Coastal Structures ('07 Fall)
Mid-Term Exam (10/25 09:30 – 10/27 12:00)

You have to solve this exam by yourself without talking to other persons.

1. (30) Inside surf zone, the probability of the wave height being greater than or equal to an arbitrary wave height ($\hat{H}$) is given by

$$P(H \geq \hat{H}) = \exp\left[-\frac{\pi}{4}\alpha(\hat{H}/\overline{H})^2\right], \quad \alpha > 1.0$$

(for example, see Goda (1975), Coastal Engineering in Japan, Vol. 18). $\alpha = 1.0$ in offshore area.

(a) Derive the expression for the wave height that is exceeded by pN of the waves where N is the total number of waves and $p \leq 1.0$.

(b) Derive the expression for H_p.

(c) Compare $H_p/\overline{H}$ in offshore area ($\alpha = 1.0$) and inside surf zone ($\alpha > 1.0$), and provide a possible explanation for the difference.

2. (30) This problem makes use of the model for random wave breaking proposed by Battjes and Janssen (1978). The notations used herein are the same as in the paper of Battjes and Stive (1985), hereafter referred to as B&S. The probability density function $p(H)$ of the individual wave height H is expressed as

$$p(H) = \frac{2}{H_{rms}'}\left(\frac{H}{H_{rms}'}\right)\exp\left[-\left(\frac{H}{H_{rms}'}\right)^2\right] \quad \text{for } H < H_m$$

where H_{rms}' = unknown reference wave height; and H_m = average breaker height estimated by Eq. (2) in B&S. The fraction of breaking waves denoted by Q is given by

$$Q = 1 - \int_0^{H_m} p(H)dH$$

The root-mean-square wave height, H_{rms} is given by

$$H_{rms}^2 = QH_m^2 + \int_0^{H_m} H^2 p(H)dH$$

(a) Derive Eq. (3) in B&S which expressed Q as a function of H_{rms}/H_m. Show that $H_{rms} = H_{rms}'$ if $Q = 0$.

(b) Show that irregular wave breaking is limited essentially to the region landward of $H_{m0}/h \cong 0.5$ where h = water depth, which is assumed to decrease landward, and H_{m0} = spectral estimate of the significant wave height. It is noted that H_{rms} was calculated using Eq. (8) in B&S. To simplify your calculations, assume that $k_p h << 1$ and $\gamma \cong 0.8$ in Eq. (2) in B&S.

3. (20) In a beach of constant slope of 1:30, a block mound seawall of the slope of 1/2 is constructed to protect a coastal highway. The design significant wave height, period, and principal angle of incidence of the deepwater waves are 3.0 m, 8.0 s, and $40°$, respectively.

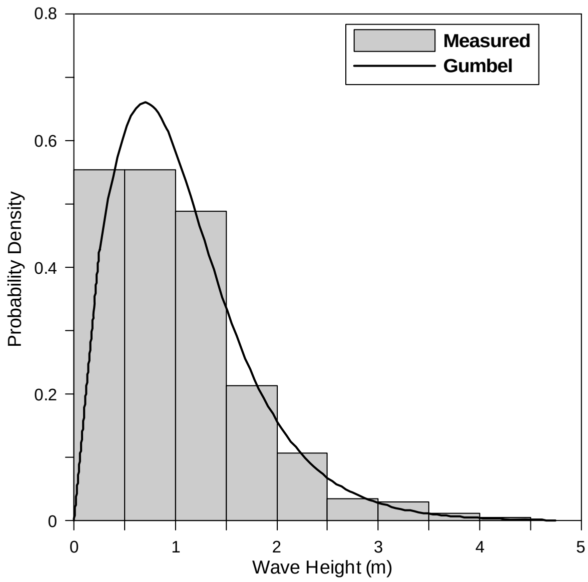
   (a) The sea wall is built in a depth of 4.0 m. Randomly placed two-layer Tetrapod armor units are used to protect the seawall. Calculate the required crest elevation of the seawall. Also calculate the required weight of Tetrapod.

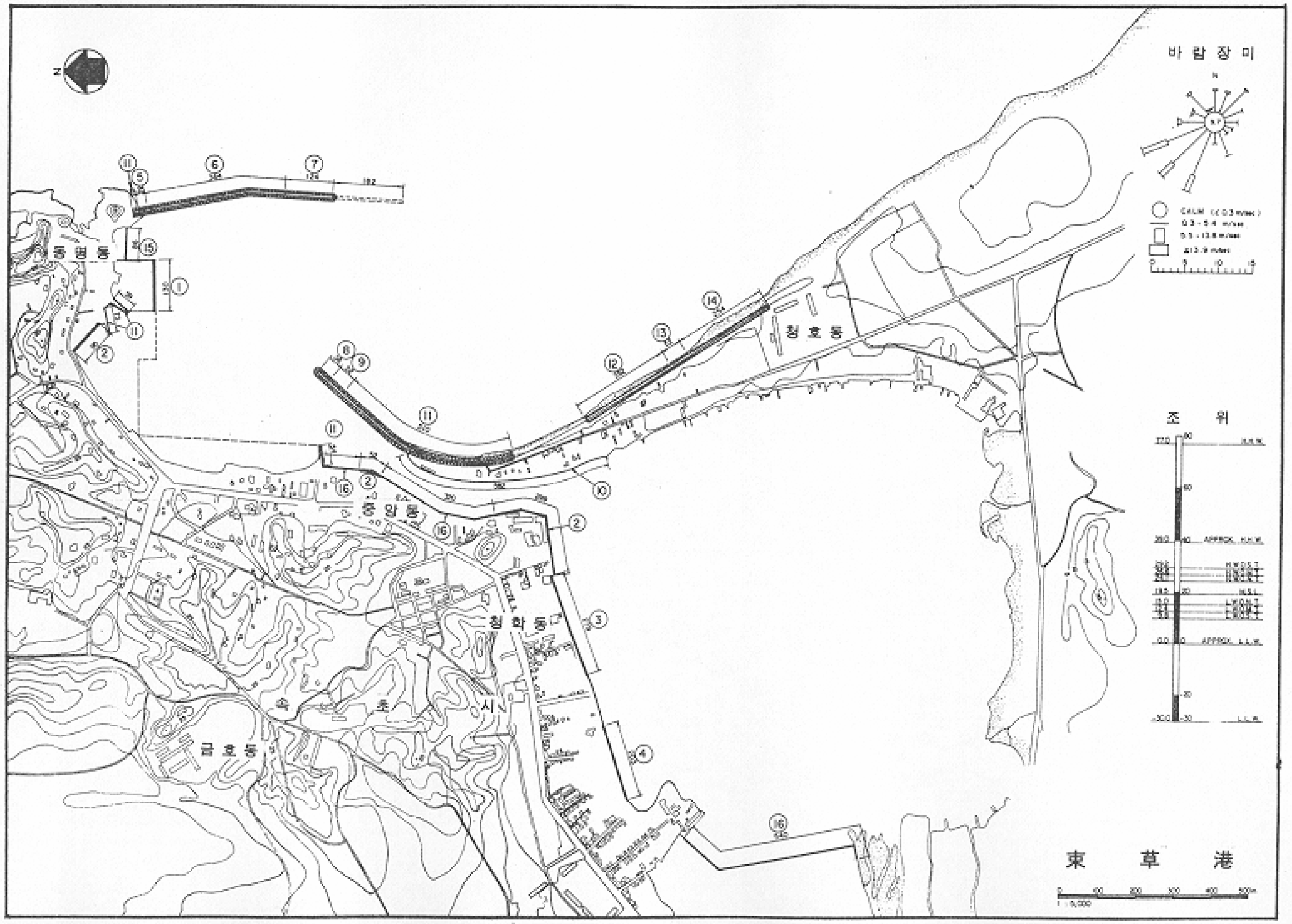
   (b) After a long time, the beach is eroded so that the water depth at the seawall increases to 5.0 m. Calculate the wave overtopping rate and required weight of Tetrapod. Explain the change of these values in relation to wave breaking.

4. (20) You are asked to estimate the exceedance probability of wave height at berth ① inside the Sokcho port whose layout and cross-section of breakwater are shown in the attached figures. The lengths of the breakwaters ⑤, ⑥, and ⑦ are 25, 364, and 124 m, respectively. Assume that these breakwaters have the same cross-section as shown in the figure. According to the wind rose and shoreline geometry given in the figure, the waves from NNE to SE seem to affect the tranquility inside the port. The arm lengths of the wind rose are given in the table. The histogram of probability density of observed offshore significant wave heights is shown below and is given in the table. The prevailing significant wave period is 5.0 s for $H_s \le 1$ m, 6.0 s for $1 < H_s \le 2$ m, and 7.0 s for $H_s > 2$ m. Assume that the water depth inside the port is constant as 13.0 m. You may make reasonable assumptions with clear descriptions to simplify the problem or to use figures and tables in the textbook.

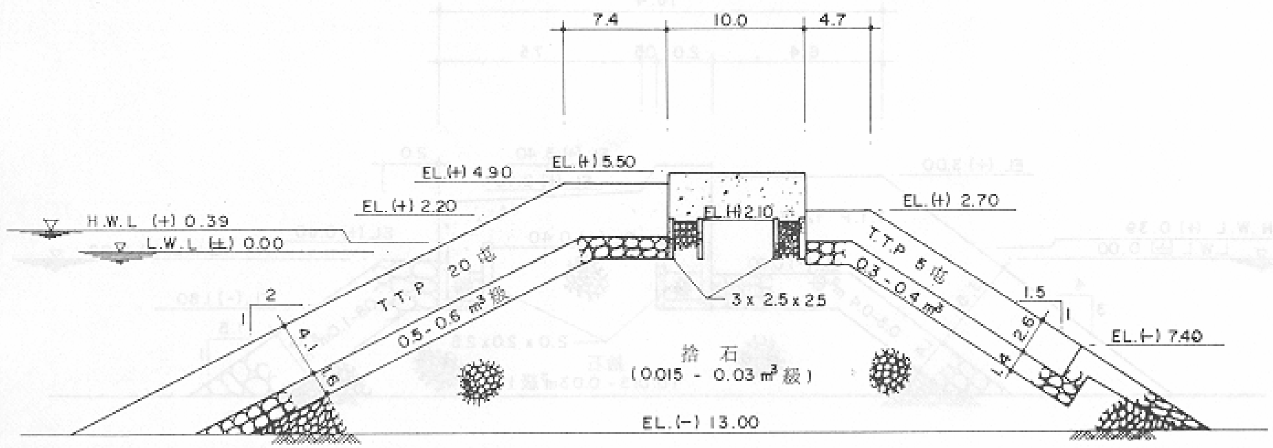
Direction	NNE	NE	ENE	E	ESE	SE
Arm length	10	16	9	5.5	3.5	2.5

H (m)	0-0.5	0.5-1.0	1.0-1.5	1.5-2.0	2.0-2.5	2.5-3.0	3.0-3.5	3.5-4.0	4.0-4.5
p.d.	0.56	0.56	0.48	0.22	0.11	0.03	0.025	0.01	0.005




東 草 港
바 람 장 미
조 위
동명동
중앙동
청학동
청호동
금호동
속 초 시
CALM
APPROX. H.H.W.
M.S.L.
APPROX. L.L.W.
1 : 10,000

東草港	防波堤築造標準斷面圖 (6)	延長 = 364 m



設計條件

潮位 (H.W.L)	m	0.39
波高	〃	4.5
週期	sec	14
波向		E, ENE
風向		W
風速	m/sec	46.0
潮差	〃	0.21～0.23
土質條件		風化岩

1 m 當數量

名稱	規格	單位	數量	名稱	規格	單位	數量
上置콘크리트	σ_{28} = 170 kg/㎠	㎥	34.1	捨石	0.3～0.4 ㎥	㎥	47.13
方塊속채움捨石		〃	7.8	〃	0.5～0.6 ㎥	〃	56.32
方塊바닥고르기		㎡	7.0	테트라포트製作据置	20 屯	個	110.085
上置 〃		〃	5.0	〃	5 屯	〃	59.15
捨石	0.015～0.03 ㎥級	㎥	491.9				