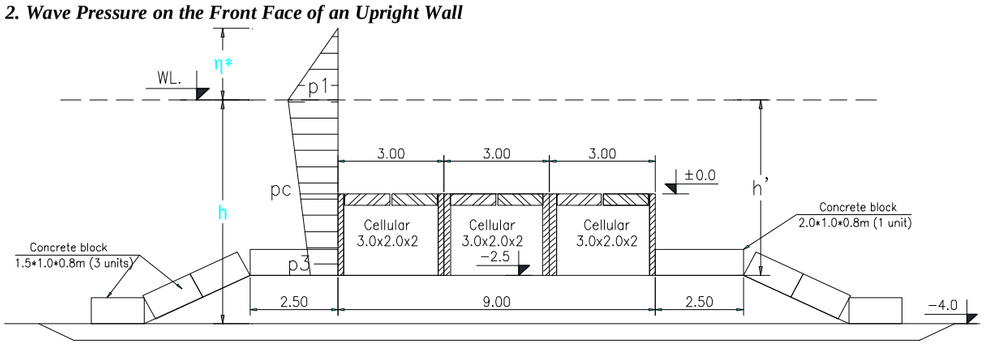
- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**0.43**
- Crest Level (CDL):	0.0
- Bottom Upright Wall Level (CDL):	-2.5
- Bottom Width of Upright Wall (m):	9.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-4.0
- Significant Wave Height ($H_{1/3}$), m:	2.985
- H_{max}, m:	4.012
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	78.98



Sketch of detail of super structure



2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30	
β (deg) =	60.936	
cos β:	0.486	
H_D (m):	4.012	
L (m):	78.98	
LWL (CDL):	0.43	
Sea bed Level (CDL):	-4.0	
Crest Level (CDL):	0.0	
h (m):	4.43	
h' (m)	2.93	
ρ_0 (t/m3):	1.025	
g (m/s2):	9.81	
4 πh/L	0.705	
2 πh/L	0.352	
λ	1.000	*Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	4.47
α_1 =	1.025
α_3 =	0.961
(1+cosβ)	1.486
$\alpha_1 \lambda \rho_0 H_D$	4.214
p_1 (t/m2) =	3.13
p_c (at crest level), (t/m2) =	3.11
p_3 (t/m2) =	3.01

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ bottom\ Elev.}$ (t/m) =	7.65

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	21.87
Wconc. cover (total), t/m	5.36

Sliding	**S.F. at bottom Elev.**	**2.85**

Overturning	$Mp_{at\ O}$	9.62
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	220.97
	S.F. at O	**22.97**

	30 years	
CD1	+ 0	m
CD2	-2.5	m
LWL	**+ 0.43**	m
a	3	m
h	2.5	m
hu	2.00	m
b	2.00	m
t	0.20	m
hc	0.50	m
a_{inside}	2.6	m
$S_{conc.\ cell}$ (1 cell.)	1.84	m2
$\gamma_{conc.}$	2.4	t/m3
$\gamma'_{conc.}$	1.375	t/m3
$W_{conc.\ cell}$ (1 cell.)	**6.33**	t/cell.
$S_{rubber\ filling}$ (1 cell.)	4.16	m2
$\gamma_{rubber\ stone}$	2.6	t/m3
$\gamma'_{rubber\ stone}$	1.575	t/m3
void ratio	37%	
$W_{rubber\ filling}$ (1 cell.)	**8.26**	t/cell.
$W_{conc.\ cover\ side}$	1.79	t/m

Upper Layer	Nos. of cellular block	3.00	unit
	x_{O1}	4.50	m
	M_{O1}	220.97	tm/m

Wave	$P_{up\ to\ bottom\ Elev.}$	7.65	t/m
	$y_{p\ upto\ bottom\ Elev.}$	1.257	m
	$Mp_{at\ O2}$	9.62	t.m/m

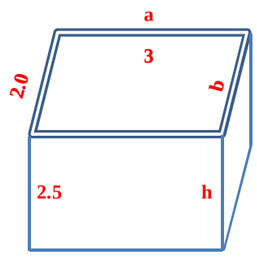
G. STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - Section for GL upto CD -3.0m

(Clause 5.5.2 - OCDI)

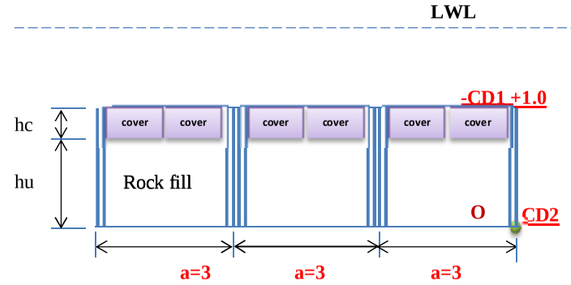
I. Wave Force under Wave Crest

1. Input data:

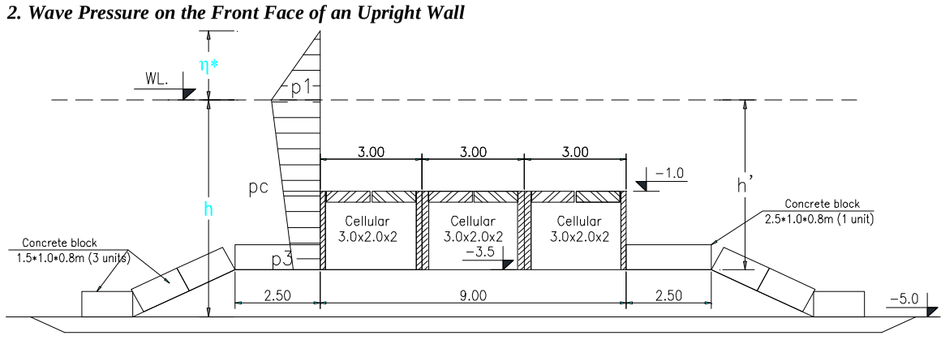
- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**0.43**
- Crest Level (CDL):	-1.0
- Bottom Upright Wall Level (CDL):	-3.5
- Bottom Width of Upright Wall (m):	9.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-5.0
- Significant Wave Height ($H_{1/3}$), m:	3.457
- H_{max}, m:	4.595
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	84.32



Sketch of detail of super structure



2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30
β (deg) =	60.681
cos β:	0.490
H_D (m):	4.595
L (m):	84.32
LWL (CDL):	0.43
Sea bed Level (CDL):	-5.0
Crest Level (CDL):	-1.0
h (m):	5.43
h' (m)	3.93
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	0.809
2 πh/L	0.405
λ	1.000 *Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	5.13
α_1 =	1.004
α_3 =	0.945
(1+cosβ)	1.490
$\alpha_1 \lambda \rho_0 H_D$	4.728
p_1 (t/m2) =	3.52
p_c (at crest level), (t/m2) =	3.45
p_3 (t/m2) =	3.33

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ bottom\ Elev.}$ (t/m) =	8.47

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	21.87
Wconc. cover (total), t/m	5.36

Sliding	**S.F. at bottom Elev.**	**2.57**

Overturning	$Mp_{at\ O}$	10.65
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	220.97
	S.F. at O	**20.74**

	30 years	
CD1	-1	m
CD2	-3.5	m
LWL	**+ 0.43**	m
a	3	m
h	2.5	m
hu	2.00	m
b	2.00	m
t	0.20	m
hc	0.50	m
a_{inside}	2.6	m
$S_{conc.\ cell}$ (1 cell.)	1.84	m2
$\gamma_{conc.}$	2.4	t/m3
$\gamma'_{conc.}$	1.375	t/m3
$W_{conc.\ cell}$ (1 cell.)	**6.33**	t/cell.
$S_{rubber\ filling}$ (1 cell.)	4.16	m2
$\gamma_{rubber\ stone}$	2.6	t/m3
$\gamma'_{rubber\ stone}$	1.575	t/m3
void ratio	37%	
$W_{rubber\ filling}$ (1 cell.)	**8.26**	t/cell.
$W_{conc.\ cover\ side}$	1.79	t/m

Upper Layer	Nos. of cellular block	3.00	unit
	x_{O1}	4.50	m
	M_{O1}	220.97	tm/m

Wave	$P_{up\ to\ bottom\ Elev.}$	8.47	t/m
	$y_{p\ upto\ bottom\ Elev.}$	1.258	m
	$Mp_{at\ O2}$	10.65	t.m/m

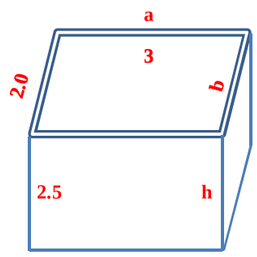
G. STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - Section for GL upto CD -3.0m

(Clause 5.5.2 - OCDI)

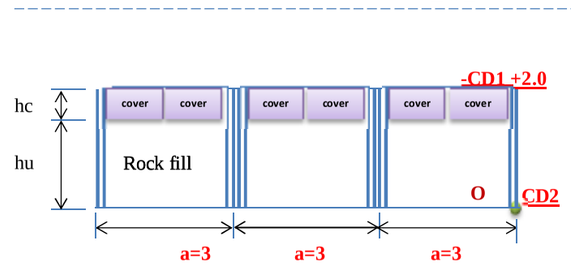
I. Wave Force under Wave Crest

1. Input data:

- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**0.43**
- Crest Level (CDL):	-2.0
- Bottom Upright Wall Level (CDL):	-4.5
- Bottom Width of Upright Wall (m):	9.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-6.0
- Significant Wave Height ($H_{1/3}$), m:	4.036
- H_{max}, m:	5.296
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	88.23

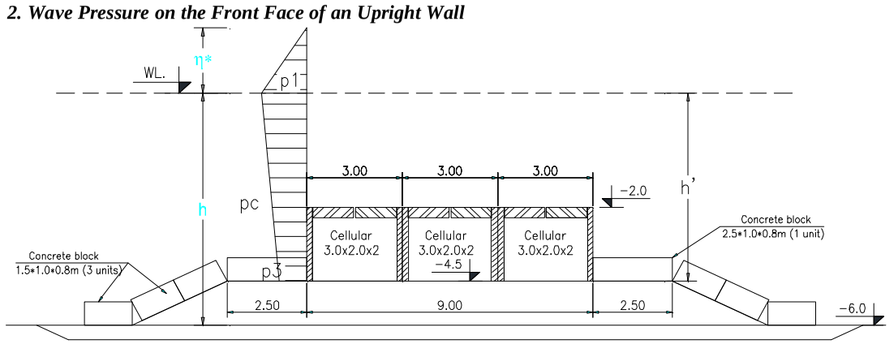


Sketch of detail of super structure



	30 years	
CD1	-2	m
CD2	-4.5	m
LWL	+ **0.43**	m
a	3	m
h	2.5	m
hu	2.00	m
b	2.00	m
t	0.20	m
hc	0.50	m
a inside	2.6	m
$S_{conc.\ cell}$ (1 cell.)	1.84	m2
$\gamma_{conc.}$	2.4	t/m3
$\gamma'_{conc.}$	1.375	t/m3
$W_{conc.\ cell}$ (1 cell.)	**6.33**	t/cell.
$S_{rubber\ filling}$ (1 cell.)	4.16	m2
$\gamma_{rubber\ stone}$	2.6	t/m3
$\gamma'_{rubber\ stone}$	1.575	t/m3
void ratio	37%	
$W_{rubber\ filling}$ (1 cell.)	**8.26**	t/cell.
$W_{conc.\ cover\ side}$	1.79	t/m

2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30	
β (deg) =	60.374	
cos β:	0.494	
H_D (m):	5.296	
L (m):	88.23	
LWL (CDL):	0.43	
Sea bed Level (CDL):	-6.0	
Crest Level (CDL):	-2.0	
h (m):	6.43	
h' (m)	4.93	
ρ_0 (t/m3):	1.025	
g (m/s2):	9.81	
4 πh/L	0.916	
2 πh/L	0.458	
λ	1.000	*Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	5.94
α_1 =	0.981
α_3 =	0.926
(1+cosβ)	1.494
$\alpha_1 \lambda \rho_0 H_D$	5.325
p_1 (t/m2) =	3.98
p_c (at crest level), (t/m2) =	3.83
p_3 (t/m2) =	3.68

5.3. Total wave pressure on Upright Wall

P up to bottom Elev. (t/m) =	9.40

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	21.87
Wconc. cover (total), t/m	5.36

Sliding	**S.F. at bottom Elev.**	**2.32**

Overturning	$Mp_{at\ O}$	11.82
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	220.97
	S.F. at O	**18.69**

Upper Layer	Nos. of cellular block	3.00	unit
	x_{O1}	4.50	m
	M_{O1}	220.97	tm/m

Wave	$P_{up\ to\ bottom\ Elev.}$	9.40	t/m
	$y_{p\ upto\ bottom\ Elev.}$	1.258	m
	$Mp_{at\ O2}$	11.82	t.m/m

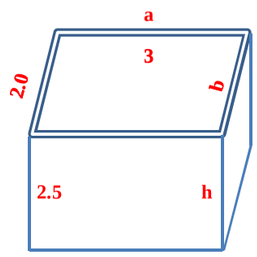
G. STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - Section for GL upto CD -3.0m

(Clause 5.5.2 - OCDI)

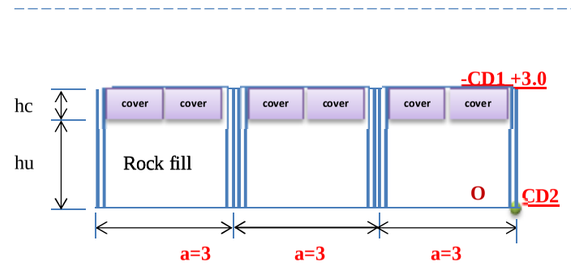
I. Wave Force under Wave Crest

1. Input data:

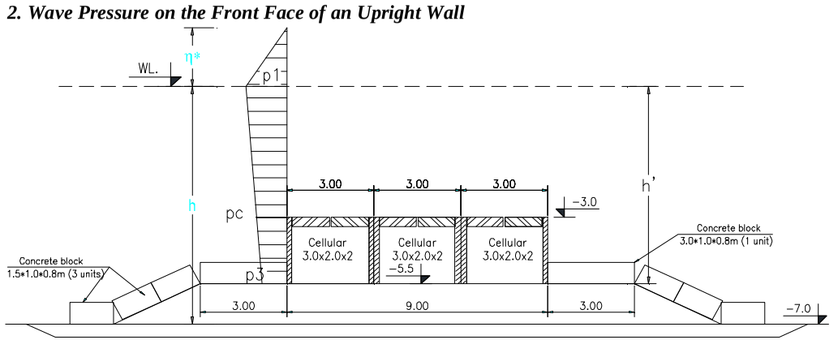
- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**0.43**
- Crest Level (CDL):	-3.0
- Bottom Upright Wall Level (CDL):	-5.5
- Bottom Width of Upright Wall (m):	9.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-7.0
- Significant Wave Height ($H_{1/3}$), m:	4.545
- H_{max}, m:	5.922
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	95.19



Sketch of detail of super structure



2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30	
β (deg) =	59.653	
cos β:	0.505	
H_D (m):	5.922	
L (m):	95.19	
LWL (CDL):	0.43	
Sea bed Level (CDL):	-7.0	
Crest Level (CDL):	-3.0	
h (m):	7.43	
h' (m)	5.93	
ρ_0 (t/m3):	1.025	
g (m/s2):	9.81	
4 πh/L	0.981	
2 πh/L	0.490	
λ	1.000	*Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	6.69
α_1 =	0.966
α_3 =	0.913
(1+cosβ)	1.505
α_1 λ ρ_0 H_D	5.866
p_1 (t/m2) =	4.41
p_c (at crest level), (t/m2) =	4.19
p_3 (t/m2) =	4.03

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ bottom\ Elev.}$ (t/m) =	10.28

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	21.87
Wconc. cover (total), t/m	5.36

Sliding	**S.F. at bottom Elev.**	**2.12**

Overturning	$Mp_{at\ O}$	12.93
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	220.97
	S.F. at O	**17.09**

	30 years	
CD1	-3	m
CD2	-5.5	m
LWL	**+ 0.43**	m
a	3	m
h	2.5	m
hu	2.00	m
b	2.00	m
t	0.20	m
hc	0.50	m
a_{inside}	2.6	m
$S_{conc.\ cell}$ (1 cell.)	1.84	m2
$\gamma_{conc.}$	2.4	t/m3
$\gamma'_{conc.}$	1.375	t/m3
$W_{conc.\ cell}$ (1 cell.)	**6.33**	t/cell.
$S_{rubber\ filling}$ (1 cell.)	4.16	m2
$\gamma_{rubber\ stone}$	2.6	t/m3
$\gamma'_{rubber\ stone}$	1.575	t/m3
void ratio	37%	
$W_{rubber\ filling}$ (1 cell.)	**8.26**	t/cell.
$W_{conc.\ cover\ side}$	1.79	t/m

Upper Layer	Nos. of cellular block	3.00	unit
	x_{O1}	4.50	m
	M_{O1}	220.97	tm/m

Wave	$P_{up\ to\ bottom\ Elev.}$	10.28	t/m
	$y_{p\ upto\ bottom\ Elev.}$	1.258	m
	$Mp_{at\ O2}$	12.93	t.m/m

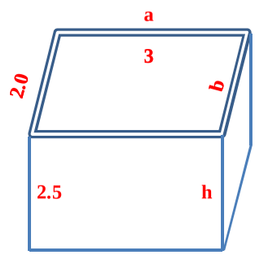
G. STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - Section for GL upto CD -3.0m

(Clause 5.5.2 - OCDI)

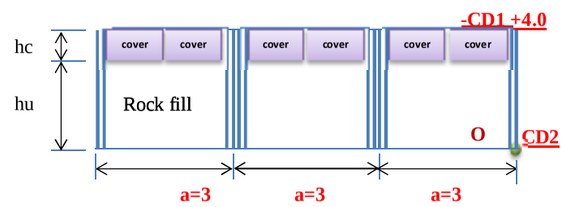
I. Wave Force under Wave Crest

1. Input data:

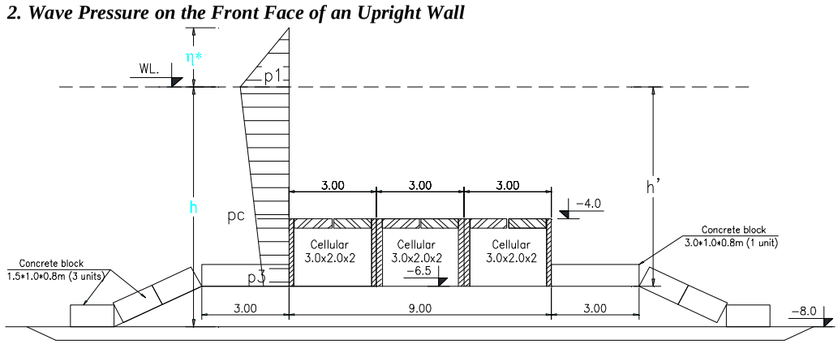
- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**0.43**
- Crest Level (CDL):	-4.0
- Bottom Upright Wall Level (CDL):	-6.5
- Bottom Width of Upright Wall (m):	9.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-8.0
- Significant Wave Height ($H_{1/3}$), m:	4.956
- H_{max}, m:	6.47
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	99.27



Sketch of detail of super structure



2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30
β (deg) =	59.6
cos β:	0.506
H_D (m):	6.47
L (m):	99.27
LWL (CDL):	0.43
Sea bed Level (CDL):	-8.0
Crest Level (CDL):	-4.0
h (m):	8.43
h' (m)	6.93
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.067
2 πh/L	0.534
λ	1.000 *Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	7.31
α_1 =	0.947
α_3 =	0.895
(1+cosβ)	1.506
α_1 λ ρ_0 H_D	6.278
p_1 (t/m2) =	4.73
p_c (at crest level), (t/m2) =	4.41
p_3 (t/m2) =	4.23

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ bottom\ Elev.}$ (t/m) =	10.81

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	21.87
Wconc. cover (total), t/m	5.36

Sliding	**S.F. at bottom Elev.**	**2.02**

Overturning	$Mp_{at\ O}$	13.60
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	220.97
	S.F. at O	**16.25**

	30 years
CD1	-4 m
CD2	-6.5 m
LWL	**+ 0.43** m
a	3 m
h	2.5 m
hu	2.00 m
b	2.00 m
t	0.20 m
hc	0.50 m
a_{inside}	2.6 m
$S_{conc.\ cell}$ (1 cell.)	1.84 m2
$\gamma_{conc.}$	2.4 t/m3
$\gamma'_{conc.}$	1.375 t/m3
$W_{conc.\ cell}$ (1 cell.)	**6.33** t/cell.
$S_{rubber\ filling}$ (1 cell.)	4.16 m2
$\gamma_{rubber\ stone}$	2.6 t/m3
$\gamma'_{rubber\ stone}$	1.575 t/m3
void ratio	37%
$W_{rubber\ filling}$ (1 cell.)	**8.26** t/cell.
$W_{conc.\ cover\ side}$	1.79 t/m

Upper Layer	Nos. of cellular block	3.00	unit
	x_{O1}	4.50	m
	M_{O1}	220.97	tm/m

Wave	$P_{up\ to\ bottom\ Elev.}$	10.81	t/m
	$y_{p\ upto\ bottom\ Elev.}$	1.259	m
	$Mp_{at\ O2}$	13.60	t.m/m

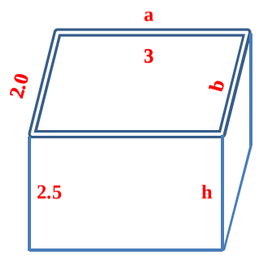
G. STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - Section for GL upto CD -3.0m

(Clause 5.5.2 - OCDI)

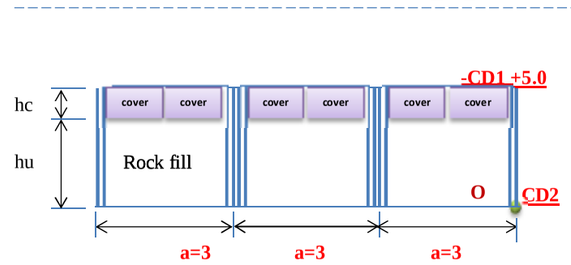
I. Wave Force under Wave Crest

1. Input data:

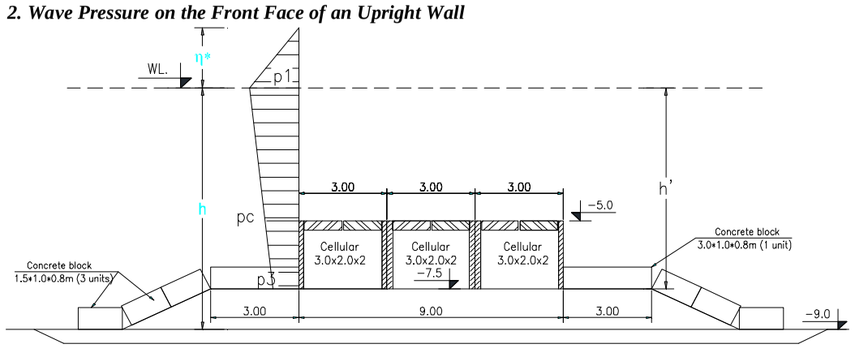
- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**0.43**
- Crest Level (CDL):	-5.0
- Bottom Upright Wall Level (CDL):	-7.5
- Bottom Width of Upright Wall (m):	9.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-9.0
- Significant Wave Height ($H_{1/3}$), m:	5.022
- H_{max}, m:	7.17
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	104.19



Sketch of detail of super structure



2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30
β (deg) =	59.43
cos β:	0.509
H_D (m):	7.17
L (m):	104.19
LWL (CDL):	0.43
Sea bed Level (CDL):	-9.0
Crest Level (CDL):	-5.0
h (m):	9.43
h' (m)	7.93
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.137
2 πh/L	0.569
λ	1.000 *Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	8.11
α_1 =	0.931
α_3 =	0.880
(1+cosβ)	1.509
α_1 λ ρ_0 H_D	6.839
p_1 (t/m2) =	5.16
p_c (at crest level), (t/m2) =	4.74
p_3 (t/m2) =	4.54

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ bottom\ Elev.}$ (t/m) =	11.59

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	21.87
Wconc. cover (total), t/m	5.36

Sliding	**S.F. at bottom Elev.**	**1.9**

Overturning	$Mp_{at\ O}$	14.59
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	220.97
	S.F. at O	**15.14**

	30 years	
CD1	-5	m
CD2	-7.5	m
LWL	+ **0.43**	m
a	3	m
h	2.5	m
hu	2.00	m
b	2.00	m
t	0.20	m
hc	0.50	m
a_{inside}	2.6	m
$S_{conc.\ cell}$ (1 cell.)	1.84	m2
$\gamma_{conc.}$	2.4	t/m3
$\gamma'_{conc.}$	1.375	t/m3
$W_{conc.\ cell}$ (1 cell.)	**6.33**	t/cell.
$S_{rubber\ filling}$ (1 cell.)	4.16	m2
$\gamma_{rubber\ stone}$	2.6	t/m3
$\gamma'_{rubber\ stone}$	1.575	t/m3
void ratio	37%	
$W_{rubber\ filling}$ (1 cell.)	**8.26**	t/cell.
$W_{conc.\ cover\ side}$	1.79	t/m

Upper Layer	Nos. of cellular block	3.00	unit
	x_{O1}	4.50	m
	M_{O1}	220.97	tm/m

Wave	$P_{up\ to\ bottom\ Elev.}$	11.59	t/m
	$y_{p\ upto\ bottom\ Elev.}$	1.259	m
	$Mp_{at\ O2}$	14.59	t.m/m

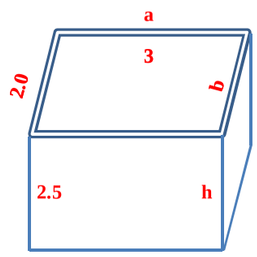
G. STABILITY CALCULATION DUE TO WAVE FORCE OF SAND PROTECTION TRAINING DIKE - Section for GL upto CD -3.0m

(Clause 5.5.2 - OCDI)

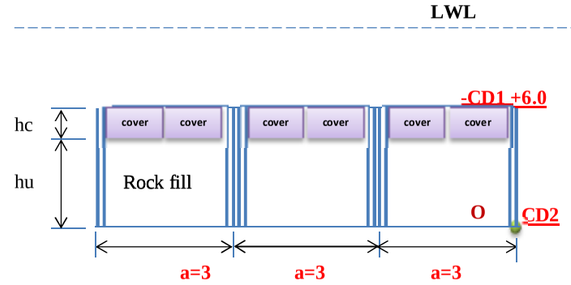
I. Wave Force under Wave Crest

1. Input data:

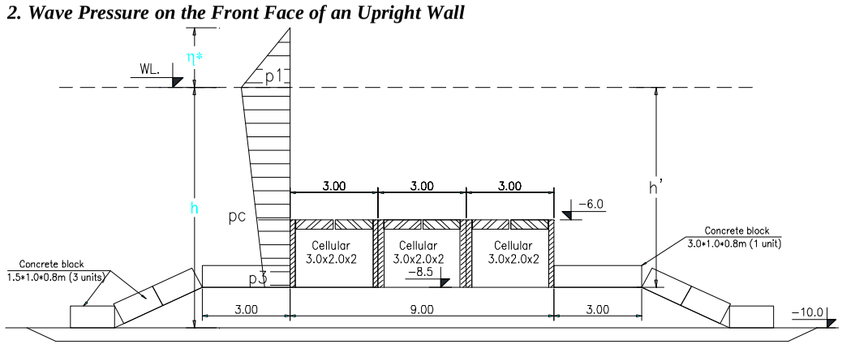
- Wave Return Period:	30 years
- Tide Level - LWL (CDL):	**0.43**
- Crest Level (CDL):	-6.0
- Bottom Upright Wall Level (CDL):	-8.5
- Bottom Width of Upright Wall (m):	9.0
- Back Fill Level (CDL):	
- Crest Level of Armor stone (CDL):	
- Seabed slope:	
- Seabed Surface Level (CDL):	-10.0
- Significant Wave Height ($H_{1/3}$), m:	5.079
- H_{max}, m:	7.818
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	108.50



Sketch of detail of super structure



2. Wave Pressure on the Front Face of an Upright Wall



Wave Pressure Distribution Used in Design Calculation

At still water level: $p_1 = 0.5(1+\cos\beta)\lambda\alpha_1\rho_0 g H_D$

At toe of upright wall: $p_3 = p_u = \alpha_3 p_1$

$$\lambda = \exp\left[-10\left(\frac{h}{L}\right)^{1.5}\left(1-\frac{h'}{h}\right)^{5}\right] \qquad \eta^* = 0.75(1+\cos\beta)\lambda H_D$$

$$\alpha_1 = 0.6+\frac{1}{2}\left[\frac{4\pi h/L}{\sinh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_3 = 1+\frac{h'}{\eta^*}(if\_h' \le 0)$$

4. Wave Height and Wavelength Used in the Wave Pressure Calculation

H_D = Hmax *breaking zone*

5. Results of Calculation

5.1. Input data

	30
β (deg) =	59.72
cos β:	0.504
H_D (m):	7.818
L (m):	108.50
LWL (CDL):	0.43
Sea bed Level (CDL):	-10.0
Crest Level (CDL):	-6.0
h (m):	10.43
h' (m)	8.93
ρ_0 (t/m3):	1.025
g (m/s2):	9.81
4 πh/L	1.208
2 πh/L	0.604
λ	1.000 *Upright wall*

5.2. Wave pressure on the front face of an Upright wall

η* =	8.82
α_1 =	0.914
α_3 =	0.864
(1+cosβ)	1.504
α_1 λ ρ_0 H_D	7.325
p_1 (t/m2) =	5.51
p_c (at crest level), (t/m2) =	4.97
p_3 (t/m2) =	4.76

5.3. Total wave pressure on Upright Wall

$P_{up\ to\ bottom\ Elev.}$ (t/m) =	12.17

II. Safety Factor

μ (friction factor between conc. cell. stone & stone):	0.80
Wcon. cell. (total), t/m	21.87
Wconc. cover (total), t/m	5.36

Sliding	**S.F. at bottom Elev.**	**1.79**

Overturning	$Mp_{at\ O}$	15.32
	$M_{conc.\ cell.\ at\ O2}$ (=W*t)	220.97
	S.F. at O	**14.42**

	30 years	
CD1	-6	m
CD2	-8.5	m
LWL	+ **0.43**	m
a	3	m
h	2.5	m
hu	2.00	m
b	2.00	m
t	0.20	m
hc	0.50	m
a_{inside}	2.6	m
$S_{conc.\ cell}$ (1 cell.)	1.84	m2
$\gamma_{conc.}$	2.4	t/m3
$\gamma'_{conc.}$	1.375	t/m3
$W_{conc.\ cell}$ (1 cell.)	**6.33**	t/cell.
$S_{rubber\ filling}$ (1 cell.)	4.16	m2
$\gamma_{rubber\ stone}$	2.6	t/m3
$\gamma'_{rubber\ stone}$	1.575	t/m3
void ratio	37%	
$W_{rubber\ filling}$ (1 cell.)	**8.26**	t/cell.
$W_{conc.\ cover\ side}$	1.79	t/m

Upper Layer	Nos. of cellular block	3.00	unit
	x_{O1}	4.50	m
	M_{O1}	220.97	tm/m

Wave	$P_{up\ to\ bottom\ Elev.}$	12.17	t/m
	$y_{p\ upto\ bottom\ Elev.}$	1.259	m
	$Mp_{at\ O2}$	15.32	t.m/m

14. Summary of Cellular caisson dimension & Safety factor

SUMMARY OF CELLULAR DIMENSION of CASE B-1&2

No.	Alternative	Seabed Elev. (m)	Cellular dimension				Remark
			width (m)	length (m)	height (m)	thickness (m)	
1	CASE B-1	0.0	3.00	2.00	1.50	0.20	Single layer cellular
2		-1.0	3.00	2.00	2.00	0.20	Single layer cellular
3		-2.0	3.00	2.00	3.00	0.20	Single layer cellular
4		-2.0	3.00	2.00	3.50	0.20	Single layer cellular
5		-3.0	3.00	2.00	1.50	0.20	Double layer cellular
6		-4.0	3.00	2.00	2.50	0.20	Double layer cellular
7		-5.0	3.00	2.00	2.75	0.20	Double layer cellular
7	CASE B-2	0.0	3.00	2.00	1.50	0.20	Single layer cellular
8		-1.0	3.00	2.00	1.50	0.20	Single layer cellular
9		-2.0	3.00	2.00	2.50	0.20	Single layer cellular
10		-3.0	3.00	2.00	2.50	0.20	Single layer cellular
11		-4.0	3.00	2.00	2.50	0.20	Single layer cellular
12		-5.0	3.00	2.00	2.50	0.20	Single layer cellular

SUMMARY OF CELLULAR DIMENSION of CASE A-1&2

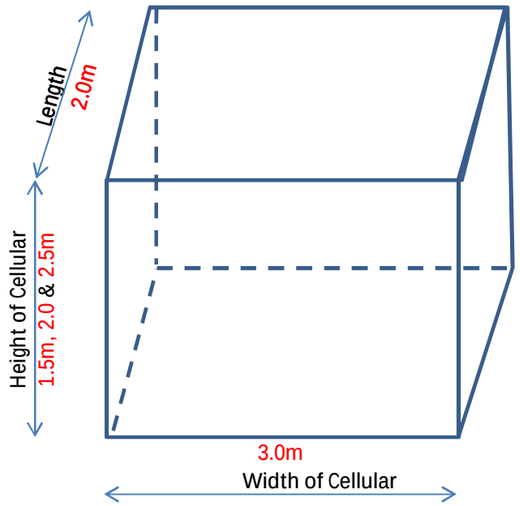
No.	Alternative	Seabed Elev. (m)	Cellular dimension			
			width (m)	length (m)	height (m)	thickness (m)
1	CASE A-1	0.0	2.50	1.00	2.00	0.20
2		-1.0	2.50	1.00	2.00	0.20
3		-2.0	2.50	1.00	2.20	0.20
4		-3.0	3.00	1.00	2.20	0.20
5		-4.0	3.00	1.00	2.50	0.20
6		-5.0	3.00	1.00	2.50	0.20
7	CASE A-2	0.0	2.50	1.00	2.00	0.20
8		-1.0	2.50	1.00	2.00	0.20
9		-2.0	2.50	1.00	2.20	0.20
10		-3.0	3.00	1.00	2.20	0.20
11		-4.0	3.00	1.00	2.50	0.20
12		-5.0	3.00	1.00	2.50	0.20

SUMMARY OF CELLULAR STABILITY COFFICIENT of CASE B-1&2

No.	Alternative	Seabed Elev. (m)	SAFETY FACTORS	
			SLIDING	OVERTURNING
1	CASE B-1	0.0	1.95	9.70
2		-1.0	1.81	10.10
3		-2.0	1.57	5.00
4		-3.0	1.38	6.98
5		-4.0	1.30	4.71
6		-5.0	1.83	5.60
7	CASE B-2	0.0	2.25	17.89
8		-1.0	2.08	16.53
9		-2.0	2.56	20.62
10		-3.0	2.29	18.49
11		-4.0	1.84	14.86
12		-5.0	2.00	16.15

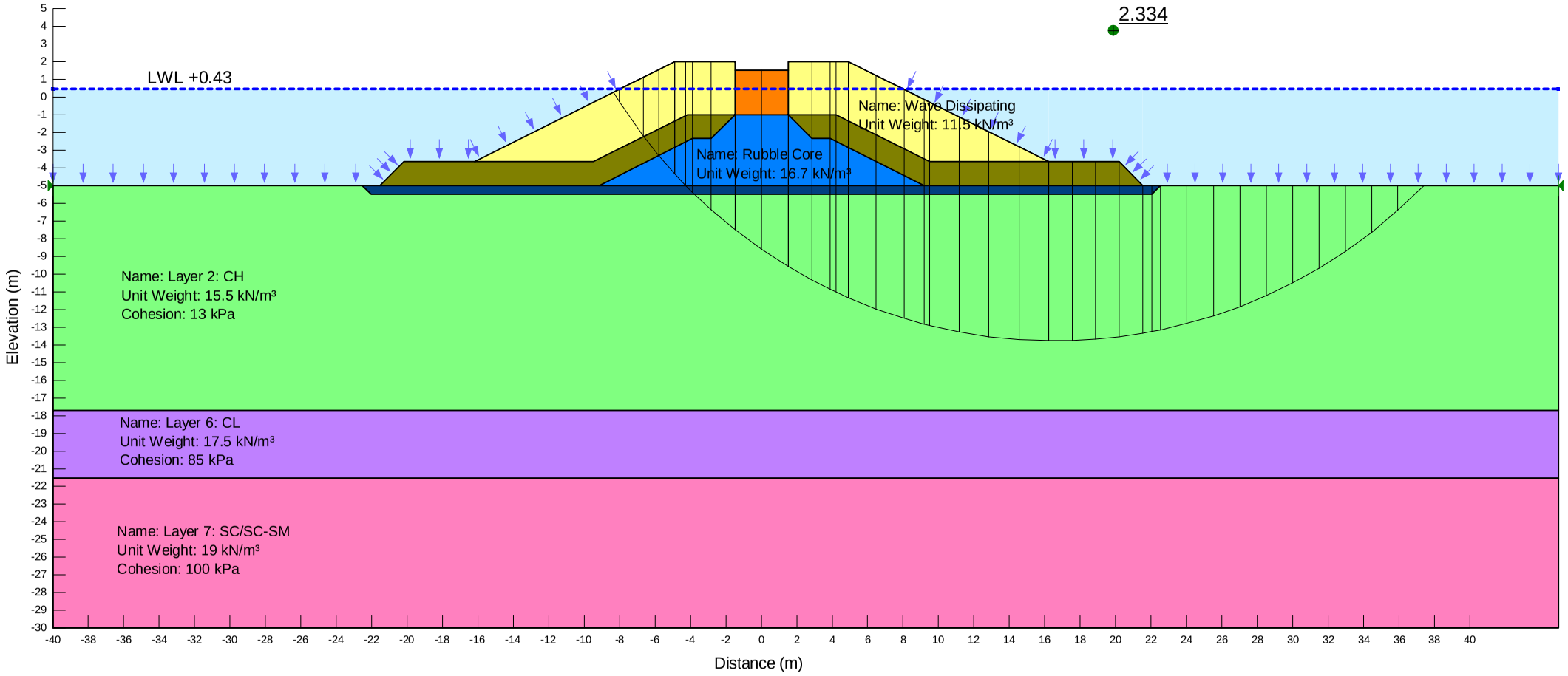
SUMMARY OF CELLULAR TYPES

Alternative	Cellular dimension				Remark
	width (m)	length (m)	height (m)	thickness (m)	
CASE B-1	3.0	2.0	2.00	0.2	Cellular Type 1
	3.0	2.0	2.50	0.2	Cellular Type 2
	3.0	2.0	2.75	0.2	Cellular Type 3
	3.0	2.0	3.00	0.2	Cellular Type 4
	3.0	2.0	3.50	0.2	Cellular Type 5
CASE B-2	3.0	2.0	1.5	0.2	Cellular Type 1
	3.0	2.0	2.5	0.2	Cellular Type 3

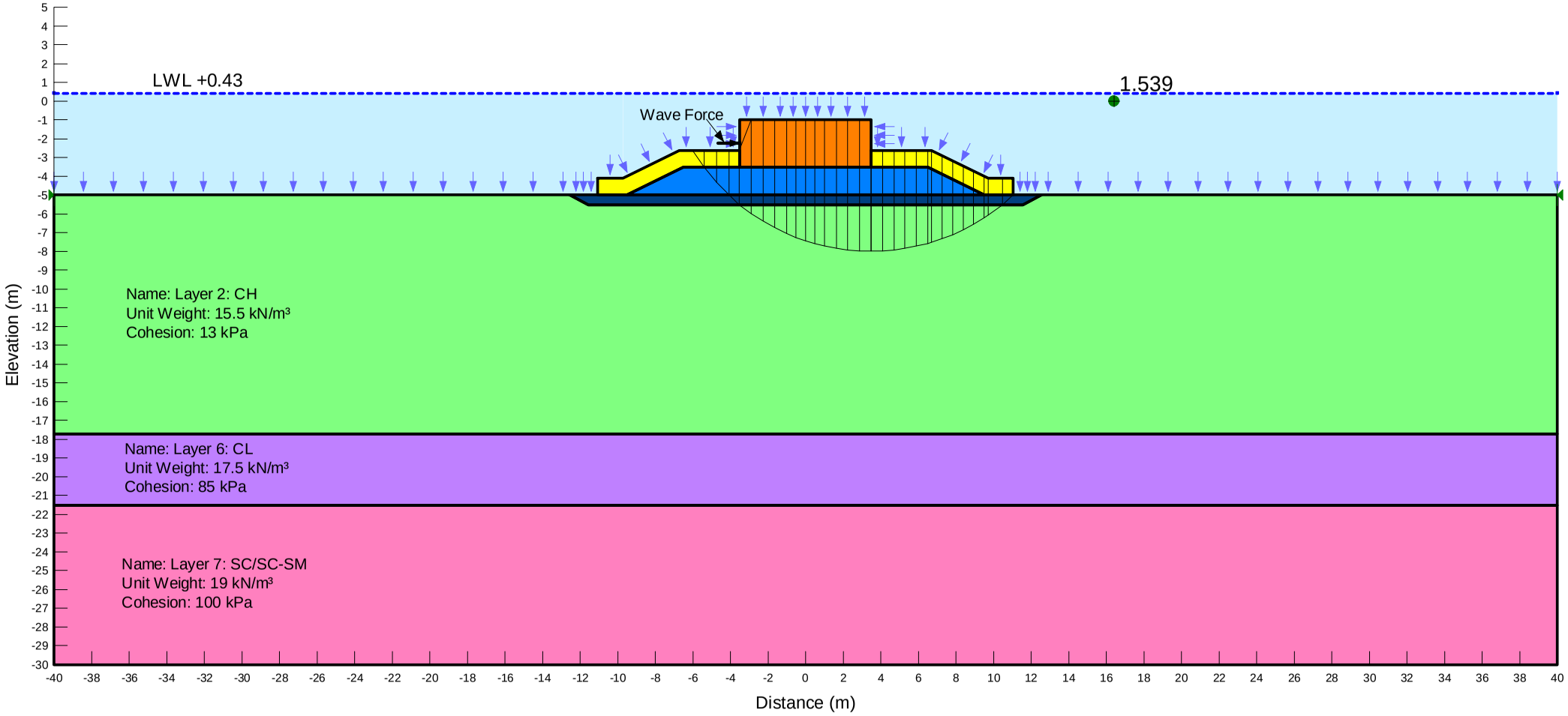


15 SLOPE STABILITY ANALYSIS OF SAND PROTECTION TRAINING DIKE - G.L. -5.0m

SLOPE STABILITY OF SAND PROTECTION DIKE
CASE A: RUBBLE MOUND CELLULAR COVERS BY TETRAPOD BLOCKS
TYPICAL CROSS SECTION GL.-5.0 (BOREHOLE - D26)

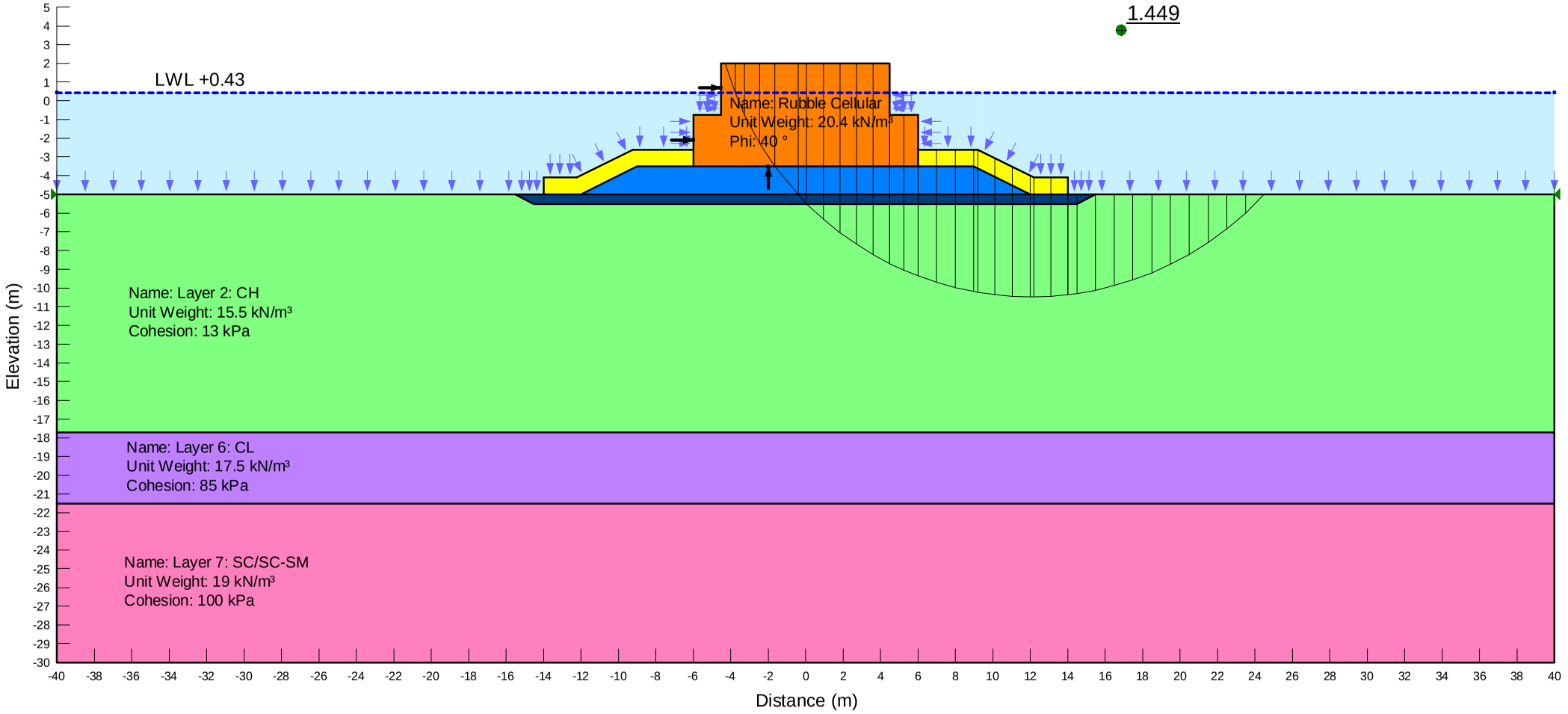


SLOPE STABILITY OF SAND PROTECTION DIKE
ALTERNATIVE: RUBBLE MOUND CONCRETE CELLULAR
TYPICAL CROSS SECTION GL.-5.0 (BOREHOLE - D26)



Appendix 19-15-2

SLOPE STABILITY OF SAND PROTECTION DIKE
CASE B: RUBBLE MOUND CONCRETE CELLULAR
TYPICAL CROSS SECTION (BOREHOLE: D26)



16. EXTERNAL FORCE CALCULATION OF CELLULAR CAISSON

I. CELLULAR TYPE 1:

Cellular Dimenssion:

Width, B:	3	m
Length, L:	2	m
Height, H:	2	m
Wall thickness, t:	0.2	m

Parameter of material filling:

γ_s	2.6	t/m^3
γ'_s	1.575	t/m^3
void ratio:	37%	
γ'_{sub}	0.99	t/m^3
Internal angle:	40	^{o}

Earth Pressure on Cellular wall:

Live load on top of cellular:	0.5	t/m^2
H	2	m
Ka	0.217	
$p_{a\ at\ top}$	0.11	t/m
$p_{a\ at\ bottom}$	0.54	t/m

Wave Pressure on Cellular wall:

$p_{at\ top}$	2.98	t/m	*See in section D*
$p_{at\ bottom}$	2.90	t/m	*See in section D*

Combination of horizontal pressure:

$p_{at\ top}$	2.87	t/m
$p_{at\ bottom}$	2.36	t/m
$p_{average}$	2.62	t/m

Internal force of Cellular wall:

Moment of faceline direction

M^- =	**-0.87**	tm/m
M^+ =	**0.44**	tm/m

II. CELLULAR TYPE 2:

Cellular Dimenssion:

Width, B:	3	m
Length, L:	2	m
Height, H:	2.5	m
Wall thickness, t:	0.2	m

Parameter of material filling:

γ_s	2.6	t/m^3
γ'_s	1.575	t/m^3
void ratio:	0.37	
γ'_{sub}	0.99	t/m^3
Internal angle:	40	^{o}

Earth Pressure on Cellular wall:

Live load on top of cellular:	0.5	t/m^2
H	2.5	m
Ka	0.217	
$p_{a\ at\ top}$	0.11	t/m
$p_{a\ at\ bottom}$	0.65	t/m

Wave Pressure on Cellular wall:

$p_{at\ top}$	4.33	t/m	*See in section G*
$p_{at\ bottom}$	4.17	t/m	*See in section G*

Combination of horizontal pressure:

$p_{at\ top}$	4.22	t/m
$p_{at\ bottom}$	3.52	t/m
$p_{average}$	3.87	t/m

Internal force of Cellular wall:

Moment of faceline direction

$M^- = p_{average}.L^2/12$	**-1.29**	tm/m
$M^+ = p_{average}.L^2/24$	**0.65**	tm/m

III. CELLULAR TYPE 3:

Cellular Dimenssion:

Width, B:	3	m
Length, L:	2	m
Height, H:	3	m
Wall thickness, t:	0.2	m

Parameter of material filling:

γ_s	2.6	t/m^3
γ'_s	1.575	t/m^3
void ratio:	0.37	
γ'_{sub}	0.99	t/m^3
Internal angle:	40	^{o}

Earth Pressure on Cellular wall:

Live load on top of cellular:	0.5	t/m^2

H	3	m	
Ka	0.217		
$p_{a\ at\ top}$	0.11	t/m	
$p_{a\ at\ bottom}$	0.76	t/m	

Wave Pressure on Cellular wall:

$p_{at\ top}$	3.47	t/m	*See in section G*
$p_{at\ bottom}$	3.32	t/m	*See in section G*

Combination of horizontal pressure:

$p_{at\ top}$	3.36	t/m
$p_{at\ bottom}$	2.57	t/m
$p_{average}$	2.96	t/m

Internal force of Cellular wall:

Moment of faceline direction

$M^{-} = p_{average}.L^2/12$	**-0.99**	tm/m
$M^{+} = p_{average}.L^2/24$	**0.49**	tm/m

IV. CELLULAR TYPE 4:

Cellular Dimenssion:

Width, B:	3	m
Length, L:	2	m
Height, H:	2.75	m
Wall thickness, t:	0.2	m

Parameter of material filling:

γ_s	2.6	t/m^3
γ'_s	1.575	t/m^3
void ratio:	0.37	
γ'_{sub}	0.99	t/m^3
Internal angle:	40	^{o}

Earth Pressure on Cellular wall:

Live load on top of cellular:	0.5	t/m^2	
H	2.75	m	
Ka	0.217		
$p_{a\ at\ top}$	0.11	t/m	
$p_{a\ at\ bottom}$	0.70	t/m	

Wave Pressure on Cellular wall:

$p_{at\ top}$	4.65	t/m	*See in section G*
$p_{at\ bottom}$	4.46	t/m	*See in section G*

Combination of horizontal pressure:

$p_{at\ top}$	4.54	t/m
$p_{at\ bottom}$	3.75	t/m
$p_{average}$	4.15	t/m

Internal force of Cellular wall:

Moment of faceline direction

$M^{-} = p_{average}.L^2/12$	**-1.38**	tm/m
$M^{+} = p_{average}.L^2/24$	**0.69**	tm/m

V. CELLULAR TYPE 5:

Cellular Dimenssion:

Width, B:	3	m
Length, L:	2	m
Height, H:	3.5	m
Wall thickness, t:	0.2	m

Parameter of material filling:

γ_s	2.6	t/m^3
γ'_s	1.575	t/m^3
void ratio:	0.37	
γ'_{sub}	0.99	t/m^3
Internal angle:	40	^{o}

Earth Pressure on Cellular wall:

Live load on top of cellular:	0.5	t/m^2
H	3.5	m
Ka	0.217	
$p_{a\ at\ top}$	0.11	t/m
$p_{a\ at\ bottom}$	0.86	t/m

Wave Pressure on Cellular wall:

$p_{at\ top}$	3.47	t/m	*See in section G*
$p_{at\ bottom}$	3.30	t/m	*See in section G*

Combination of horizontal pressure:

$p_{at\ top}$	3.36	t/m
$p_{at\ bottom}$	2.43	t/m
$p_{average}$	2.90	t/m

Internal force of Cellular wall:

Moment of faceline direction

$M^{-} = p_{average}.L^2/12$	**-0.97**	tm/m
$M^{+} = p_{average}.L^2/24$	**0.48**	tm/m

17. REINFORCEMENT CALCULATION OF CELLULAR CAISSON

(According to TCVN 4116-85)

GENERAL PARAMETER

Construction Grade:	III	
Concrete Grade:	M400	
Re-bar Grade:	AII	
STRENGTH STATE:		
R_a=	2700.00	kG/cm²
E_a=	2.10E+06	kG/cm²
R_n=	175.00	kG/cm²
R_k=	12.00	kG/cm²
CRACKING WIDTH STATE:		
R_a=	2700.00	kG/cm²
E_a=	2.10E+06	kG/cm²
R_n=	225.00	kG/cm²
R_k=	18.00	kG/cm²
$[a_t]$=	0.080	mm

KIND OF STRUCTURE: CELLULAR WALL

Position checking	**Support**	**Span**
Width of calculated wall strip, b (cm)	100.00	100.00
Thickness of wall, h (cm)	20.00	20.00
Height of wall, h_o (cm)	14.30	14.30
Bending Moment (t.m)	**1.38**	**0.69**
Bar diameter, ϕ (mm)	**14**	**14**
Area of reinforcement, f_a (cm²)	1.54	1.54
Maximum of bar spacing, s (cm)	**20**	**20**
No. of bar, n (bar)	5	5
Total area of reinforcement, F_a (cm²)	7.70	7.70
Minimum cover to tension reinforcement, a (cm)	5.00	5.00
Distance to center of bar, a_o (cm)	5.70	5.70
Percentage of re-bar, m (%)	**0.54%**	**0.54%**
Checking of re-bar percentage	**OK**	**OK**
Height of compression concrete area, ξ (cm)	1.19	1.19
$z = h_o - \xi/2$ (cm)	13.71	13.71
Reinforcement stress, σ_a (kG/cm²)	**1311.10**	**655.551**
Checking of reinforcement stress	**OK**	**OK**
Cracking width, a_t (mm)	**0.074**	**0.037**
Cracking width allowance, $[a_t]$ (mm)	0.08	0.08
Checking of cracking width	**OK**	**OK**

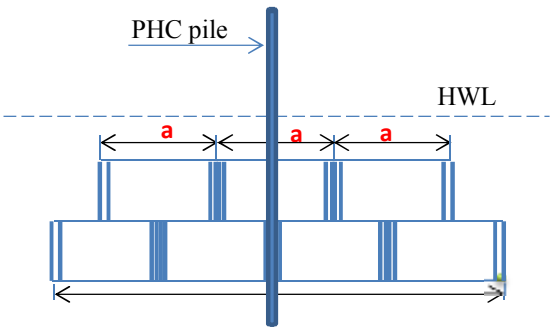
Appendix 19-18

Calculation of PHC Pile Foundation for Beacon Marker

CALCULATION OF WAVE FORCE ON SINGLE PILE (According to EM 1110-2-1100)
Sand Protection Training Dike - Section for GL upto CD -5.0m

1. Input data:

- Wave Return Period:	30 years
- Tide Level - HWL (CDL):	**3.55**
- Crest Level (CDL):	2.0
- Crest Level of Beacon's pile (CDL):	5.0
- Seabed Surface Level (CDL):	-5.0
- Significant Wave Height ($H_{1/3}$), m:	4.96
- H_{max}, m:	6.615
- Wave Period (T), sec:	12.8
- Wave Length (L), m:	100.31



2. Wave Pressure on the single pile

According to Morison et al. (1950)'s equation:

Total wave force: F = F_i + F_D

Where in:

F_i - the force due of inertia

$$F_i = C_M \rho g \frac{\pi D^2}{4} H K_i \qquad (VI-5-285)$$

F_D - the force due to drag

$$F_D = C_D \frac{1}{2} \rho g D H^2 K_D \qquad (VI-5-286)$$

k - wave number (rad/m), $k = \frac{2\pi}{L}$

ω - wave frequency (rad/s), $\omega = \frac{2\pi}{T} = (gk.tanh\, kd)^{\frac{1}{2}}$

$$\eta = \frac{H}{2}\cos\frac{2\pi t}{T} = \frac{H}{2}\cos\omega t$$

ρ - density of seawater (normally 1.025 t/m^3)
D - diameter of pipe pile
C_D - drag coefficient, = 1
C_M - inertia coefficient, = 2

Similarly, Total moment: M= M_i + M_D

$$M_i = C_M \rho g \frac{\pi D^2}{4} H K_i dS_i = F_i dS_i \qquad (VI-5-287)$$

$$M_D = C_D \frac{1}{2} \rho g D H^2 K_D dS_D = F_D dS_D \qquad (VI-5-288)$$

$$K_i = \frac{1}{2} tanh\left(\frac{2\pi d}{L}\right) sin\left(-\frac{2\pi t}{T}\right) = \frac{1}{2} tanh(kd) sin(-\omega t) \qquad (VI-5-294)$$

$$K_D = \frac{1}{8}\left(1 + \frac{4\pi d/L}{sinh[4\pi d/L]}\right) cos\left(\frac{2\pi t}{T}\right)\left|cos\left(\frac{2\pi t}{T}\right)\right| = \frac{1}{8}\left(1 + \frac{2kd}{\sinh 2kd}\right) cos(\omega t)|cos(\omega t)| \qquad (VI-5-295)$$

$$S_i = 1 + \frac{1 - cosh[2\pi d/L]}{(2\pi d/L) sinh[2\pi d/L]} = 1 + \frac{1 - coshkd}{kd \sinh kd} \qquad (VI-5-296)$$

$$S_D = \frac{1}{2} + \frac{1}{2n}\left(\frac{1}{2} + \frac{1 - cosh[4\pi d/L]}{(4\pi d/L) sinh[4\pi d/L]}\right) = \frac{1}{2} + \frac{1}{2n}\left(\frac{1}{2} + \frac{1 - \cosh 2kd}{2kd \sinh 2kd}\right) \qquad (VI-5-297)$$

$$n = \frac{1}{2}\left(1 + \frac{4\pi d/L}{sinh[4\pi d/L]}\right) = \frac{1}{2}\left(1 + \frac{2kd}{\sinh 2kd}\right) \qquad (VI-5-298)$$

Vary t = (0,T/4, T) ⇒ ωt = (0,π/2, 2π) = (0, 1.571, 6.287) = 0, 1, 1.571, 2, 3, 4, 5, 6, 7

d (m)	k (rad/m)	ω (rad/s)	Ts (s)	C_D	C_M	ρ (kN/m^3)	D (m)
1.6	0.063	0.244	8.60	1	2	10.25	0.7

K_i	K_D	S_i	S_D	n	η
0.048sin(-ωt)	0.249cos(ωt)/cos(ωt)/	0.50	0.50	0.997	2.48cos(ωt)

ωt	K_i	K_D	F_i (t), kN	F_D (t), kN	**F (t), kN**	M_i (t), kNm	M_D (t), kNm	**M (t), kNm**
0	0.00	0.249	0.0	215.8	**215.8**	0.0	167.5	**167.5**
1	-0.04	0.073	-15.6	63.0	**47.4**	-12.1	48.9	**36.8**
1.571	-0.05	0.000	-18.6	0.0	**-18.6**	-14.4	0.0	**-14.4**
2	-0.04	-0.043	-16.9	-37.4	**-54.3**	-13.1	-29.0	**-42.1**
3	-0.01	-0.244	-2.6	-211.5	**-214.1**	-2.0	-164.2	**-166.2**
4	0.04	-0.106	14.1	-92.2	**-78.1**	10.9	-71.6	**-60.7**
5	0.05	0.020	17.8	17.4	**35.2**	13.8	13.5	**27.3**
6	0.01	0.230	5.2	198.9	**204.1**	4.0	154.4	**158.4**
7	-0.03	0.142	-12.2	122.6	**110.4**	-9.5	95.2	**85.7**

Summarize of maximum wave force on pipe pile

F (t), kN	**M (t), kNm**	**Safety factor**	**F (kN)**	**M (kNm)**
215.8	167.5	**2.5**	**539.4**	**418.7**

Selecting PHC Pile (JIS A5337)

Dia (mm)	Thk (mm)	Type	Bending moment (kNm)	
			Cracking	Breaking
700	110	C	441.5	882.9

3. Bearing capacity checking

Location: **B1** Borehole: **D6**

Self weight of beacon marker

Dead weight of light beacon : 3.4 kN

Copping conection: 1.0 kN

PHC pile weight

Dimensions		Unit weight (kg/m)	Elevation of pile		Length (m)	Weight per pile (kN)
Dia (mm)	Thk (mm)		Top (m CD)	Bottom (m CD)		
700	110	509.7	5	-15	20	100.01

Negative friction on steel pile

	Elevation		Layer Thk m	Soil Condition		f 2N of Cu	As m2	F per pile kN
	Top m CD	Bottom m CD		SPT-N	Cu kPa			
Layer 1b	-2.4	-3.3	0.9	4.5		9.0	1.98	17.8
Layer 2	-3.3	-11.2	7.9	0.8	12.5	12.5	17.37	217.9
Layer 3b	-11.2	-15.0	3.8	7.8		15.6	8.36	130.4
							Total	**366.1**

Total downward load: F_{down} **= 470.5** kN

Bearing capacity

Ru = 300 x N x Ap $R_u = 300NA_p + 2\bar{N}A_s$

	Elevation		Layer Thk m	Ni	Ap m2	As m3	Rs per pile kN	Rtoe per pile kN
	Top m CD	Bottom m CD						
Rubble layer	2.0	-2.4	4.4	10	0.38	9.68	193.5	
Layer 1b	-2.4	-3.3	0.9	4.5	0.38	1.98	17.8	
Layer 2	-3.3	-11.2	7.9	0.8	0.38	17.37	27.8	
Layer 3b	-11.2	-15.6	3.8	7.8	0.38	8.36	130.4	900.5
						Total, Ru:	**1270.0**	

Ra = Ru/2.5 = **508.0** kN > F_{down} **OK**

Bearing capacity checking

Location: **B2** Borehole: **D11**

Self weight of beacon marker

Dead weight of light beacon : 3.4 kN

Copping conection: 1.0 kN

PHC pile weight

Dimensions		Unit weight (kg/m)	Elevation of pile		Length (m)	Weight per pile (kN)
Dia (mm)	Thk (mm)		Top (m CD)	Bottom (m CD)		
700	110	509.7	5	-15	20	100.01

Negative friction on steel pile

	Elevation		Layer Thk m	Soil Condition		f 2N of Cu	As m2	F per pile kN
	Top m CD	Bottom m CD		SPT-N	Cu kPa			
Layer 1a	-1.94	-6.74	4.8	4.8		9.6	10.56	101.3
Layer 2	-6.74	-12.64	5.9	0.8	12.5	12.5	12.97	162.8
Layer 3b	-12.64	-18.7	2.36	7.8		15.6	5.19	81.0
							Total	**345.1**

Total downward load: F_{down} = **449.5** kN

Bearing capacity

Ru = 300 x N x Ap $R_u = 300NA_p + 2\bar{N}A_s$

	Elevation		Layer Thk m	Ni	Ap m2	As m3	Rs per pile kN	Rtoe per pile kN
	Top m CD	Bottom m CD						
Rubble layer	2.0	-1.94	3.94	10	0.38	8.66	173.3	
Layer 1a	-1.94	-6.74	4.8	4.8	0.38	10.56	101.3	
Layer 2	-6.74	-12.64	5.9	0.8	0.38	12.97	20.8	
Layer 3b	-12.64	-18.74	2.36	7.8	0.38	5.19	81.0	900.5
						Total, Ru:	**1276.9**	

Ra = Ru/2.5 = **510.8** kN > F_{down} **OK**

Bearing capacity checking

Location: **B3** Borehole: **D16**

Self weight of beacon marker

Dead weight of light beacon : 3.4 kN

Copping conection: 1.0 kN

PHC pile weight

Dimensions		Unit weight (kg/m)	Elevation of pile		Length (m)	Weight per pile (kN)
Dia (mm)	Thk (mm)		Top (m CD)	Bottom (m CD)		
700	110	509.7	5	-15	20	100.01

Negative friction on steel pile

	Elevation		Layer Thk m	Soil Condition		f 2N of Cu	As m2	F per pile kN
	Top m CD	Bottom m CD		SPT-N	Cu kPa			
Layer 1a	-1.77	-3.57	1.8	4.8		9.6	3.96	38.0
Layer 2	-3.57	-13.57	10	0.8	12.5	12.5	21.99	275.9
Layer 3b	-13.57	-20.4	1.43	7.8		15.6	3.14	49.1
							Total	**362.9**

Total downward load: F_{down} = **467.4** kN

Bearing capacity

Ru = 300 x N x Ap $R_u = 300NA_p + 2\bar{N}A_s$

	Elevation		Layer Thk m	Ni	Ap m2	As m3	Rs per pile kN	Rtoe per pile kN
	Top m CD	Bottom m CD						
Rubble layer	2.0	-1.77	3.77	10	0.38	8.29	165.8	
Layer 1a	-1.77	-3.57	1.8	4.8	0.38	3.96	38.0	
Layer 2	-3.57	-13.57	10	0.8	0.38	21.99	35.2	
Layer 3b	-13.57	-20.37	1.43	7.8	0.38	3.14	49.1	900.5
						Total, Ru:	**1188.6**	

Ra = Ru/2.5 = **475.4** kN > F_{down} **OK**

Bearing capacity checking

Location: **B4** Borehole: **D21**

Self weight of beacon marker

Dead weight of light beacon : 3.4 kN

Copping conection: 1.0 kN

PHC pile weight

Dimensions		Unit weight (kg/m)	Elevation of pile		Length (m)	Weight per pile (kN)
Dia (mm)	Thk (mm)		Top (m CD)	Bottom (m CD)		
700	110	509.7	5	-15	20	100.01

Negative friction on steel pile

	Elevation		Layer Thk m	Soil Condition		f 2N of Cu	As m2	F per pile kN
	Top m CD	Bottom m CD		SPT-N	Cu kPa			
Layer 1b	-2.07	-3.67	1.6	4.5		9.0	3.52	31.7
Layer 2	-3.67	-13.77	10.1	0.8	12.5	12.5	22.21	278.6
Layer 4	-13.77	-19.0	1.23	10.7		21.4	2.70	57.9
							Total	**368.2**

Total downward load: F_{down} **= 472.6** kN

Bearing capacity

Ru = 300 x N x Ap $R_u = 300NA_p + 2\bar{N}A_s$

	Elevation		Layer Thk m	Ni	Ap m2	As m3	Rs per pile kN	Rtoe per pile kN
	Top m CD	Bottom m CD						
Rubble layer	2.0	-2.07	4.07	10	0.38	8.95	179.0	
Layer 1b	-2.07	-3.67	1.6	4.5	0.38	3.52	31.7	
Layer 2	-3.67	-13.77	10.1	0.8	0.38	22.21	35.5	
Layer 4	-13.77	-18.97	1.23	10.7	0.38	2.70	57.9	1235.4
						Total, Ru:	**1539.5**	

Ra = Ru/2.5 = **615.8** kN > F_{down} **OK**

Bearing capacity checking

Location: **B5** Borehole: **D26**

Self weight of beacon marker

Dead weight of light beacon : 3.4 kN

Copping conection: 1.0 kN

PHC pile weight

Dimensions		Unit weight (kg/m)	Elevation of pile		Length (m)	Weight per pile (kN)
Dia (mm)	Thk (mm)		Top (m CD)	Bottom (m CD)		
700	110	509.7	5	-20	25	125.01

Negative friction on steel pile

	Elevation		Layer Thk m	Soil Condition		f 2N of Cu	As m2	F per pile kN
	Top m CD	Bottom m CD		SPT-N	Cu kPa			
Layer 2	-4.82	-17.72	12.9	0.8	12.5	12.5	28.37	355.9
Layer 6	-17.72	-21.25	2.28	13.2	40.1	40.1	5.01	201.1
							Total	**556.9**

Total downward load: F_{down} = **686.4** kN

Bearing capacity

Ru = 300 x N x Ap $R_u = 300NA_p + 2\bar{N}A_s$

	Elevation		Layer Thk m	Ni	Ap m2	As m3	Rs per pile kN	Rtoe per pile kN
	Top m CD	Bottom m CD						
Rubble layer	2.0	-4.82	6.8	10	0.38	15.00	300.0	
Layer 2	-4.82	-17.72	12.9	0.8	0.38	28.37	45.4	
Layer 6	-17.72	-21.25	2.28	13.2	0.38	5.01	132.4	1524.0
						Total, Ru:	**2001.7**	

Ra = Ru/2.5 = **800.7** kN > F_{down} **OK**

Appendix 21-1

Details and technical matters of the Simulation Models of Suspended Solid Dispersion (Case 6 – Case 11)

Details and technical matters of the simulation models are described in this APPENDIX.

1. Updated Parameters

Updated parameters from the previous simulation (see Chapter 12.3 in the main report) are as follows.

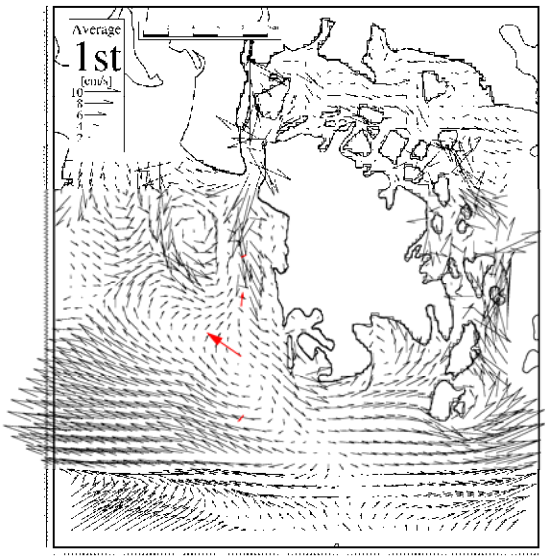
- Tidal current regime based on the survey result conducted in May 2011 (See Chapter 2.3).
- Harmonic constants and residual current calculated using the data above.

2. Reproducibility of the Hydrodynamic Model

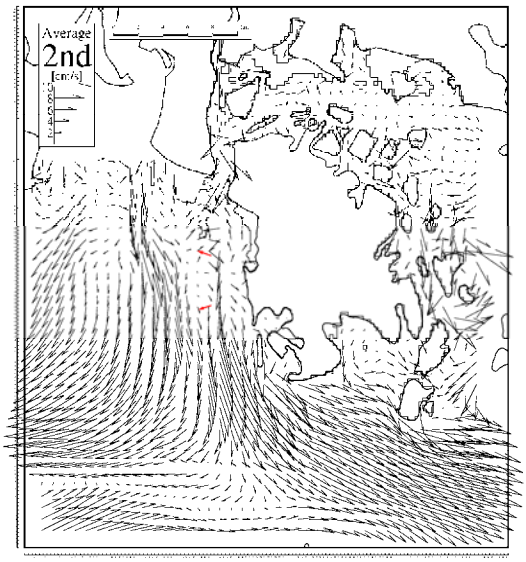
After necessary parameters are set up and the hydrodynamic model was established, reproducibility of the model was confirmed, comparing with existing data.

Horizontal distribution of residual currents at each layer by computation in wet and dry season is shown in Figure 2.1, Figure 2.2, Figure 2.3 and Figure 2.4.

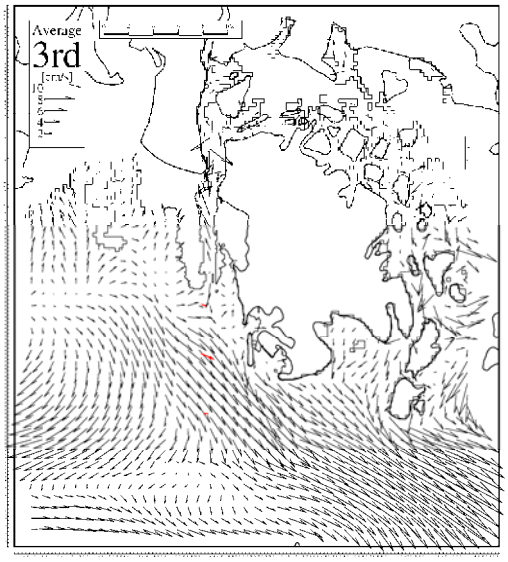
1st Layer



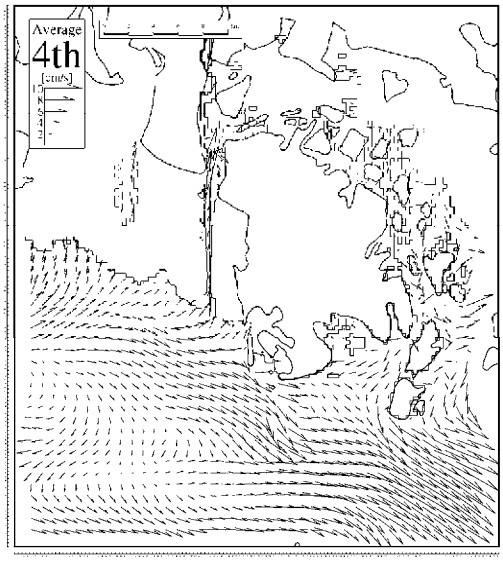
2nd Layer



3rd Layer



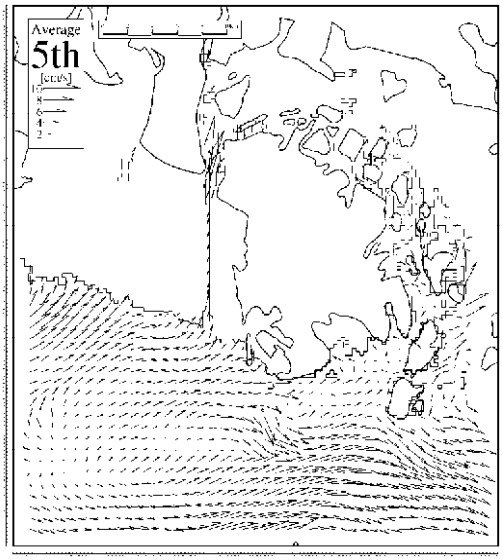
4th Layer



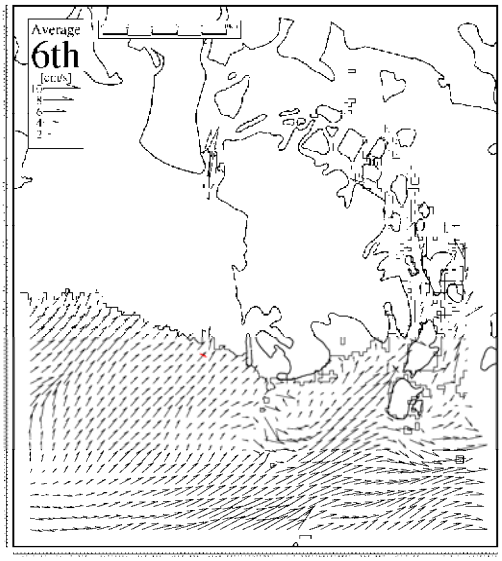
→ : computation,→ : observation(May 2011)

Figure 2.1 Residual Current by Computation at Present Condition (Medium Domain, 300m mesh, 1st layer - 4th layer, Wet season)

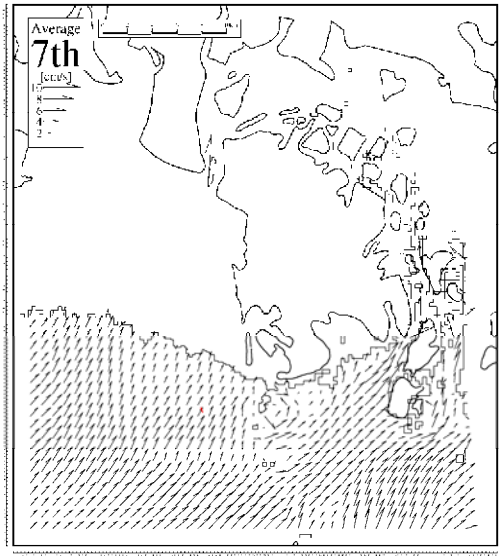
5th Layer



6th Layer



7th Layer

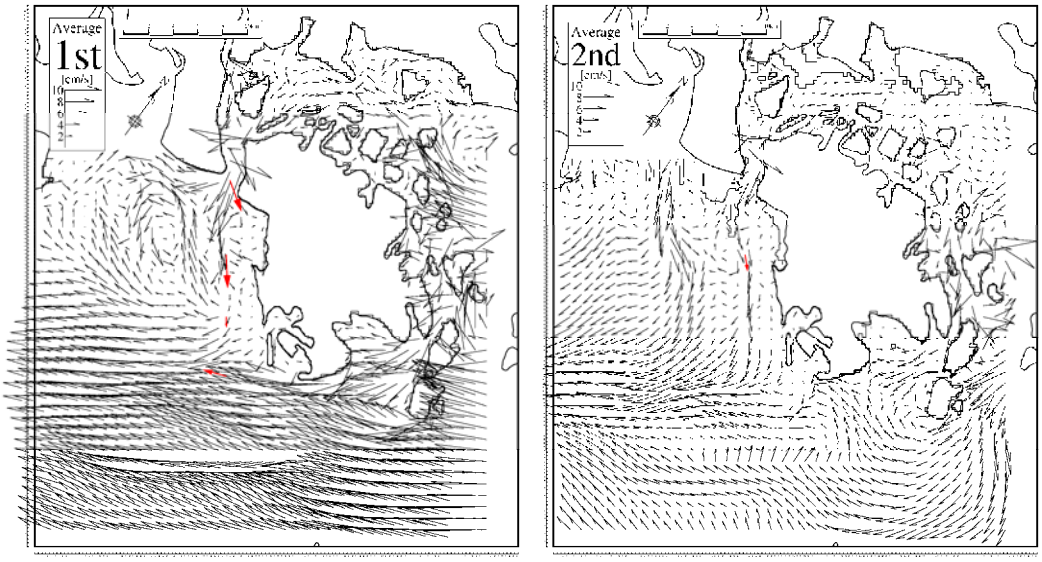


→ : computation,→ : observation(May 2011)

Figure 2.2 Residual Current by Computation at Present Condition (Medium Domain, 300m mesh, 5th – 7th layer, Wet season)

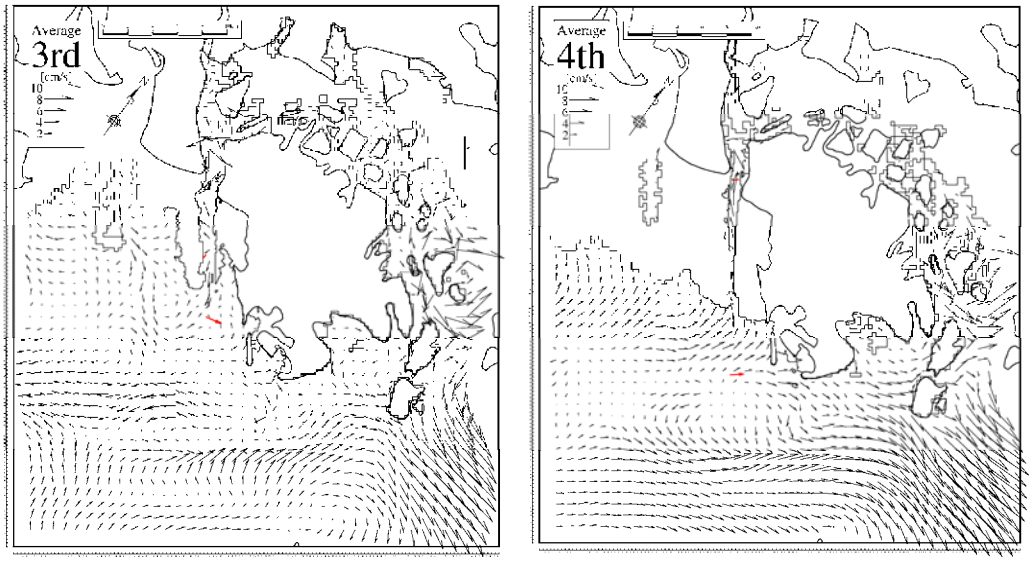
1st Layer

2nd Layer



3rd Layer

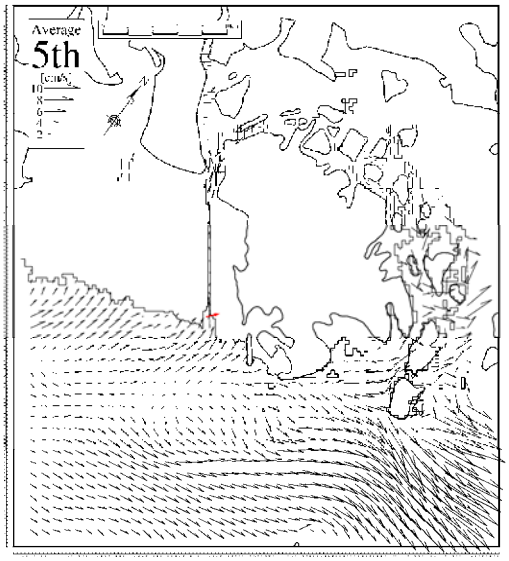
4th Layer



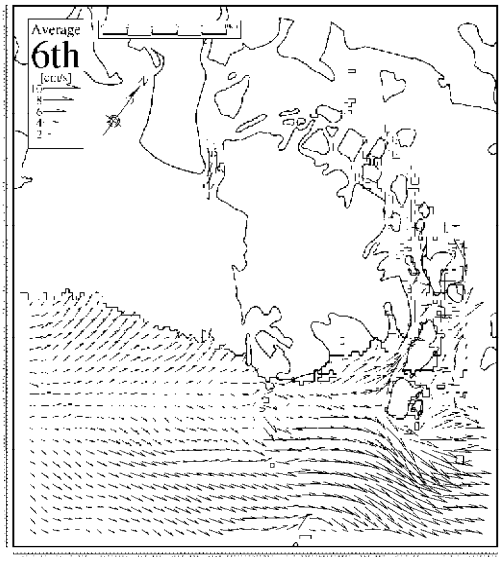
→ : computation,→ : observation(Nov. – Dec. 2009)

Figure 2.3 Residual Current by Computation at Present Condition (Medium Domain, 300m mesh, 1st layer - 4th layer, Dry season)

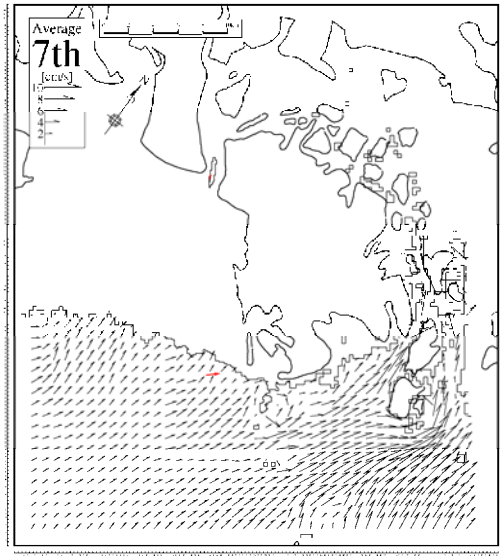
5th Layer



6th Layer



7th Layer



→ : computation,→ : observation(Nov. – Dec. 2009)

Figure 2.4 Residual Current by Computation at Present Condition (Medium Domain, 300m mesh, 5th – 7th layer, Dry season)

3. Silt Protector

In the simulation SS removal ratio, which is calculated by the following equation, is used to express the effectiveness of the silt protector[1]. The actual ration is referred to the case examples in Japan.

$$R = (1 - (SS_{out} \div SS_{in})) \times 100$$

where:
R: SS removal ratio (%)
SS_{in}: SS concentration inside of the silt protector (mg/L)
SS_{out}: SS concentration outside of the silt protector (mg/L)

Generally SS removal ratio varies with grain size composition and elapsed time from the generation of SS. According to the manual SS removal ratio ranges from 40 to 80%, and 50% of the ratio value is commonly used in the assessments in Japan. In this project, silt protector is planned to be installed using both standing type and hanging type silt protectors. Although lap over portion between standing type and hanging type is about 2m, 40% of SS removal ration is uniformly used in this simulation.

4. SS load

Used unit load and calculated SS load based on the construction plan is summarized in Table 4.1.

Generally SS load by dumping is much significant than that by dredging.

Table 4.1 Summary of SS Load

Case	Work Type	Vessel Type	Size	Existing Unit Laod (t/m3)×10^{-3}	75% Particle Size	Used Unit Load (t/m3)×10^{-3}	Unit Work Load (m3/day/vessel)	Number of Vessel	Total Work Load (m3/日)	SS Load (t/日)	Work Hour
6,7,10,11	Dredging	Pump	8000PS	4.26	80.32	5.3	126500	2	253000	1340.9	24
	Overflow	Hopper Barge	–	7.68	90.05	8.53	–	–	253000	2158.1	24
	Dumping	Hopper Barge	500m3	15.79	70.93	22.26	35000	6	210000	4674.6 (2804.8)	24
8,9	Dredging	Pump	8000PS	4.26	80.32	5.3	126500	2	253000	1340.9	24
	Overflow	Hopper Barge	–	7.68	90.05	8.53	–	–	253000	2158.1	24
	Dumping	Hopper Barge	500m3	15.79	70.93	22.26	35000	6	210000	4674.6 (2804.8)	24
	Dredging	Pump	4000PS	4.26	80.32	5.3	60000	3	180000	954.0	24
	Overflow from Dumping Site	–	–	–	–	–	–	–	–	7728.6 (4637.2)	24

SS load in paraenthesis (60% of original SS load) was used for dredging (Case 6,7,and 10) and overflow from dumping site Case 8 and 9), considering the effectiveness of silt protector.

[1] Guideline for Prediction of Influence of Suspended Solid on Port Construction, April 2004, Ministry of Land, Infrastructure, Transport and Tourism, Japan

5. Suspended Solid Dispersion

All outputs by computation are shown in this section.

5.1 Case 6

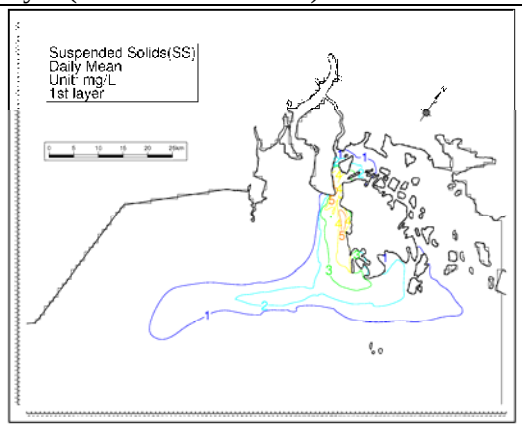
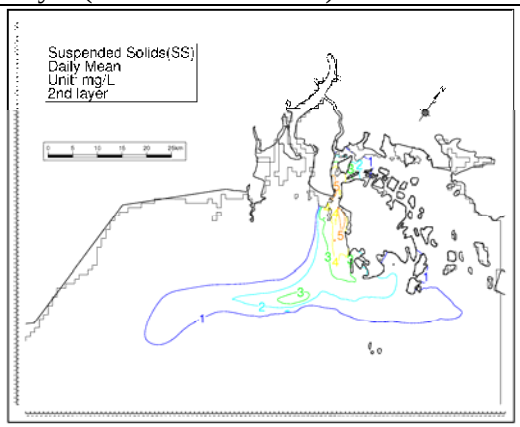
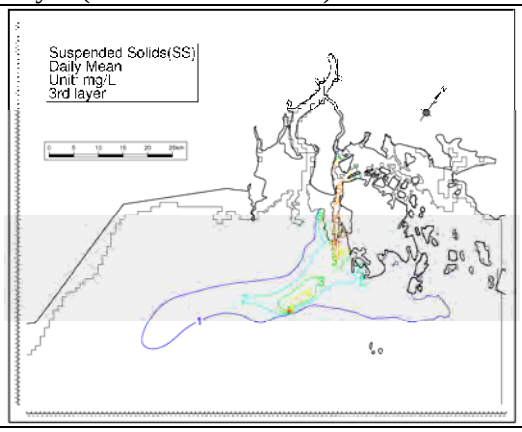
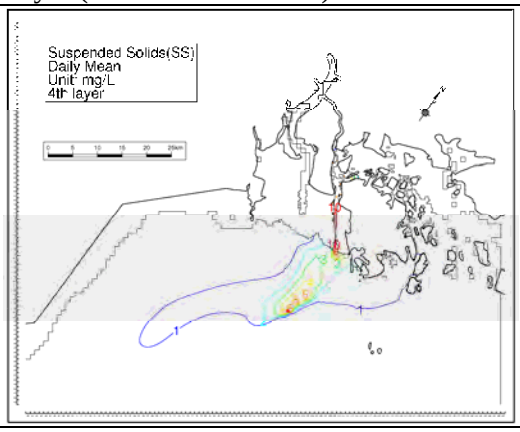
1st layer (0-2m below surface)	2nd Layer (2-4m below surface)
	
3rd Layer (4-6m below surface)	4th Layer (6-8m below surface)
	

Figure 5.1 (1) SS Dispersion Prediction (Case 6, Daily Average, Large Domain)

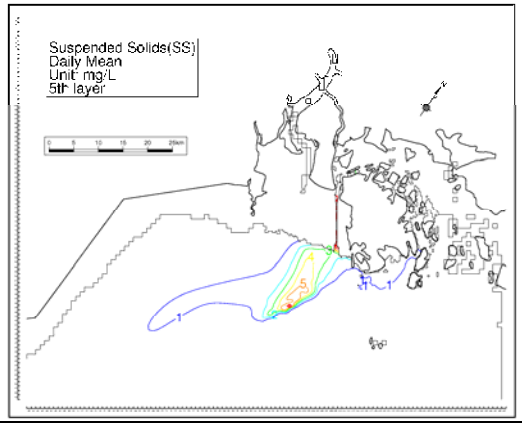
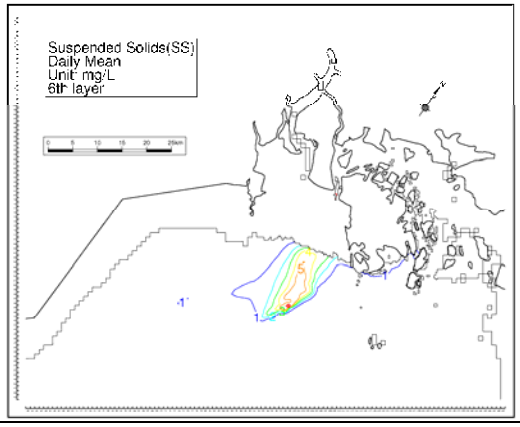
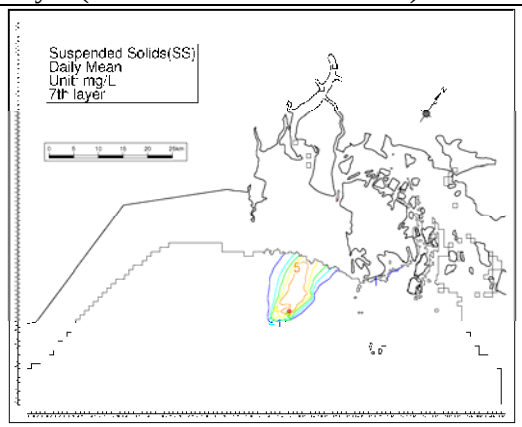
5th Layer (8-10m below surface)	6th Layer (10-12m below surface)
	
7th Layer (12m below surface-Bottom)	
	

Figure 5.1 (2) SS Dispersion Prediction (Case 6, Daily Average, Large Domain)

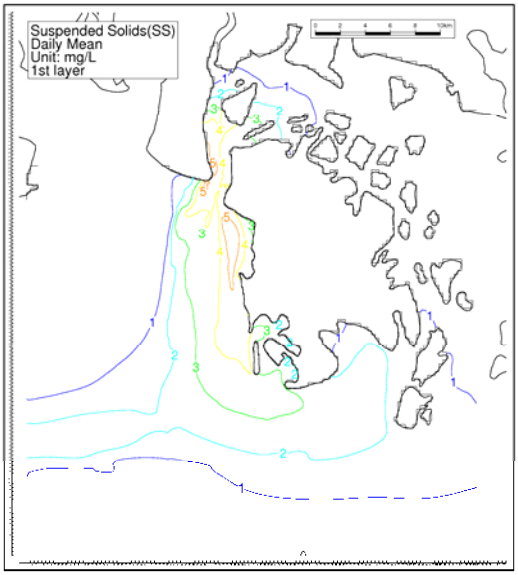
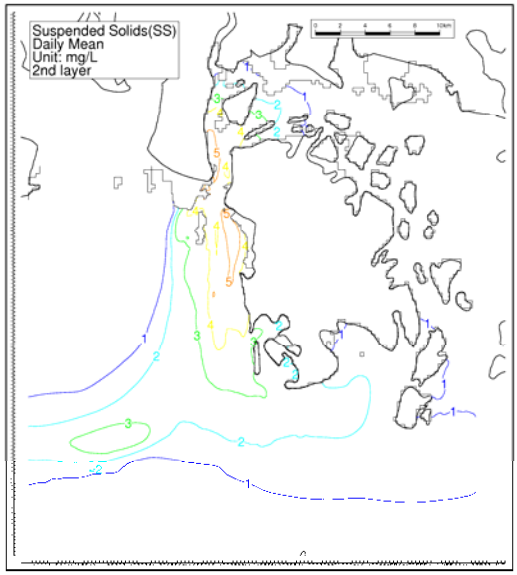
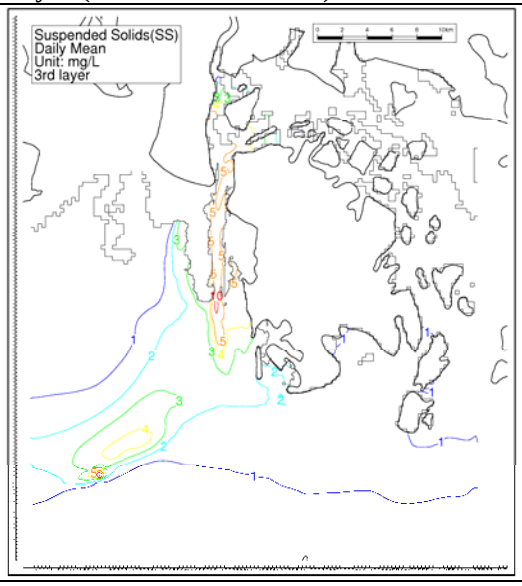
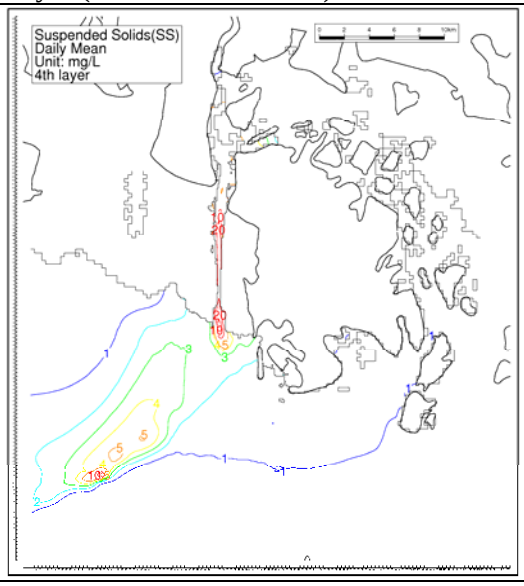
1st layer (0-2m below surface)	2nd Layer (2-4m below surface)
	
3rd Layer (4-6m below surface)	4th Layer (6-8m below surface)
	

Figure 5.2 (1) SS Dispersion Prediction (Case 6, Daily Average, Medium Domain)

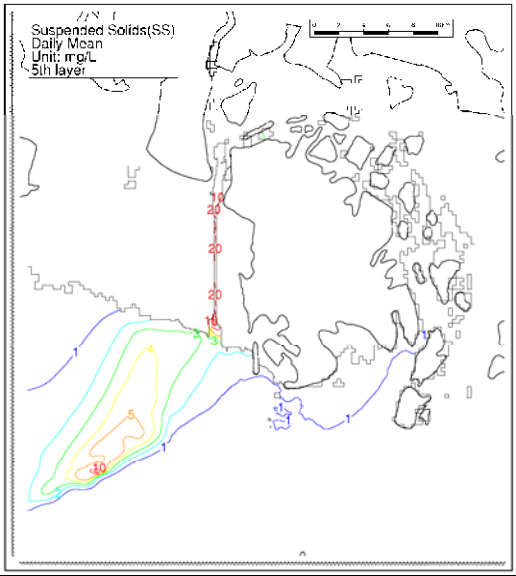
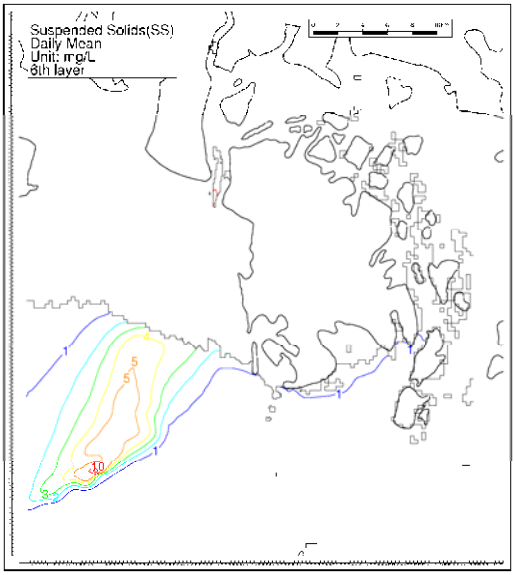
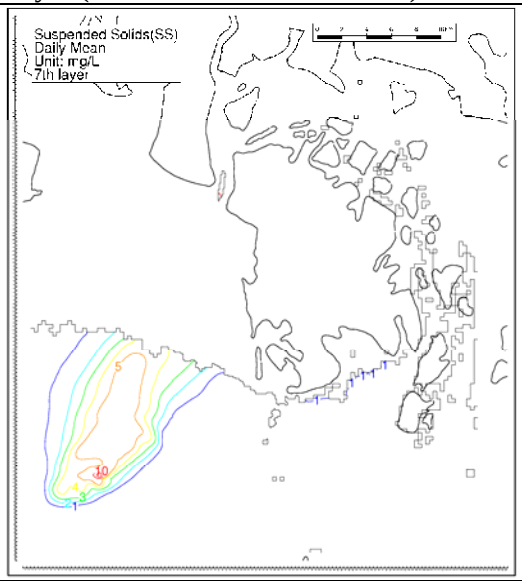
5th Layer (8-10m below surface)	6th Layer (10-12m below surface)
	
7th Layer (12m below surface-Bottom)	
	

Figure 5.2 (2) SS Dispersion Prediction (Case 6, Daily Average, Medium Domain)

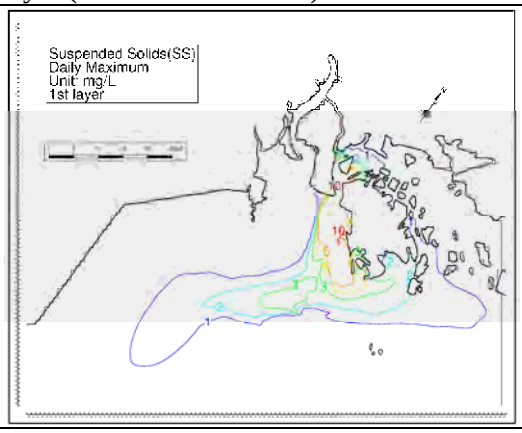
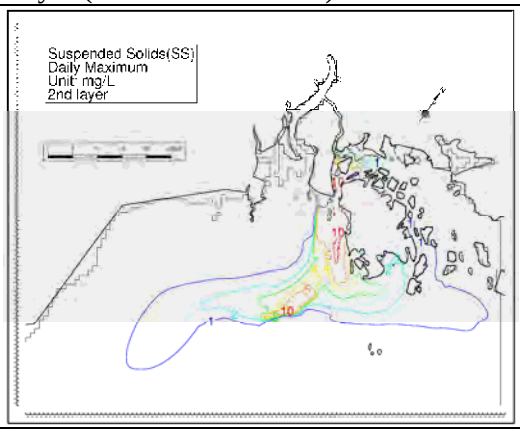
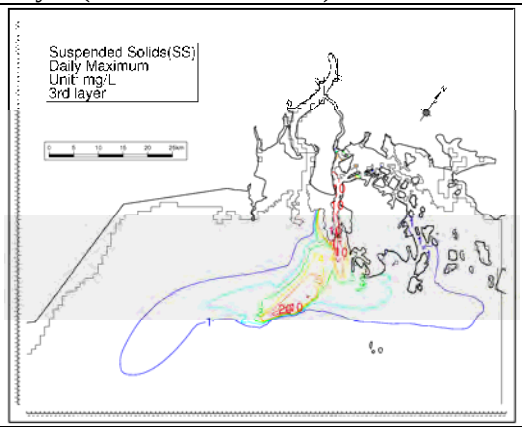
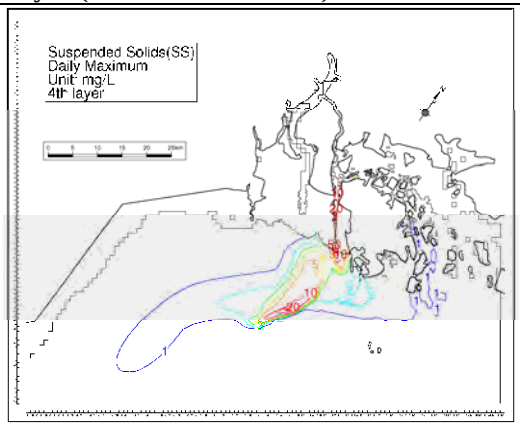
1st layer (0-2m below surface)	2nd Layer (2-4m below surface)
	
3rd Layer (4-6m below surface)	4th Layer (6-8m below surface)
	

Figure 5.3 (1) SS Dispersion Prediction (Case 6, Daily Maximum, Large Domain)

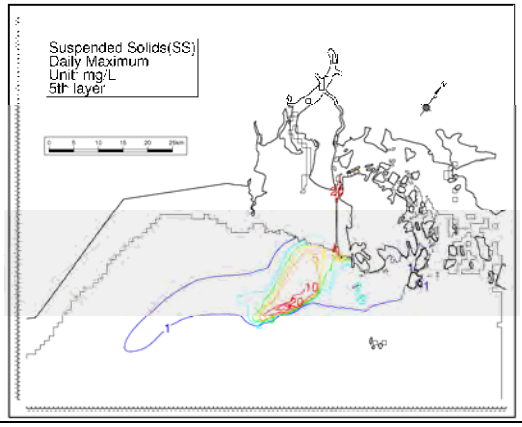
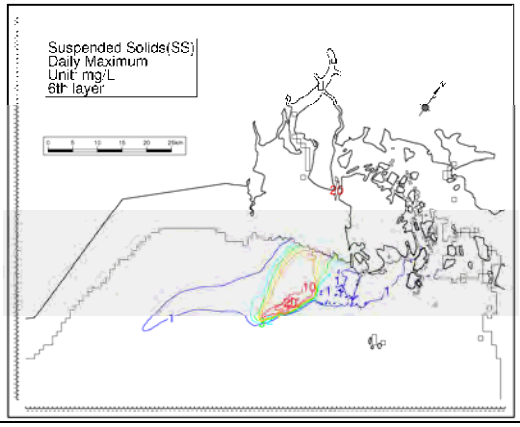
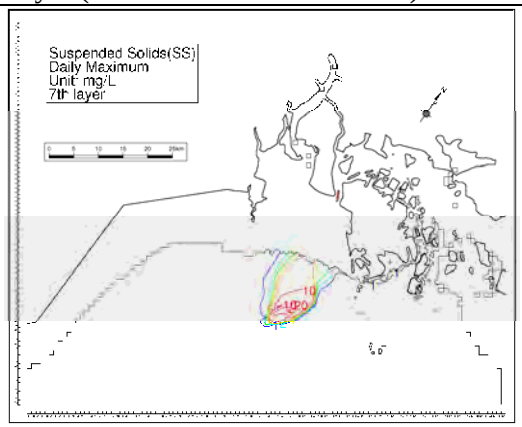
5th Layer (8-10m below surface)	6th Layer (10-12m below surface)
	
7th Layer (12m below surface-Bottom)	
	

Figure 5.3 (2) SS Dispersion Prediction (Case 6, Daily Maximum, Large Domain)

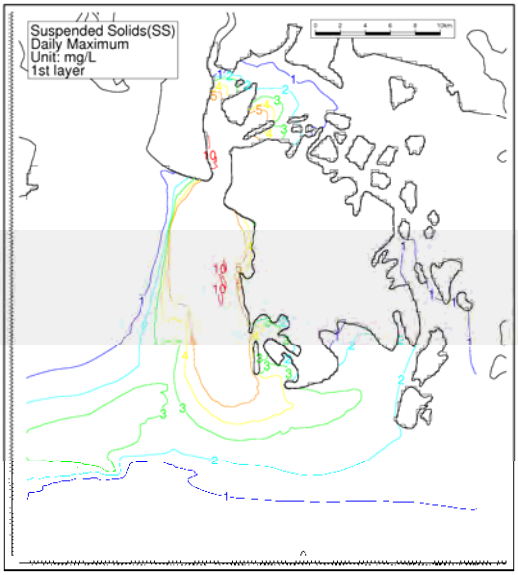
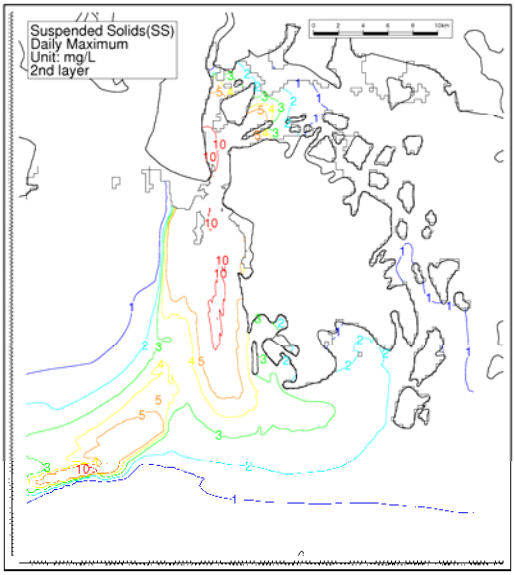
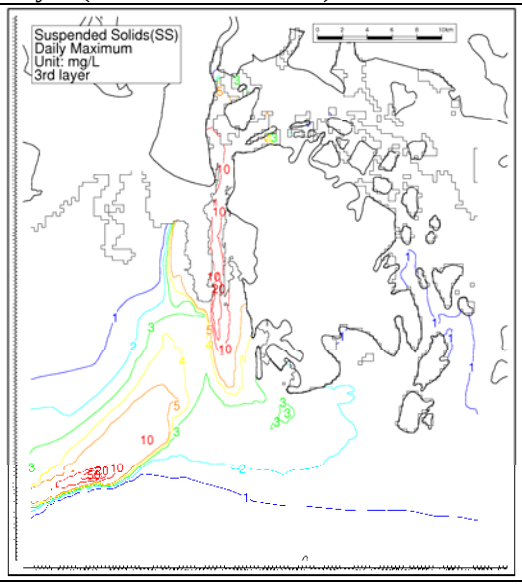
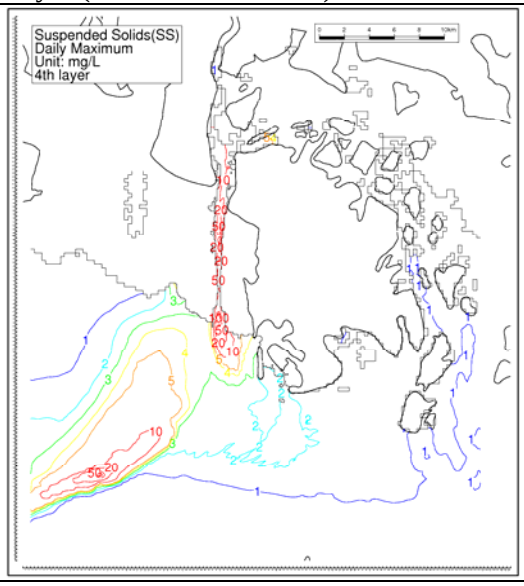
1st layer (0-2m below surface)	2nd Layer (2-4m below surface)
	
3rd Layer (4-6m below surface)	4th Layer (6-8m below surface)
	

Figure 5.4 (1) SS Dispersion Prediction (Case 6, Daily Maximum, Medium Domain)

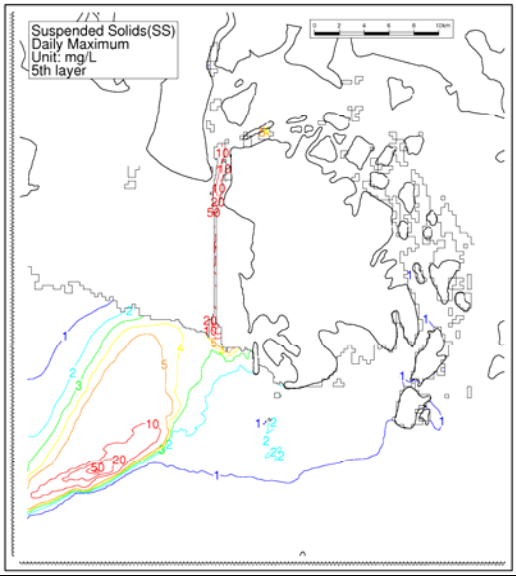
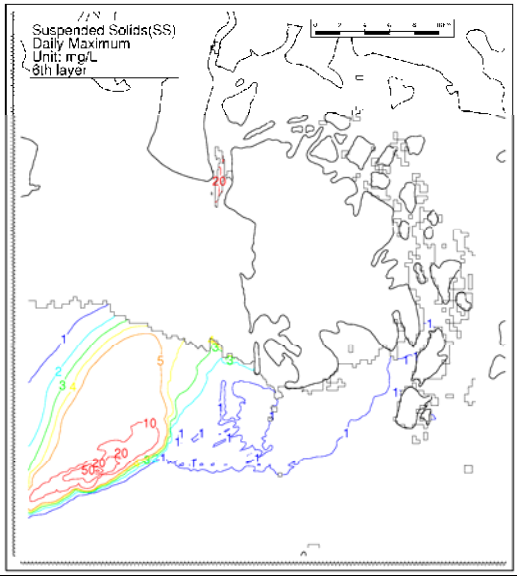
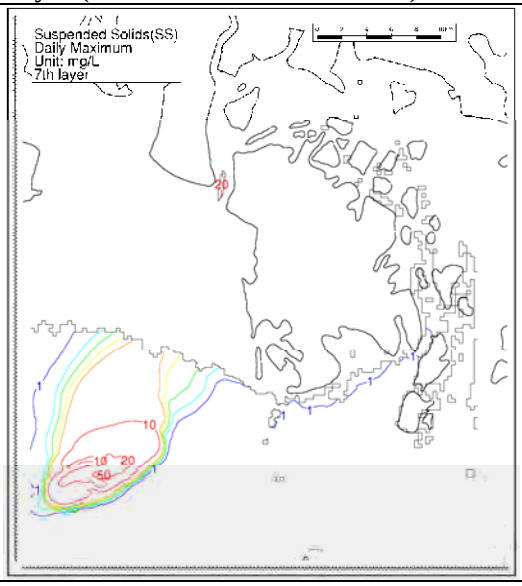
5th Layer (8-10m below surface)	6th Layer (10-12m below surface)
	
7th Layer (12m below surface-Bottom)	
	

Figure 5.4 (2) SS Dispersion Prediction (Case 6, Daily Maximum, Medium Domain)

5.2 Case 7

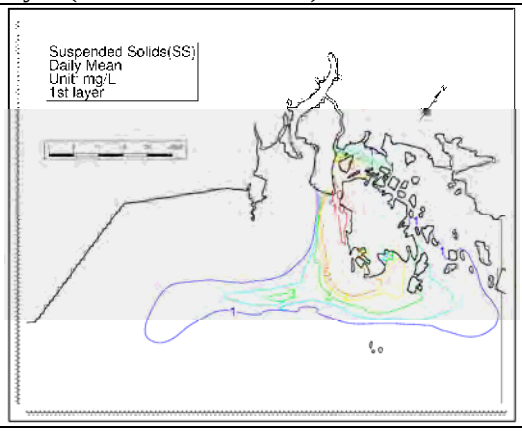
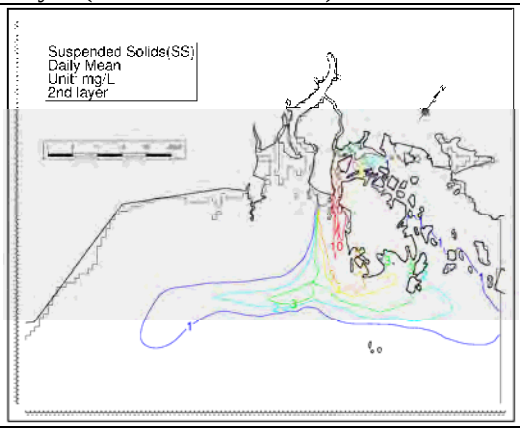
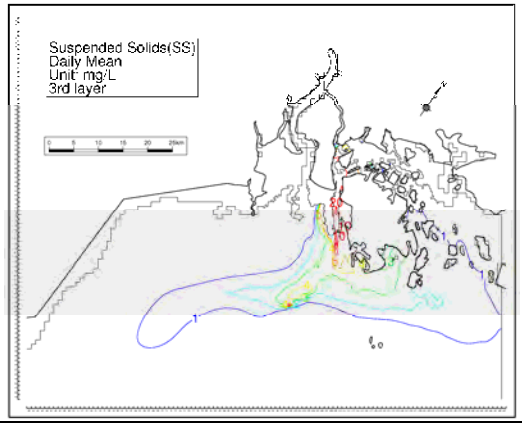
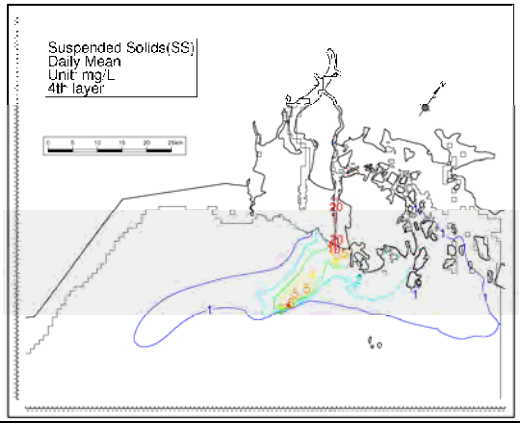
1st layer (0-2m below surface)	2nd Layer (2-4m below surface)
	
3rd Layer (4-6m below surface)	4th Layer (6-8m below surface)
	

Figure 5.5 (1) SS Dispersion Prediction (Case 7, Daily Average, Large Domain)

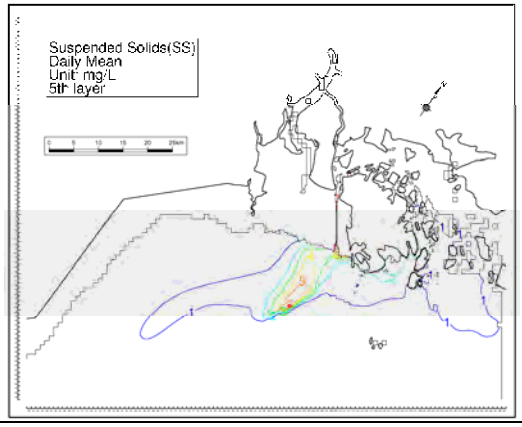
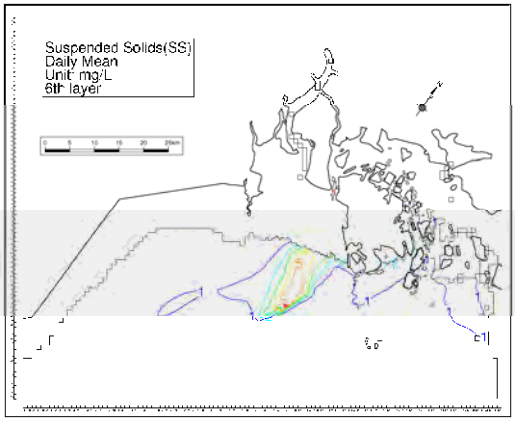
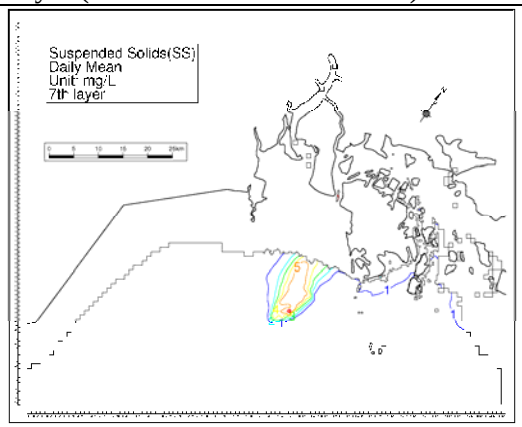
5th Layer (8-10m below surface)	6th Layer (10-12m below surface)
	
7th Layer (12m below surface-Bottom)	
	

Figure 5.5 (2) SS Dispersion Prediction (Case 7, Daily Average, Large Domain)

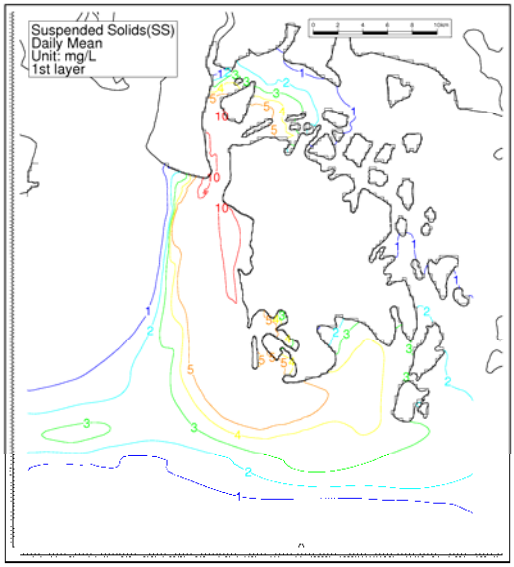
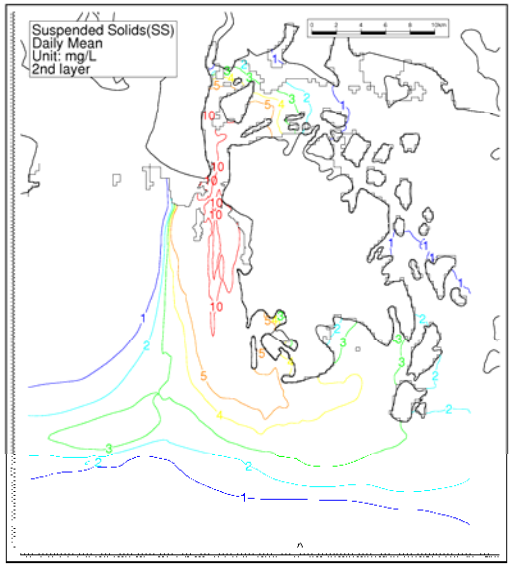
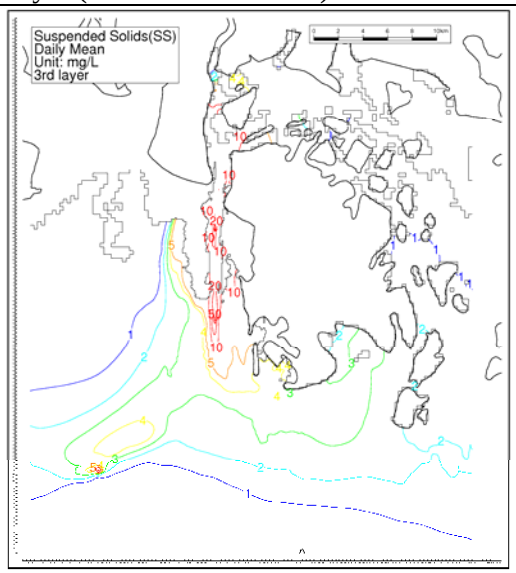
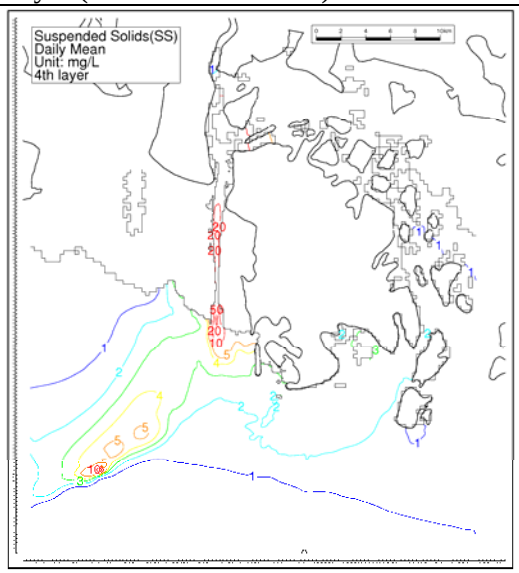
1st layer (0-2m below surface)	2nd Layer (2-4m below surface)
	
3rd Layer (4-6m below surface)	4th Layer (6-8m below surface)
	

Figure 5.6 (1) SS Dispersion Prediction (Case 7, Daily Average, Medium Domain)

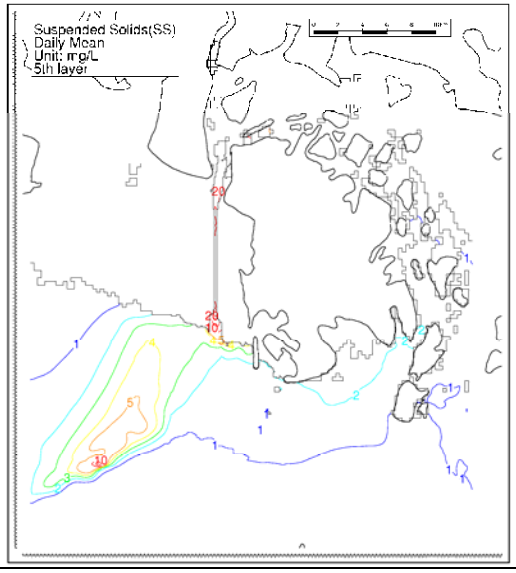
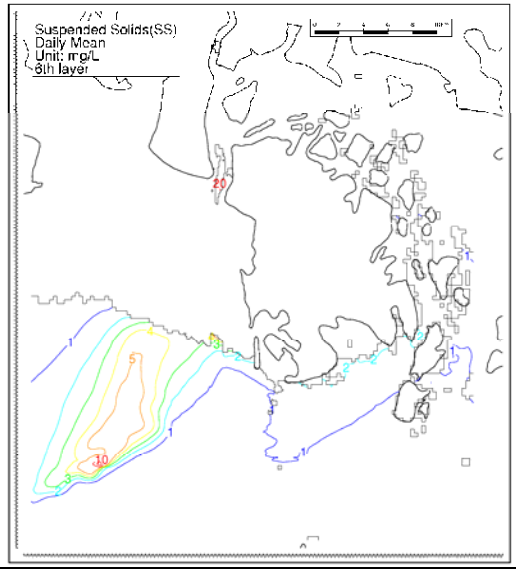
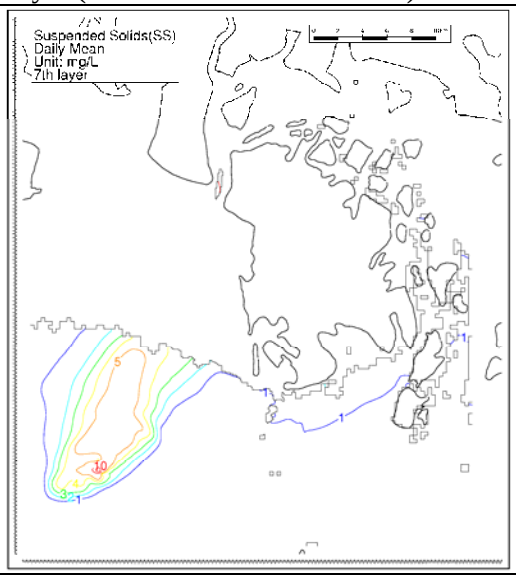
5th Layer (8-10m below surface)	6th Layer (10-12m below surface)
	
7th Layer (12m below surface-Bottom)	
	

Figure 5.6 (2) SS Dispersion Prediction (Case 7, Daily Average, Medium Domain)

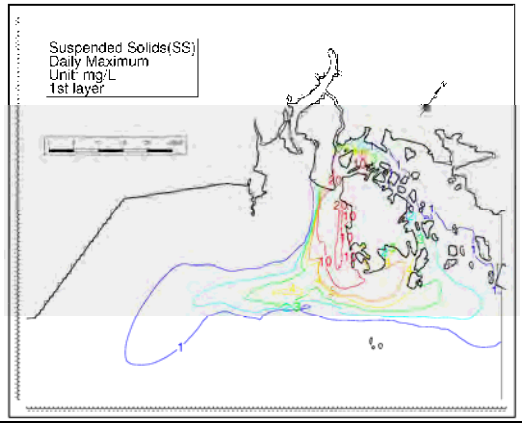
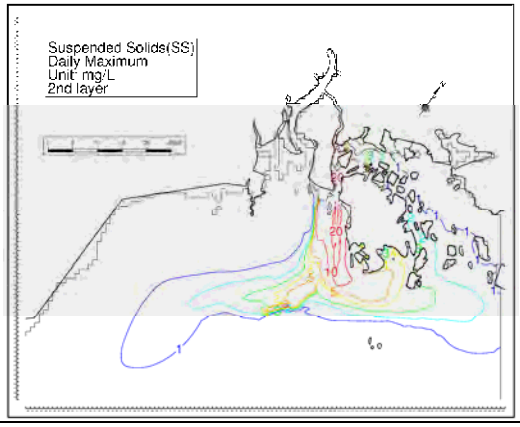
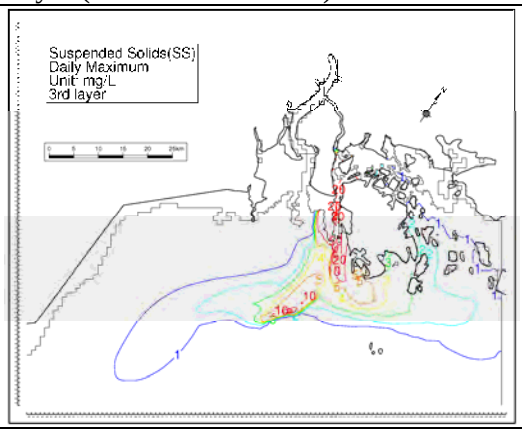
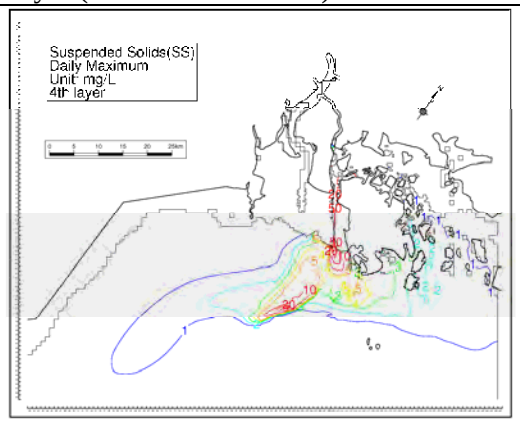
1st layer (0-2m below surface)	2nd Layer (2-4m below surface)
	
3rd Layer (4-6m below surface)	4th Layer (6-8m below surface)
	

Figure 5.7 (1) SS Dispersion Prediction (Case 7, Daily Maximum, Large Domain)

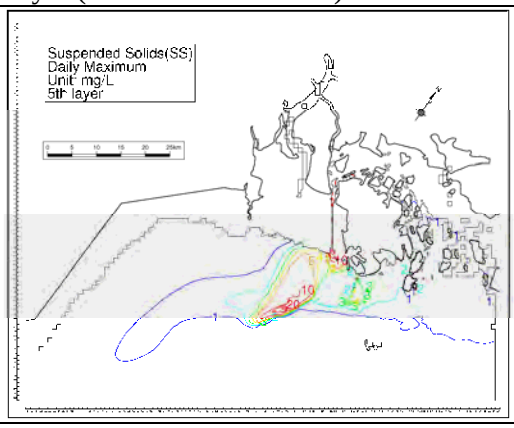
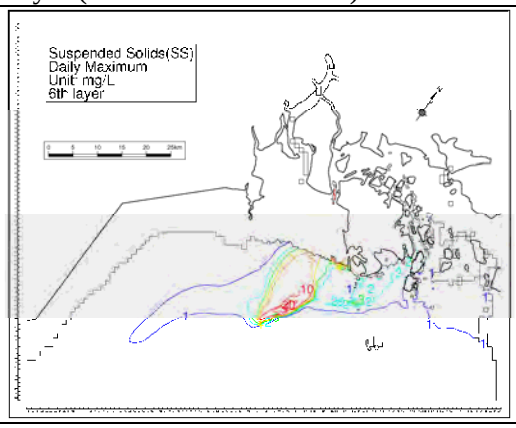
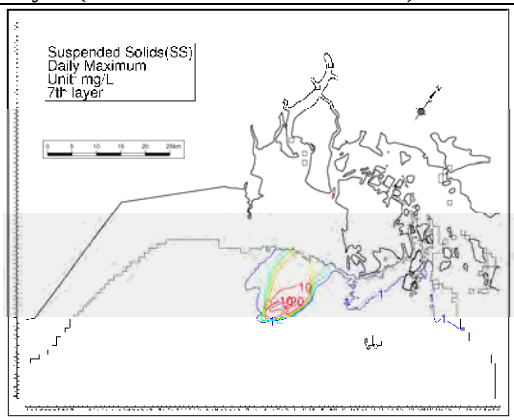
5th Layer (8-10m below surface)	6th Layer (10-12m below surface)
	
7th Layer (12m below surface-Bottom)	
	

Figure 5.7 (2) SS Dispersion Prediction (Case 7, Daily Maximum, Large Domain)

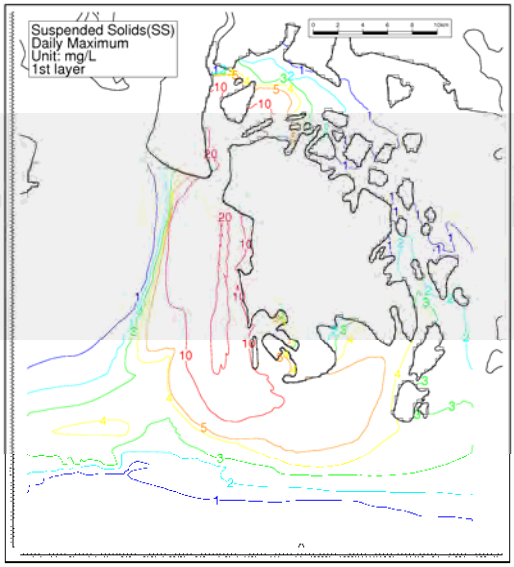
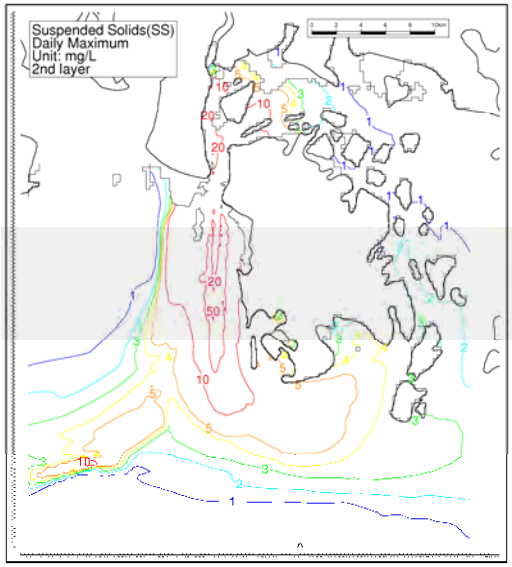
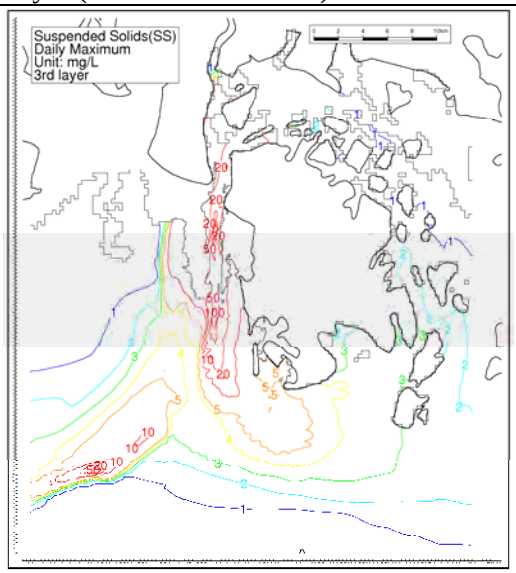
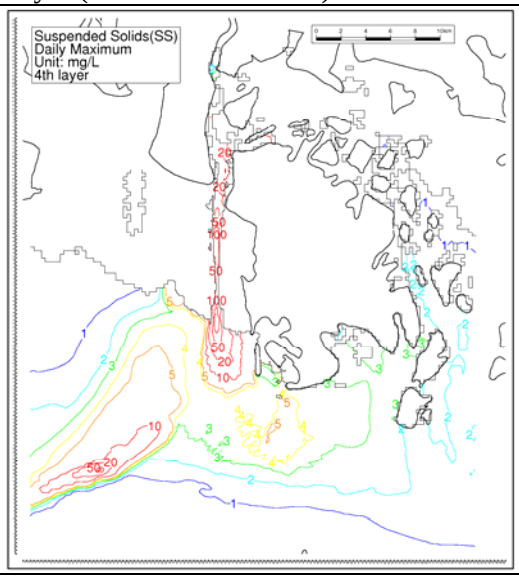
1st layer (0-2m below surface)	2nd Layer (2-4m below surface)
	
3rd Layer (4-6m below surface)	4th Layer (6-8m below surface)
	

Figure 5.8 (1) SS Dispersion Prediction (Case 7, Daily Maximum, Medium Domain)

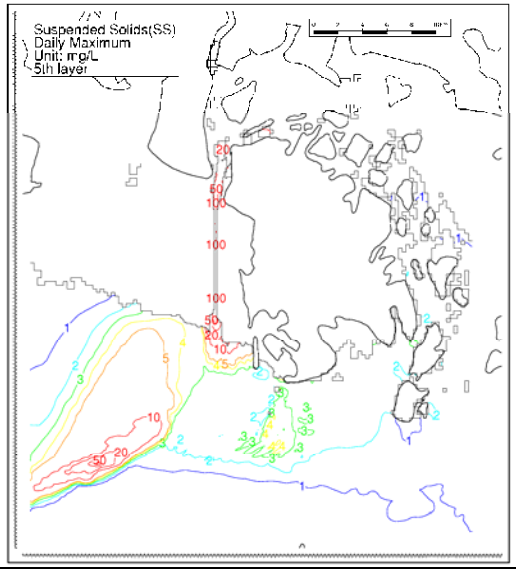
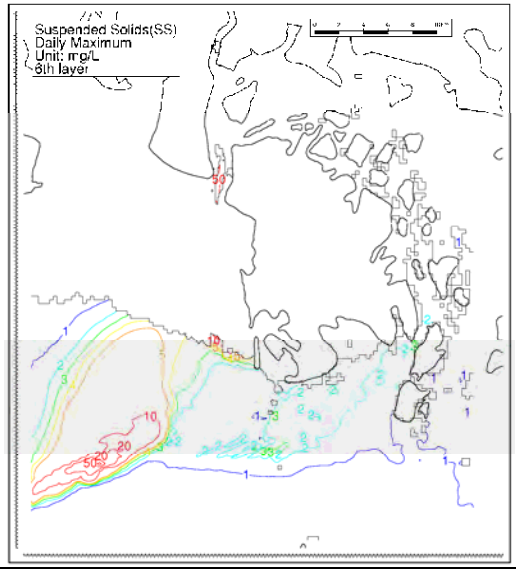
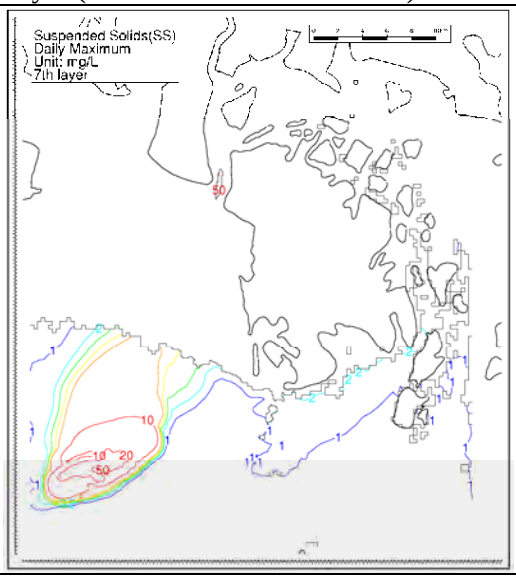
5th Layer (8-10m below surface)	6th Layer (10-12m below surface)
	
7th Layer (12m below surface-Bottom)	
	

Figure 5.8 (2) SS Dispersion Prediction (Case 7, Daily Maximum, Medium Domain)

5.3 Case 8

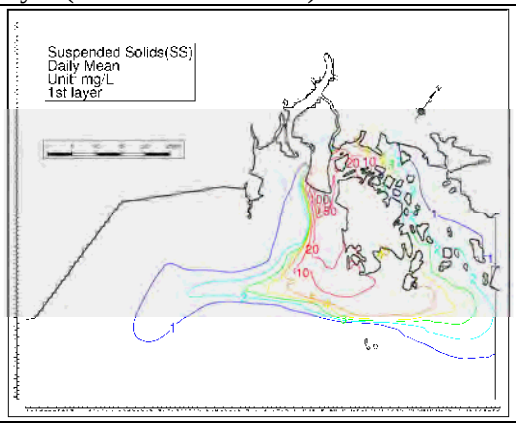
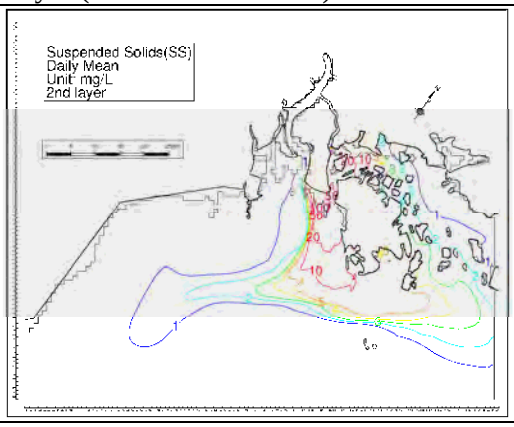
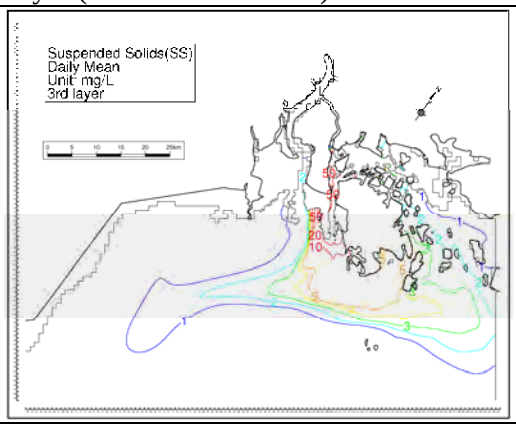
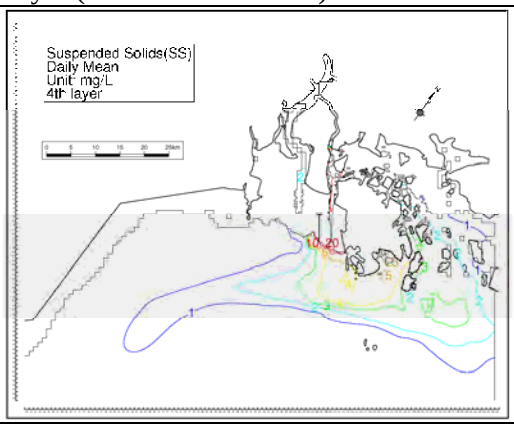
1st layer (0-2m below surface)	2nd Layer (2-4m below surface)
	
3rd Layer (4-6m below surface)	**4th Layer (6-8m below surface)**
	

Figure 5.9 (1) SS Dispersion Prediction (Case 8, Daily Average, Large Domain)

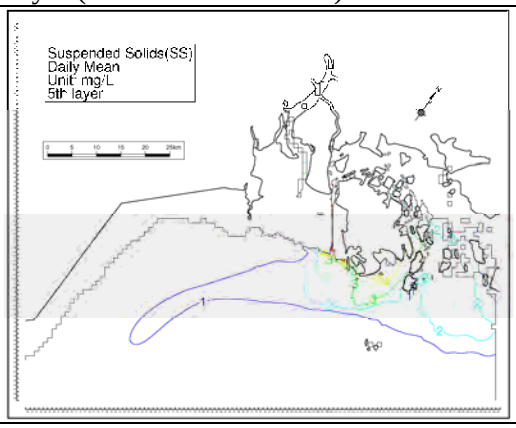
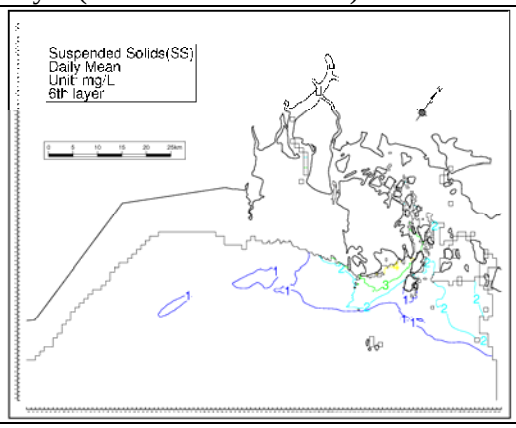
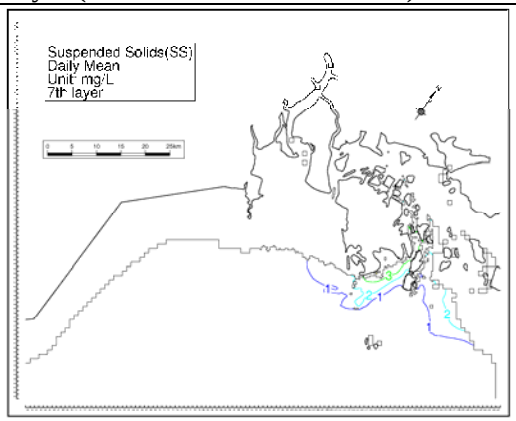
5th Layer (8-10m below surface)	6th Layer (10-12m below surface)
	
7th Layer (12m below surface-Bottom)	
	

Figure 5.9 (2) SS Dispersion Prediction (Case 8, Daily Average, Large Domain)

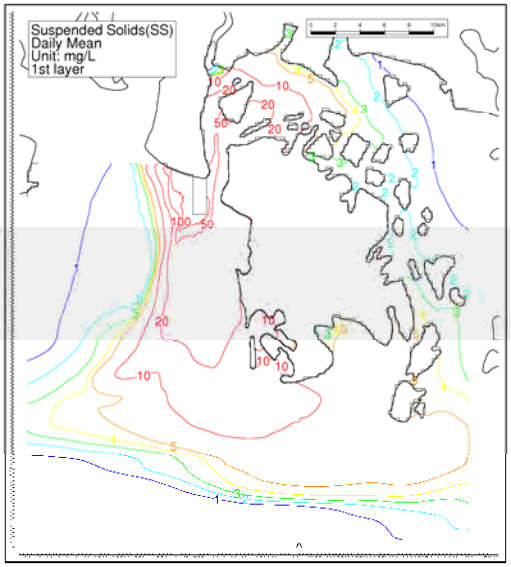
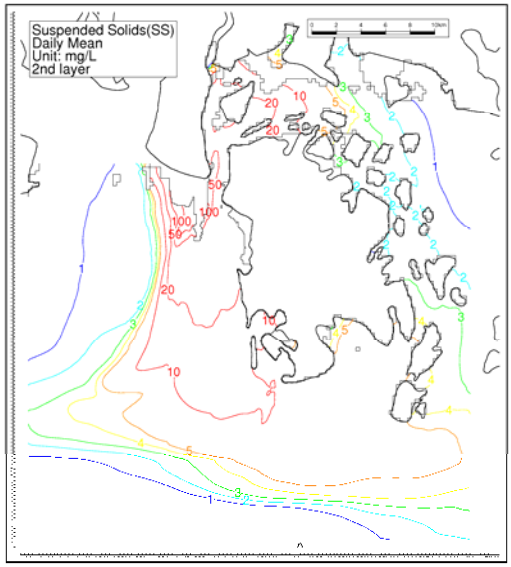
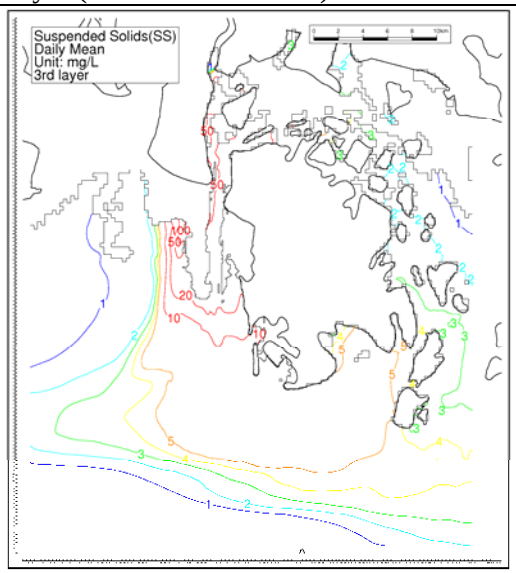
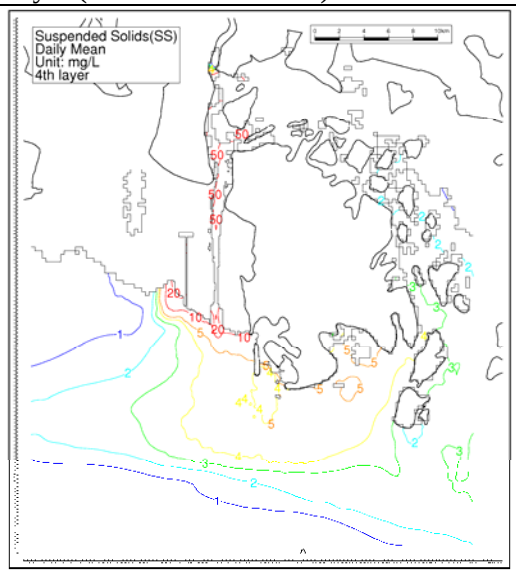
1st layer (0-2m below surface)	2nd Layer (2-4m below surface)
	
3rd Layer (4-6m below surface)	4th Layer (6-8m below surface)
	

Figure 5.10 (1) SS Dispersion Prediction (Case 8, Daily Average, Medium Domain)

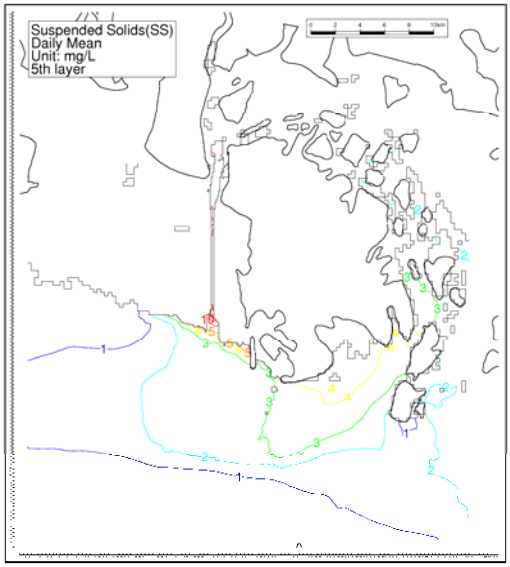
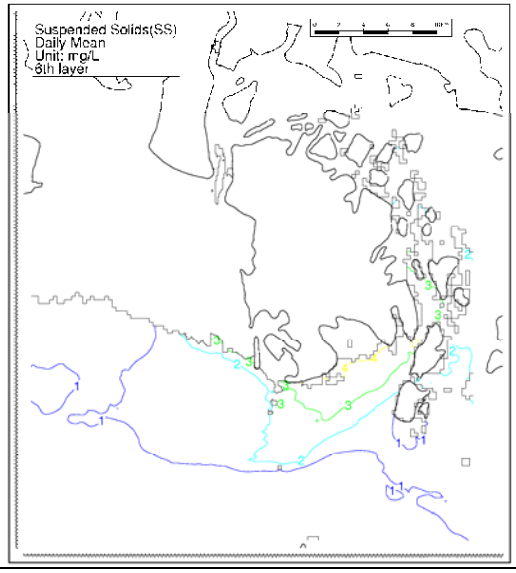
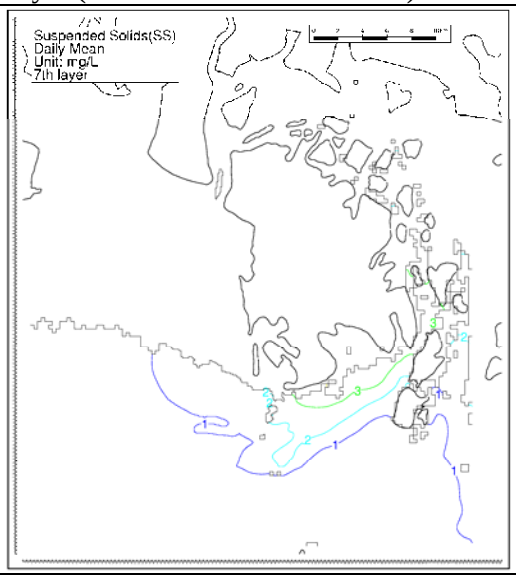
5th Layer (8-10m below surface)	6th Layer (10-12m below surface)
	
7th Layer (12m below surface-Bottom)	
	

Figure 5.10 (2) SS Dispersion Prediction (Case 8, Daily Average, Medium Domain)

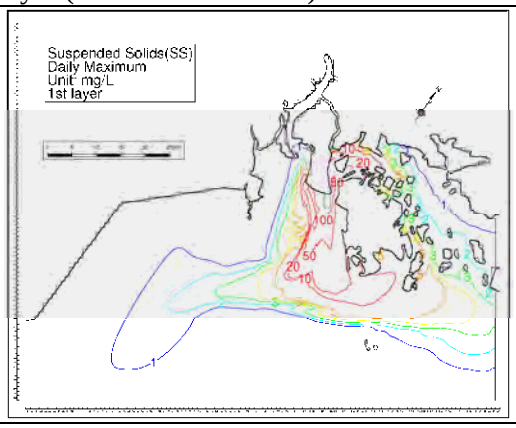
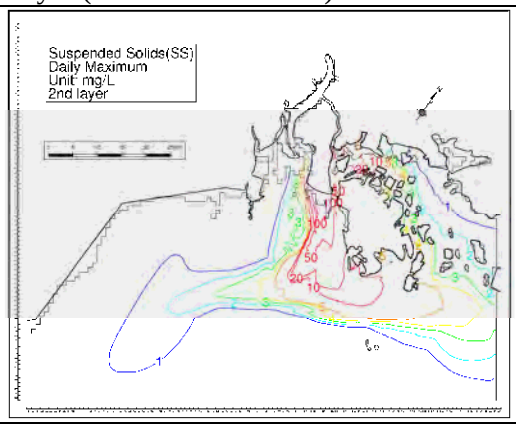
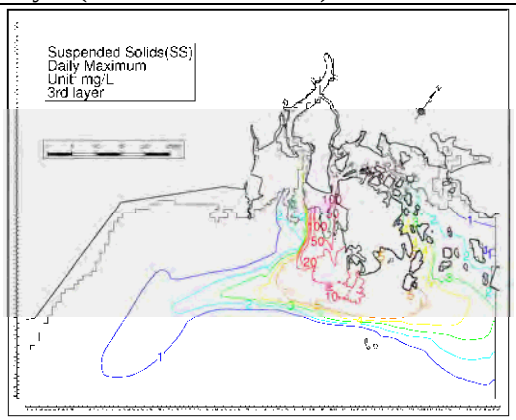
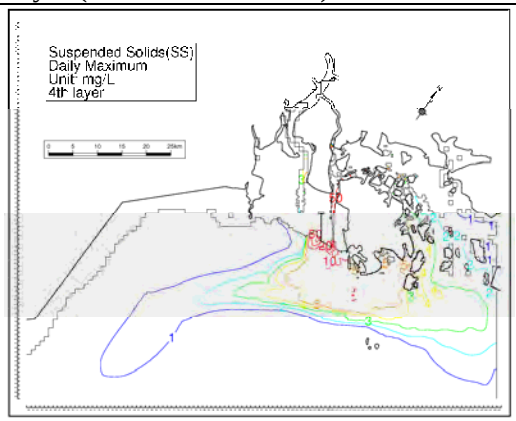
1st layer (0-2m below surface)	2nd Layer (2-4m below surface)
	
3rd Layer (4-6m below surface)	**4th Layer (6-8m below surface)**
	

Figure 5.11 (1) SS Dispersion Prediction (Case 8, Daily Maximum, Large Domain)

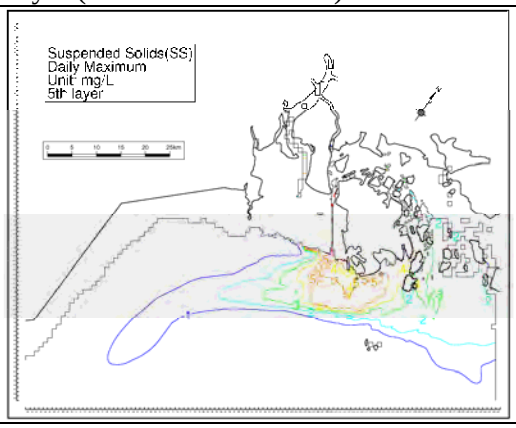
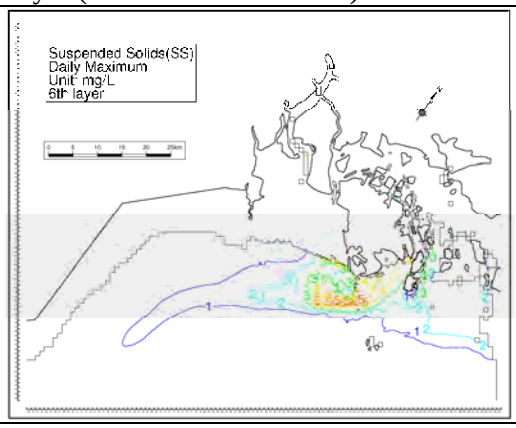
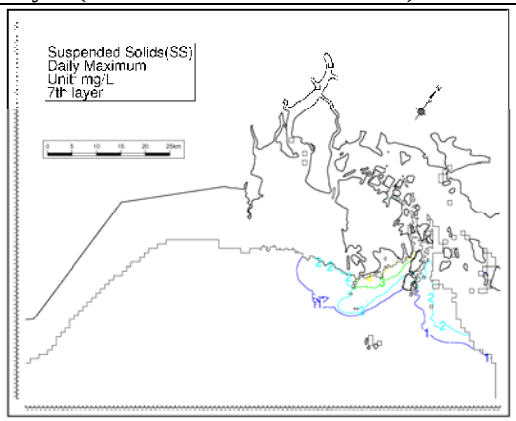
5th Layer (8-10m below surface)	6th Layer (10-12m below surface)
	
7th Layer (12m below surface-Bottom)	
	

Figure 5.11 (2) SS Dispersion Prediction (Case 8, Daily Maximum, Large Domain)

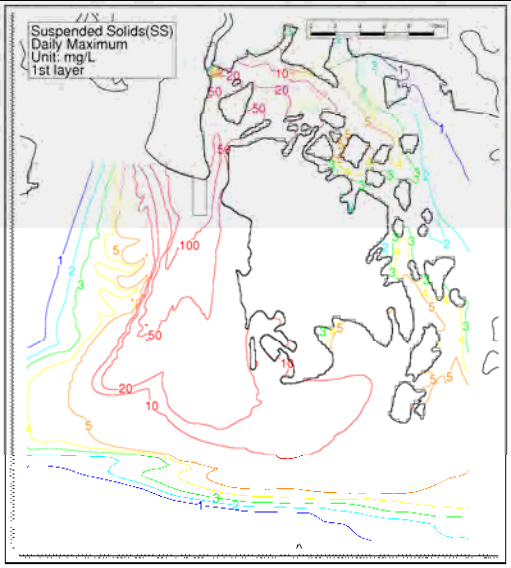
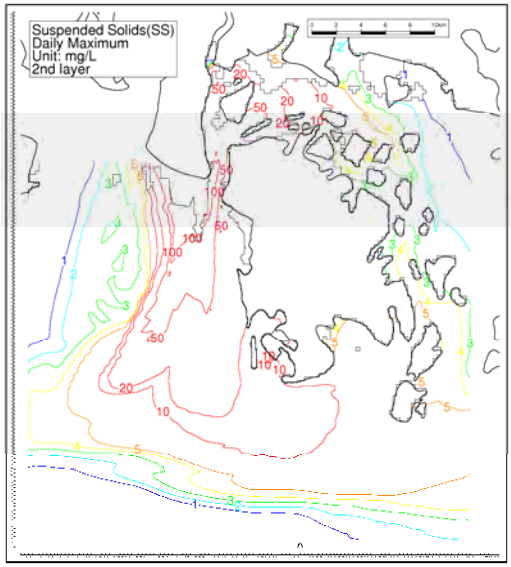
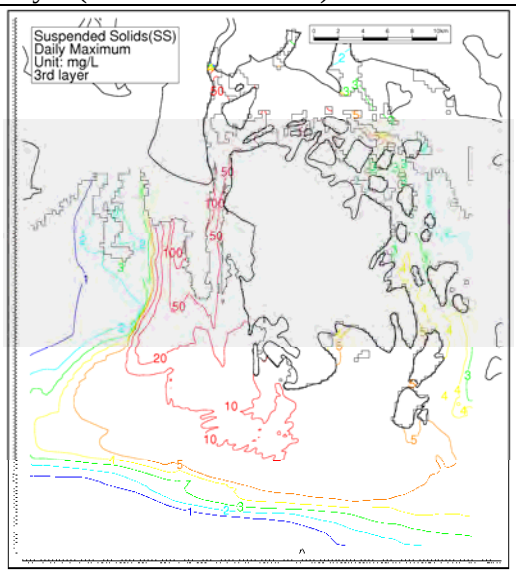
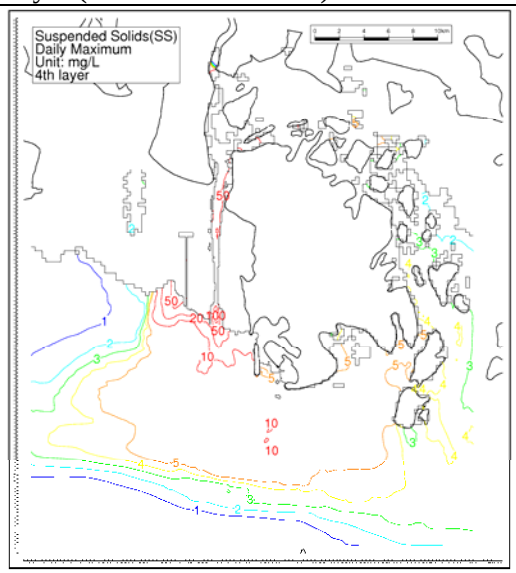
1st layer (0-2m below surface)	2nd Layer (2-4m below surface)
	
3rd Layer (4-6m below surface)	4th Layer (6-8m below surface)
	

Figure 5.12 (1) SS Dispersion Prediction (Case 8, Daily Maximum, Medium Domain)

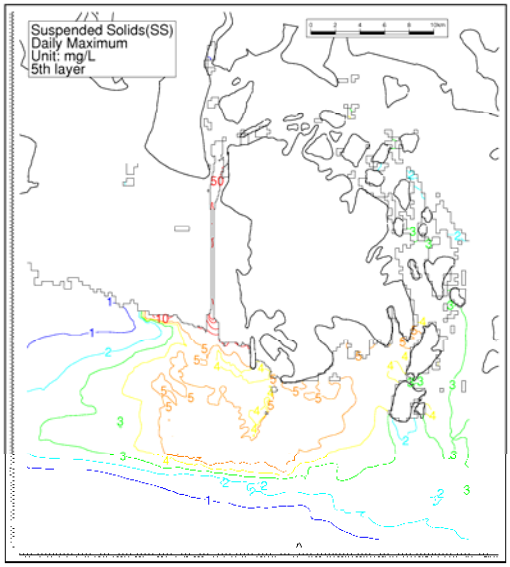
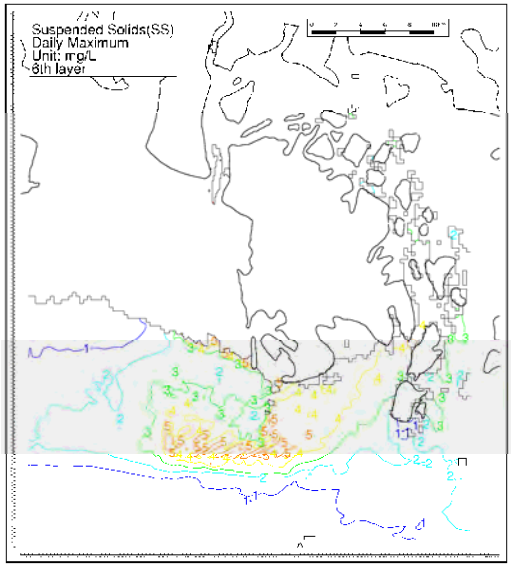
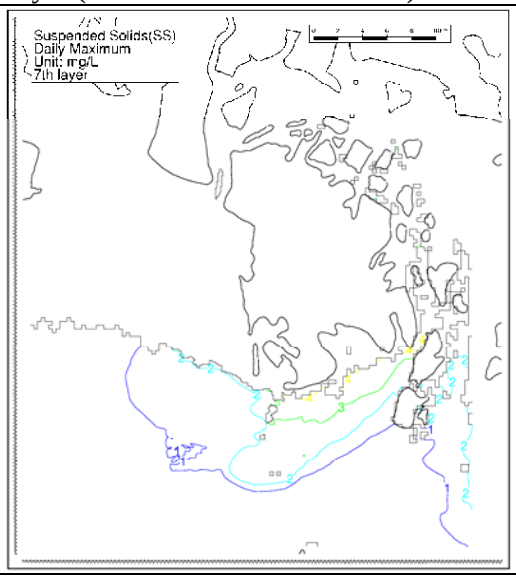
5th Layer (8-10m below surface)	6th Layer (10-12m below surface)
	
7th Layer (12m below surface-Bottom)	
	

Figure 5.12 (2) SS Dispersion Prediction (Case 8, Daily Maximum, Medium Domain)

5.4 Case 9

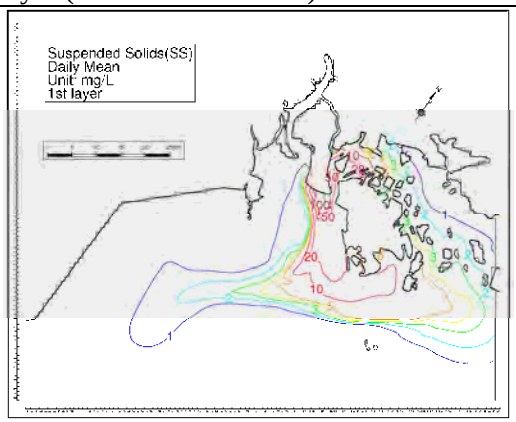
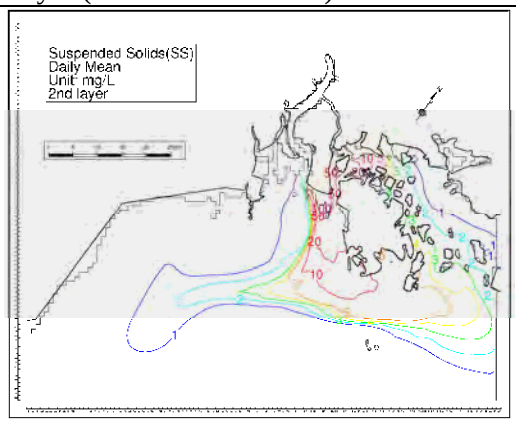
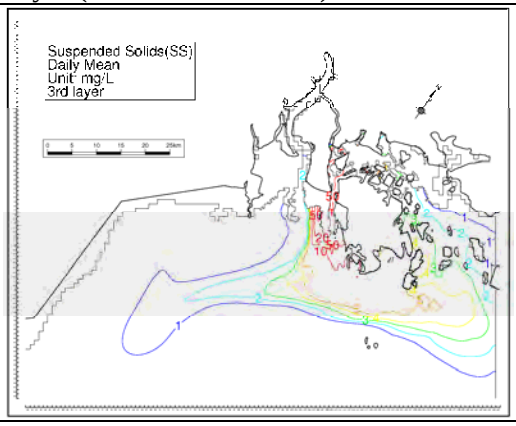
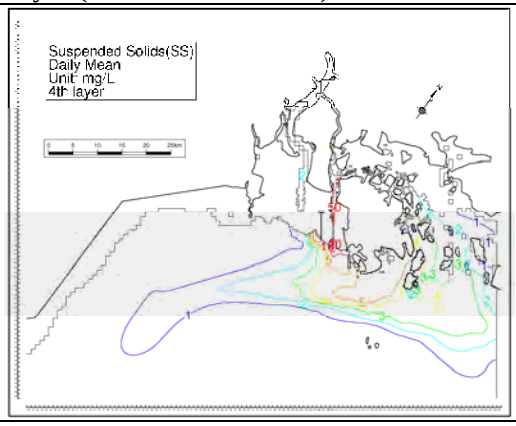
1st layer (0-2m below surface)	2nd Layer (2-4m below surface)
	
3rd Layer (4-6m below surface)	**4th Layer (6-8m below surface)**
	

Figure 5.13 (1) SS Dispersion Prediction (Case 9, Daily Average, Large Domain)

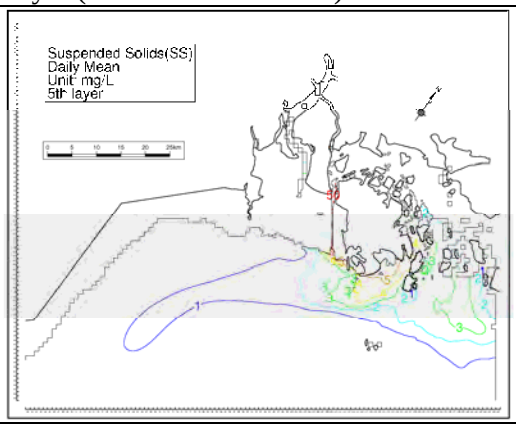
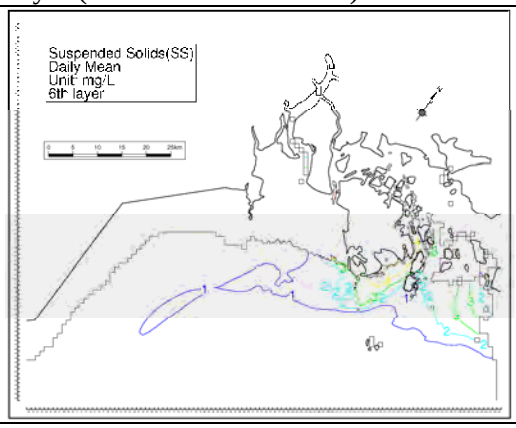
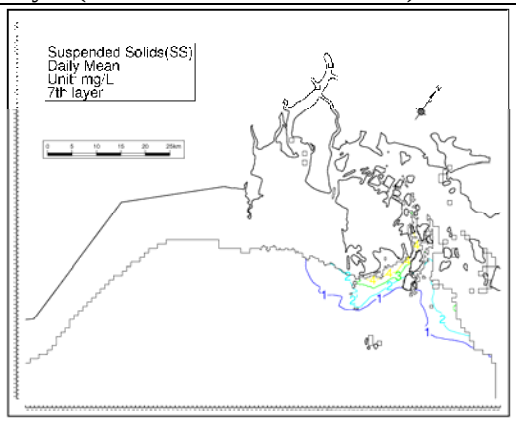
5th Layer (8-10m below surface)	6th Layer (10-12m below surface)
	
7th Layer (12m below surface-Bottom)	
	

Figure 5.13 (2) SS Dispersion Prediction (Case 9, Daily Average, Large Domain)

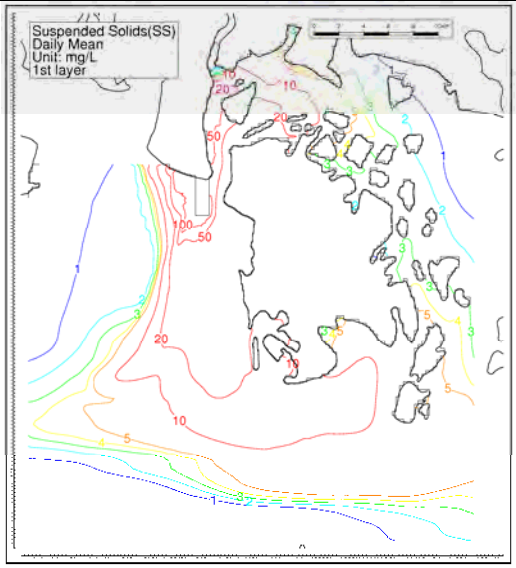
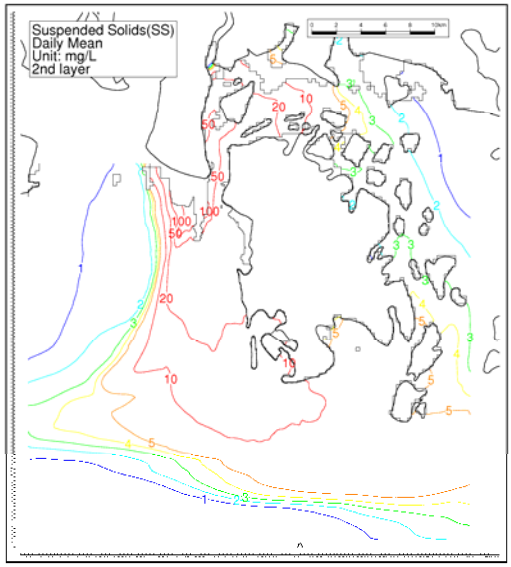
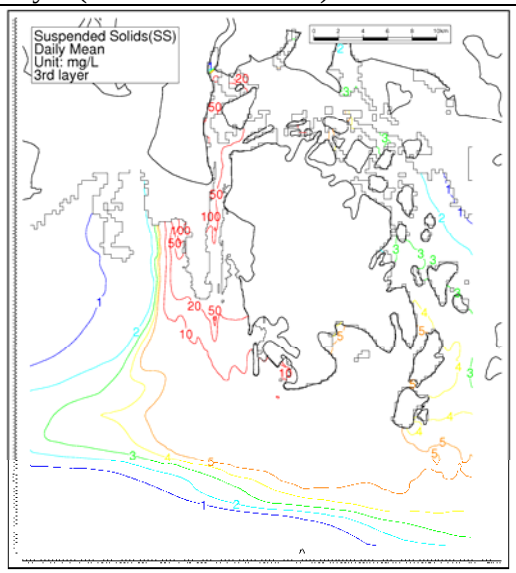
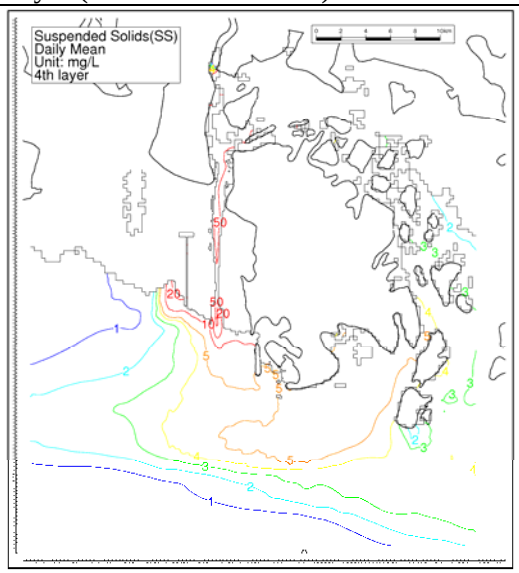
1st layer (0-2m below surface)	2nd Layer (2-4m below surface)
	
3rd Layer (4-6m below surface)	4th Layer (6-8m below surface)
	

Figure 5.14 (1) SS Dispersion Prediction (Case 9, Daily Average, Medium Domain)

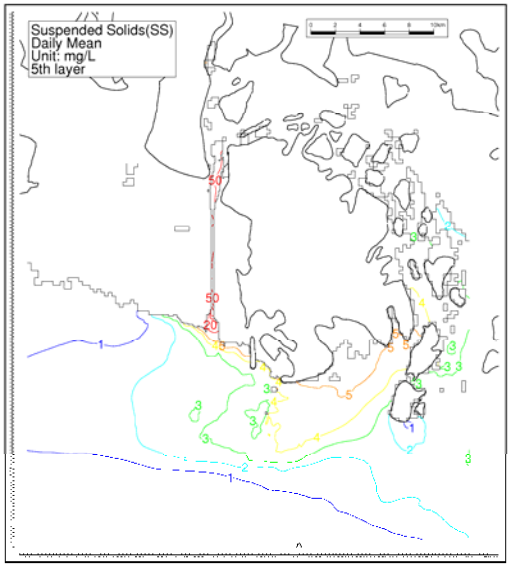
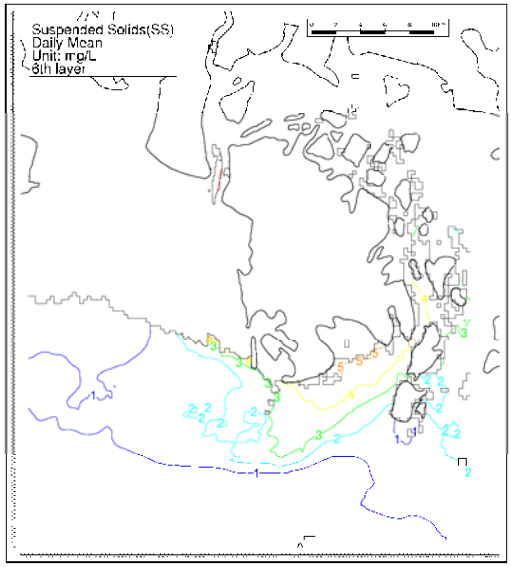
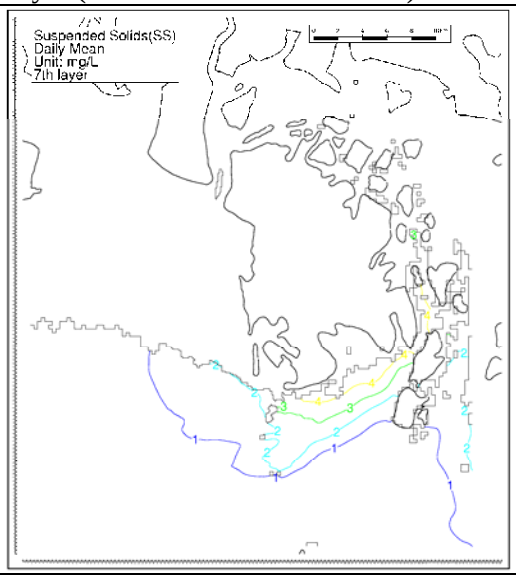
5th Layer (8-10m below surface)	6th Layer (10-12m below surface)
	
7th Layer (12m below surface-Bottom)	
	

Figure 5.14 (2) SS Dispersion Prediction (Case 9, Daily Average, Medium Domain)

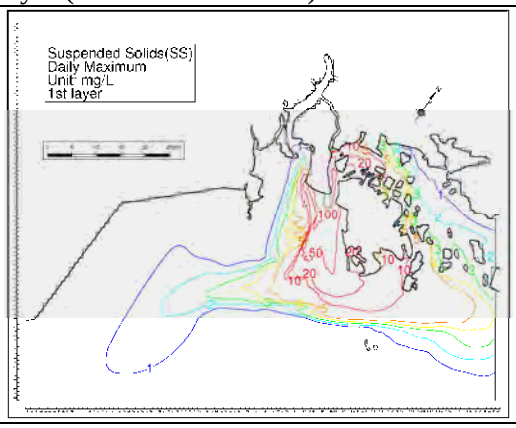
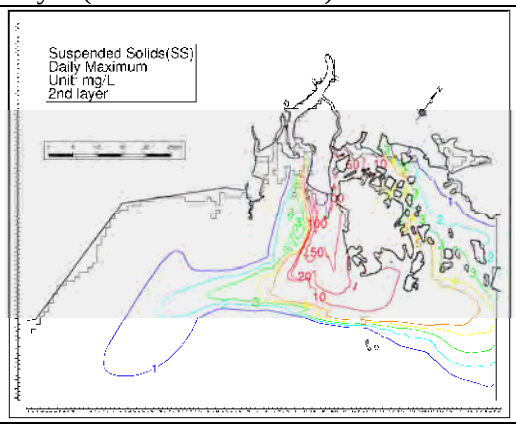
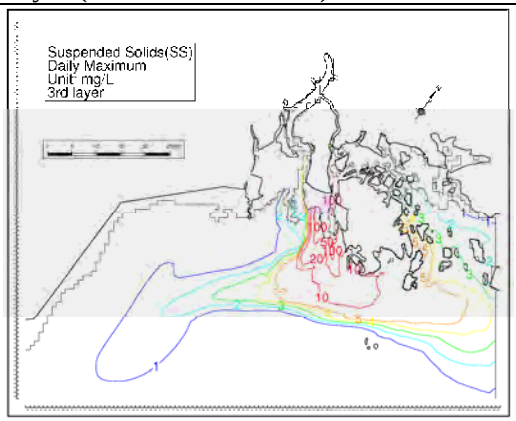
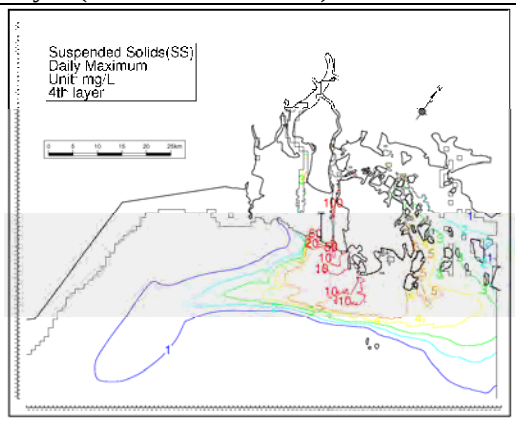
1st layer (0-2m below surface)	2nd Layer (2-4m below surface)
	
3rd Layer (4-6m below surface)	4th Layer (6-8m below surface)
	

Figure 5.15 (1) SS Dispersion Prediction (Case 9, Daily Maximum, Large Domain)

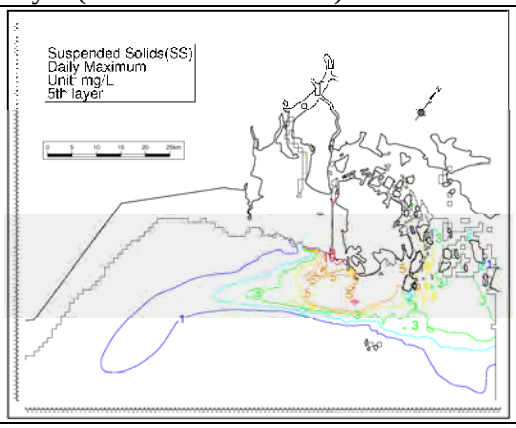
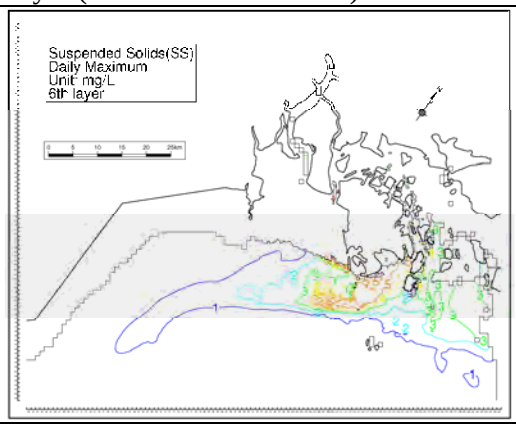
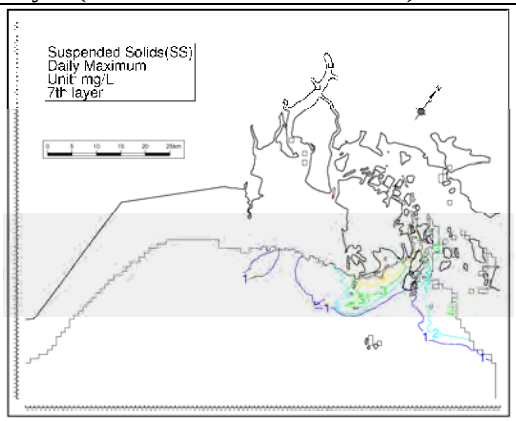
5th Layer (8-10m below surface)	6th Layer (10-12m below surface)
	
7th Layer (12m below surface-Bottom)	
	

Figure 5.15 (2) SS Dispersion Prediction (Case 9, Daily Maximum, Large Domain)

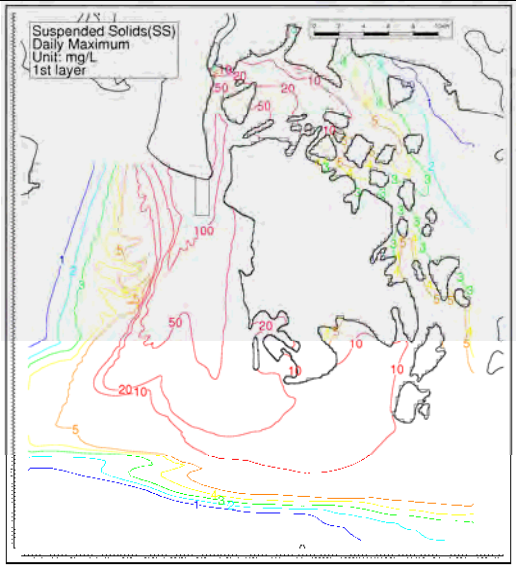
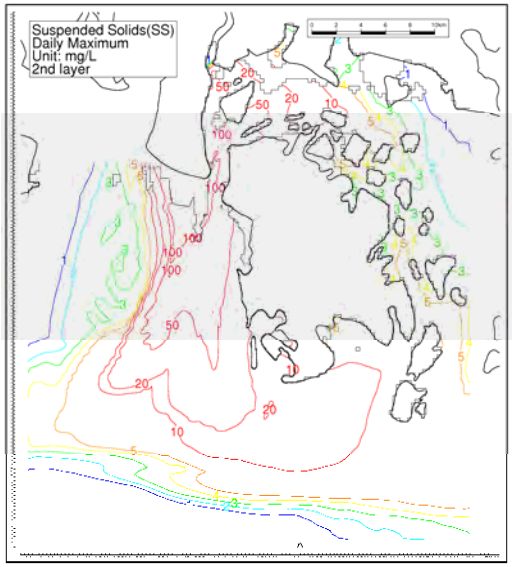
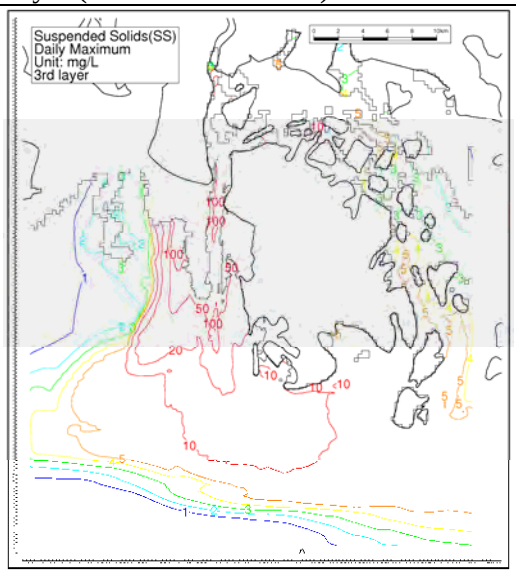
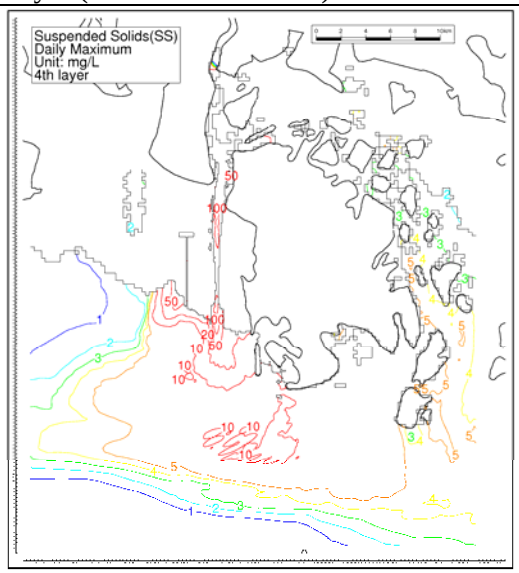
1st layer (0-2m below surface)	2nd Layer (2-4m below surface)
	
3rd Layer (4-6m below surface)	4th Layer (6-8m below surface)
	

Figure 5.16 (1) SS Dispersion Prediction (Case 9, Daily Maximum, Medium Domain)

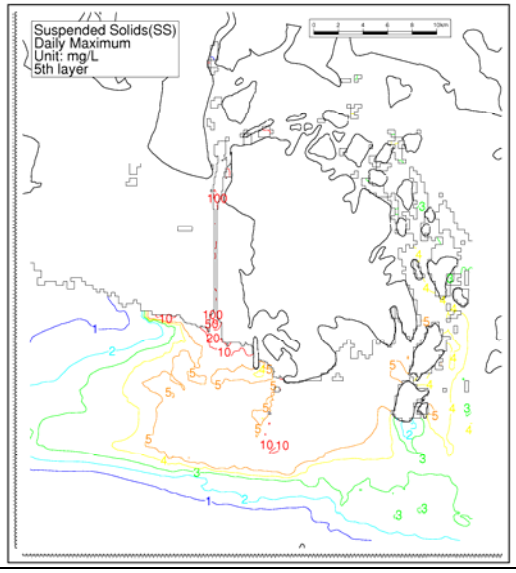
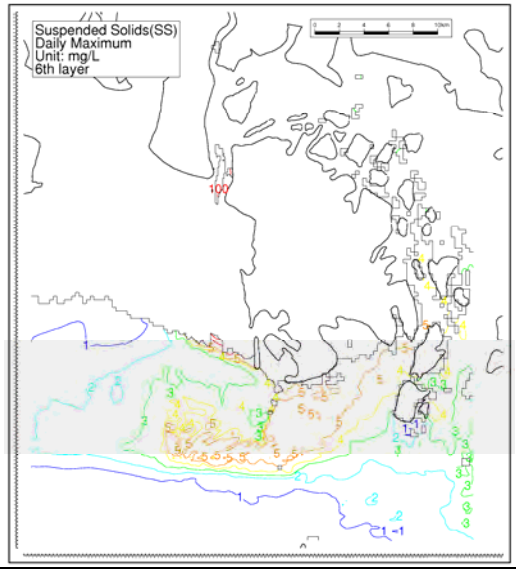
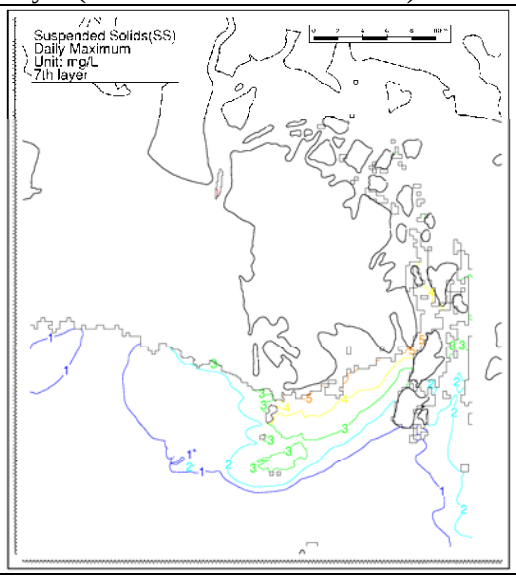
5th Layer (8-10m below surface)	6th Layer (10-12m below surface)
	
7th Layer (12m below surface-Bottom)	
	

Figure 5.16 (2) SS Dispersion Prediction (Case 9, Daily Maximum, Medium Domain)

5.5 Case 10

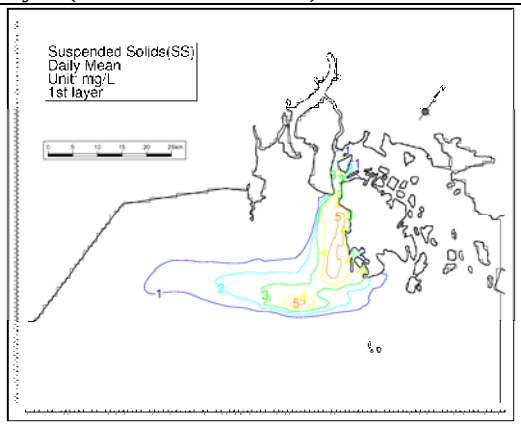
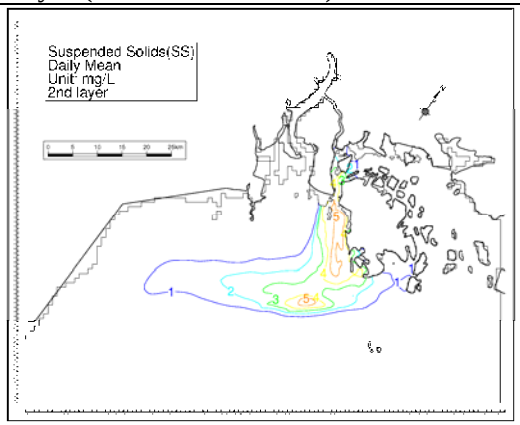
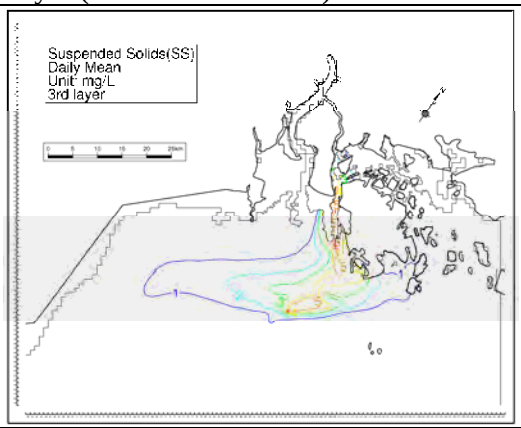
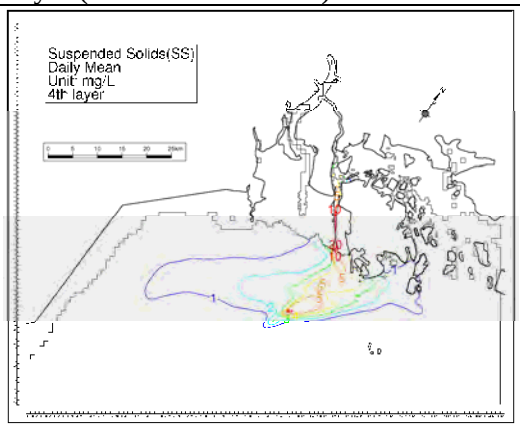
1st layer (0-2m below surface)	2nd Layer (2-4m below surface)
	
3rd Layer (4-6m below surface)	4th Layer (6-8m below surface)
	

Figure 5.17 (1) SS Dispersion Prediction (Case 10, Daily Average, Large Domain)

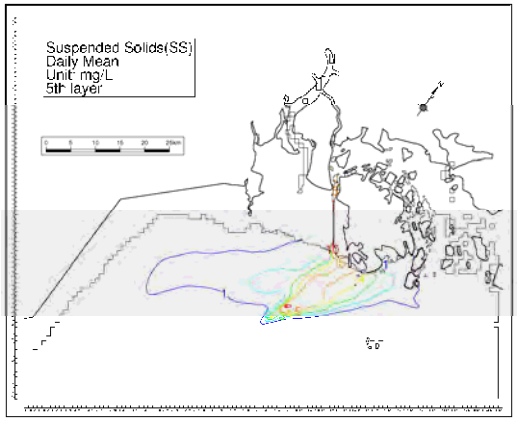
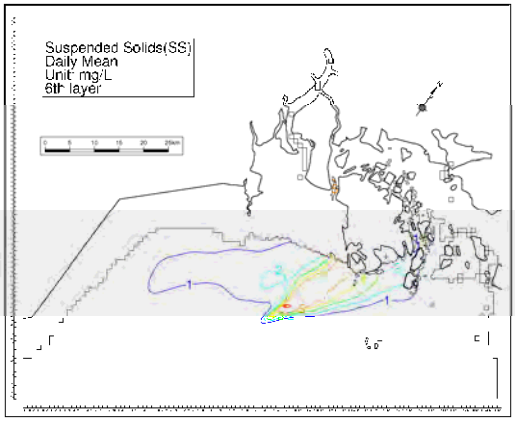
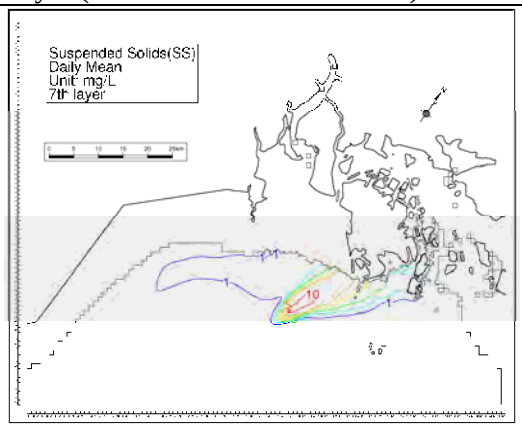
5th Layer (8-10m below surface)	6th Layer (10-12m below surface)
	
7th Layer (12m below surface-Bottom)	
	

Figure 5.17 (2) SS Dispersion Prediction (Case 10, Daily Average, Large Domain)

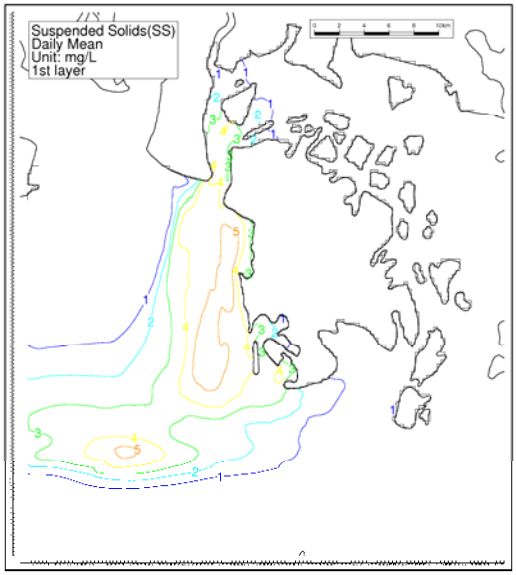
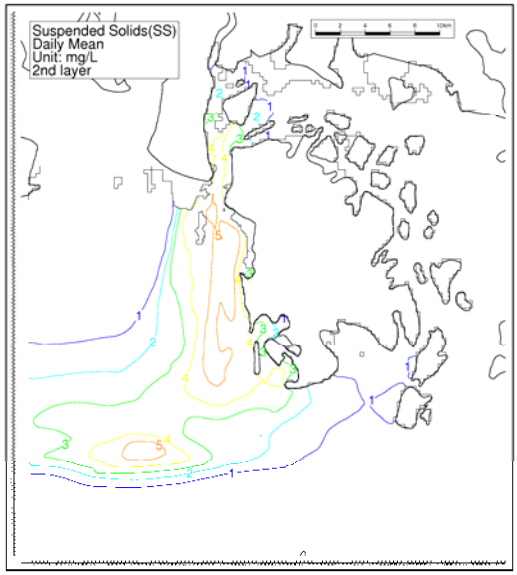
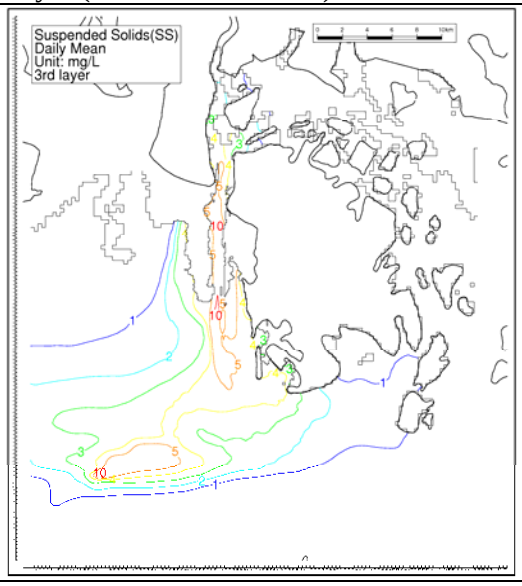
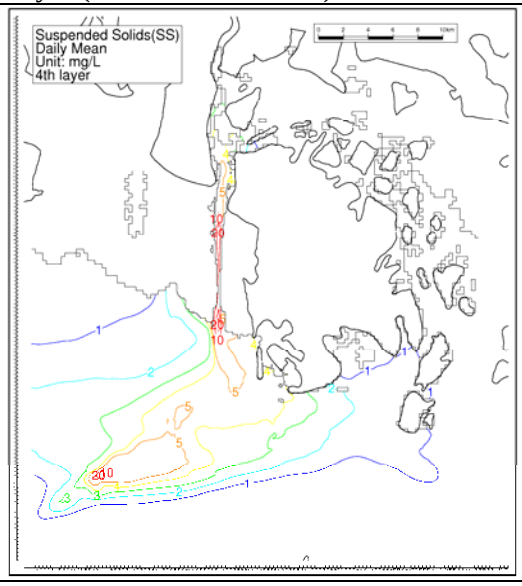
1st layer (0-2m below surface)	2nd Layer (2-4m below surface)
	
3rd Layer (4-6m below surface)	4th Layer (6-8m below surface)
	

Figure 5.18 (1) SS Dispersion Prediction (Case 10, Daily Average, Medium Domain)

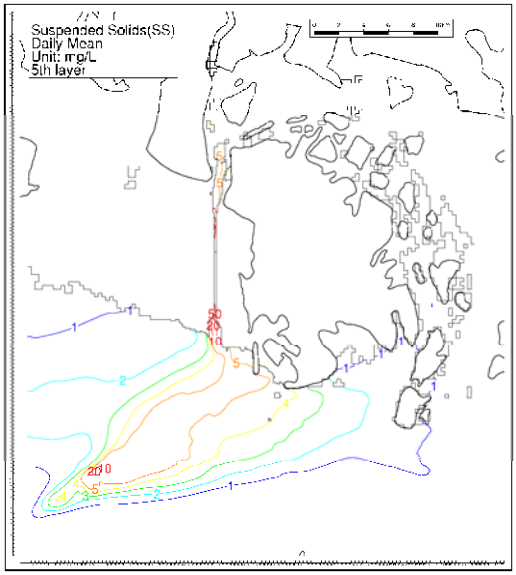
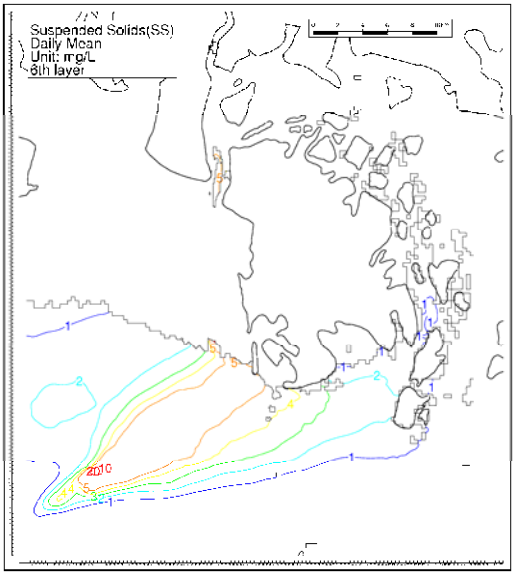
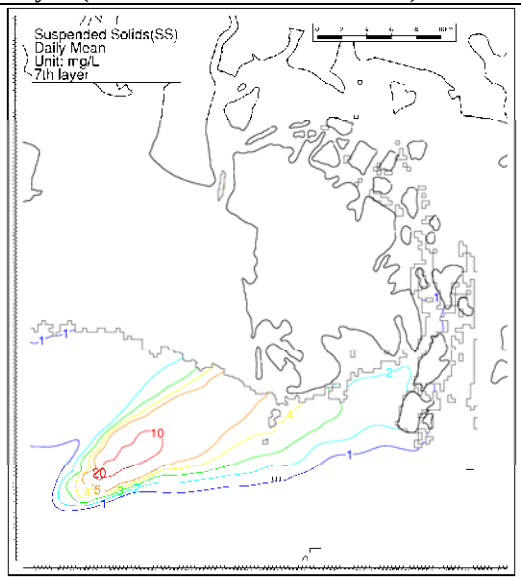
5th Layer (8-10m below surface)	6th Layer (10-12m below surface)
	
7th Layer (12m below surface-Bottom)	
	

Figure 5.18 (2) SS Dispersion Prediction (Case 10, Daily Average, Medium Domain)

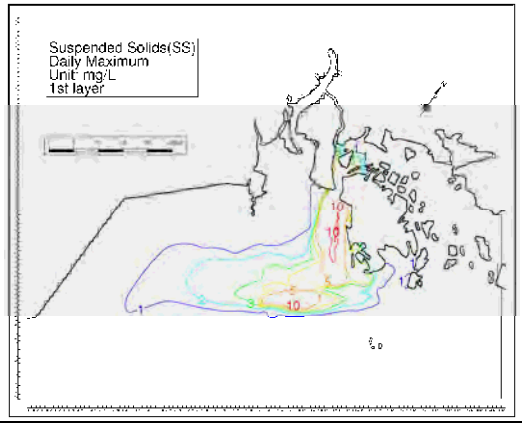
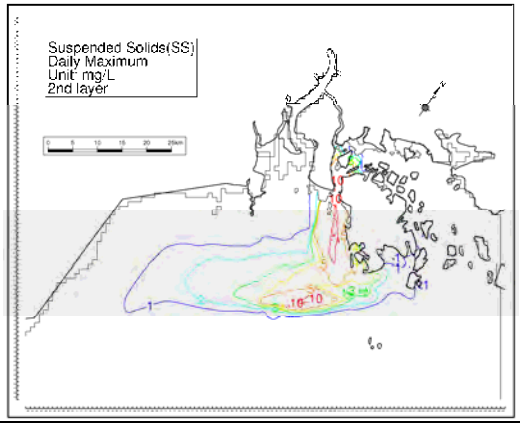
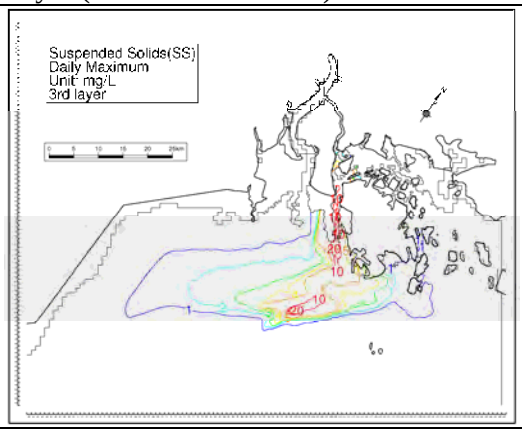
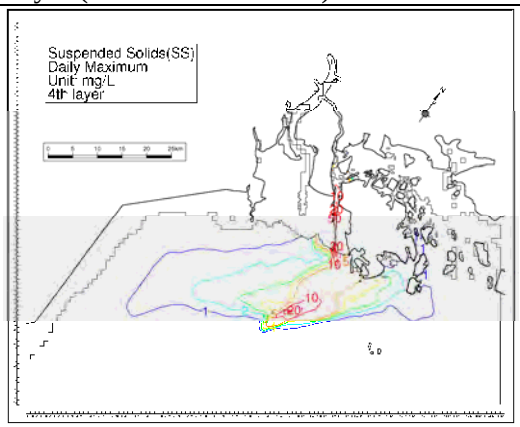
1st layer (0-2m below surface)	2nd Layer (2-4m below surface)
	
3rd Layer (4-6m below surface)	4th Layer (6-8m below surface)
	

Figure 5.19 (1) SS Dispersion Prediction (Case 10, Daily Maximum, Large Domain)

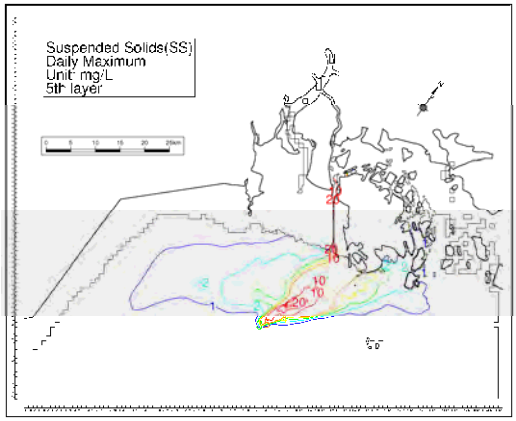
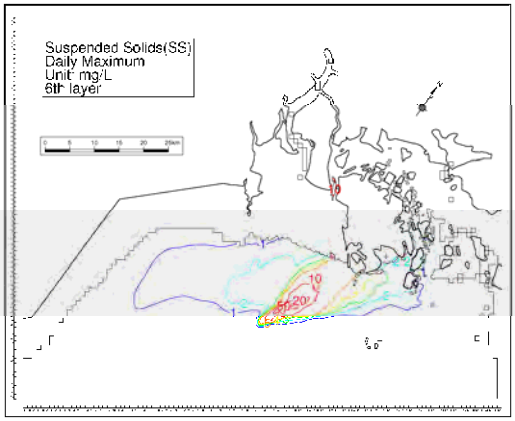
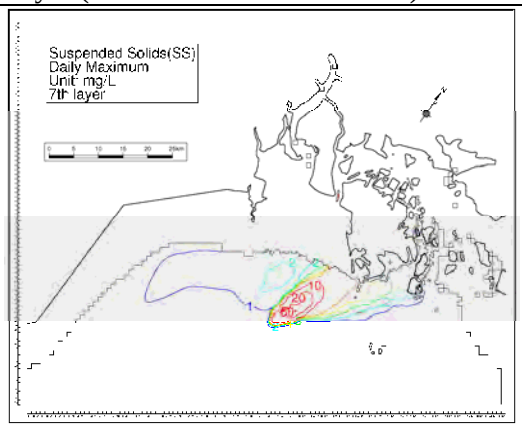
5th Layer (8-10m below surface)	6th Layer (10-12m below surface)
	
7th Layer (12m below surface-Bottom)	
	

Figure 5.19 (2) SS Dispersion Prediction (Case 10, Daily Maximum, Large Domain)

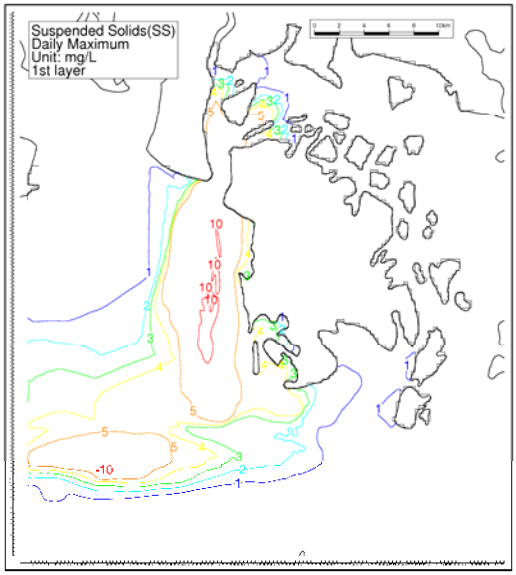
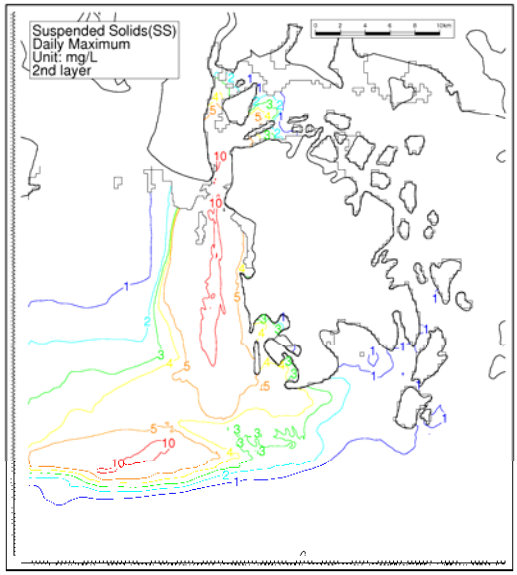
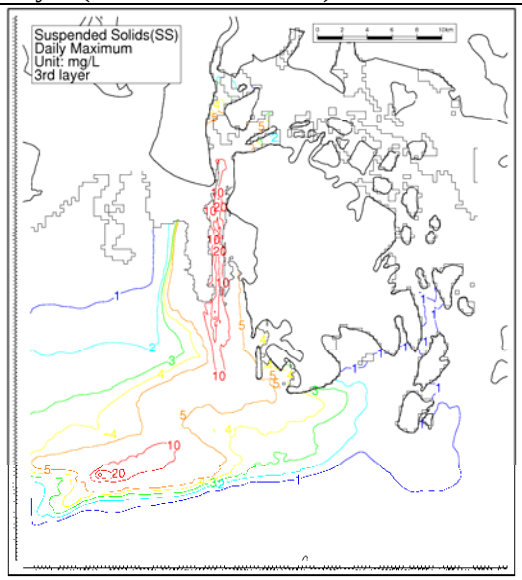
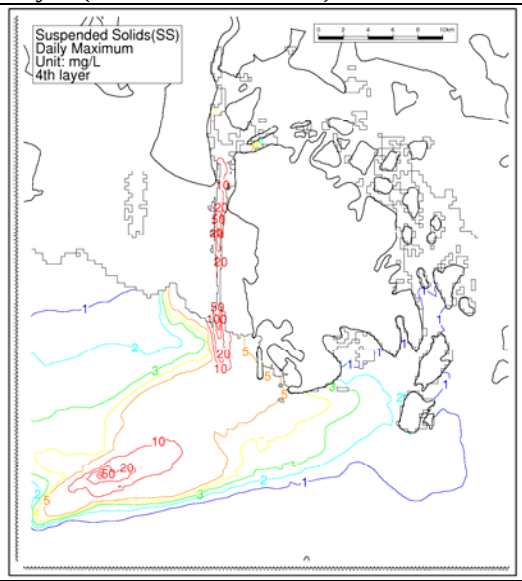
1st layer (0-2m below surface)	2nd Layer (2-4m below surface)
	
3rd Layer (4-6m below surface)	4th Layer (6-8m below surface)
	

Figure 5.20 (1) SS Dispersion Prediction (Case 10, Daily Maximum, Medium Domain)

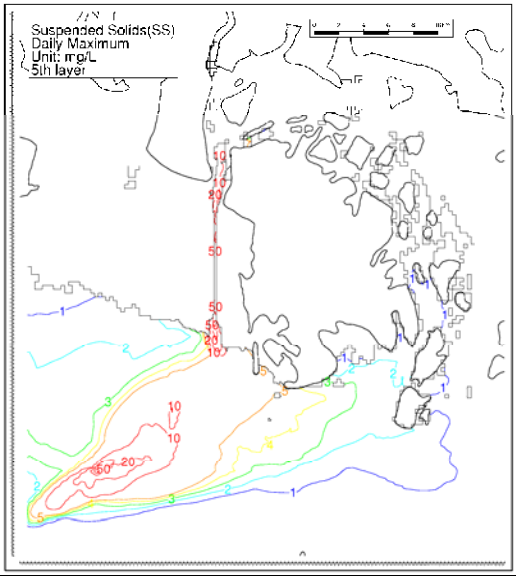
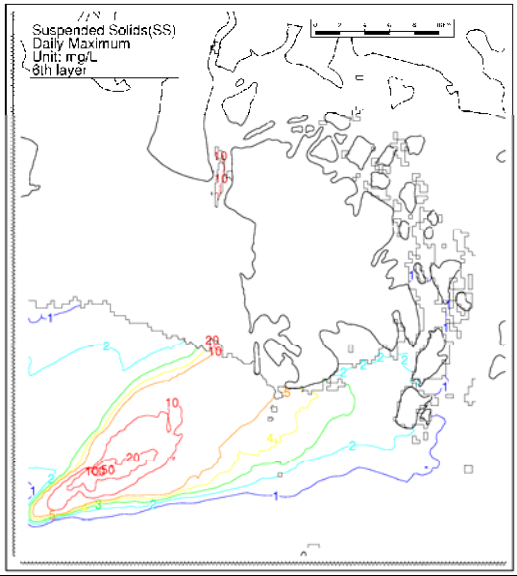
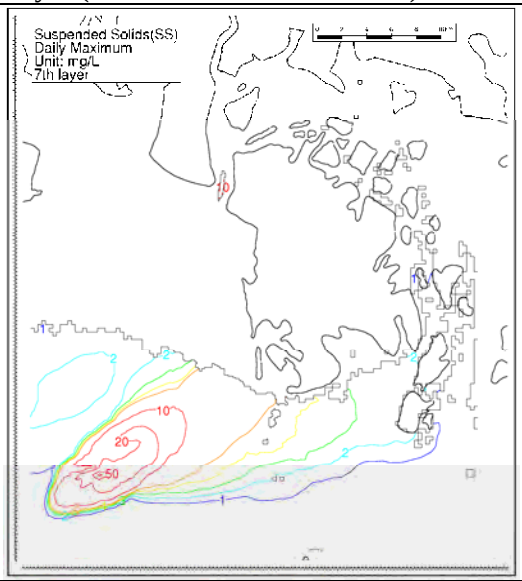
5th Layer (8-10m below surface)	6th Layer (10-12m below surface)
	
7th Layer (12m below surface-Bottom)	
	

Figure 5.20 (2) SS Dispersion Prediction (Case 10, Daily Maximum, Medium Domain)

5.6 Case 11

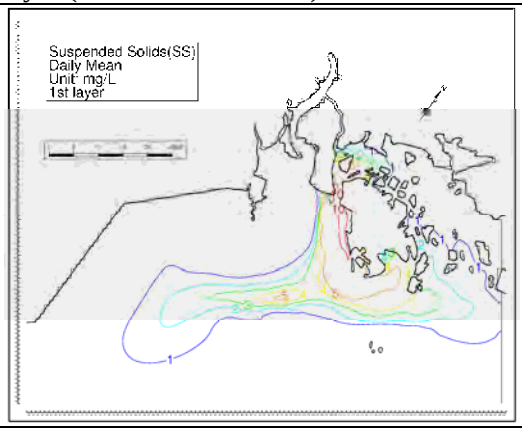
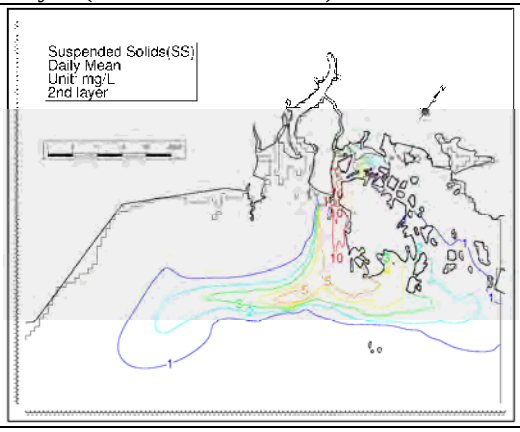
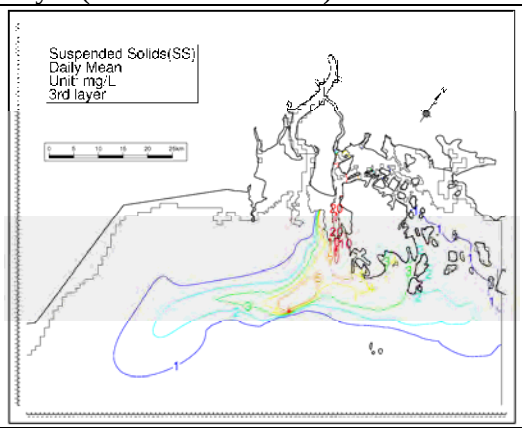
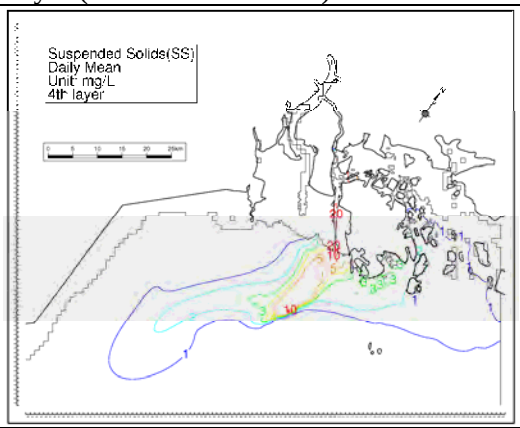
1st layer (0-2m below surface)	2nd Layer (2-4m below surface)
	
3rd Layer (4-6m below surface)	**4th Layer (6-8m below surface)**
	

Figure 5.21 (1) SS Dispersion Prediction (Case 11, Daily Average, Large Domain)

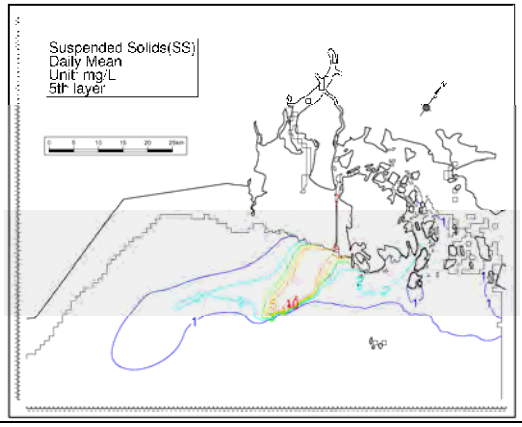
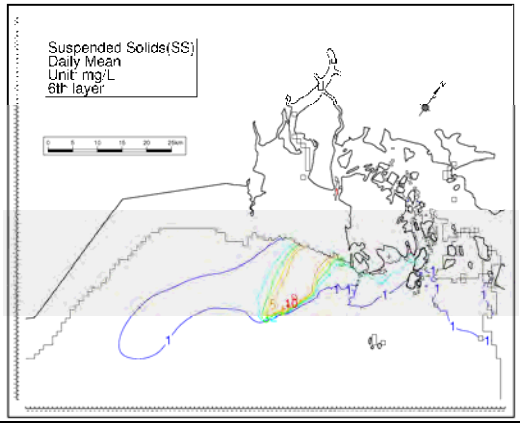
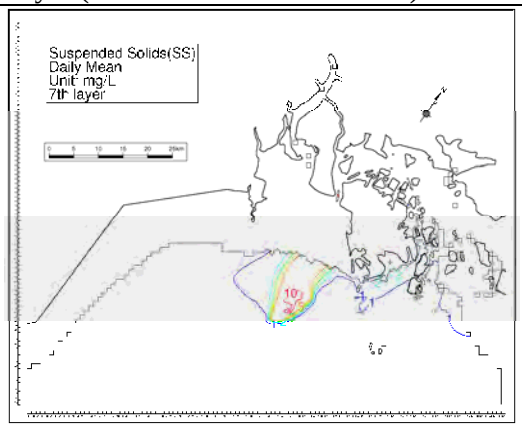
5th Layer (8-10m below surface)	6th Layer (10-12m below surface)
	
7th Layer (12m below surface-Bottom)	
	

Figure 5.21 (2) SS Dispersion Prediction (Case 11, Daily Average, Large Domain)

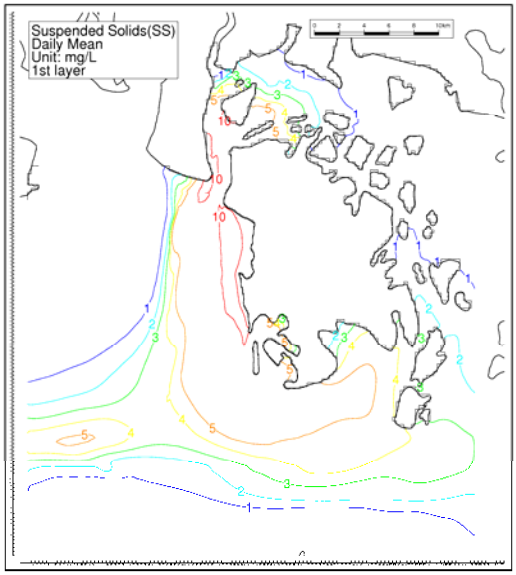
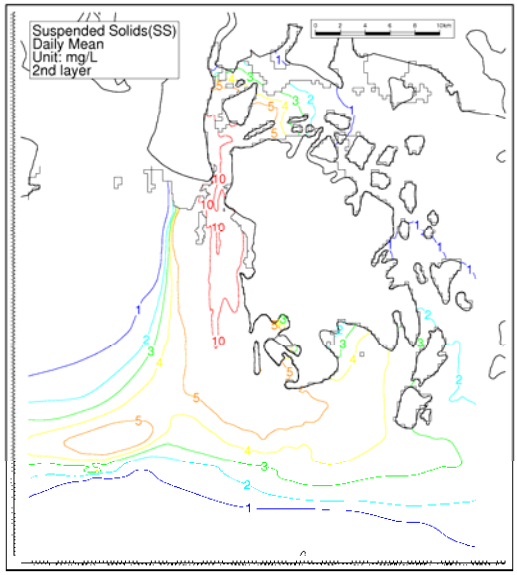
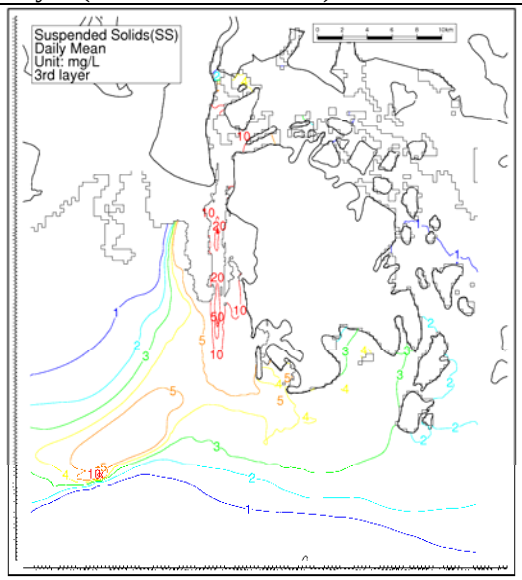
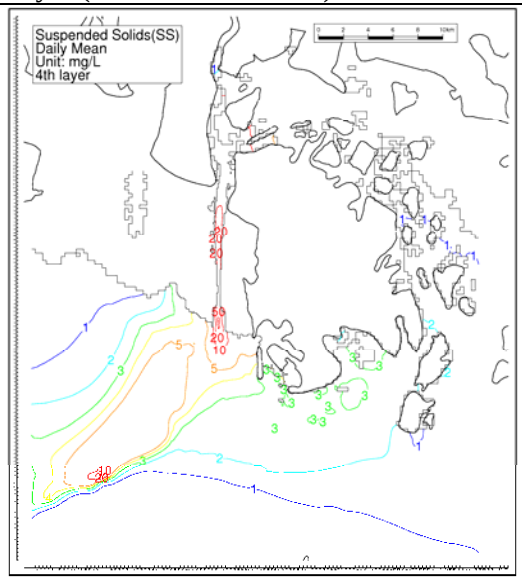
1st layer (0-2m below surface)	2nd Layer (2-4m below surface)
	
3rd Layer (4-6m below surface)	4th Layer (6-8m below surface)
	

Figure 5.22 (1) SS Dispersion Prediction (Case 11, Daily Average, Medium Domain)

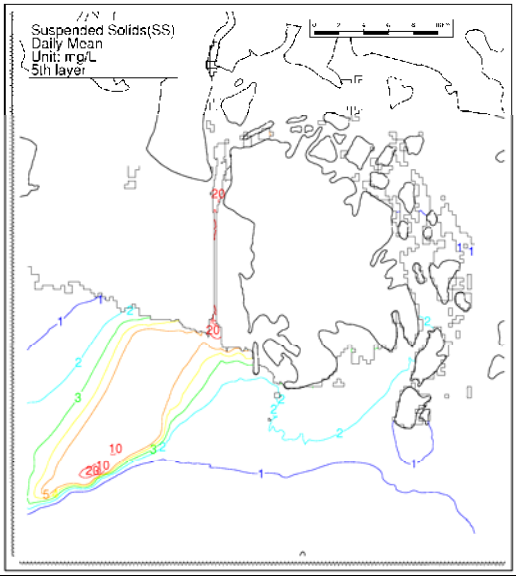
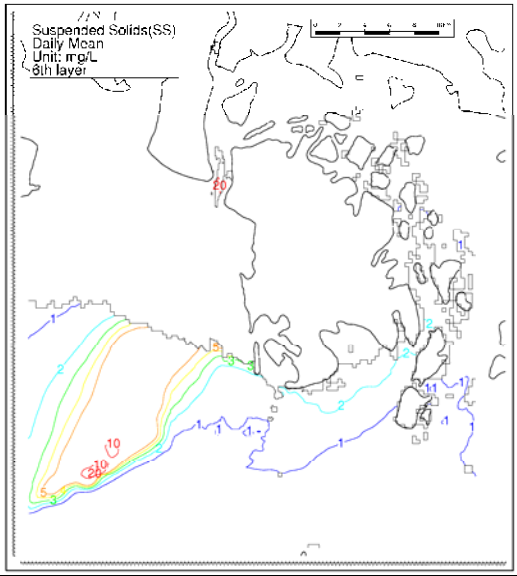
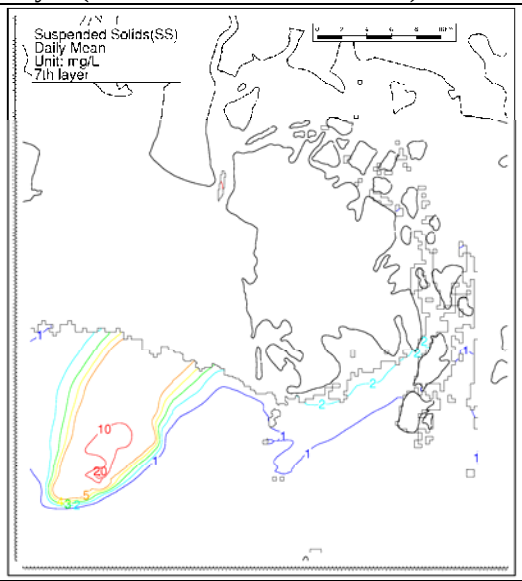
5th Layer (8-10m below surface)	6th Layer (10-12m below surface)
	
7th Layer (12m below surface-Bottom)	
	

Figure 5.22 (2) SS Dispersion Prediction (Case 11, Daily Average, Medium Domain)

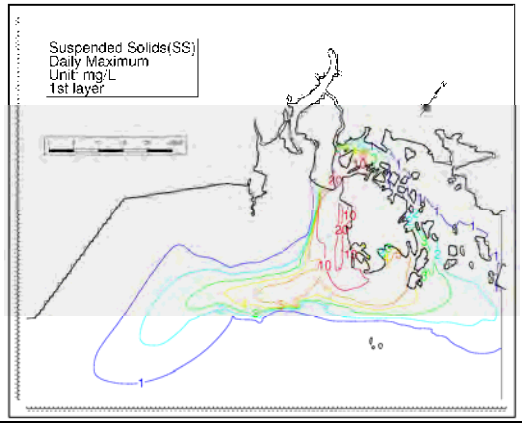
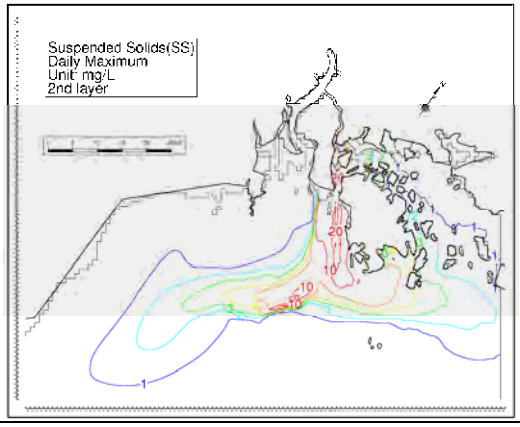
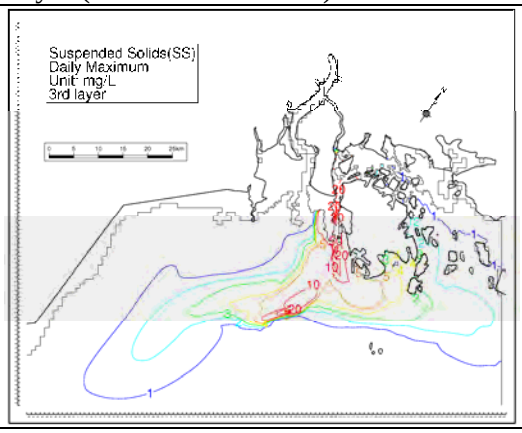
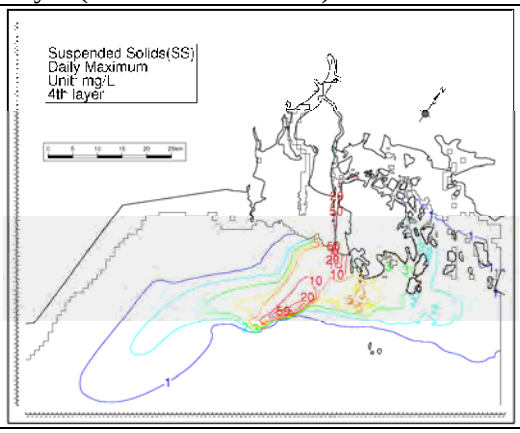
1st layer (0-2m below surface)	2nd Layer (2-4m below surface)
	
3rd Layer (4-6m below surface)	4th Layer (6-8m below surface)
	

Figure 5.23 (1) SS Dispersion Prediction (Case 11, Daily Maximum, Large Domain)

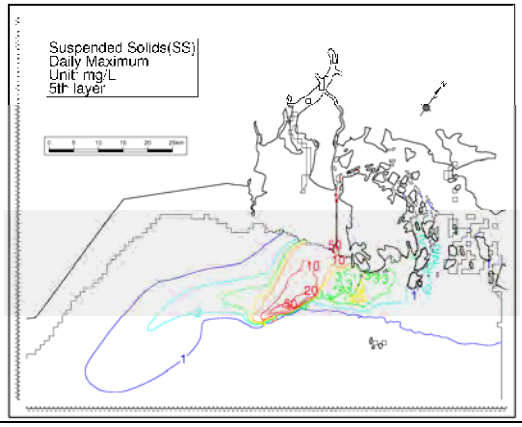
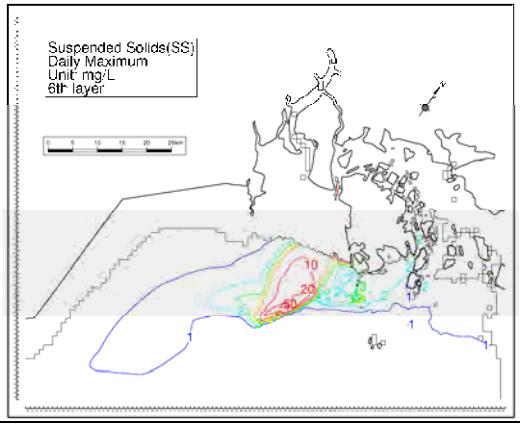
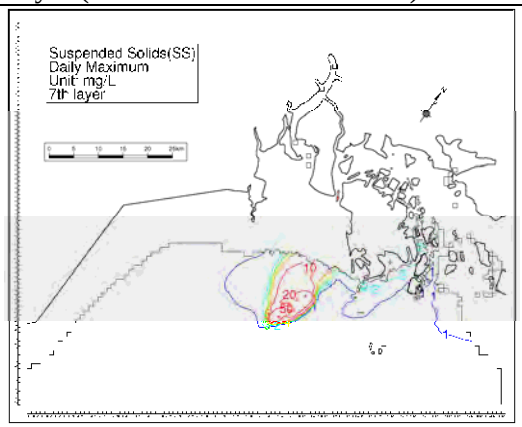
5th Layer (8-10m below surface)	6th Layer (10-12m below surface)
	
7th Layer (12m below surface-Bottom)	
	

Figure 5.23 (2) SS Dispersion Prediction (Case 11, Daily Maximum, Large Domain)

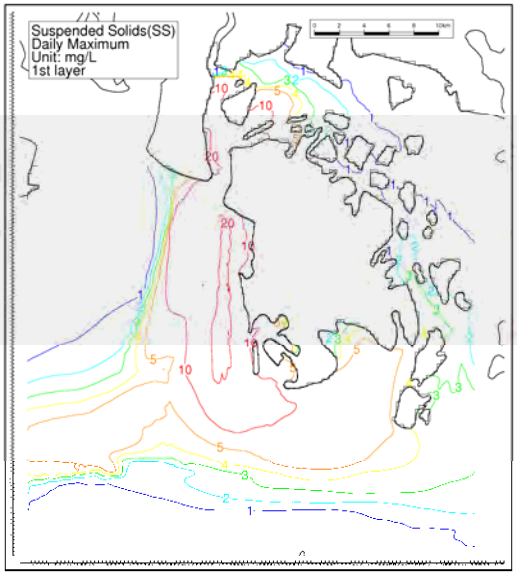
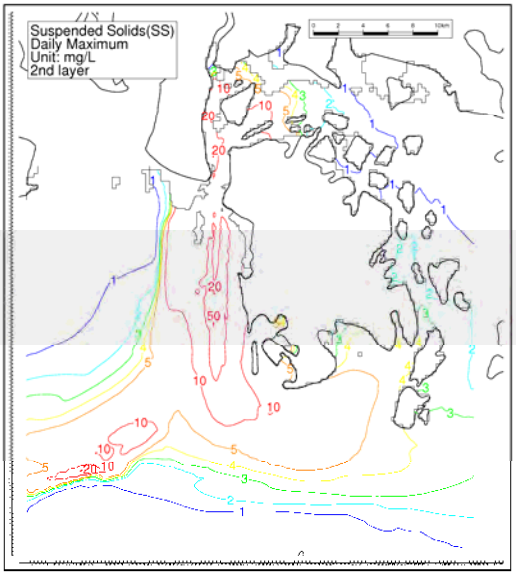
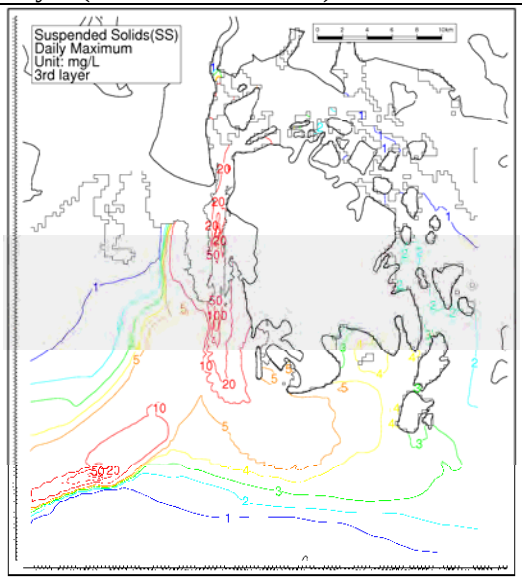
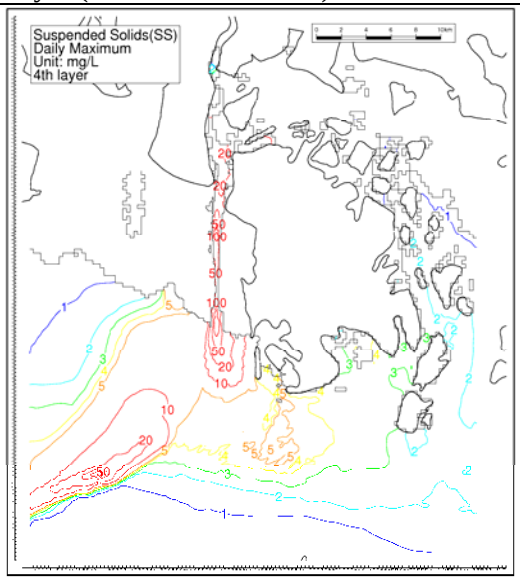
1st layer (0-2m below surface)	2nd Layer (2-4m below surface)
	
3rd Layer (4-6m below surface)	4th Layer (6-8m below surface)
	

Figure 5.24 (1) SS Dispersion Prediction (Case 11, Daily Maximum, Medium Domain)

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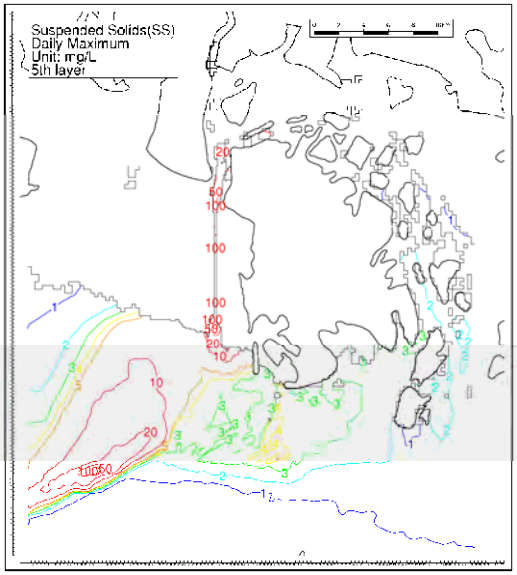	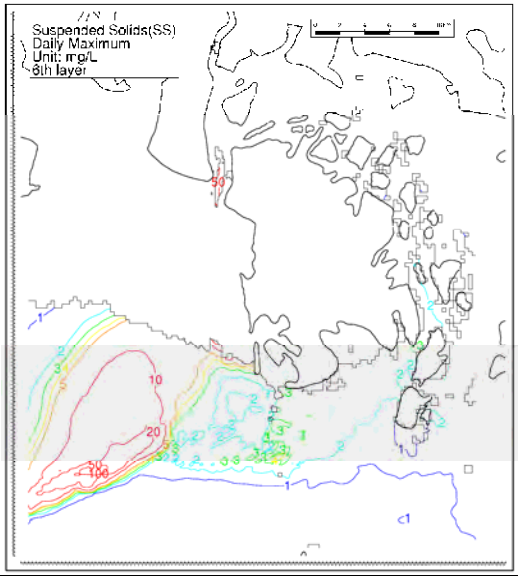
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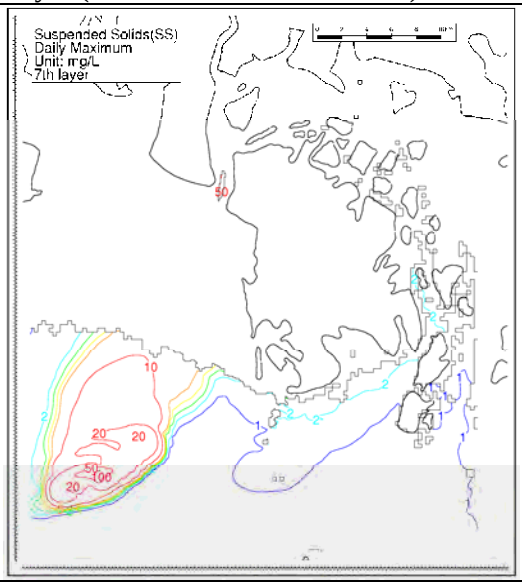	

Figure 5.24 (2) SS Dispersion Prediction (Case 11, Daily Maximum, Medium Domain)

Appendix 21-2

Draft Proposal on Income Restoration Program

MINISTRY OF TRANSPORT
VIETNAM MARITIME ADMINISTRATION

MARITIME PROJECT MANATEMENT UNIT II, VINAMARINE
JAPAN INTERNATIONAL COOPERATION AGENCY

HAI PHONG INTERNATIONAL GATEWAY PORT (LACH HUYEN GATEWAY PORT) CONSTRUCTION PROJECT (2012-2016)

DRAFT PROPOSAL ON INCOME RESTORATION PROGRAM

Hanoi, October 2011

ABBREVIATIONS

CPC	=	Commune People's Committee
DARD	=	Department of Agriculture and Rural Development
DMS	=	Detailed Measurement Survey
DOF	=	Department of Finance
DONRE	=	Department of Natural Resources and Environment
DPC	=	District People's Committee
EA	=	Executing Agency
FHH	=	Female-headed household
GOV	=	Government of Viet Nam
HH	=	Household
IMO	=	Independent Monitoring Organization
IRP	=	Income restoration program
JBIC	=	Japan Bank for International Cooperation
JCC	=	Joint Coordination Committee
JICA	=	Japan International Cooperation Agency
JV	=	Joint Venture
LURC	=	Land Use Rights Certificate
MARD	=	Ministry of Agriculture and Rural Development
MPMU	=	Maritime Project Management Unit
MSC	=	No.1 Maritime Safety Company No.1
MOLISA	=	Ministry of Labor, Invalids and Social Assistance
NGO	=	Non-government Organization
PAPs	=	Project Affected person or persons, household, firm or private institution
PPMU	=	Provincial Management Unit
PPC	=	Provincial People's Committee
RC	=	Resettlement Committee
RCS	=	Replacement Cost Study
RPF	=	Resettlement Policy Framework
RAP	=	Resettlement Action Plan
VINALINES	=	Vietnam National Shipping Lines
VINAMARINE	=	Vietnam National Maritime Bureau

TABLE OF CONTENT

I. GENERAL INTRODUCTION

1.1 Project Introduction

Hai Phong International Gateway Port is the major gateway to the sea, the most vital transport hub of the northern region – the centre of industry, commerce, services, and tourism of the region and the country, and therefore needed to be prioritized.

Being located in the most important axes of the Southeast Asia region not only in terms of economic but also defense and security, Lach Huyen is likely to play a more important role in the international transshipment and maritime services. The city Master Plan to 2020, approved by the Prime Minister, defines Lach Huyen port's location right in the waterway corridor of Cat Ba – Cat Hai – Quang Ninh.

The construction and investment of Hai Phong International Gateway Port has been agreed determined by the Government and Ministry of Transport toward the direction of developing the city to be a modernized and industrialized city.

The construction of dumpsite are considered by MPMU2 in aspects of economy, society, national defence and environment including production of effected households in the project area and also public consultations were hold in project area with communes and Cat Hai DPC. The option of Cat Hai Nam dumpsite has been selected by the consensus of people in the affected communes and Cat Hai District People's Committee.

1.2 Purpose and assistance policy of Income Restoration Program

1.2.1 Purpose

Assists affected households to (i) restore their incomes to at least pre-project level; and (ii) increase their new income generation capacities.

1.2.2 Objectives

To work out income restoration activities and implementation plan based on results of consultation with affected communities and commune PCs and opinions of functional offices.

1.2.3 Targeted Beneficiary of the Income Restoration Program (IRP)

IRP targeted beneficiaries are whose land is acquired 30% or more of total production land (salt or aqua cultural production land) or whose income sources are affected by the project.

Figure 1. Proposed Dump Site and Potential Affected Fishermen

1.2.4 Policies on occupational change and job creation assistance for land affected households

The project affected households by land acquisition and resettlement will be provided compensation and assistance based on the Decision 1263/2010/QD-UBND dated 30/7/2010 and Decision 130/2010/QĐ-UBND dated 23/1/2010 of Hai Phong PPC modified and supplementary regulation for compensation, assistance and resettlement when the Government acquire land on Hai Phong territory. According to Decree No. 131/2006/ND-CP, regulations "in the case of international treaties on ODA which the Socialist Republic of Vietnam is a contracting party contains provisions different from the provisions of the law of Vietnam shall comply with the provisions of international agreements "(Article 2, Section 5).

Table 1: Assistance policy of Hai Phong CPC and Project

Provision	Allowance	Allowance rate
1. Decision 130/2010/QĐ-UBND ; Chapter IV: provision 12 Article 2: assistance for allocated agricultural land	2.1 Occupational change and job	-In-cash allowance equivalent to 2 times of agri-land price depending on location and not more than regulated land size allocation. -Participation in vocational training on PAP's requirement.
- Loss from 30% - 70% allocated agri. land	2.2 Life stabilization	6 months (without relocation) and 12 months (with relocation) x 30kg rice /person/month
- Loss from > 70% allocated agri. land	2.2 Life stabilization	12 months (without relocation) and 24 months (with relocation) x 30kg rice /person/month
1. Project entitlement matrix Severely affected agricultural land, business and income generation activities	Assistance for occupational change	- Based on the Decision 1263/2010/QD-UBND dated 30/7/2010 and Decision 130/2010/QĐ-UBND dated 23/1/2010 of Hai Phong PPC - All PAPs of working age that are engaged in agricultural or similar production and experience significant impacts on their productive land will receive assistance to attend vocational training centers for a change in occupation. The training will be of a value up to a pre-agreed sum of US$200 per trainee an allowance subsistence of US$100 per trainee totally to maximum US$300 per trainee during the training period, three or six months on average;

II. THE INCOME REHABILITATION PROPOSAL

2.1 Result of public consultation

- Analyzed data on income restoration measures proposed during consultation taken in May 2011 shows the demands of the surveyed households: 54% with loan, 9 % with assistance for cultivation and husbandry (inputs and extension training), and 11% with recruitment in the project activities both of construction and operation. , and 16% wants to participate in vocational training for new occupations like mechanics, construction, business, service.
- Results of the public consultation taken in September 2011 with commune authorities, mass organization and functional offices of the DPC show that IRP proposals with the 2 components of vocational training and agricultural production have also reached a consensus of affected communes, of which vocational training is addressed as a sustainable measures, and a unanimity of both CPCs and DPC.

Table 2 : Summarized results of public consultation in affected communes

Proposed activity	Cat Hai town	Dong Bai	Hoang Chau	Nghia Lo	Van Phong	Phu Long	total	Note
Agriculture: extension training, initial assistance								
1. Livestock								Constraint in limited land size
Pig	1	3	3	3	2	3	15	
Cow, goat	0	3	3	3	2	3	14	Dong Bai proposes porcupine
Big shrimp,	2	3	2	2	2	3	14	
Baby shrimp	0	0	0	0	0	0	0	High risk than big shrimp
2. Cultivation	1	3	2	2	2	2	12	Dong Bai: most interested in mushroom
3. With salt production	2	2	2	2	2		10	Low price, Phu Long has no salt land
Off-farm: vocational training (New master plan changes economic structure)								
1. Driver, construction, mechanics,	3	3	3	3	3	3	18	
2. Services, handicraft…	3	3	3	3	3	3	18	
3. Trading, small business	3	3	3	3	3	3	18	
Credit								
Training for capacity building on accessing loans	2	3	2	1	2	2	12	want to get money

Assessed IRP demands: 3: high, 2: medium, 1: less, 0: no demand

- After taking the consultation with commune authorities and functional division of the DPC based on their opinions collected during consultation, the Consultants had drafted the report of IRP proposal. By the end of September, the drafted report was sent to the CPCs and Cat Hai DPC for getting their final comments to finalize the IRP report for submission to JICA and the project management offices. Written comments of the local CPCs and DPC officially sent to the Consultant are generalized as follows*:*

Table 3: Opinions of CPCs and DPC on draft IRP report

Commune	**Content**	**Impact**			
		Aquaculture	**Fishing**	**Livestock**	**Salt production**
Common opinion	**Totally raise opinions to choose the alternative of Nam Cat Hai dumping site, because:** - Creates condition for improvement and protection of the existing break- water dyke reducing damage of storm and water waves annually hit the area -Not much affects production activities of local people.	Small number of aqua cultural production households will be affected	Few number of aquacultural production households will be affected and location of proposed dumping site is not the main fishing area but only the preparation place for fishing activities to be done in the main fishing area. .	No impact	No impact because production water sourced through Cai Cu, Luong , Bo Cau and No.1 will not be polluted and even deposited through canal No. 1 before flowing to the field.
Đong Bai	Quite agree with the report content.	43 households will be affected	3 households will be affected (6 labors)	0	0
Van Phong	- Interested in information related to loans, and - Vocational training for driver	No impact due to production water sourced from canal No. 1	Only few households will be affected because there are 50 fishing households in the commune with 89 labor (*about 10% will be affected = 5 HHs)*	0	0
Nghia Lo	- Interested in assistance for vocational training and job creation, and - Must strictly minimize impacts on sanitation and environment	14 households will be affected	Only few households will be affected because there are 35 fishing households in the commune *(about 10% will be affected = 4*	0	0

			HHs)		
Cat Hai Town	No impact on production activities of local people	No impact	Without impact , because coastal fishing area is in Nam Trieu and Lach Got	0	0
Fatherland Front of Cat Hai DPC	Vocational training and job creation are details proposed but it needs to reconsider about the big difference in impacts of the tow alternatives				
Economic and Infrastructure Division – Cat Hai DPC	Should apply vocational training assistance of 300$ also for those with career change but without requirement for vocational training			Assistance for goat & cow production should be given to other activities due to limitation of grassing land, etc.	Not sure about effective of clean salt production
Total PAPs		**57 HHs**	**12 HHs**	0	0

Note:

(1) There are about 69 affected households (according to the CPCs' opinions: very small numbers of aquaculture and fishing households will be affected , so rate of the PAPs is estimated about 10% of them).

(2) Regarding opinion of applying US$300 for those with career change but without requirement for vocational training, based on the Project policy framework: The training value will be given directly to the training institution involved.

2.2 Impact of constructed dumping site on affected household

Based on the written comments of CPCs and DPC's functional offices expressing that all ideas (100%) have chosen the dumping site in Nam Cat Hai Island. It is therefore, in the IRP proposal report, the Consultants has only considered to the alternative of Nam Cat Hai site for their estimation:

Table 4 : **Number of potentially affected households by Nam Cat Hai dump site**

Commune	Fishing	Salt production	Aqua-culture	Livestock production	Total
Hoang Chau	0	0	0	0	0
Đong Bai	3	0	43	0	46
Nghia Lo	4	0	14	0	18
Van Phong	5	0	0	0	5
Cat Hai town	0	0	0	0	0
Phu Long	0	0	0	0	0
Total	**12**	**0**	**57**	**0**	**69**

The above tables show that, with Nam Cat Hai dumpsite, about 69 households with 150 labors will be affected; most of them live on aquaculture and fishing in Bong Bai and Nghia Lo commune

But assistance policy framework is provided for land affected persons only and not for environmental production affected persons such as fishing area and water for production. It's therefore, during implementation, the PPC should base on the currently related-legal document to assist affected fishermen. It needs to encourage them to voluntarily change their occupation, provide vocational training, extension training, and low interest loans for income restoration. For those will be change occupation, local authorities should assist them in selling their fishing facilities like boat, net, etc. : providing information of facility prices, valuation of facilities, introduction of the place/organization for selling their facilities. By doing so, they can get back and reinvest capital to new income activities. It can be referred to the following policies:

- Decision No. 289/QĐ-TTg dated 18/3/2008 of the Prime Minister on promulgating some policies assisting ethnic minorities, policy-entitled, poor, and nearly poor households and fishing households;
- Decision No. 63/2010/QĐ-TTg dated 15/10/2010 on assistance loans and interest rate for agricultural production including aquaculture;
- Decree No. 41/2010/NĐ-CP dated 12/4/2010 on credit policy for agriculture and rural development.
- Decree No.66/2006/ND-CP dated 7/7/2006 on policy for development of rural industry
- Decision No. 1956/QĐ-TTg dated 27/11/2009 on approval of the Theme "Vocational training for rural labors to the year 2020" of the Prime Minister
- Inter-ministry Circular No. 112/2010/TTLT-BTC-BLĐTBXH dated 30/7/2010 on instruction for management and utilization of state budget to implement the Theme "Vocational training for rural labors to the year 2020" attached with the Decision No. 1956/QĐ-TTg dated 27/11/2009 of the Prime Minister.
- Decision No. 1342/QĐ-UBND ngày 10/8/2010 of Hai Phong PPC on approval of the Theme "Vocational training for rural labors in Hai Phong to the year 2020"

2.3 Proposed IRP activities

The focus of the income rehabilitation activities is to assist affected households to: (1) engage in short-term agriculture-related income generation activities; and (2) venture on long-term non-farm economic activities. Overall, income rehabilitation activities approach is to build the capacity of the affected households to be responsible in rebuilding his livelihood and shun from being dependent.

Number of the households will be identified during implementation of assessing project impact on household income, household needs based on their resources for practical activities. However, cash will not be directly provided to the households but through service providing offices like extension center, vocational center, seed producers, etc.

a. Production activities: Agricultural activities are proposed in IRP to help to use production land more effectively, increase income value in cultivated area unit, to provision high quality products and to meet consumption demand of project area; create jobs and short-term income sources for those unable in changing into off-farm careers such as women and the older.

b. Vocational training and employment creation: This component has proposed employment opportunities for working-age persons enabling them to change their careers and earn income from new careers. Through need assessment, basic information of household members is listed including age, education level, needs of training or employment. Revision of employment sources availably around the project area and in the sites of project construction and supervision consultant is prepared. Simple or skill works will be informed to the affected households and they will be assisted in vocational training through the fund to be budgeted for the project income rehabilitation.

2.3.1 Agricultural production activities

According to the survey, aquaculture households want to maintain these livelihood activities which are at the same time are options for career change of the fishing households, so IRP will be prepared for meeting their desires.

IRP will help them in income rehabilitation through providing them with fertilizer, seed, livestock, veterinary, and extension training. Extensionists will help households to develop models in their land.

Table 5: Assistance for agricultural production

No.	Activity	Measure	Scale	Time	Estimated amount (1000VND)	Responsibilities
1	Model of pig production for meat	Provide initial input (pig and feed)	10 HHs	2012	30,000	District DARD Veterinary station
2	Cultivation (vegetable, mushroom)	Provide seed and fertilizer	10 HHs	2012	20,000	District DARD Extension station
	Total		**20 HHs**		**50,000**	

- ***Husbandry:***

Assistance for PAPs in livestock production aims to (i) create a stable activity for PAPs, especially woman headed households to develop production , increase income , and contribute in poverty alleviation; (ii) Contribute in provide food-staff for demand of local people and project workers; and (iii) Fully take advantages of every resources locally available for livestock production.

*Pig rearing**:*** IRP will assist households participating pig rearing with feed and breeding. Households have cages available before receiving pig. To ensure quality of the pig, District DARD and Veterinary Station will contact with high quality providers for purchasing IRP pigs of high quality breeding and free from morbidity. Responsible officials in this task will have to build specific plans for each village when starting implementation. Households have cages available before receiving pig.

- ***Cultivation:*** IRP is prepared for model of vegetable and mushroom; IRP participating households will be provided with seed, fertilizer and trained in technologies of mushroom and vegetable production. District DARD and Extension station will select crops suitable to mobilize stabilities land resources for higher economic efficiency to increase household income.
The successful model will be developed in the area.

- ***Extension training:***

The training program will be held for all affected households, the household may participate depending on preferences. Each session will be held 1 day of both theory and practice. During implementation, if the content of IRP training is the same or similar with that available in the district extension program, IRP training will be formulated as an intensive training for consolidation of the district training to make the transferred knowledge more sustainable and effective.

The training will be held at the villages or commune depends on participants, the in-field workshop will be held on the field to introduce to all households in the more techniques. For

training on cultivation technology, training programs must be implemented before the commencement of cropping season at least 10 days before. For extension training on livestock, the extension staff must make arrangements with the village head to determine training date. District extension officers are directly to compile and teach farmers.

Table 6: Estimated assistance for agro-qua extension training

No.	Activity	Method	Scale	Time	Estimated amount (1000VND)	Responsibilities
1	Cultivation technology (mushroom, fruit tree, subsidy crop)	In-door and in-filed training (theory and practice)	2 courses	2012	10,000	District DARD Extension station
2	Husbandry	Training in classroom and in household' s area (theory and practice)	2 courses	2012	10,000	District DARD Extension station
	Total		**4 courses**		**20,000**	

2.3.2 Vocational training and employment creation

Presently, rural occupation development has been encouraged by the Government as approval on the Theme "Vocational training for rural s to the year 2020" (by Decision No. 1956/QĐ-TTg dated 27/11/2009), Hai Phong PPC has also approved the theme "Vocational training for rural labors to the year 2020" in Hai Phong city (Decision No. 1342/QĐ-UBND dated 18/10/2010). That's why, occupational change of working age labors of PAPs are in accordance with the Government' s plan and Hai Phong city as well.

According to the theme "Vocational training for rural labours to the year 2020" in Hai Phong province:

- *The theme applicants :*

Rural labours at working age, with education and health in accordance with professional requirement. Giving priority to vocational training for those of the preferential policy households contributed to the revolution, poor households, land production affected households, the disable households.

- *The theme content :*

- Agricultural training:

- Subjects: Cultivation, husbandry, forestry, aquaculture, salt production; agro-forestry aquacultural processing; agro-production services, and other related aspects;
- Level: elementary level and less than 3-month course of vocational training;
- Method of vocational training: diverse and flexible organization with formal training in vocational centers or on the job-training in commune, factory, in-field, etc.

- Non-agricultural training:
- Subjects: technology, technician, production and processing, hotel, restaurant, tourist service, transportation, handicraft, and others
- Level: elementary level and less than 3-month course of vocational training
- Method of vocational training: diverse and flexible organization with formal training in vocational centers or on the job-training in commune, factory, in-field, etc.; integrated organization with theory in vocational training center and practice in workshops, enterprises.
- Vocation training assistance :
    - PPC will have annually and periodically adjusted assistant rates in conformity with the changes of socio-economic situation;
    - Rural labors attending vocational training can be loaned under student credit regulation. Rural labors who will work in rural area after completed training will be provided with non-interest loan for vocational training attendance;
    - Rural labors that completed vocational training can be loaned from the national fund for employment creation for career development.

- ***Vocational training:***

Needs of vocational training and employment will be investigated and assessed and employment opportunities in surrounding areas and the project construction sites and offices will be conducted searched and informed to the households. District Income Restoration Management Committee (DIRMC) and related functional offices will cover this task.

For those who want to work in mechanic sector or other non-farming occupation they will be provided with vocational training like electric repair, varied category license of drivers, hotel receptionist, tailor, hair stylist, etc, they will be afforded with professional trainings on such occupations. DOLISA will help to build specific plans for each vocational training based on the needs of the beneficiary households and searching work opportunities, they will work with service providers like vocational training centers, technical high schools, with enterprises or factories demanding labor requirements to formulate training contents, budget and plan. Vocational training to be provided by the project will be practical enabling them to find the job.

Project assistant policy: Each member at labor age of seriously affected households will receive an assistance of one vocational training card costing 200 USD and an additional allowance of 100 USD for one course averaging from 3-6 months. Total cost of vocational training maximum is 300 USD/labor. Following are estimated budgets for vocational training.

Table 7: Estimated budget for vocational training - career change

No.	Training	Unit	Quantity	Price unit (1000 VND)	Amount (1000 VND)
I	***Driver***				**65,000**
1	Training fee	Person	10	4,500	45,000
2	Allowance subsistence	Person	10	2,000	20,000
II	***Electric welding, electricity (civil. industrial), electronic, etc.***				***80,000***
1	Training fee	Person	20	2,000	40,000
2	Allowance subsistence	Person	20	2,000	40,000
III	***Cooking, tailor, construction, hair maker, and handicraft (bamboo, embroidering...)***				***120,000***
1	Training fee	Person	30	2,000	60,000
2	Allowance subsistence	Person	30	2,000	60,000
IV	***Construction***				***120,000***
1	Training fee	Person	30	2,000	60,000
2	Allowance subsistence	Person	30	2,000	60,000
V	***Office informatics, restaurant services, hotel, Business sales, etc.***				***120,000***
1	Training fee	Person	30	2,000	60,000
2	Allowance subsistence	Person	30	2,000	60,000
	Total		**120**		**505,000**

- ***Job opportunities related to project:*** The construction contractors will be requested on providing provisions recruiting local labors as much as possible with special priority to PAPs to carry out both simple and skill works.

2.3.3 Credit:

The IRP will provide training on credit access: help households with big loan demand to meet borrowing requirements given by the banks like assisting to formulate production or business planning and foresee unexpected risks…

PPC/DPC should create favorable conditions for the affected households to get the loan through Government's incentive policies such as Decision No. 41/2010/ NĐ-CP dated 12 / 04 / 2010 on credit for agriculture and rural development.

III. RISKS AND MITIGATION MEASURES

1. Risks: there will be some risks relating to implementation of IRP activities. Affected households are the implementer; the other stakeholders are the assistants. In-time and necessary instructions are very important. The unexpected risks may be improper use of

supported allowances for non-livelihood recovery activities, the households should be instructed about financial management before receiving compensation payment and implementation of income restoration activities should be carried out closely with the compensation payment.

2. Lacked or untimely provided services supporting IRP activities possibly impact on effectiveness. So, it is needed to synchronously provide supporting services, such livestock production, aquaculture bearing the risk related to veterinary service, sanitation, medicines, etc. Therefore, in-time assistance in input supply and extension services is very important factor for risk mitigation. Market information is also important, actually, prices of production materials are usually changeable tending to higher but selling price normally reduce in harvesting time, resulting in high input but low output making unexpected income. For preventions, market information should be timely provided for households by the related offices to avoid loss caused by fluctuation of prices.

IV. IMPLEMENTATION METHOD AND ORGANIZATION

4.1 Implementation method

District Income Restoration Management Committee (DIRMC) will be established for IRP implementation. IRP activities will be implemented by the cooperation of DIRMC, MPMU2 and support of the Monitoring Consultants.

- Identification of income restoration activities is based on household‘s needs. With assistances of DIRMC and the Consultant, community need assessment will be conducted in each commune to find out IRP need and appropriate activities. NOT all but ONLY the feasible and practical activities which is analyzed as effective for income restoration can be assisted.
- Implementation of income restoration activities should be combined assistance program conducted in the district. At the same time, all IR activities will be dovetailed to existing related government programs both at the provincial and district levels and that of Non-Government Organizations operating within the affected communes, thus ensuring multi-disciplinary approach in program coordination.
- Formulation, management, and implementation of income restoration activities will be done by the local related offices and people.

4.2 Implementation organization:

The District Income Restoration Management Committee (DIRMC):

The DIRMC shall be the key actor in the implementation of the IRP: with assistance from project consultant (PC) to :

a. Conduct needs assessment in all affected communes;
b. Prepares IRP action plans and the corresponding budget;

c. Implement the approved action plans if possible linking with other existing programs within the district for possible integration of IR activities with; and
d. Submit monthly progress report to MPMU2

The Marine Project Management Unit II (MPMU2)

The MPMU2 shall be the financial management agency of the IRP. It shall have the following functions:

a. Reviews all plans submitted plans for approval;
b. Submits plans and budgets to the project Donor/JICA ;
c. Transfer approved IRP finance to DIRMC; and
d. Monitors IRP implementation

The Project Consultant (PC)

The PC will provide technical assistance to the DIRMC. It shall have the following functions:

a. Assists DIRMC in Commune Needs Assessment (CNA), Planning and Budgeting;
b. Assists DIRMC in IRP implementation;
c. Assists the monitoring of relevant agencies

V. MONITORING

Monitoring program will be established to see how affected households are able to rehabilitate and improve their socio-economic conditions, to identify success of such activities, to identify difficulties faced and how to find tune the program to obtain the desired goals. Modification in the program and additional cash and materials assistance to the participating affected households will be provided as and when necessary. The external monitoring agency will also be mobilized to carry out its independent monitoring and evaluation.

VI. ESTIMATES FOR INCOME RESTORATION PROGRAM

Budget will be sourced from the project: According to the Decree No. 131/2006/NĐ-CP dated 9/11/2006 on regulation of management and utilization of official development assistance (ODA) capital: Provision 2: Primary principle for management and utilization of ODA capital at Article 5: comply with regulations of the Vietnam law and international treaty on ODA that the Socialist Republic of Vietnam is a member. In the case of provisions in international treaty on ODA that the Socialist Republic of Vietnam is a member are different to provisions in Vietnam law, provisions in this international treaty will be complied. Meantime, JICA and WB's performance standards or safeguard policies have required client to conduct environmental assessment and consider a project potential impacts on surrounding communities (referred to O.P. 4.01) .

Estimates of IRP applicable for Nam Cat Hai dumping site will be **661,250,000 VND equivalents to 31,488 USD.**

Table 8: Estimate for IRP implementation

(1USD = 21.000VND)

	Activities	Unit	Quantity	Amount (1000 VND)	USD
1	Vocational training	*Person*	120	505,000	24,048
2	Agro-production Assistance	*HH*	20	50,000	2,381
3	Agro-extension	*Course*	4	20,000	952
	Total			***575,000***	***27,381***
3	Administration (5%)			28,750	1,369
4	Contingencies (10%)			57,500	2,738
	Total			**661,250**	**31,488**