SULTAN QABOOS UNIVERSITY

Department of Civil and Architectural Engineering
B.Eng. Examinations, Fall Semester 2006

COASTAL ENGINEERING **CIVL 5076**

December 25, 2006 09:00-12:00

The following is provided for this examination

1. Answer booklet
2. Design aids: formulae, graphs and charts.

Candidates are permitted to bring into the examination room

Calculator (programmable or non-programmable).

Instructions to candidates:

1. Attempt all questions.
2. The paper consists of FIVE questions.
3. The allowed time is three hours.
4. Assume water density as **1030 kg/m^3** wherever required.

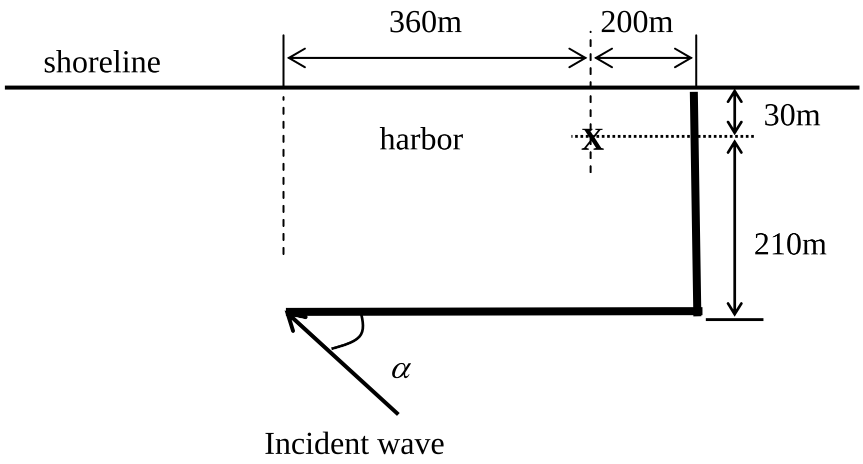
NAME: **ID #:**

Date:

Question	**1**	**2**	**3**	**4**	**5**	**Total**
Marks						

1. Consider the L-shaped breakwater protecting a harbor region 6m deep, as shown in the following figure. A record of incident waves is shown in the table below. Which wave condition results in the highest wave at point X behind the breakwater?

[30%]



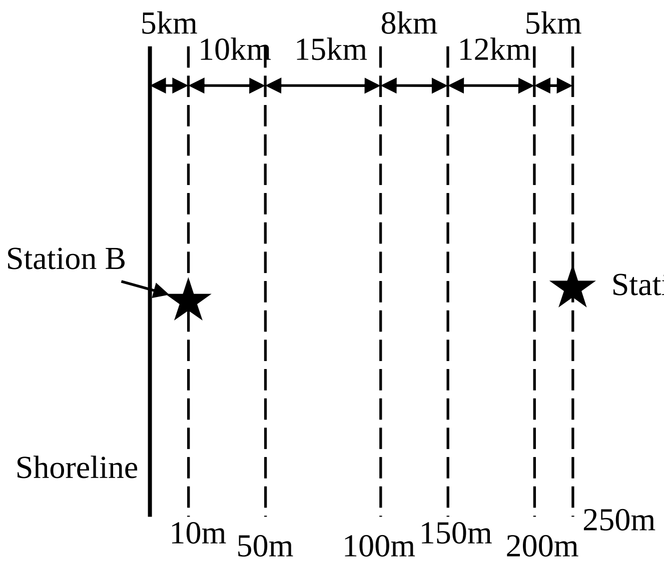
No:	H_i (m)	T (sec)	α (deg)
1	2	54.4	60
2	3	27.3	45
3	3.5	11.2	90
4	4.5	6.1	105

2. A 2.4m high wave with a period of 8 sec in deep water is propagating toward the shore without refracting. A water particle velocity of 0.25 m/s on the bottom is required to initiate movement of the seabed particles. At what water depth the particles at the seabed will start moving as the wave shoals? **[20%]**

3. The bottom profile at a project site on Al-Batinah coast is shown as follows. If a tsunami wave with height 2m and period 30minutes reaches Station A at 7:00 a.m.

(a) What time will it arrive at Station B? **[5%]**

(b) What will be the tsunami height at Station B?. **[10%]**



4. If the significant wave height in a wave record is 4m and the significant wave period is 7.5 sec. Using the properties of Raleigh distribution answer the following:

(a) How many waves would be smaller than 5m height in a 30 minute long wave record? **[10%]**

(b) Estimate the average wave height for this record? **[2%]**

(c) Estimate the maximum wave height in a wave record of 1 hour duration? **[3%]**

5. The head of a rubble mound breakwater is to be constructed at Sohar port with a face slope of 1:2. The design water depth at this location is 7 m and the bottom slope fronting the structure is 1:30. The deep water significant wave height is 4m and a significant period of 8 sec.

(a) What weight tetrapod armor units (specific gravity=2.4) are required for the head of breakwater? Note: Check if the waves are breaking or nonbreaking. **[10%]**

(b) What should be the crest width according to specifications? **[5%]**

(c) What will be the armor unit placement density? **[5%]**

The following formulae and graphs are provided.

$$\eta = \frac{H}{2}\cos(kx - \sigma t) \qquad \phi = \frac{H}{2}\frac{g\cosh k(d+y)}{\sigma\cosh kd}\sin(kx - \sigma t)$$

$$\sigma^2 = gk\tanh(kd) \qquad C = \sqrt{\frac{gL}{2\pi}\tanh(2\pi\frac{d}{L})} = \frac{gT}{2\pi}\tanh(2\pi\frac{d}{L})$$

$$L = \frac{gT^2}{2\pi}\tanh(kd) \qquad L_0 = \frac{gT^2}{2\pi} \qquad W = \frac{w_r H_i^3}{K_D(S_r - 1)^3\cot\theta} \qquad t_T = \sum\frac{\Delta S}{\sqrt{gd_s}}$$

$$u = \left(\frac{\pi H}{T}\right)\frac{\cosh k(d+y)}{\sinh(kd)}\cos(kx - \sigma t) \qquad v = \left(\frac{\pi H}{T}\right)\frac{\sinh k(d+y)}{\sinh(kd)}\sin(kx - \sigma t)$$

$$\zeta = \left(\frac{H}{2}\right)\frac{\cosh k(d+y)}{\sinh(kd)}\sin(kx - \sigma t) \qquad \varepsilon = \left(\frac{H}{2}\right)\frac{\sinh k(d+y)}{\sinh(kd)}\cos(kx - \sigma t)$$

$$p = -\rho gy + \left(\frac{\rho gH}{2}\right)\frac{\cosh k(d+y)}{\cosh(kd)}\cos(kx - \sigma t) \qquad H_{rms} = 0.706H_s = 1.129H_{100}$$

$$E = \frac{\rho gH^2 L}{8} \qquad P = \frac{nE}{T} \qquad n = \frac{1}{2}\left(1 + \frac{2kd}{\sinh(2kd)}\right)$$

$$p(H) = \frac{2H}{(H_{rms})^2}e^{-(H/H_{rms})^2} \qquad \frac{H_1}{H_2} = \sqrt{\frac{n_2 L_2}{n_1 L_1}}K_R, \qquad \left(\frac{H}{L}\right)_{\max} = \frac{1}{7}\tanh(kd)$$

$$K_R = \sqrt{\frac{\cos\alpha_0}{\cos\alpha}} \qquad H_{rms} = \sqrt{\sum\frac{H_i^2}{N}} \qquad \frac{\sin\alpha}{L} = \frac{\sin\alpha_0}{L_0}$$

$$\Delta y = \frac{\pi H^2}{L}\coth kd \qquad H = \frac{(1 + C_R)}{2}H_i \qquad H_{\max} = 0.707H_s\sqrt{\ln N}$$

$$B = nk_\Delta\left(\frac{W}{w_r}\right)^{1/3} \qquad r = Ank_\Delta\left(1 - \frac{p}{100}\right)\left(\frac{w_r}{W}\right)^{2/3}$$

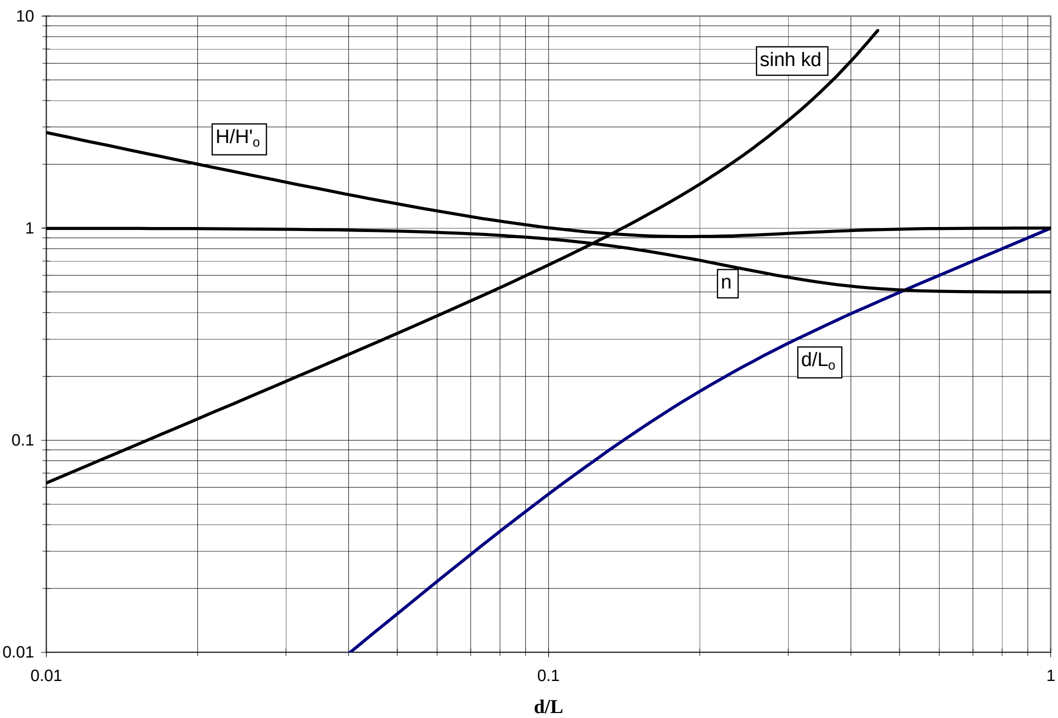
$$N_s = \max\left\{1.3\left(\frac{1-K}{K^{1/3}}\right)\left(\frac{d_l}{H_i}\right) + 1.8e^{\left(-1.5\frac{(1-K)^2}{K^{1/3}}\frac{d_l}{H_i}\right)}; 1.8\right\}$$

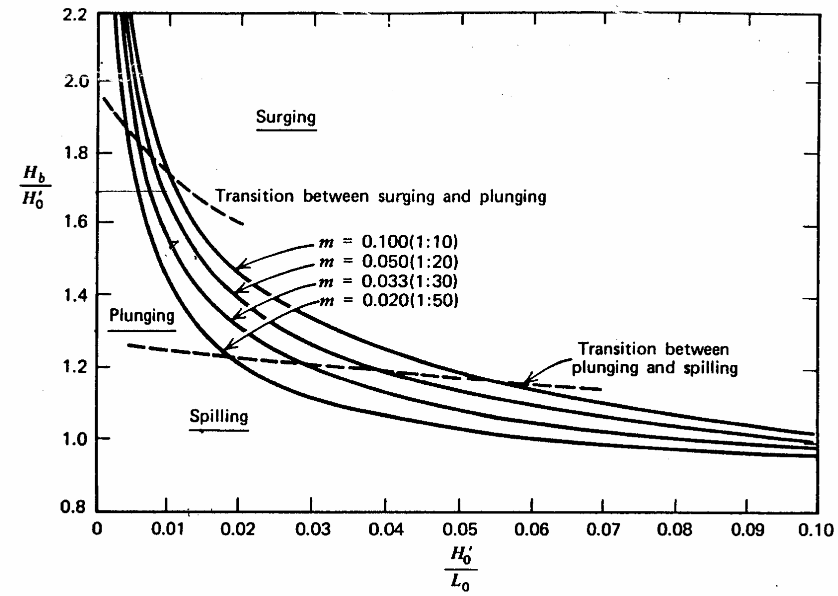
$$K = \frac{4\pi d_l / L}{\sinh(4\pi d_l / L)}\sin(2\pi B / L)^2$$

TABLE 3.1. WAVE DIFFRACTION COEFFICIENTS, K_D, AS A FUNCTION (WIEGEL, 1962) OF INCIDENT WAVE DIRECTION θ, AND POSITION, r/L AND β

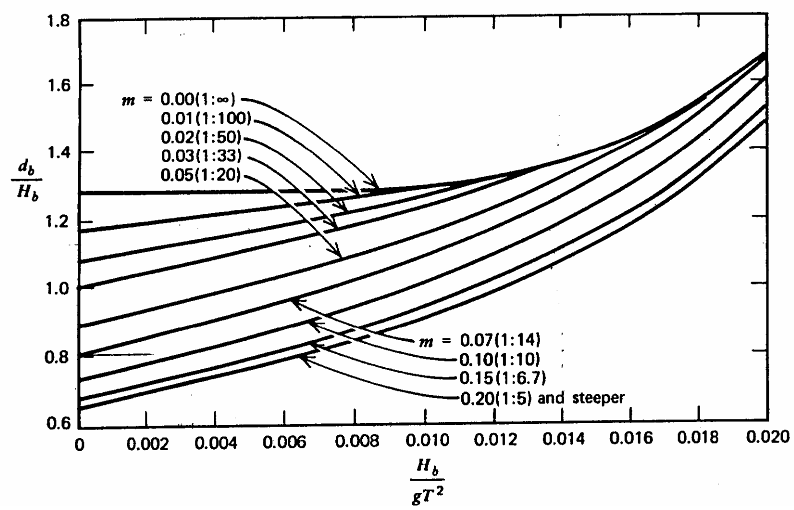
r/L	β (Degrees) 0	15	30	45	60	75	90	105	120	135	150	165	180
							$\theta = 15°$						
1/2	0.49	0.79	0.83	0.90	0.97	1.01	1.03	1.02	1.01	0.99	0.99	1.00	1.00
1	0.38	0.73	0.83	0.95	1.04	1.04	0.99	0.98	1.01	1.01	1.00	1.00	1.00
2	0.21	0.68	0.86	1.05	1.03	0.97	1.02	0.99	1.00	1.00	1.00	1.00	1.00
5	0.13	0.63	0.99	1.04	1.03	1.02	0.99	0.99	1.00	1.01	1.00	1.00	1.00
10	0.35	0.58	1.10	1.05	0.98	0.99	1.01	1.00	1.00	1.00	1.00	1.00	1.00
							$\theta = 30°$						
1/2	0.61	0.63	0.68	0.76	0.87	0.97	1.03	1.05	1.03	1.01	0.99	0.95	1.00
1	0.50	0.53	0.63	0.78	0.95	1.06	1.05	0.98	0.98	1.01	1.01	0.97	1.00
2	0.40	0.44	0.59	0.84	1.07	1.03	0.96	1.02	0.98	1.01	0.99	0.95	1.00
5	0.27	0.32	0.55	1.00	1.04	1.04	1.02	0.99	0.99	1.00	1.01	0.97	1.00
10	0.20	0.24	0.54	1.12	1.06	0.97	0.99	1.01	1.00	1.00	1.00	0.98	1.00
							$\theta = 45°$						
1/2	0.49	0.50	0.55	0.63	0.73	0.85	0.96	1.04	1.06	1.04	1.00	0.99	1.00
1	0.38	0.40	0.47	0.59	0.76	0.95	1.07	1.06	0.98	0.97	1.01	1.01	1.00
2	0.29	0.31	0.39	0.56	0.83	1.08	1.04	0.96	1.03	0.98	1.01	1.00	1.00
5	0.18	0.20	0.29	0.54	1.01	1.04	1.05	1.03	1.00	0.99	1.01	1.00	1.00
10	0.13	0.15	0.22	0.53	1.13	1.07	0.96	0.98	1.02	0.99	1.00	1.00	1.00
							$\theta = 60°$						
1/2	0.40	0.41	0.45	0.52	0.60	0.72	0.85	1.13	1.04	1.06	1.03	1.01	1.00
1	0.31	0.32	0.36	0.44	0.57	0.75	0.96	1.08	1.06	0.98	0.98	1.01	1.00
2	0.22	0.23	0.28	0.37	0.55	0.83	1.08	1.04	0.96	1.03	0.98	1.01	1.00
5	0.14	0.15	0.18	0.28	0.53	1.01	1.04	1.05	1.03	0.99	0.99	1.00	1.00
10	0.10	0.11	0.13	0.21	0.52	1.14	1.07	0.96	0.98	1.01	1.00	1.00	1.00
							$\theta = 75°$						
1/2	0.34	0.35	0.38	0.42	0.50	0.59	0.71	0.85	0.97	1.04	1.05	1.02	1.00
1	0.25	0.26	0.29	0.34	0.43	0.56	0.75	0.95	1.02	1.06	0.98	0.98	1.00
2	0.18	0.19	0.22	0.26	0.36	0.54	0.83	1.09	1.04	0.96	1.03	0.99	1.00
5	0.12	0.12	0.13	0.17	0.27	0.52	1.01	1.04	1.05	1.03	0.99	0.99	1.00
10	0.08	0.08	0.10	0.13	0.20	0.52	1.14	1.07	0.96	0.98	1.01	1.00	1.00
							$\theta = 90°$						
1/2	0.31	0.31	0.33	0.36	0.41	0.49	0.59	0.71	0.85	0.96	1.03	1.03	1.00
1	0.22	0.23	0.24	0.28	0.33	0.42	0.56	0.75	0.96	1.07	1.05	0.99	1.00
2	0.16	0.16	0.18	0.20	0.26	0.35	0.54	0.69	1.08	1.04	0.96	1.02	1.00
5	0.10	0.10	0.11	0.13	0.16	0.27	0.53	1.01	1.04	1.05	1.02	0.99	1.00
10	0.07	0.07	0.08	0.09	0.13	0.20	0.52	1.14	1.07	0.96	0.99	1.01	1.00

r/L	β (Degrees) 0	15	30	45	60	75	90	105	120	135	150	165	180
							$\theta = 105°$						
1/2	0.28	0.28	0.29	0.32	0.35	0.41	0.49	0.59	0.72	0.85	0.97	1.01	1.00
1	0.20	0.20	0.24	0.23	0.27	0.33	0.42	0.56	0.75	0.95	1.06	1.04	1.00
2	0.14	0.14	0.13	0.17	0.20	0.25	0.35	0.54	0.83	1.08	1.03	0.97	1.00
5	0.09	0.09	0.10	0.11	0.13	0.17	0.27	0.52	1.02	1.04	1.04	1.02	1.00
10	0.07	0.06	0.08	0.08	0.09	0.12	0.20	0.52	1.14	1.07	0.97	0.99	1.00
							$\theta = 120°$						
1/2	0.25	0.26	0.27	0.28	0.31	0.35	0.41	0.50	0.60	0.73	0.87	0.97	1.00
1	0.18	0.19	0.19	0.21	0.23	0.27	0.33	0.43	0.57	0.76	0.95	1.04	1.00
2	0.13	0.13	0.14	0.14	0.17	0.20	0.26	0.16	0.55	0.83	1.07	1.03	1.00
5	0.08	0.08	0.08	0.09	0.11	0.13	0.16	0.27	0.53	1.01	1.04	1.03	1.00
10	0.06	0.06	0.06	0.07	0.07	0.09	0.13	0.20	0.52	1.13	1.06	0.98	1.00
							$\theta = 135°$						
1/2	0.24	0.24	0.25	0.26	0.28	0.32	0.36	0.42	0.52	0.63	0.76	0.90	1.00
1	0.18	0.17	0.18	0.19	0.21	0.23	0.28	0.34	0.44	0.59	0.78	0.95	1.00
2	0.12	0.12	0.13	0.14	0.14	0.17	0.20	0.26	0.37	0.56	0.84	1.05	1.00
5	0.08	0.07	0.08	0.08	0.09	0.11	0.13	0.17	0.28	0.54	1.00	1.04	1.00
10	0.05	0.06	0.06	0.06	0.07	0.08	0.09	0.13	0.21	0.53	1.12	1.05	1.00
							$\theta = 150°$						
1/2	0.23	0.23	0.24	0.25	0.27	0.29	0.33	0.38	0.45	0.55	0.68	0.83	1.00
1	0.16	0.17	0.17	0.18	0.19	0.22	0.24	0.29	0.36	0.47	0.63	0.83	1.00
2	0.12	0.12	0.12	0.13	0.14	0.15	0.18	0.22	0.28	0.39	0.59	0.86	1.00
5	0.07	0.07	0.08	0.08	0.08	0.10	0.11	0.13	0.18	0.29	0.55	0.99	1.00
10	0.05	0.05	0.05	0.06	0.06	0.07	0.08	0.10	0.13	0.22	0.54	1.10	1.00
							$\theta = 165°$						
1/2	0.23	0.23	0.23	0.24	0.26	0.28	0.31	0.35	0.41	0.50	0.63	0.79	1.00
1	0.16	0.16	0.17	0.17	0.19	0.20	0.23	0.26	0.32	0.40	0.53	0.73	1.00
2	0.11	0.11	0.12	0.12	0.13	0.14	0.16	0.19	0.23	0.31	0.44	0.68	1.00
5	0.07	0.07	0.07	0.07	0.08	0.09	0.10	0.12	0.15	0.20	0.32	0.63	1.00
10	0.05	0.05	0.05	0.06	0.06	0.06	0.07	0.08	0.11	0.11	0.21	0.58	1.00
							$\theta = 180°$						
1/2	0.20	0.25	0.23	0.24	0.25	0.28	0.31	0.34	0.40	0.49	0.61	0.78	1.00
1	0.10	0.17	0.16	0.18	0.18	0.23	0.22	0.25	0.31	0.38	0.50	0.70	1.00
2	0.02	0.09	0.12	0.12	0.13	0.18	0.16	0.18	0.22	0.29	0.40	0.60	1.00
5	0.02	0.06	0.07	0.07	0.07	0.08	0.10	0.12	0.14	0.18	0.27	0.46	1.00
10	0.01	0.05	0.05	0.04	0.06	0.07	0.07	0.08	0.10	0.13	0.20	0.36	1.00





Surging
Transition between surging and plunging
m = 0.100(1:10)
m = 0.050(1:20)
m = 0.033(1:30)
m = 0.020(1:50)
Plunging
Transition between plunging and spilling
Spilling
$\frac{H_b}{H_0'}$
$\frac{H_0'}{L_0}$



m = 0.00(1:∞)
0.01(1:100)
0.02(1:50)
0.03(1:33)
0.05(1:20)
m = 0.07(1:14)
0.10(1:10)
0.15(1:6.7)
0.20(1:5) and steeper
$\frac{d_b}{H_b}$
$\frac{H_b}{gT^2}$

Table A-1

K_D Values for Use in Determining Armor Unit Weight (Source: EM 1110-2-2904)							
			Structure Trunk[7]		Structure Head		
Armor Units	n[2]	Placement	Breaking Wave	Nonbreaking Wave	Breaking Wave	Nonbreaking Wave	Slope cot θ
Quarrystone							
Smooth rounded	2	Random	1.2[1]	2.4	1.1[1]	1.9	1.5-3.0[8]
Smooth rounded	>3	Random	1.6[1]	3.2[1]	1.4[1]	2.3[1]	1.5-3.0[8]
Rough angular	1	Random[3]	---[3]	2.9[1]	---[3]	2.3[1]	1.5-3.0[8]
Rough angular	2	Random	2.0	4.0	1.9[1] 1.6[1] 1.3	3.2 2.8 2.3	1.5 2.0 3.0
Rough angular	>3	Random	2.2[1]	4.5[1]	2.1[1]	4.2[1]	1.5-3.0[8]
Rough angular	2	Special[4]	5.8	7.0	5.3[1]	6.4	1.5-3.0[8]
Parallelepiped[9]	2	Special	7.0 - 20.0	8.5 - 24.0[1]	---	---	1.0-3.0
Tetrapod and Quadripod	2	Random	7.0	8.0	5.0[1] 4.5[1] 3.5[1]	6.0 5.5 4.0	1.5 2.0 3.0
Tribar	2	Random	9.0[1]	10.0	8.3[1] 7.8[1] 6.0	9.0 8.5 6.5	1.5 2.0 3.0
Dolos	2	Random	15.0[6]	31.0[6]	8.0[1] 7.0	16.0[1] 14.0[1]	2.0[5] 3.0
Modified cube	2	Random	6.5[1]	7.5	---	5.0[1]	1.5-3.0[8]
Hexapod	2	Random	8.0[1]	9.5	5.0[1]	7.0[1]	1.5-3.0[8]
Toskane	2	Random	11.0[1]	22.0	---	---	1.5-3.0[8]
Tribar	1	Uniform	12.0	15.0	7.5[1]	9.5[1]	1.5-3.0[8]
Quarrystone - graded angular riprap	-	Random	2.2	2.5	---	---	---

(1) CAUTION: These K_D values are unsupported and are provided only for preliminary design.

(2) n is the number of units comprising the thickness of the armor layer.

(3) The use of single layer of quarrystone armor units is not recommended for structures subject to breaking waves, and only under special conditions for structures subject to nonbreaking waves. When it is used, the stone should be carefully placed.

(4) Special placement with long axis of stone placed perpendicular to structure face.

(5) Stability of dolosse on slopes steeper than 1 on 2 should be substantiated by site-specific tests.

(6) Refers to no-damage criteria (<5 percent displacement, rocking, etc.); if no rocking (<2 percent) is desired, reduce K_D 50 percent (Zwamborn and Van Niekerk, 1982).

(7) Applicable to slopes ranging from 1 on 1.5 to 1 on 5.

(8) Until more information is available, the use of K_D should be limited to slopes ranging from 1 on 1.5 to 1 on 3. Some armor units tested on a structure head indicate a K_D-slope dependence.

(9) Parallelepiped-shaped stone: long slab-like stone with long dimension approximately three times the shortest dimension (Markle and Davidson, 1979).

Table A-2

Layer Coefficient and Porosity for Various Armor Units (Source: SPM)				
Armor Unit	n	Placement	Layer Coefficient	Porosity %
Quarrystone (smooth)	2	Random	1.02	38
Quarrystone (rough)	2	Random	1.00	37
Quarrystone (rough)	>3	Random	1.00	40
Quarrystone (parallelepiped)	2	Special	-	27
Cube (modified)	2	Random	1.10	47
Tetrapod	2	Random	1.04	50
Quadripod	2	Random	0.95	49
Hexipod	2	Random	1.15	47
Tribar	2	Random	1.02	54
Dolos	2	Random	0.94	56
Toskane	2	Random	1.03	52
Tribar	1	Uniform	1.13	47
Quarrystone	Graded	Random	-	37