Question I (5 Marks):

A wave tank is 200m long, 5.00m wide and 7.00m deep. The tank is filled to a depth of 5.50m with fresh water and a 1.1m high, 6.0-sec period wave is generated.

a) Calculate the wave celerity and length using linear wave theory.

b) Calculate the corresponding deep water wave length and celerity.

Solution

Given: $H = 1.1\text{m}$ $T = 6$ sec $d = 5.5\text{m}$

$L_0 = 1.56T^2 \rightarrow L_0 = 56.16\text{m}$

$d_1/L_0 = 5.5/56.16 = 0.10$

$\rightarrow d_1/L_1 = 0.04 \quad \rightarrow L_1 = 5.5/0.141 = 39.0\text{m}$

$$C_1 = \frac{L_1}{T} = \frac{39}{6} = 6.50\ m/s$$

$$C_o = \frac{L_o}{T} = \frac{56.16}{6} = 9.36\ m/s$$

Question II (5 Marks):

A wave train is observed approaching a coast that has straight parallel near-shore contours in the north-south direction. Where the depth is 5m, the wave length is 85m and the wave crest forms an angle of 12 degrees with the shore (waves from south-west). What is the incident wave direction in deep water?

Solution

Given: $d_1 = 5$ m $\quad L_1 = 85$ m

$d_1/L_1 = 5/85 = 0.06$

$\rightarrow d_1/L_0 = 0.02 \quad \rightarrow L_0 = 5/0.02 = 250\text{m}$

According to Snell's Law gives:

$\sin \propto_o / \sin \propto_1 = L_o / L_1$

$\sin \propto_o / \sin(12) = 250/85$

$\alpha_o = 37.7^o$

Question III (3 Marks):

The table below gives a ranked individual wave heights recordings. It is required to estimate H_{max}, T_{Hmax}, $H_{1/10}$, $T_{H1/10}$ and significant wave height and period.

If the mean of waves heights and periods are 2.9 m and 10.20 sec respectively, what are significant wave height and period (use Rayleigh distribution)? (5 Marks)

Solution

H_{max}=5.5m, T_{Hmax}=12.5s, $H_{1/10}$=(5.5+4.8)/2=5.15m, $T_{H1/10}$=(12.5+13)/2=12.75s

H_x=4.44m, T_x=12.78s.

- use Rayleigh distribution $H_x=1.6\times2.9=4.64$m

Question IV (7 Marks):

Seven consecutive hourly observations of fastest mile wind speed U = 18m/s are observed. Find Hmo and Tp for fetch = 50 km at deep water location using the SPM (1984) method. What would be the result if the fetch length was changed to be = 150km?

Solution

The wind stress factor is

$$U_A = 0.71(18)^{1.23} = 24.84\ m/s$$

Fetch = 50 km

Type of wind wave

The given fastest wind speed indicates that wind is constant in 7 hours, the minimum necessary wind duration is

$$t_{min} = 68.8\left(\frac{gF}{U_A^2}\right)^{\frac{2}{3}}\left(\frac{U_A}{g}\right) = 14949 = 4.15\ hours < 7\ hours$$

Therefore it is fetch-limited condition.

Because

$$\frac{gF}{U_A^2} = 794\ \ < 23123$$

it is not fully arisen sea.

H_{mo} and T_p are given by

$$H_{mo} = 0.0016(794)^{\frac{1}{2}}\left(\frac{U_A^2}{g}\right) = 2.83m$$

$$T_p = 0.2857(794)^{\frac{1}{3}}\left(\frac{U_A}{g}\right) = 6.68s$$

Fetch = 150 km

Type of wind wave

The given fastest wind speed indicates that wind is constant in 7 hours, the minimum necessary wind duration is

$$t_{min} = 68.8\left(\frac{gF}{U_A^2}\right)^{\frac{2}{3}}\left(\frac{U_A}{g}\right) = 49084 = 8.63\ hours\ > 7\ hours$$

Therefore it is duration-limited condition.

$$7 * 3600 = 68.8\left(\frac{gF}{U_A^2}\right)^{\frac{2}{3}}\left(\frac{U_A}{g}\right) \quad \rightarrow \text{ F (fictional fetch) =109427 m}$$

H_{mo} and T_p are given by

$$H_{mo} = 0.0016\left(\frac{9.81 \times 109427}{24.84^2}\right)^{\frac{1}{2}}\left(\frac{U_A^2}{g}\right) = 4.20m$$

$$T_p = 0.2857\left(\frac{9.81 \times 109427}{24.84^2}\right)^{\frac{1}{3}}\left(\frac{U_A}{g}\right) = 8.7s$$