UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: November 2022

Module Number: CE 6251 **Module Name: Coastal Engineering**

[Three Hours]

[Answer **all questions**, each Question carries 20 marks]

Q1. a) With the use of neat sketches where necessary, discuss the differences between Airy wave theory and Stokes second order wave theory.

[5.0 Marks]

b) A wave front with a mean wave period of 8 s is approaching a sloping beach, parallel to the bottom contours. The nearshore bottom contours in this area are straight and shore parallel. If the wave height and the shoaling coefficient of this wave front at a nearshore depth are 2.12 m and 1.06, respectively, using the wave table in Page 4, determine the corresponding depth of propagation of the wave front. Using the calculated depth, determine the maximum horizontal velocity (u) and the maximum vertical acceleration (a_z) components of this wave front on the sea bed.

With usual notations,

$$\Phi = \frac{gH}{2\omega}\frac{\cosh k(d+z)}{\cosh kd}\sin(kx - \omega t) \;\; ; u = \frac{\partial \phi}{\partial x} \; ; w = \frac{\partial \phi}{\partial z} ; a_z = \frac{\partial w}{\partial t} \; ; K_s = \frac{H}{H_0}$$

[10.0 Marks]

c) Using Figure Q1, deduce whether the wave front mentioned in Q1 part (b) is breaking or not at this depth. Assume the average slope of the sea bed as 0.050.

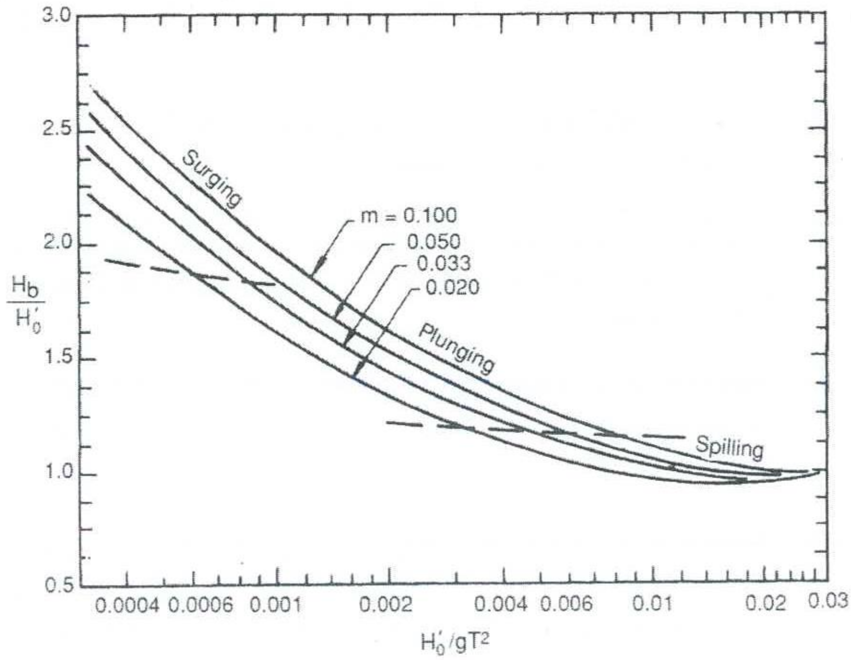

Figure Q1: Dimensionless breaker height and type versus bottom slope and deep water steepness.

[5.0 Marks]

Q2. a) Discuss the influence of sea bed slope on the processes of wave shoaling and breaking.

[5.0 Marks]

b) A wave in a 100 m deep ocean has a period of 10 s and a height of 2.2 m and propagates towards the nearshore without refraction and energy gain or loss.

i) Deduce the classification of this wave (deep, shallow or intermediate) at 100 m depth.

ii) Determine the wave height and the water particle velocity and pressure at a point 5 m below the still water level under a wave crest, at a water depth of 8 m.

iii) Using Figure Q1, determine the type of breaking, and breaking wave height of this wave front if the slope of the sea bed is 1: 10.

[15.0 Marks]

With usual notations,

Velocity potential of small amplitude wave theory

$$\Phi = \frac{gH}{2\omega}\frac{\cosh k(d+z)}{\cosh kd}\sin(kx - \omega t)$$

Pressure field $p = -\rho g z + \frac{\rho g H}{2}\left[\frac{\cosh k(d+z)}{\cosh kd}\right]\cos(kx - \omega t)$

$$\frac{H}{H_0} = K_s\, K_r \;\; ; \text{where } K_s = \sqrt{\frac{L_0}{2nL}};\; K_r = \sqrt{\frac{B_0}{B}} \;\; ; n = \frac{1}{2}\left(1 + \frac{2kd}{\sinh 2kd}\right)$$

Unrefracted deep water wave height $\frac{H_0^1}{gT^2}$

Q3. a) Discuss briefly the major facilities to be provided when developing a commercial harbour and explain how these facilities are arranged in the sheltered area of the harbour for safe and efficient harbour operations.

[6.0 Marks]

b) What are the major issues associated with sand nourishment when employed as a shore protection measure?

[7.0 Marks]

c) Explain briefly the management strategies adopted in the Integrated Coastal Zone Management Programme in conserving coastal habitats in Sri Lankan coastal zone.

[7.0 Marks]

Q4. a) Discuss the significance of physical modeling studies compared with the mathematical and process oriented numerical modeling approaches.

[5.0 Marks]

b) Briefly discuss the importance of maintaining the same surface roughness of the armour units in the prototype and in the model, in physical model testing of coastal structures. How the model armor units are arranged to reduce the contact friction?

[5.0 Marks]

c) Physical model test is planned to investigate the armour layer stability of a breakwater constructed using rock armors of density of $2665\ \mathrm{kg/m^3}$, each weighing 2 tons. 1:40 stability model has been set up using scaled prototype rock armors, in freshwater. Calculate the weight of the armor units to be used in the model.

[10.0 Marks]

With usual notations Hudson stability number is given by $\frac{\gamma_a{}^{1/3}H}{\left[\frac{\gamma_a}{\gamma_w}-1\right]W_a{}^{1/3}}$

Sea water and fresh water densities are $1025\ kg/m^3$, $1000\ kg/m^3$, respectively.

Q5. Figure Q5 depicts two shore parallel detached breakwaters erected in the surf zone of a coastal environment.

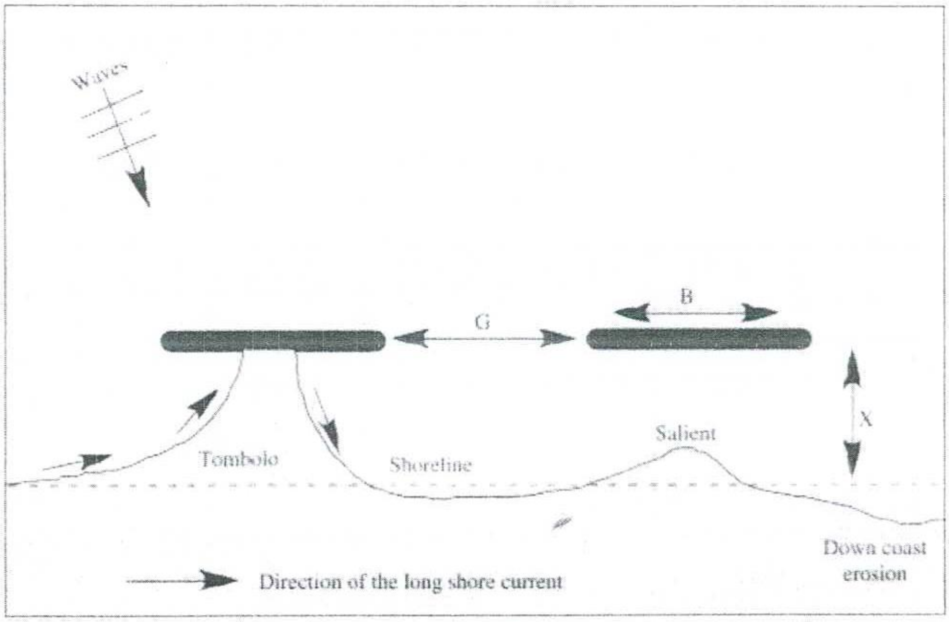

Figure Q5

a) Discuss the functional significance of a breakwater in a harbor design.

[5.0 Marks]

b) Explain the formation of Tombolo as shown in Figure Q5, due to the erection of the breakwater.

[5.0 Marks]

c) Evaluate the impact of oblique wave fronts in the sediment motion in this coastal environment.

[5.0 Marks]

d) Propose a remedial measure to minimize the down coast erosion shown in Figure Q5, and appraise its suitability considering the wave directions, presence of coastal structures and prevailing morphodynamics in this environment.

[5.0 Marks]

Wave Table

h/L_o	tanh kh	h/L	kh	sinh kh	cosh kh	G	H/H_o
0.000	0.000	0.0000	0.000	0.000	1.00	1.000	∞
002	112	0179	112	113	01	0.992	2.12
004	158	0253	159	160	01	983	1.79
006	193	0311	195	197	02	975	62
008	222	0360	226	228	03	967	51
0.010	0.248	0.0403	0.253	0.256	1.03	0.958	1.43
015	302	0496	312	317	05	938	31
020	347	0576	362	370	07	918	23
025	386	0648	407	418	08	898	17
0.030	0.420	0.0713	0.448	0.463	1.10	0.878	1.13
035	452	0775	487	506	12	858	09
040	480	0833	523	548	14	838	06
045	507	0888	558	588	16	819	04
0.050	0.531	0.0942	0.592	0.627	1.18	0.800	1.02
055	554	0993	624	665	20	781	1.01
060	575	104	655	703	22	762	0.993
065	595	109	686	741	24	744	981
070	614	114	716	779	27	725	971
0.075	0.632	0.119	0.745	0.816	1.29	0.707	0.962
080	649	123	774	854	31	690	955
085	665	128	803	892	34	672	948
090	681	132	831	929	37	655	942
095	695	137	858	0.968	39	637	937
0.10	0.709	0.141	0.886	1.01	1.42	0.620	0.933
11	735	150	940	08	48	587	926
12	759	158	0.994	17	54	555	920
13	780	167	1.05	25	60	524	917
14	800	175	10	33	67	494	915
0.15	0.818	0.183	1.15	1.42	1.74	0.465	0.913
16	835	192	20	52	82	437	913
17	850	200	26	61	90	410	913
18	864	208	31	72	1.99	384	914
19	877	217	36	82	2.08	359	916
0.20	0.888	0.225	1.41	1.94	2.18	0.335	0.918

h/L_o	tanh kh	h/L	kh	sinh kh	cosh kh	G	H/H_o
0.20	0.888	0.225	1.41	1.94	2.18	0.335	0.918
21	899	234	47	2.05	28	313	920
22	909	242	52	18	40	291	923
23	918	251	57	31	52	271	926
24	926	259	63	45	65	251	929
0.25	0.933	0.268	1.68	2.60	2.78	0.233	0.932
26	940	277	74	75	2.93	215	936
27	946	285	79	2.92	3.09	199	939
28	952	294	85	3.10	25	183	942
29	957	303	90	28	43	169	946
0.30	0.961	0.312	1.96	3.48	3.62	0.155	0.949
31	965	321	2.02	69	3.83	143	952
32	969	330	08	3.92	4.05	131	955
33	972	339	13	4.16	28	120	958
34	975	349	19	41	53	110	961
0.35	0.978	0.358	2.25	4.68	4.79	0.100	0.964
36	980	367	31	4.97	5.07	091	967
37	983	377	37	5.28	37	083	969
38	984	386	43	61	5.70	076	972
39	986	395	48	5.96	6.04	069	974
0.40	0.988	0.405	2.54	6.33	6.41	0.063	0.976
41	989	415	60	6.72	6.80	057	978
42	990	424	66	7.15	7.22	052	980
43	991	434	73	7.60	7.66	047	982
44	992	443	79	8.07	8.14	042	983
0.45	0.993	0.453	2.85	8.59	8.64	0.038	0.985
46	994	463	91	9.13	9.18	035	986
47	995	472	2.97	9.71	9.76	031	987
48	995	482	3.03	10.3	10.4	028	988
49	996	492	09	11.0	11.0	026	990
0.50	0.996	0.502	3.15	11.7	11.7	0.023	0.990
∞	1.000	∞	∞	∞	∞	0.000	1.000