Specialty A

Problem 1

The issue of global warming can be expressed analogically by using a cylindrical tank whose cross-sectional area is $A(m^2)$ with an attached pipe whose cross-sectional area is $a(m^2)$, as is shown in Figure 1.1.

In this analogy,

- the tank corresponds to the atmosphere;
- the volume of the water in the tank expressed by the water level H (m) is the amount of carbon in the atmosphere;
- the outlet discharge from the pipe q (m^3/s) is the natural absorption flux of carbon;
- the inlet discharge to the tank Q (m^3/s) is the carbon flux emitted into the atmosphere by human beings;
- the water in the tank is ideal fluid;
- all energy loss inside and outside of the tank and pipe can be neglected; and
- it is assumed that hydrostatic pressure is applied to any points including the water surface and the outlet of the pipe.

The following dimensions are given: $a = 0.01m^2$, $A = 100m^2$ and gravity acceleration $g = 10.0m/s^2$.

(1) We assume that the amount of carbon in the atmosphere in 1900 was under a steady state which corresponded to the water level $H = 5m$. Then, calculate the carbon emission by human beings at the time which corresponds to the inlet discharge in this analogy.

(2) We assume that human beings emit doubling carbon emission and the volume of carbon in the atmosphere is under a steady state at a specific time because the natural absorption flux of carbon is balanced with the emission. Then, calculate the volume of carbon stored in the atmosphere at the time by using the depth of water in this analogy.

(3) It is reported that the volume of carbon corresponding to the water depth in the tank that is obtained by the problem 1 (2) seriously damages human beings. If the carbon emission could be cut to zero immediately, how long would it take for the volume of carbon in the atmosphere to get back to the state in 1900? Derive the equation to calculate the time length in this analogy. You need not to solve the equation numerically.

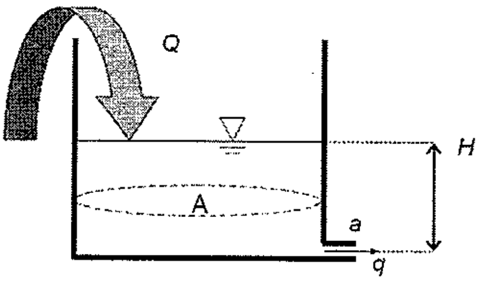


Figure 1.1

Problem 2

Answer the following questions.

(1) Consider the steady uniform flow in a straight open channel. Water is flowing only in the channel direction and the velocity in other directions can be neglected. In this channel, flow direction is X-axis and vertical direction is Y-axis. The velocity is kept constant in the cross-sectional direction (Z-axis). Moreover external forces and the effect of turbulence can be neglected. Then, derive the momentum equation of the flow in this channel.

(2) Consider the steady uniform flow in a straight open channel. Water is flowing only in the channel direction and the velocity in other directions can be neglected. In this channel, flow direction is X-axis and vertical direction is Y-axis. The velocity is kept constant in the cross-sectional direction (Z-axis). Moreover external forces can be neglected. The viscosity can be neglected because the target area is apart from the channel bed. Derive the momentum equation of the flow in this channel.

(3) Reynolds stress can be derived based on the Prandtl's mixing length assumption. The mixing length is proportional to the depth and the proportionality coefficient is Karman constant κ. In the case of above question (2), derive the differential equation to represent the velocity profile in the vertical direction.

Problem 3

Cross-section of a river channel is composed of high water channels that are inundated during flood but are usually utilized for playground etc. and a low flow channel where water is running through in usual discharge. Answer the following questions.

(1) Figure 3.1 shows a single cross section and a compound cross-section. In which channel, discharge is larger when the channels are filled with water? Select an answer from "Single > Compound", "Single < Compound" or "Single =Compound" by adding the reason . The roughness of side walls and riverbed is same, and the roughness and the riverbed slope are equivalent between two channels.

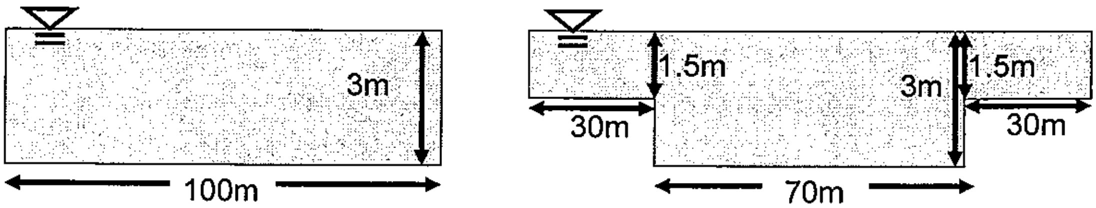


Figure 3.1 Single cross-section (left) and compound cross-section (right)

(2) When a flood occurs, water level in a channel rises. This phenomenon can be represented by a following equation

$$\frac{\partial Q}{\partial x} + \frac{\partial A}{\partial t} = 0$$

where "x" is distance in flow direction, "Q" is discharge, "A" is cross-sectional area, and "t" is time.

Which river channel shown in Figure 3.1 can store more water while the discharge changes from usual discharge Q_A to flood discharge Q_B. Select an answer from "Single > Compound", "Single < Compound" or "Single =Compound", by adding the reason expressed by the above equation. When the discharge is Q_B, water flows also on the flood plains, while water runs only through low flow channel when the discharge is Q_A.

(3) Recently, flood plains are covered with trees in many rivers. Tree growth in a river channel causes several problems in flood control in addition to environmental problems. What kinds of flood risk can be concerned as trees in a river channel grow? Explain possible risks in each area, a), b) and c), within a few lines respectively.

a) Protected inland around the river section covered with trees.

b) River structures in a low flow channel adjacent to the river section covered with trees.

c) Further down reach of the river section covered with trees.

Problem 4

Answer the following questions on flood disasters in Japan and Bangladesh.

(1) There are several types of flood disasters that commonly occur both in Japan and Bangladesh. Here, types of flood disasters are classified according to meteorological factors, topography, and geographical factors. Then, describe the common types of flood disasters for both countries. In addition, describe different types of flood disasters between two countries.

(2) Flood disaster in Bangladesh sometimes causes a huge damage that cannot be imagined to occur in Japan. Why can such a huge damage be caused there? Describe several reasons.

(3) In case that "global warming" is evident in the middle and end of this century, the severity of flood disasters is anticipated to increase. Then, describe "adaptation measures" that Japan should promote for coping with the increase of the severity of flood disasters as mentioned above. Describe your opinion in about 25 lines. (Note: There are two kinds of "measures" against anticipated climate change: one is "adaptation measures" and the other is "mitigation measures." Here, "adaptation measures" is a technical word that denotes measures for better flood defenses and so on, while "mitigation measures" is a technical word that indicates measures for reducing green-house gas emission. Therefore, you should not describe measures for reducing green-house gas emission.)

Specialty A

Problem 1

In an urban area shown in Figure 1-1, the ground is investigated at four points (A, B, C and D) with distances of 750 m in the East-West direction, and 600 m in the North-South direction. The ground surface altitude and the depth of ground water surface from the ground surface at each point are shown in Table 1-1. The ground is uniform sandy layer (permeability coefficient $k = 2.0 \times 10^{-1}$ cm/s, dry density $\rho_d = 1.92$ g/cm^3, and soil particle density $\rho_s = 2.40$ g/cm^3) for a depth of 15 m, with an impermeable layer laid below it. Estimate the shape of ground water surface in the area of square A, B, C and D, and assuming that the ground water levels are nearly unchanged through out the year, answer the following questions. A coordinate x - y is defined as show in Figure 1-1, with Point C to be the origin.

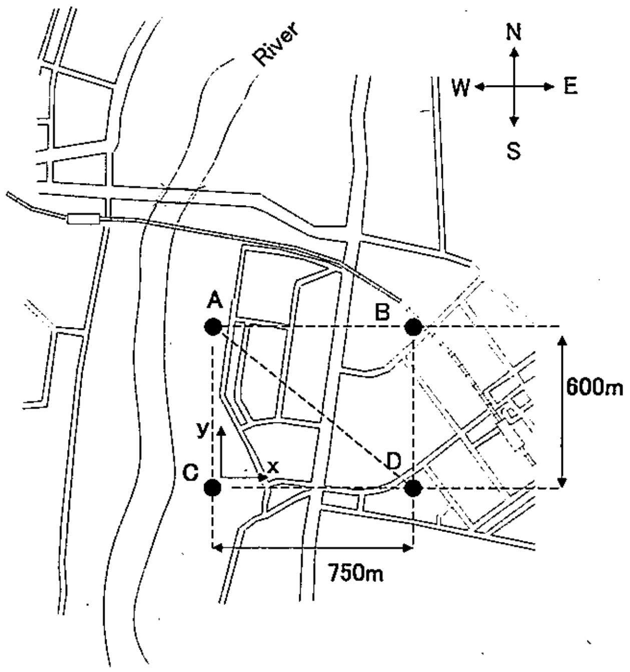


Figure 1-1

Table 1-1

Point	Coordinate(x)	Coodinate(y)	Ground surface altitude	Depth of water surface from ground surface
A	0 m	600 m	42 m	3 m
B	750 m	600 m	55 m	6 m
C	0 m	0 m	36 m	1 m
D	750 m	0 m	52 m	7 m

(1) Calculate the direction of ground water flow in the area of square A, B, C and D.

(2) Calculate the amount of ground water flowing through the area below the segment A-D per 1 minute.

(3) A water-soluble pollutant contaminated the ground water at Point B. The pollutant moves together with the ground water without diffusion, without changing the permeability of the ground water. Estimate the point where the pollutant could reach after 100 days.

Problem 2

Consider a strip foundation of 20m wide and 4m high constructed in clay ground as shown in Figure 2-1, where ground water level is equal to the ground surface (GL = 0m). An unconfined compression test was performed on an undisturbed sample taken from 5m below the ground level. A stress-strain relationship is shown in Figure 2-2. The soil sample was fully saturated, having soil particle density, ρ_s, of 2.6 g/cm^3, water content, w, of 46%. Triaxial compression tests on isotropically consolidated specimens were also conducted. The effective stress paths obtained from the tests are schematically shown in Figure 2-3. Use the value of acceleration of gravity, g =9.8m/s^2, density of water, ρ_w=1.0g/cm^3, if necessary.

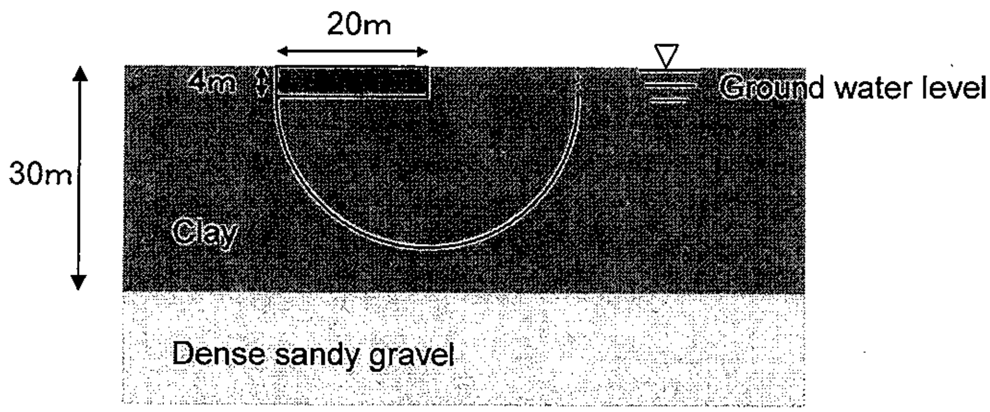


Figure 2-1 Ground and foundation

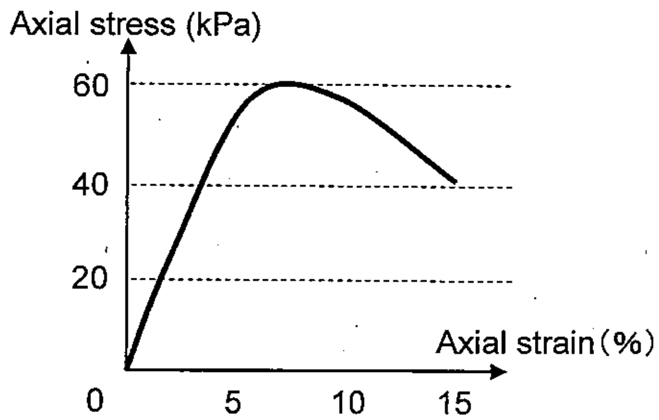
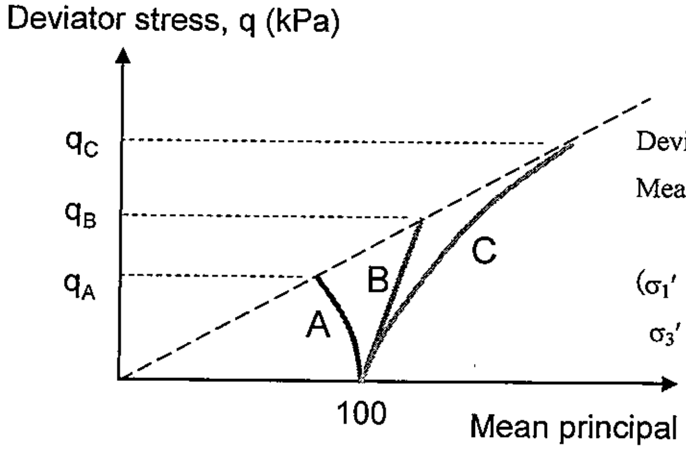


Figure 2-2 Stress strain relationship obtained from an unconfined compression test on undisturbed sample taken from GL = - 5m



Deviator stress: $q = \sigma_1' - \sigma_3'$

Mean principal effective stress: $p' = (\sigma_1' + 2 \times \sigma_3')/3$

(σ_1' : Maximum effective principal stress

σ_3' : Minimum effective principal stress)

Test condition :

Specimen	Effective confining pressure in isotropic consolidation and swelling	Drainage condition in shear
A	100kPa	Undrained
B	100kPa	Drained
C	Consolidated to 200kPa, then swelled to 100kPa	Undrained

Figure 2-3 Effective stress paths obtained from triaxial compression tests on undisturbed sample taken from GL = - 5m

(1) Calculate void ratio, e, and saturated unit weight, γ_{sat}.

(2) Calculate undrained shear strength, c_u.

(3) Estimate the maximum allowable load (per unit length) on the foundation, by assuming a circular slip line as shown in Figure 2-1. Unit weight of foundation is 22kN/m^3. Safety factor is 1. The value of c_u is independent of the depth. The load on the foundation is uniformly distributed. You can ignore the resistance of soil above GL = - 4m.

(4) It was found that the foundation was incapable of bearing a designed load. How do you solve this problem? Give three examples of possible countermeasures and/or modification of foundation, with the explanation of the mechanism behind.

(5) Explain the stability of foundation and ground in the following three cases with reference to Figure 2-3.

a) construction of an upper structure on the foundation in short period

b) construction of a upper structure on the foundation in long period, allowing enough time for consolidation

c) ground preloading preceded the upper structure construction

Problem 3

(1) Explain effects of the following factors on the deformation and strength characteristics of sand.

a) density

b) confining pressure

c) anisotropy

d) drainage condition

(2) Explain the roles and functions of following methods in the research of geotechnical engineering. Give specific examples in the explanation.

a) model experiments and laboratory soil experiments

b) site investigations

c) theoretical or empirical modeling and numerical analysis .