GX506

Ollscoil na hÉireann

National University of Ireland, Galway

SECOND SEMESTER EXAMINATIONS, SUMMER 1999

B.E. Degree

Offshore and Coastal Engineering

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Time allowed: *Three* hours

Answer *five* questions
Each question carries 20 marks

Relevant set of graphs and formulas are available from the invigilator

1. (a) Describe with sketches the important features of a rocky coast. Explain how the geology of an area is an important factor in the configuration of an eroding coast. (7 marks)

   (b) Advance wave rays from deep water to an embayment; and to a headland. In deep water the rays are normal to the coastline. (5 marks)

   (c) If a coastline has irregularly shaped bottom contours and a graphical method is used to evaluate the angle α between wave crest and bottom contour, explain how the refraction template is used for this purpose and why it works. (8 marks)

2. (a) Briefly develop the formula for the fundamental period of oscillation of a closed basin. Use this formula to evaluate the fundamental period of oscillation of a lake with a mean depth of 18.6 metres and a length of 10 kilometres. (10 marks)

   (b) A deepwater oscillatory wave with a wavelength L_o=150 metres, a height H_o=2 metres, and a celerity C_o=16 metres per second moves shoreward with its crest parallel to the depth contours. Calculate the wave height for the given wave when the depth d is 5 metres. Determine the rate at which energy per unit crest width is transported towards the shoreline and the total energy per unit width delivered to the shore in 1 hour by the given waves. (5 marks)

   (c) Describe the set of coastal formations that prevail when sea cliffs are fronted

by beaches. (5 marks)

3. (a) Morison's equation for the force on a pile consists of an inertial term and a drag term. Explain how these two terms arise. (5 marks)

   (b) Derive Morison's equation for the inertia force per unit length on an oblique cylinder. Include a carefully executed definition sketch. (7 marks)

   (c) A design wave with height H=6.0 metres and period T=11 seconds acts on a cylinder with diameter D=1.1 metres in water of depth d=28 metres. The cylinder is oblique and makes an angle of 50° with the vertical axis. Its projection on the horizontal plane makes an angle of 40° with the direction of wave propagation. The cylinder has a length of 15 metres. The upstream end of the cylinder is 4 metres above the seabed, and the downstream end is higher than the upstream end. Find the inertia force on the cylinder when the crest is 30 metres from the upstream end. Take C_M=1.5 and C_D=0.7. If we take the waves as propagating in the $+x$ direction, then 'upstream' refers to $-\infty$ and 'downstream' refers to $+\infty$. Sketch the cylinder and wave propagation direction and locate the various dimensions on the sketch. Take one segment only when subdividing the cylinder. (8 marks)

4. (a) The cover layer of a breakwater consists of two layers of rough quarrystone. The breakwater is designed for nonbreaking waves and minor overtopping from a no-damage design wave of $H_{D=0}$=2.44 metres and a stability coefficient of K_D=4.0. Find the anticipated percentage damage from a wave height H=2.74 metres. (5 marks)

   (b) A 33.5 tonne concrete armour unit is required for the protection of a rubble-mound structure against a given wave height in salt water. The unit weight of water is 10 kN/m^3. The unit weight of concrete used is 22.8 kN/m^3 . Find the required weight of armour unit for concrete with
   (i) unit weight of 22 kN/m^3 and
   (ii) unit weight of 26.7 kN/m^3.
   Comment on the results. (5 marks)

   (c) Describe carefully the method for the evaluation of wave forces and moments on smooth vertical walls. Distinguish breaking from non-breaking waves. (10 marks)

5. (a) In the case of a floating body, name the six degrees of freedom and illustrate using a sketch. (4 marks)

   (b) In plan, a tension-leg platform is built around a square of sides 86.25 metres. Vertical columns, each of height 60 metres and with a circular cross-section of diameter 16.87 metres, are centred at the corners of the square. Four pontoons with rectangular cross-sections connect the columns along the sides of the square. Each pontoon has a depth of 10.5 metres and a breadth of 7.5 metres. The bases of the pontoons and columns lie in the same horizontal plane. A vertical plane containing the axes of two adjacent columns is a plane of symmetry for the

pontoon joining the two columns. The superstructure rests on top of the columns. The TLP floats with a draught of 35.0 metres in seawater of depth 450 metres and is connected to the seabed by four vertical tethers, each tether coming from the centre of the base of a different column. The centre of gravity (c.g.) of the TLP lies at the centre of the square in plan and 3 metres above the free surface. The mass of the TLP is 40,500 tonnes.

(i) Find the pretension in each tether assuming seawater to have a density of 1.025 tonnes/m^3. (4 marks)

(ii) What horizontal force is needed to cause the c.g. of the TLP to surge by 0.8 metres, to sway by 1.0 metre and where should the force be located to cause the TLP to yaw by 2.5°? (4 marks)

(iii) Evaluate the horizontal displacements of the tops of the tethers as a result of the force application in (ii) above. (4 marks)

(iv) In the absence of tethers and applied forces, what would be the draught of the TLP? (4 marks)

6. (a) Develop a computer simulation model for obtaining the shape of shorelines in the longitudinal direction. Sketch possible solutions from such a model for the shape of beaches between groynes and the shape of deltas at the mouth of rivers. (10 marks)

(b) Fig.Q6 a portion of a beach terminated on the south by a rocky headland. With offshore wave statistics and wave-refraction diagrams the longshore transport is determined to be:

S_l (south)=200,000 m^3/year

S_l (north)=130,000 m^3/year

A combination of field measurements and surveys indicates that the sea cliff has been retreating at a rate of 0.4 metres/year. The cliff has an average height of 8 metres, and a total length of 1270 metres is exposed to wave erosion. It is found by sampling that about 60% of the material would remain on the beach once it has eroded.

Five years of measurements indicate that the dunes advanced shoreward at an average rate of 0.125 cm/day. The dunes have a mean height of 4 metres, and they extend for 1100 metres along the coast.

Repeated surveys over a two-year period indicate a 200,000 m^3 loss of beach sand to the canyon.

The river has a drainage area of 2000 km^2. The effective precipitation in the area is 85 cm/year. Sediment samples from the river suggest that only about 10% of the total load is coarse enough to remain on the beach.

Is the beach eroding or accreting? (10 marks)

7. A tidal estuary is a body of water where freshwater interacts with saline sea water. It is also a place where biodegradable wastes originating near the estuary are disposed. In assessing the impact a proposed outfall might have on an estuary, the engineer will have to develop a model for oxygen depletion.

(a) Develop such a model with respect to a fixed reference frame and an oscillating frame. What advantages does the oscillating frame have over the fixed

one? (8 marks)

(b) Apply a time average to the oscillating frame model and indicate how this simplifies the model. (8 marks)

(c) How does a knowledge of the salinity distribution help in developing the model? (4 marks)

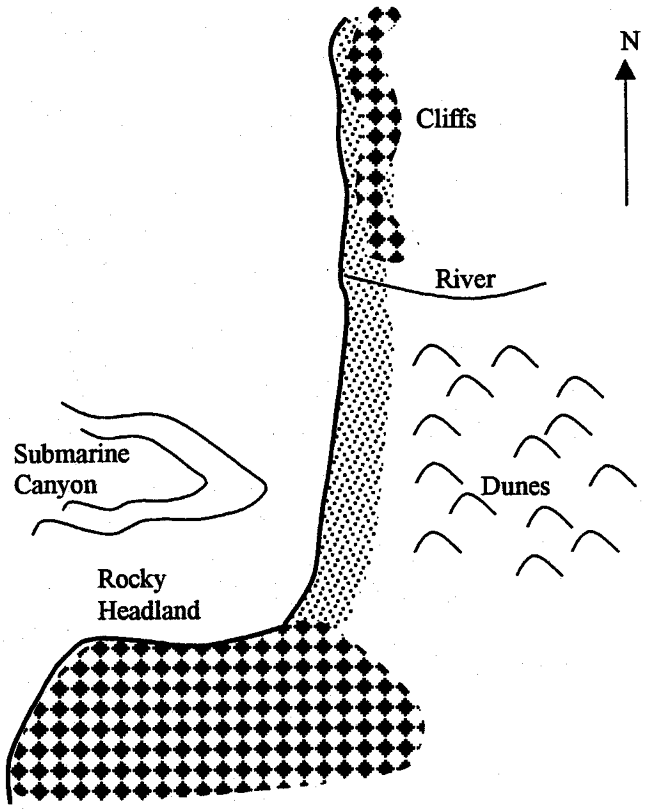

Fig. Q6