UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 7 Examination in Engineering: July 2017

Module Number: CE 7251

Module Name: Coastal Engineering Applications and Management

[Three Hours]

[Answer all questions, each question carries TWELVE marks]

Q1 (a) Explain (i) diffraction (ii) refraction (iii) shoaling of water waves.

[3 marks]

(b) Explain how (i) longshore currents and (ii) tidal currents are generated

[2marks]

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

(i) Kollupitiya, Colombo
(ii) An unpopulated coastal area in Hambanthota

[4 marks]

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

[3 marks]

Q2 An offshore gravity platform to drill petroleum oil should be designed in a water depth of h=30m. 1 in 10,000 year wave height, H=14m and wave period, T=12 seconds. The deck is supported on four similar (identical) concrete columns with diameter, d=5m and foundation diameter D=10m [see Figures Q2(a) and Q2(b)]. Use wave table given in the appendix.

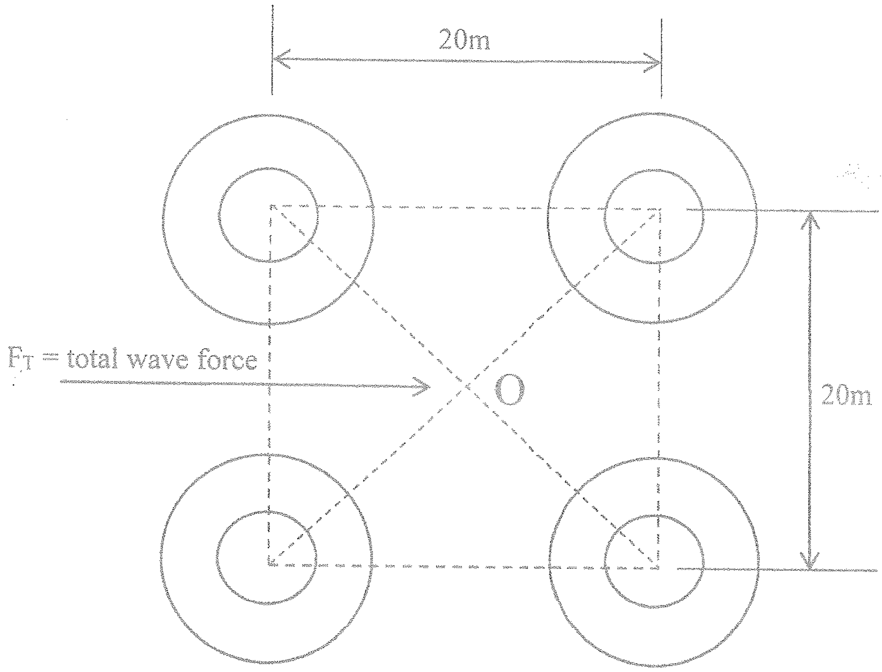

Figure Q2(a) Plan of the offshore platform

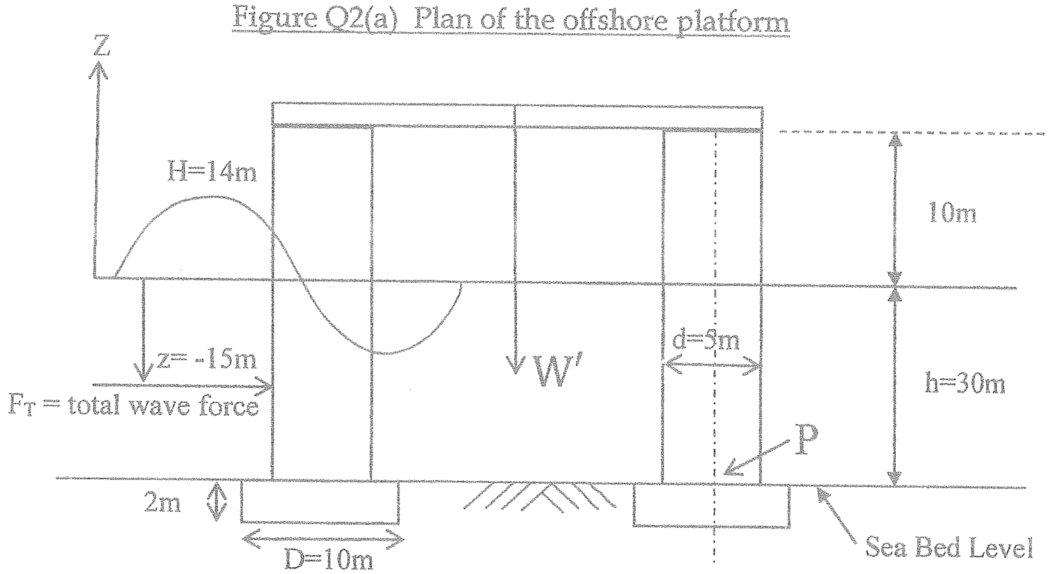

Figure Q2(b) Side view of the offshore platform

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

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

Derive horizontal orbital velocity(U) and acceleration (a_x) at the mid-depth, i.e., z = - 0.5h for (kx-ωt) = π/3.

[3 marks]

(b) Calculate drag and inertia forces on a single column for (kx-ωt) = π/3 and estimate the wave induced horizontal force per column. Assume velocity and acceleration at the mid-depth are applicable to the full submerged part of the column.

[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 x h and the displaced volume of water, $\forall = \frac{\pi D^2}{4} h$, C_D=0.7, C_M=2.0, density of water =1030 kg/m³.

(c) Calculate total wave force (F_T) on the structure. [1 mark]

(d) Calculate the total submerged weight of the structure, W′ neglecting the weight of the deck. Assume density of concrete is 2400kg/m³. [2 marks]

(e) Show calculations to confirm the structure is safe against overturning (Hint - take moments around point P, assume wave force acts at the mid depth, the structure is rigidly jointed to act as a single unit).

[3 marks]

Q3 It is proposed to construct a vertical quay wall in a harbour for berthing of vessels using a reinforced vertical concrete wall as shown in Figure Q3. Incoming wave height, Hinc=1.25m and wave period , T=8 seconds, density of sea water ρ= 1030kg/m³. Use Wave Table given in the Appendix.

(a) What is the height of the reflected wave (Hr) ?

[2 mark]

(b) Calculate the hydrostatic pressure and peak dynamic wave pressure (Pw) at the sea bed ? Calculate P max= (hydrostatic pressure + wave pressure).

$$P_w = \frac{\rho g H_r}{2\cosh(\frac{2\pi h}{L})}$$

[4 marks]

(c) Calculate pressure P_0 at SWL. Assume $Hoc = \frac{\pi H_{inc}^2}{L} \coth\frac{2\pi h}{L}$

[3 marks]

(d) Calculate the total hydraulic force per metre length on the seaward face of the quay wall and show on a sketch the distance to the line of action of the total force from Point O.

[3 mark]

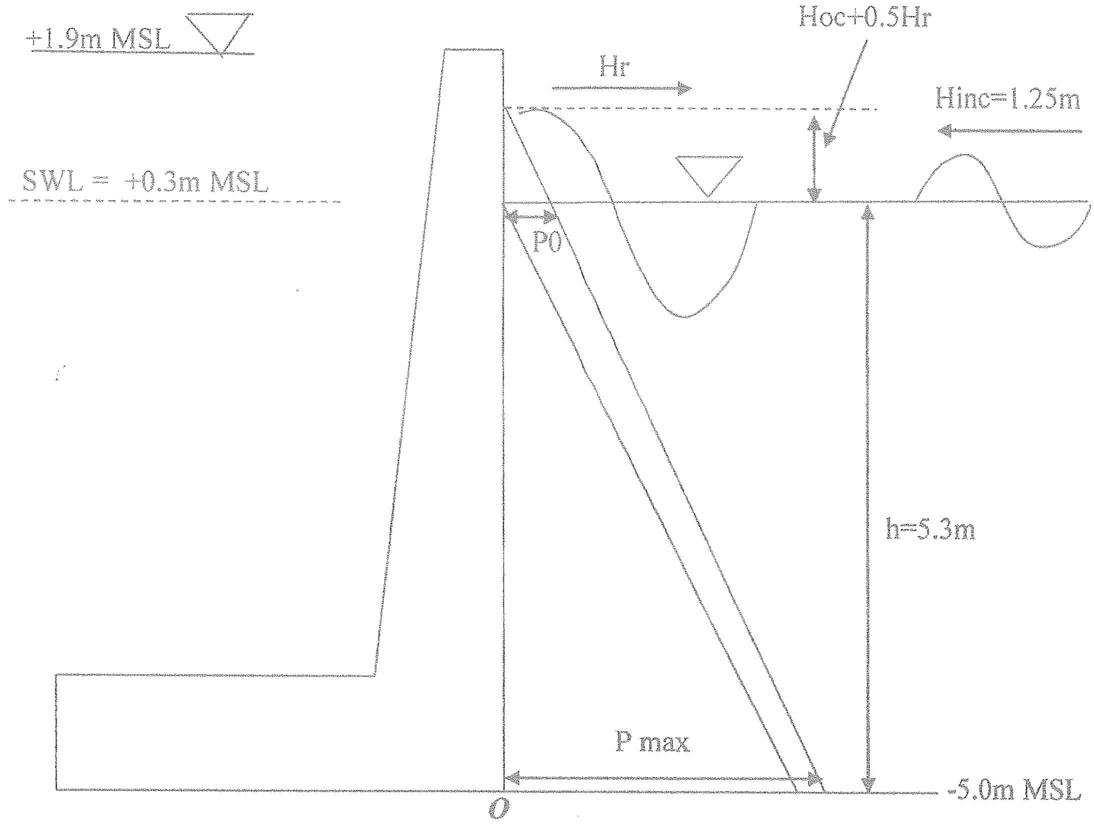

Figure Q3. Vertical Quay Wall Structure

Q4. (a) Explain the importance of median sand particle size in beach nourishment.

[3 marks]

(b) When a hard engineering solution is given to a coastal erosion problem the problem may be shifted to down coast. Explain this statement with the aid of sketches.

[3 marks]

(c) Time evolution of 1 km long and 100m wide rectangular beach fill is given by the following equation.

$$y = Y_0\left\{erf\left[\frac{\lambda}{4\sqrt{Gt}}\left(\frac{2x}{\lambda}+1\right)\right] - erf\left[\frac{\lambda}{4\sqrt{Gt}}\left(\frac{2x}{\lambda}-1\right)\right]\right\} \text{ ------ Eq. 4.1}$$

Where y is the distance to shoreline from a datum, y=0.

Original beach fill is shown with a broken line in Figure Q4(a). Calculate the shoreline position y at x=0, t=2 years after the construction (Hint – time, t should be substituted in seconds in Equation 4.1).

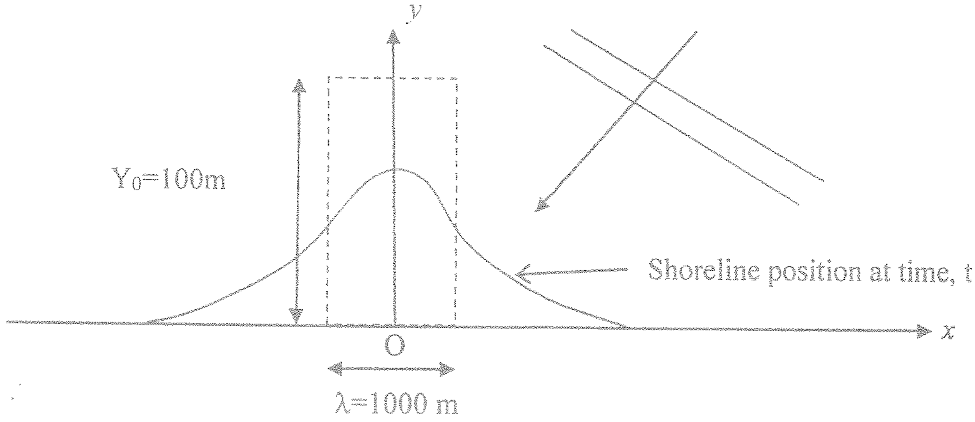

Figure Q4(a) Beach planform

$$G = \frac{KH_b^{\frac{5}{2}}\sqrt{\frac{g}{\gamma_b}}}{8\frac{(\rho_s-\rho_w)}{\rho_w}a(h_*+B)} \quad \text{------- Eq. 4.2}$$

K=0.7, $\gamma_b = 0.78$, $a = 1 - porosity = 0.6$, B=3m, h_*=4m, h_b=2m, ρ_s=2650kg/m^3, ρ=1030kg/m^3. G is alongshore diffusivity.

Use Figure Q4(b) to calculate error function (erf) for equation 4.1.

[6 marks]

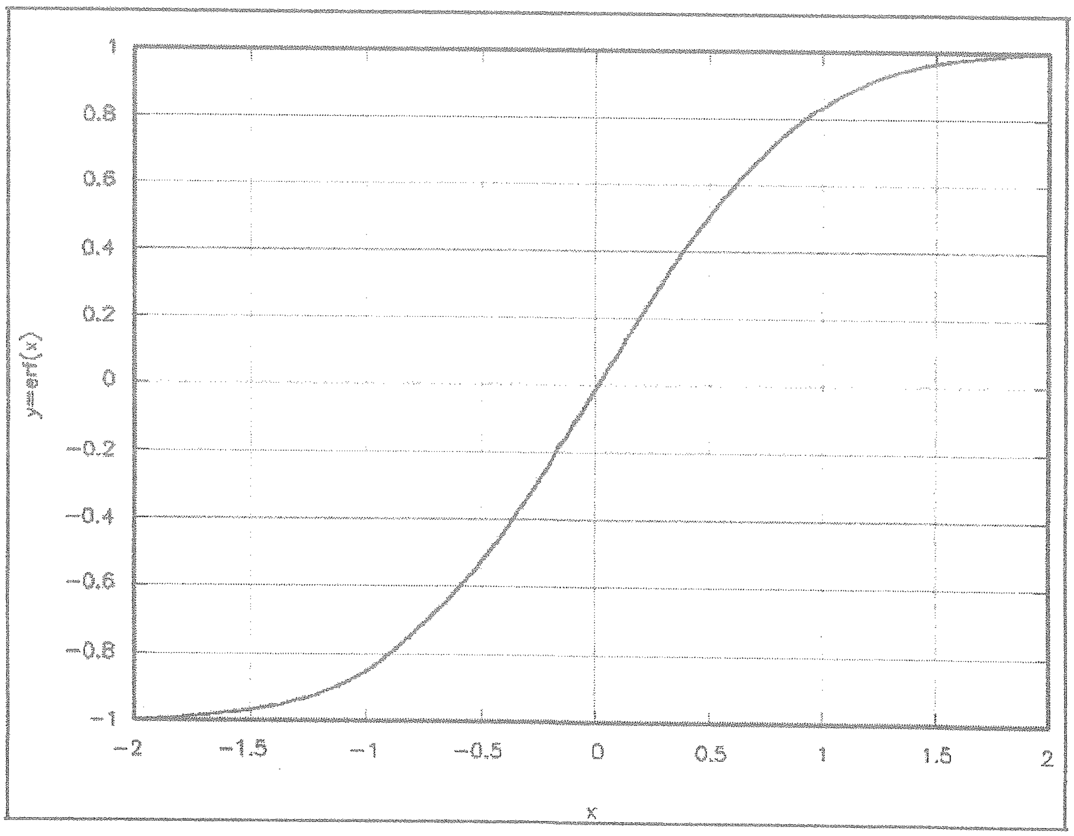

Figure Q4(b): Error Function

Q5 Assume that you have been tasked to design a rock breakwater consisting of an armour layer, secondary (under-layer) and a core made of quarry run.

(a) Using sketches if necessary, explain methods to reduce overtopping of a rock breakwater.

[4 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 for 2% exceedance probability providing a 0.6m freeboard for settlement and water level/wave exceedance.

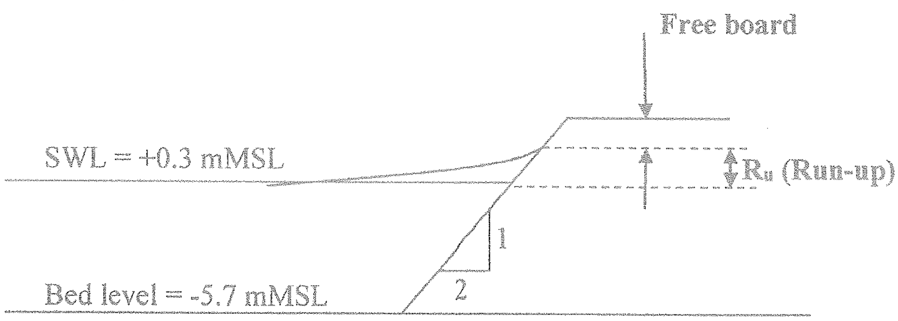

Figure Q5b

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 a breakwater slope of 1:2. Design water level (SWL) is +0.3mMSL. Bed level at the toe of the structure is -5.7mMSL. Deep water wave height, H_{s0}=2.5m, and wave period, T_m=8 sec. Nearshore transformed wave height, H_s=3.0m. Assume a breaker index, γ_b=0.78.

[5 marks]

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

Table VI-5-5

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

APPENDIX: 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	0.08329	0.5475	1.1401
0.041	0.08442	0.5556	1.1440
0.042	0.08553	0.5637	1.1479
0.043	0.08664	0.5717	1.1518
0.044	0.08774	0.5796	1.1558
0.050	0.09416	0.6267	1.1802
0.051	0.09520	0.6344	1.1843
0.052	0.09623	0.6421	1.1884
0.053	0.09726	0.6499	1.1926
0.054	0.09829	0.6575	1.1968
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	0.1366	0.9677	1.3917
0.096	0.1375	0.9755	1.3970
0.097	0.1384	0.9832	1.4023
0.098	0.1392	0.9908	1.4077
0.099	0.1401	0.9985	1.4131
0.1300	0.1665	1.248	1.5990
0.1310	0.1674	1.257	1.6060
0.1320	0.1682	1.265	1.6124
0.1330	0.1691	1.273	1.6191
0.1340	0.1699	1.282	1.6260