Specialty A

Problem 1

Answer the following questions.

(1) Flexural failure capacity of reinforced concrete beam is determined by reinforcement ratio and concrete compressive strength when the size of beam is fixed. Explain how the flexural failure capacity changes by these factors in about 15 lines. For the explanation, you should draw a diagram where the x axis is reinforcement ratio and y axis is flexural failure capacity.

(2) Figure 1 shows a comparison between measured vertical deflection at the span center and corresponding design prediction of a PC (prestressed concrete) continuous rigid frame box girder bridge with a hinge at the center span. Figure 2 shows structural dimensions of the bridge. Departure from the prediction by the linear creep law started a few hundred days after completion of the bridge. The deflection by the linear creep law was calculated by the superposition method with the creep coefficient of 1.58, which was specified in the design code for practice. The concrete compressive strength of 40 MPa, Young's modulus of 35 GPa, relative humidity of 70 %, volume to surface area ratio of 400 mm and drying shrinkage of 185 μ were used in the calculation at design. Answer the following questions.

a) Explain the mechanisms of drying shrinkage of concrete in about 5 lines.

b) Explain the mechanisms of creep of concrete in about 5 lines.

c) Explain the reason why the deflection of this PC bridge greatly exceeded the predicted values in about 8 lines.

(3) Figure 3 shows a removed concrete deck slab of a highway bridge, which was used in a cold mountainous region. Although the location of bridge is far from the ocean, severe deterioration due to rebar corrosion was found.

a) Briefly explain a possible cause of the rebar corrosion.

b) Briefly explain how rebar corrosion influences on structural performance of the concrete deck slab.

c) Explain two countermeasures and their validity to avoid similar deterioration in a new structure each in about 5 lines.

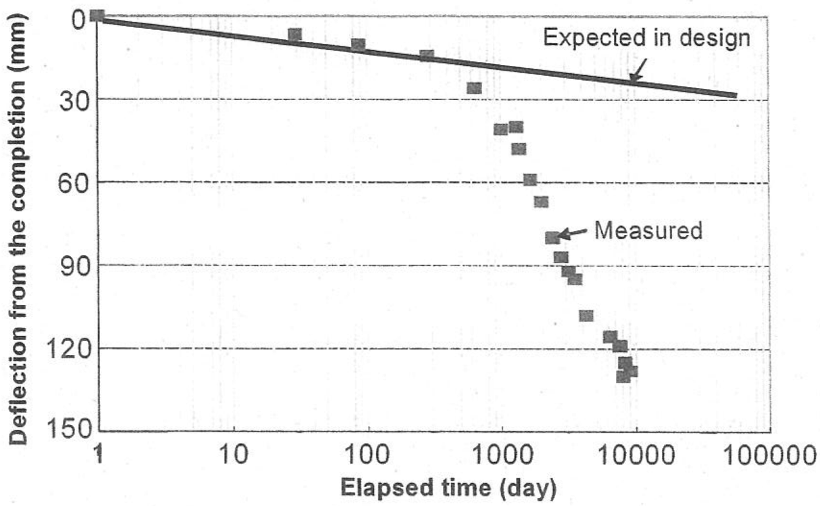


Figure 1

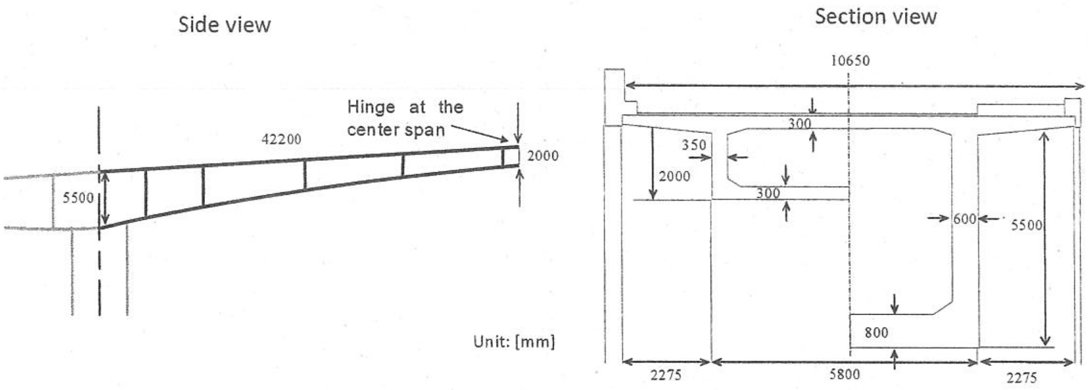


Figure 2

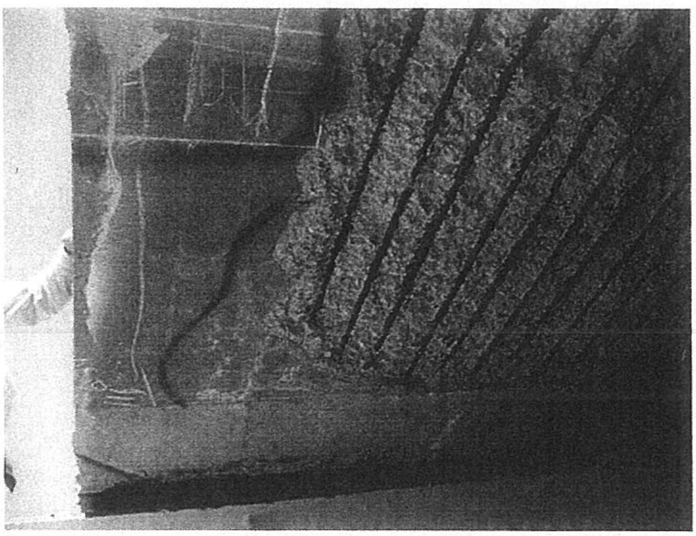


Figure 3

Problem 2

Answer the following questions.

(1) Answer the following questions on consolidation of ground.

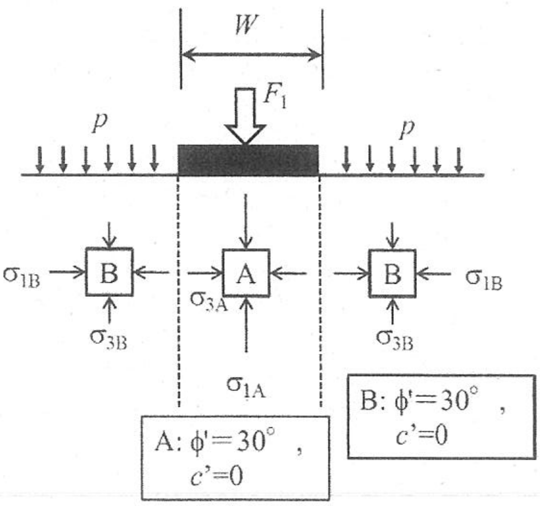
a) Explain the mechanism of consolidation in about 8 lines. If needed, schematic figure(s) can be added.

b) List up three countermeasures using different principles that can be applied to a construction work of embankments on normally-consolidated clayey ground. Explain these principles in about 3 lines each.

c) By assuming a case where a pile foundation is constructed in ground undergoing consolidation settlement, explain the matter(s) that requires attention in about 8 lines. If needed, schematic figure(s) can be added.

(2) Answer the following questions on vertical bearing capacity of a spread foundation having a width W=2.0 m that is constructed on ground with a surcharge p=10 kN/m^2. The effect of the self-weight of the subsoil material can be neglected. If needed, set $\sqrt{3} = 1.7$.

a) Illustrate Mohr's circles of stress for the two types of stress state regions as shown in Fig. 4, where the subsoil material in these regions reaches the failure states, exhibiting an internal friction angle ϕ'=30° without any cohesion (c'=0). Under these conditions, calculate the vertical bearing capacity F_1 in kN/m.



$\sigma_{3A} = \sigma_{1B}$

Figure 4

b) Failure of subsoil does not always occur simultaneously, but takes place in a progressive manner starting from the region near the foundation. As shown in Fig. 5, assume that the stress state A is the same failure state as in a), while the stress state B is a pre-failure state which is given as σ_{3B}/σ_{1B}=0.50. Under such conditions, calculate the vertical bearing capacity F_2 in kN/m.

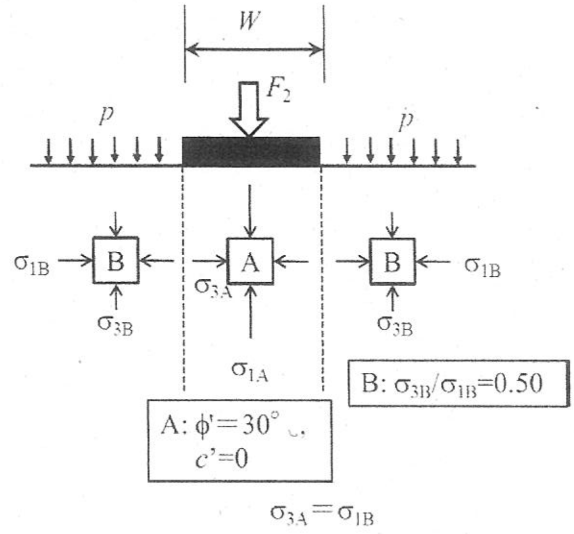


Figure 5

c) Consider another case where the subsoil below the foundation is improved. As shown in Fig. 6, assume that the region with the stress state A reaches failure, exhibiting an internal friction angle ϕ'=30° and a cohesion c'=50 kN/m^2, while the region with the stress state B remains the same pre-failure state as given in b). Under such conditions, illustrate Mohr's circles of stress for these two types of stress state regions, and calculate the vertical bearing capacity F_3 in kN/m.

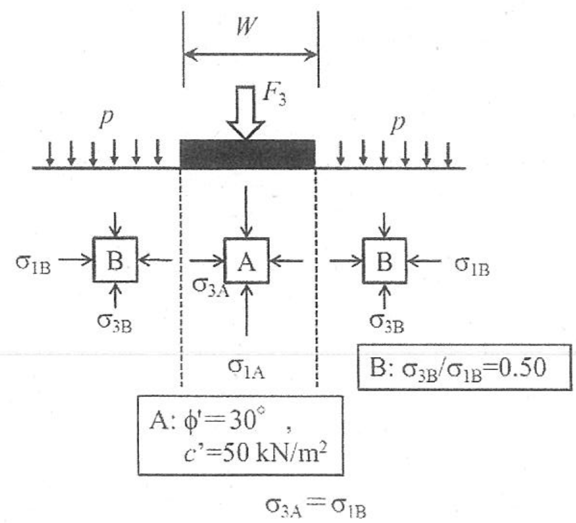


Figure 6

Specialty A

Problem 1

Answer the following questions.

(1) Consider a steady flow in a cylindrical pipe as illustrated in Figure 1. The pipe is situated horizontally and filled with fluid of density ρ. The flow is discharged at the exit (Section II) to form a jet with discharge Q. The diameter of the pipe changes gently from Section I to Section II. The cross sectional area at Section II is one fourth of that at Section I.

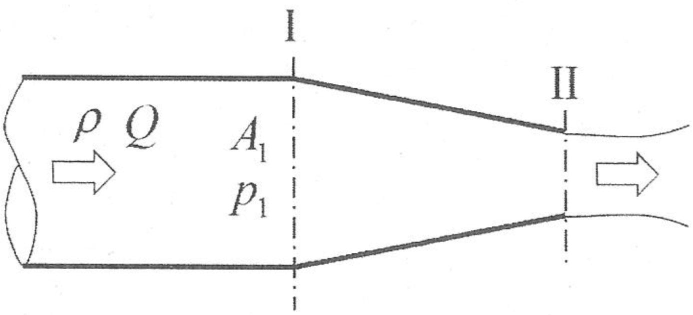


Figure 1

a) Estimate the force exerted to the tapered section of the pipe. Express the force in terms of the pressure p_1 and the cross-sectional area A_1 at Section I.

b) A plate was inserted in front of the exit perpendicularly to the jet as shown in Figure 2. The jet was then bent 90 degrees and spread symmetrically along the plate. Express the force F exerted on the plate in terms of the pressure p_1 and the cross-sectional area A_1 at Section I.

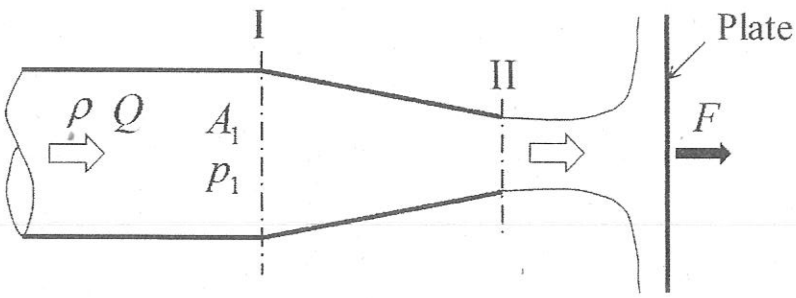


Figure 2

(2) Consider a cubic container filled with water by half up to a depth of h. Static water pressure along the side wall and the bottom is illustrated in Figure 3, where ρ is the density of water and g is the gravitational acceleration. Illustrate the pressure distributions corresponding to the following two conditions in which the container was set in motion. The motion is smooth enough for the water and the container to keep the relative stationarity. Clearly illustrate the difference in pressure distribution between the static and the following dynamic conditions.

a) the container was moved vertically upward with acceleration g
b) the container was moved vertically downward with acceleration g

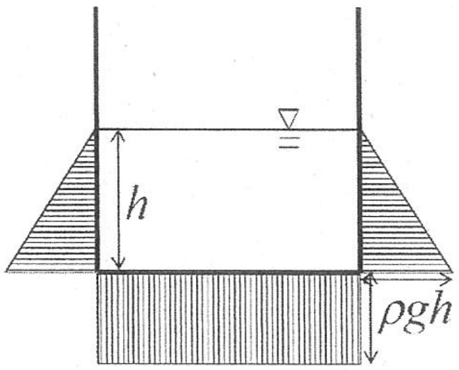


Figure 3

(3) In the structural design of a tsunami evacuation building, it is necessary to estimate the tsunami force. Consider a tsunami hitting the wall of a tsunami evacuation building as illustrated in Figure 4. The velocity distribution in front of the wall when the water pressure becomes maximum is schematically shown in Figure 5. The water pressure at Point A is known to be larger than the static water pressure corresponding to the local flow depth. In Figure 5, the following condition is achieved at all the point along the wall:

$$\frac{\partial w}{\partial t} > 0$$

where w is the vertical component of the water particle velocity and t is time. Explain the reason why the water pressure at Point A becomes larger than the corresponding static water pressure, by applying the vertical component of the momentum conservation equation along the wall.

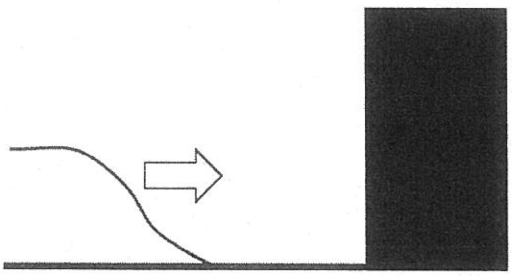


Figure 4

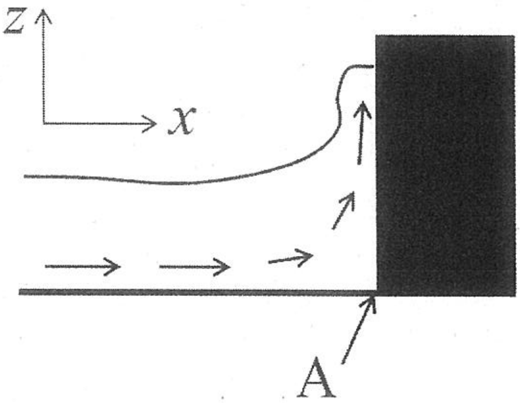


Figure 5

Problem 2

As shown in Figure 6, a sluice gate is installed in a horizontal open channel whose friction can be neglected. Water is spouting out from the opening as a steady supercritical flow and a hydraulic jump is observed upstream side of a counter-dam installed at downstream end. Upstream velocity and depth are v_0 and h_0, height of the opening is h_1, depth at B is h_2, and depth at C is h_3. B is the starting point of the hydraulic jump, and C is located just downstream of the hydraulic jump. In Figure 6, detail of water surface shape is not precisely drawn. Answer the following questions.

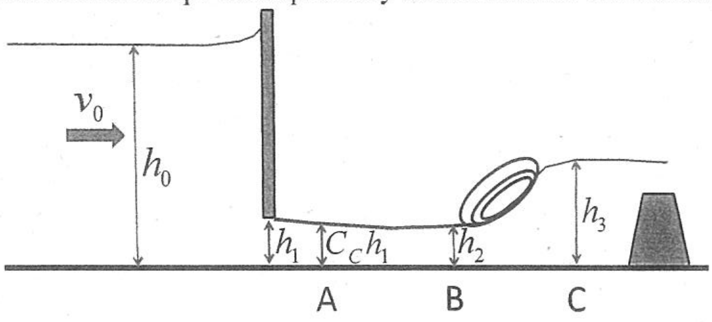


Figure 6

(1) Spouting flow becomes parallel to the horizontal bed at point A that is slightly downstream of the gate, and the depth is denoted as $C_c h_1$, where C_c is the coefficient of contraction. Obtain an expression for the unit width discharge q of the spouting flow in terms of C_c, h_0 and h_1. In addition, explain the reason why the depth at the opening cannot be used but the depth at point A has to be used in calculating the discharge.

(2) Obtain an expression for h_2 in terms of unit width discharge q and h_3.

(3) Answer whether h_2 increases or decreases, if the depth h_3 is increased by increasing the height of the counter-dam. In addition, express h_3 that causes hydraulic jump at point A in terms of $C_c h_1$ and h_0.

(4) Since the supercritical flow released from the gate generally has large energy, an energy dissipation system with a counter-dam is often installed downstream. The height of the counter-dam has to be designed properly, and expected effect cannot be obtained if the height of the counter-dam is too large or small. Explain the reason why the expected effect cannot be obtained in case of too large or too small counter-dam, respectively.

Specialty A

Problem 1

Answer the following questions.

(1) Natural monopolist often emerges in an industry that requires large-scale infrastructure, such as electric power, railway, and water supply. Answer the following questions regarding the natural monopoly.

a) The government often regulates a price to be equal to the average cost in the monopolistic industry. Explain the reason in approximately six lines.

b) What could happen if the government would not regulate the price in the monopolistic industry? Raise two possible consequences and describe them in approximately three lines each.

(2) Suppose that individuals residing near a small river purchase sand bags and provide those voluntarily to construct a bank for flood prevention. More sand bags reinforce the bank and reduce the flood risk, which lead to the increase of individual's utility level. Let the sand bags provided by an individual i be G_i; total sand bags be $G = \sum_i G_i$; the individual's consumption of a private good be X_i; his/her utility function be $U_i(X_i, G)$; and his/her income be Y_i. Assume the prices of the private good and the sand bag are P_x and P_g, respectively. Then answer the following questions. If you do not think that all the necessary information is given for solving the problems, you may give additional conditions.

a) Show that a price ratio of the sand bag to the private good should be equal to the marginal rate of substitution of the sand bag for the private good when the individual provides the sand bags voluntarily, by maximizing the individual's utility function.

b) Let the social welfare function be $W = \sum_i \alpha_i U_i(X_i, G)$ where α_i denotes a positive parameter corresponding to an individual i. Then show that the maximization of the social welfare function leads to the Pareto optimality.

c) Show a condition that the price ratio of the sand bag to the private good should satisfy under the Pareto optimality, by maximizing the social welfare function under a total income constraint.

d) Show that the marginal rate of substitution of the sand bag for the private good in the voluntary provision case should be greater than that in the Pareto optimality case, by comparing the condition shown in a) with the condition derived from c).

e) Based on the fact in d), show that the sand bags provided by the individual in the voluntary provision case should be less than that in the Pareto optimality case when the individual's utility level is constant. Illustrate a diagram if necessary.

Problem 2

Answer the following questions.

(1) Figure 1 shows a traverse network. The coordinates (X_A, Y_A) and (X_D, Y_D) are coordinates of known points A and D, respectively. We will estimate the most probable values of coordinates (X_B, Y_B) and (X_C, Y_C) of unknown points B and C. The observed angle of grid bearing at point A is θ_1. The observed angles at points B and C are α_2 and α_3, respectively. The observed

distances between points AB, BC, CD are s_1, s_2, s_3, respectively.

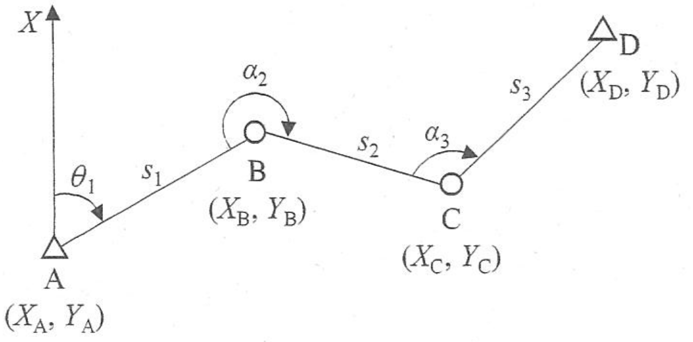


Figure1 Traverse network

a) Show the observation equations of both latitude (ΔX) and departure (ΔY).

b) Derive the normal equations from the observation equations of a). Assume that the observation precisions at all points are equal.

c) Explain how to modify the normal equations of b) in the case that the observation precisions at points are different, in about 5 lines.

(2) Answer the following questions about photogrammetry.

a) Explain the collinearity condition briefly.

b) Explain how to apply the collinearity condition to the orientation briefly.

(3) Explain two representative land cover classification methods with satellite images, in about 15 lines. The answer should include the differences between the two methods.