WAVE MECHANICS – A3

Q1 If a river is 40m wide, 5m deep, and has a total volume discharge of 400m^3/s, what is the total force acting on the cylindrical bridge pier having a diameter of 2m? Discuss any assumptions made, including your estimate of the appropriate loading coefficients.

Q2 (a) A circular cylinder of diameter *D* is positioned with its axis vertical in deep water and extends from the sea bed up through the water surface. If the cylinder is exposed to waves of amplitude *a*, frequency ω, and wave number *k*, show that the Keulegan–Carpenter number is given by:-

$$\frac{2\pi a e^{ky}}{D}$$

(b) Sketch the flow pattern and briefly explain how the flow induces forces on the cylinder when (i) $\left(a/D\right)=0.5$, and (ii) $\left(a/D\right)=50$

(c). If $\left(a/D\right)=0.5$ state whether you would expect the drag coefficient, C_D, to be large or small compared with the inertia coefficient, C_M. Using Morison's equation, derive an expression for the total force exerted by the waves on the cylinder in this case.

Q3 (a) Explain the meaning of the following forces in the context of Offshore Engineering:

(i) Drag forces
(ii) Inertia forces
(iii) Transverse (or "Lift") forces

Describe the conditions under which they are important, and outline the mechanisms that are responsible for their formation.

(b) A floating structure essentially consists of a vertical column with a draft of 40m and an external diameter of 6m. What is the maximum horizontal force if the structure is located in deep water, and subject to waves having a period of 12 seconds and a surface amplitude of 8m? It may be assumed that $C_D = C_M = 1.0$. Discuss any assumptions made.

Q4 A horizontal pipeline of diameter D = 1m is located with its centreline 3m above the bed in a water depth of d = 15m. The supports consist of concrete blocks located at 20m centres along the length of the pipe. Calculate the total horizontal force acting on a single block, if:

(a) the pipeline is subject to a tidal current of 2m/s acting perpendicular to the pipeline.
(b) the tidal current noted in part (a) above acts at 45º to the pipeline.
(c) the pipeline is subject to waves having an amplitude of a = 2m and a wavelength of λ = 75m, propagating normal to the pipeline.

It may be assumed that the loading coefficients are given by C_D = 1.0 and C_M = 1.5.