UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 7 Examination in Engineering: August 2015

Module Number: CE 7238 **Module Name: Coastal Engineering and Management**

[Three Hours]

[Answer **all questions**, each question carries TWELVE marks]

Q1 (a) Name the tools used in integrated coastal zone management? [3 marks]

(b) What are the coastal defence policy options in a shoreline management plan (SMP)?

[4 marks]

(c) Choose appropriate coastal defence policy options for the following areas where there is severe coastal erosion. Explain the reasons behind your choice.

(i) Rathmalana/Mt. Lavinia (Colombo suburbs)
(ii) An uninhabited coastal area in Hambanthota

[3 marks]

(d) (i) Define the Coastal Zone of Sri Lanka (ii) Describe the statutory functions of the Department of Coast Conservation & Coastal Resources Management.

[2 marks]

Q2 (a) What are the assumptions made in deriving small amplitude/linear wave theory?

[3 marks]

(b) Explain why linear wave theory does not accurately predict wave surface profile in the nearshore where water depths are relatively small.

[3 marks]

(c) A cylindrical wind turbine mono-pile with diameter D= 3 m is to be driven into a sandy sea bed in water depth h = 10m (Figure Q2). The design wave height, H= 2.0 m and wave period is T= 8 sec.

Linearised form of the velocity potential of a surface gravity wave is given by:

$$\phi = \frac{gH}{2\omega}\frac{\cosh k(z+h)}{\cosh(kh)}\sin(kx-\omega t)$$

(i) Derive horizontal orbital velocity (U) and acceleration (a_x) of water particles at the mid depth, i.e., z = - 0.5h when $(kx-\omega t) = \pi/4$.

[3 marks]

(ii) Calculate drag and inertia forces on the pile when $(kx-\omega t) = \pi/4$ and estimate the total force. Assume velocity and acceleration of water particles at mid depth are applicable to fully submerged part of the pile for estimating the forces on the pile.

[3 marks]

Drag force $= \frac{1}{2}\rho C_D A U^2$

Inertia force $= \rho C_M \forall a_x$

where, A= cross sectional area = $D \times h$ and volume, $\forall = \frac{\pi D^2}{4} h$, C_D= 0.7, C_M= 2.0, density of seawater =1030 kg/m³.

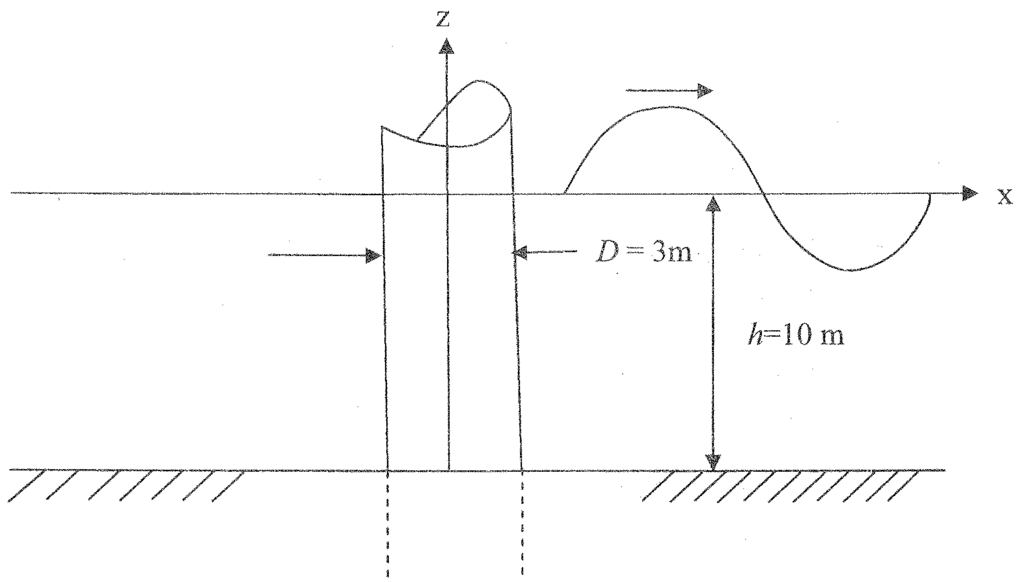

Figure Q2. Mono-pile

Q3 (a) Explain the importance of median sand particle size in beach nourishment.

[3 marks]

(b) With the aid of sketches, explain the time evolution of beach plan-form on either side of structure/s after constructing (i) a groyne (ii) detached shore-parallel breakwaters to stabilise an eroding beach. Assume initial beach is a straight line.

[3 marks]

(c) Formation of underwater longshore (shore parallel) sand bars is a part of the natural defence of the beach. Explain how they are formed and function to protect the beach [note: do not confuse sand bars with the fore-shore sand dunes].

[3 marks]

(d) A beach nourishment program has been planned for an eroded beach frontage. Existing sand has a median grain diameter of d= 0.2 mm. The beach profile is represented by the equation, $y = -Ax^{2/3}$ as shown in Figure Q3. $A = 0.067w^{0.44}$, where, w(m/s) is the sediment settling velocity given by $w = 14d^{1.1}$ with d in millimetres.

If the new sand material to be dumped on the beach is of median diameter, d=0.3mm, and design beach width is 80 m, calculate the volume of sand required per metre length of the beach. Distance to depth of closure from the shoreline is 400m.

[3 marks]

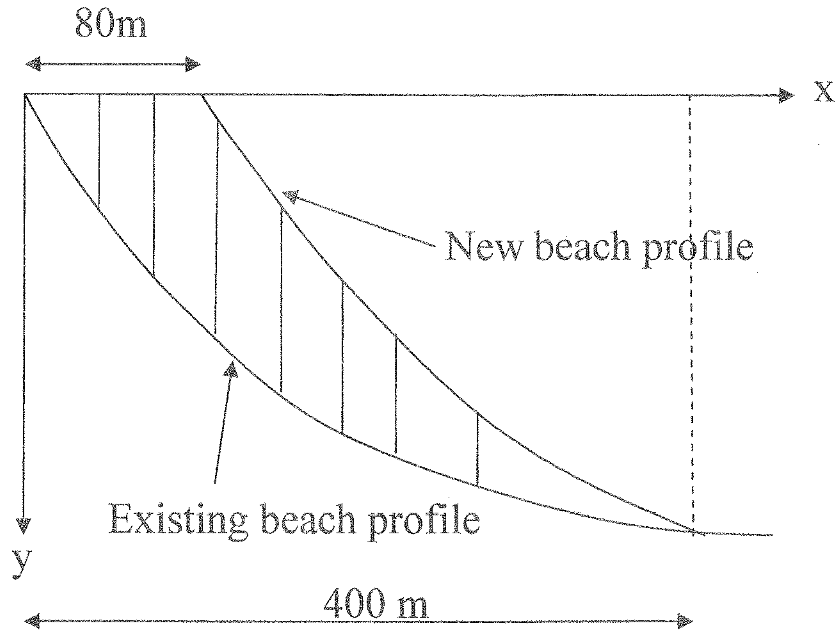

Figure Q3. Cross-shore beach profile

Q4. (a) Name the types of concrete armour units?

[3 marks]

(b) Compare the armour units in (a) in terms of energy dissipation, economy and stability.

[3 marks]

(c) (i) Explain why toe scour near a vertical sea wall is severe than in front of a sloping rock revetment on erodible ground.

[2 marks]

(ii) With the aid of sketches, propose a solution to reduce (i) scour (ii) overtopping along a vertical wall.

[1 mark]

(d) Using *Van der Meer* equation, calculate the diameter and weight of median rock armours. The following details are provided.

Van der Meer equation for plunging waves reads as;

$$\frac{H_s}{\Delta D_{n50}} = 6.2S^{0.2}P^{0.18}N_z^{-0.1}\xi_m^{-0.5} \quad \text{Eq. 4.1}$$

where, S is relative eroded area equal to 2 for initial damage. P is porosity equal to 0.3. Number of waves in a storm N_z=5000. Significant wave height, H_s=2.5 m, wave period T= 8 sec, $S_m=H_s/L_0$. Breakwater slope is tan α. $\Delta=[(\rho_s/\rho)-1]$ where, density of rock ρ_s=2650 kg/m³ and density of seawater ρ =1030 kg/m³. (Wave Table provided).

$$\xi_m = \frac{\tan\alpha}{\sqrt{S_m}} \quad \text{Eq. 4.2}$$

[3 marks]

Q5 Assume that you have been asked to design a rubble mound breakwater consisting of an armour layer, secondary/under-layer and a core made of quarry run.

(a) Explain why run up height is higher on a smooth slope than on a rubble mound slope ?.

[3 marks]

(b) Explain the functions of (i) armour layer (ii) secondary/under layer (iii) core

[3 marks]

(c) Determine the crest level of the breakwater constructed on a horizontal seabed as shown in Figure Q5, for 2% exceedance probability providing a 0.6 m freeboard for settlement and water level/wave exceedance.

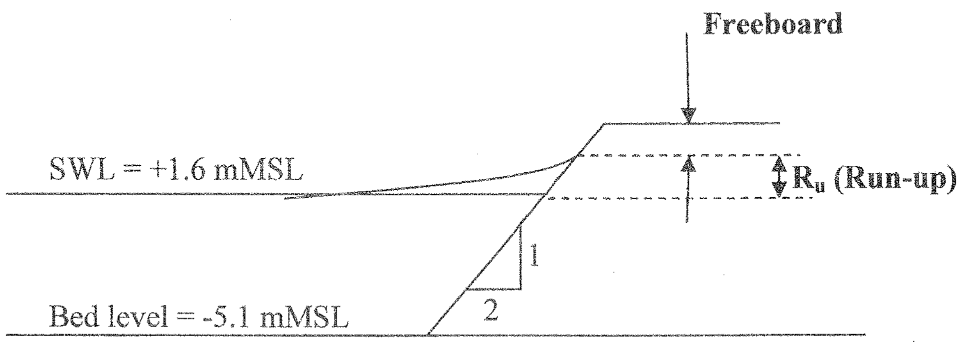

Figure Q5

The following details are provided.

Maximum wave run-up height (R_u) is given by:

$$\frac{R_{ui\%}}{H_s} = A\xi_{0m} \text{ for } 1.0<\xi_{0m} \leq 1.5 \quad \text{Eq. 5.1}$$

$$= B(\xi_{0m})^C \text{ for } 1.5<\xi_{0m} \leq (D/B)^{1/C} \quad \text{Eq. 5.2}$$

$$= D \text{ for } (D/B)^{1/C} \leq \xi_{0m} < 7.5 \quad \text{Eq. 5.3}$$

$$\xi_{0m} = \frac{\tan\alpha}{\sqrt{S_{0m}}} \quad \text{Eq. 5.4}$$

$$S_{0m} = \frac{H_{s0}}{L_0} \quad \text{Eq. 5.5}$$

Assume the seaward slope of breakwater is 1:2. Design water level (SWL) is +1.6 m MSL. Bed level at the toe of the structure is -5.1 m MSL. Deep water wave height, H_{s0} = 2.5 m, and wave period, T_m=8 sec. Nearshore transformed wave height, H_s = 3.0 m. Assume a breaker index, γ_b = 0.78. (Wave Table and Table Q5 provided).

[6 marks]

Table Q5. Coefficients *A*, *B*, *C*, *D* for Run-up calculation (for use in Eq 5.1 – 5.3)

Table VI-5-6

Coefficients in Equations VI-5-12 and VI-5-13 for Runup of Irregular Head-On Waves on Impermeable and Permeable Rock Armored Slopes

Percent[1]	A	B	C	D[2]
0.1	1.12	1.34	0.55	2.58
2.0	0.96	1.17	0.46	1.97
5	0.86	1.05	0.44	1.68
10	0.77	0.94	0.42	1.45
(significant)	0.72	0.88	0.41	1.35
50 (mean)	0.47	0.60	0.34	0.82

[1] Exceedence level related to number of waves.
[2] Only relevant for permeable slopes

Table 1. Wave table

h/L0	*h/L*	*Sinh(2πh/L)*	*Cosh(2πh/L)*
0.030	0.07135	0.4634	1.1021
0.031	0.07260	0.4721	1.1059
0.032	0.07385	0.4808	1.1096
0.033	0.07507	0.4894	1.1133
0.034	0.07630	0.4980	1.1171
0.035	0.07748	0.5064	1.1209
0.036	0.07867	0.5147	1.1247
0.037	0.07984	0.5230	1.1285
0.038	0.08100	0.5312	1.1324
0.039	0.08215	0.5394	1.1362
0.040	.08329	0.5475	1.1401
0.041	.08442	0.5556	1.1440
0.042	.08553	0.5637	1.1479
0.043	.08664	0.5717	1.1518
0.044	.08774	0.5796	1.1558
0.060	0.1043	0.7033	1.2225
0.061	0.1053	0.7110	1.2270
0.062	0.1063	0.7187	1.2315
0.063	0.1073	0.7256	1.2355
0.064	0.1082	0.7335	1.2402
0.095	.1366	0.9677	1.3917
0.096	.1375	0.9755	1.3970
0.097	.1384	0.9832	1.4023
0.098	.1392	0.9908	1.4077
0.099	.1401	0.9985	1.4131
0.1000	.1410	1.006	1.4187
0.1010	.1419	1.014	1.4242
0.1020	.1427	1.022	1.4297
0.1030	.1436	1.030	1.4354
0.1040	.1445	1.037	1.4410