Entrance Examination for the 2017,

Department of Civil Engineering,

Graduate School of Engineering, The University of Tokyo

Questions of "Civil engineering"

August 29th 2016 (Monday) 13:00 - 16:00 (180 minutes)

(Fields 4 is not provided in English.)

Please write your answers to questions in two fields which you have selected on the questionnaire sheets in advance. If you answer questions in different fields, your answers shall not be marked.

Please use different answer sheets for different questions. For each of answer sheet you have, please fill your examinee's number, field number, and question number (e.g. Field 1, Question 1).
You can use the reverse side of answer sheets. When you require additional answer sheets for Fields 1 through 6, please raise your hand. If you use multiple answer sheets for one question, please put sheet number. You can ask additional answer sheets for calculation.
You have to submit questions, questionnaire sheets, and all answer sheets (including blank sheets or ones for calculation) after the examination.
For Field 7 (Mathematics), please select two questions out of six questions. Please note that special answer sheets are provided for Field 7 and that you cannot use additional answer sheets for Field 7.

Field 1 (Structures)

Question 1

Consider a horizontal beam. The elastic modulus (Young's modulus), the second moment of area, and the span of the beam are denoted by E, I, and L, respectively.

(1) Suppose that the beam is subjected to uniformly distributed vertical load, p. Write a differential equation for the vertical deflection of the beam, w. We take the x-axis along the beam, and w is a function of x; the left and right ends are $x = 0$ and $x = L$, respectively.

(2) Write the boundary conditions when the beam is simply supported.

(3) When the beam ends are fixed, w at the center ($x=L/2$) becomes smaller compared with the case when the beam is simply supported.

a) Write the boundary conditions when the beam ends are fixed.

b) The shear force that acts at the beam ends does not change if the boundary conditions are changed from the simple support to the fixed end; the shear force is $pL/2$. Explain the reason for the same shear force briefly.

c) The bending moment that acts at the beam ends changes if the boundary conditions are changed from the simple support to the fixed end. Explain briefly the reason that w at the center becomes smaller when the beam ends are fixed, knowing that the bending moment changes.

Question 2

A structure with a mass of M[kg] attached to the top of a tower with the mass of m[kg] shown in Figure 1, is modeled as a two-degree-of-freedom system as shown in Figure 2. Here, k_1[N/m] and k_2[N/m] are spring constants.

(1) Obtain the equation of motion of this system. x_1[m] and x_2[m] are the horizontal displacement of mass M and m, respectively. f_1[N] and f_2[N] are the horizontal forces acting on mass M and m, respectively.

(2) When $M = 3m$ and $k_2 = 3k_1$, show all the eigenfrequencies and mode shapes of this system.

(3) The behavior of the system shown in Figure 2 may differ from the original structure shown in Figure 1. Describe two limitations of the simplified model.

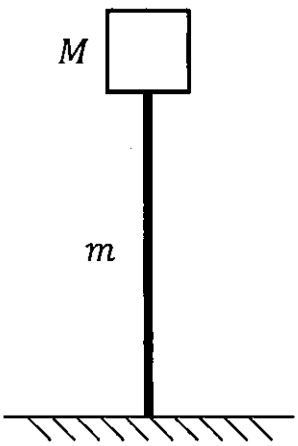

Figure 1

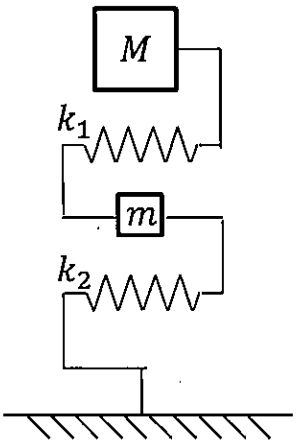

Figure 2

Field 2 (Concrete Engineering and Geotechnical Engineering)

Question 1

Answer the following questions.

(1) The accuracy of the prediction of shear capacity of reinforced concrete (RC) beam is generally lower than that of the flexural capacity. First, explain the calculation method of the predicting capacity briefly with illustrations in about 3 lines, respectively. Then, explain the reason for the lower accuracy in about 3 lines.

(2) Consider a flexural failure of RC beam with the yielding of main bar. When the bond between concrete and the main bar is lost except the anchorage zone, how does the load-displacement curve change compared to the sound one? Draw the load-displacement curves and explain the difference in about 6 lines.

(3) If the reinforcement bars are placed too much in RC, its safety reduces in some cases. Give examples explaining reasons in about 5 lines.

(4) In general, railway bridges are exposed to the larger load than the road bridges. In terms of the maintenance against fatigue, however, maintenance of the railway bridges is easier. Explain the reason in about 5 lines. Use illustrations, if needed.

(5) For the durability of RC, allowable crack width is specified in design. In some cases, however, cracks do not cause serious problems. Give an example explaining the reason in about 4 lines.

Question 2

(1) Answer the following questions in 3 to 6 lines, respectively. You can use illustrations if necessary.

a) In Japanese urban cities, including Tokyo and Osaka, large scale ground settlement had occurred from 1920s to 1960s due to pumping of ground water. Explain the mechanism by which the settlement developed.

b) Suppose a structure is constructed on a soft clay ground. Describe effective methods and their principles in order to i) reduce the amount of ground settlement and ii) shorten the time period for the consolidation, respectively.

c) Describe what is "dilatancy". Explain dilatancy characteristics of loose sand, dense sand, normally consolidated clay and over consolidated clay in drained shear behavior, respectively.

(2) Explain briefly, in 3 to 6 lines, the difference between clay and sand, with respect to the following aspects, using keywords indicated in parentheses.

a) Physical properties (grain size, consistency, void ratio)

b) Consolidation characteristics (permeability, compressibility, normal consolidation, over-consolidation)

(3) For construction of a ventilation tower of an undersea tunnel, sheet piles were driven into the sea bed in cylindrical shape. The sea bed consisted of uniform sandy soil (void ratio, e=1.0, density of sand grain, ρ_s=2.8 g/cm^3, density of water, ρ_w=1.0 g/cm^3). Ground inside the cylindrical area surrounded by the sheet piles was excavated. The water inside was pumped during the excavation. Suppose the ground water level inside was at the excavated ground surface (level A). Pore water pressure at the bottom of area ① (level B) was the same as the static water pressure at the tip of sheet pile at area ②. Answer the following questions.

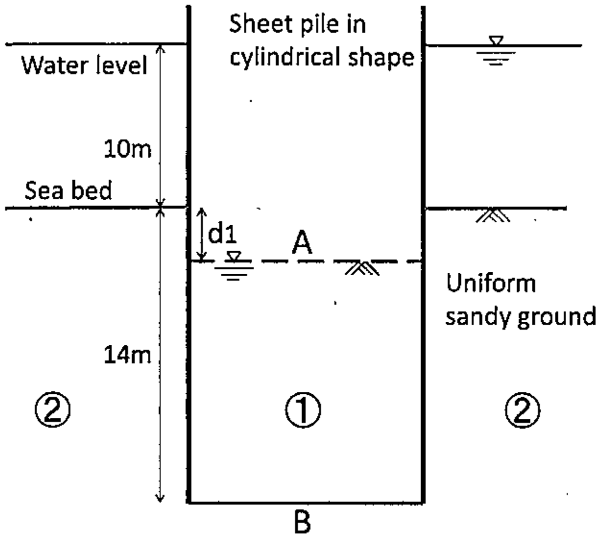

Figure 1

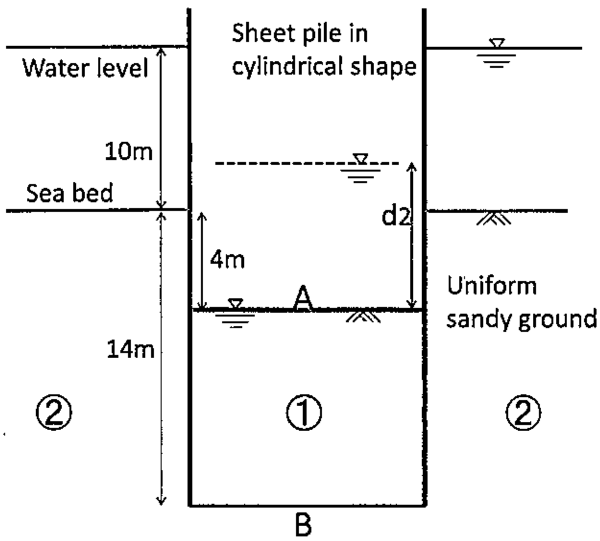

Figure 2

a) Suppose the penetration depth of the sheet pile was 14 (m) as shown in Figure 1. At the moment the excavation level reached d_1(m), area ① became unstable due to upward seepage flow. Calculate hydraulic gradient of area ① and d_1 (m).

b) At the state of a), as an urgent countermeasure to stabilize area ①, water was put inside. Then the excavation was continued to 4m below the sea bed as shown in Figure 2. Calculate the water level, d_2 (m), required for stabilizing area ①.

Field 3 (Hydrosphere Engineering)

Question 1

Two identical rectangular tanks were connected by a horizontal pipe with length of L and cross-section area of s (Figure 1). The cross-section area of each tank is A and the water with density, ρ_w, was poured into these tanks and the pipe. When the water levels in each tank were the same, the valve installed on the pipe was shut off and then the cube 1 with a side length of r_1 and the density of ρ_1 ($< \rho_w$) was floated in the left-side tank. Let us call this state, shown in Figure 1, as "initial state."

In Figure 1, x is the horizontal axis positive in the rightward direction along the center line of the pipe, X and Y are points on this horizontal axis and are respectively located at each end of the pipe, H_w is the height from the point Y to the initial water level in the right-side tank, η is the elevation from the initial water level. Define u as the horizontal velocity in the x-direction in the pipe, g as a gravitational acceleration. The water depth of the left tank is assumed to be deep enough to keep the cube floated all the time. Answer the following questions.

(1) Determine the draft, h, of the cube 1 floated in the left-side tank and the elevation of the water level in the left-side tank from X.

(2) When the valve was slowly opened, the water level on the right-side tank gradually elevated and stopped at certain level. Determine this water level change, $\eta = \eta_0$, from the initial water level.

(3) Return to the initial state. The valve was rapidly opened and then the water level in these tanks started to oscillate. Assume that cube 1 vertically moves with the oscillating water level and the draft, h, is kept constant.

a) Determine p_X and p_Y, the pressure at X and Y, when the water level in the right side tank is η. Assume that the atmospheric pressure, p_a, is zero, A is sufficiently large compared to s and thus the fluid velocity in both tanks including at locations X and Y is negligibly small.

b) Assuming perfect fluid condition, write the horizontal momentum equation of the fluid in the pipe along the horizontal axis, x, using horizontal velocity u and the pressure, p. Assume also that there is no head loss inside and outside of the pipe.

c) Integrate the momentum equation obtained in b) from X to Y in the x-direction to derive the relationship between the water level displacement, η, and the horizontal velocity in the pipe, u.

d) Apply the mass conservation equation under the assumption of perfect fluid to obtain the

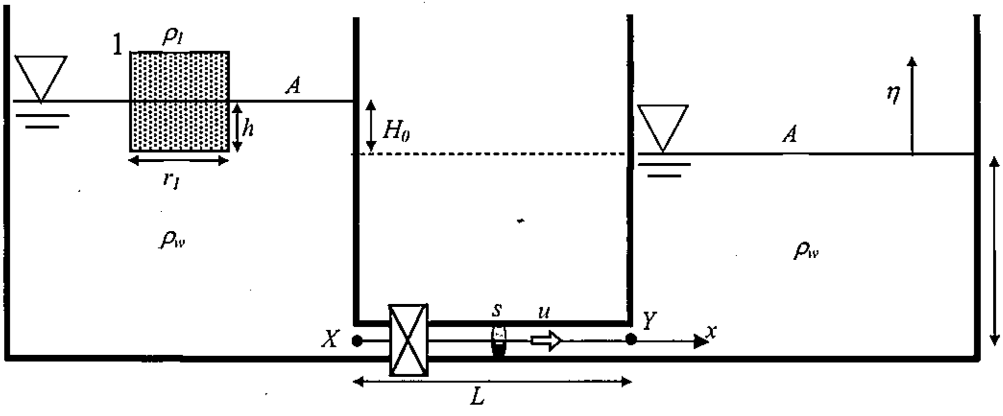

Figure 1

relationship between η and u.

e) Using the relationships derived in c) and d) to eliminate u and defining $\xi=\eta-\eta_0$, determine the governing equations of ξ.

f) Show that the horizontal velocity, u, is expressed by the following equation [1] where t is defined as the time after the instantaneous opening of the valve. Obtain the expressions of U_0 and ω in [1].

$$u = U_0 \sin \omega t \qquad [1]$$

g) The same experiment was repeated changing all the length scale of the system to one hundred times larger. Explain how many times larger did the horizontal velocity, u, and the frequency of the oscillation become under this condition.

(4) Return to the initial state and now the cube 2 with side length of r_2 and the density of ρ_2 ($>\rho_w$) was placed in the pipe. Assume that the cube 2 is sufficiently small compared to the cross-section of the pipe and thus has no influence on the oscillating horizontal velocity in the pipe, $u = U_0 \sin \omega t$, obtained in (3) f). Under this condition, the horizontal fluid force, F, acting on the cube 2 can be expressed by the following equation [2].

$$F = \rho_w C_D r_2^2 u|u| + \rho_w C_M r_2^3 \frac{\partial u}{\partial t} \qquad [2]$$

Here, the first and the second term of the right hand side of [2] are the drag force and the inertia force with C_D and C_M, the drag and the inertia coefficient, respectively.
Draw graphs of the horizontal velocity, the drag force, and the inertia force over one-wave period. Using $u = U_0 \sin \omega t$, express the peak values (equations) of these graphs.

(5) The same experiment was repeated by gradually enlarging the side length of the cube 1. The cube 2 then started to move when the side length of cube 1 reached to $r_1=R_1$. Assume that the uplift force acting on the cube 2 can be neglected and that the cube 2 starts to move when the horizontal fluid force, F, exceeds the static friction force between the cube 2 and the bed of the pipe. Assume also that the static friction force is always proportional to the normal force acting on the cube 2 and the static friction coefficient is always constant in the following questions.

a) Keep this cube 1 ($r_1=R_1$) floated in the left side tank, return to the initial state, and now the side length of the cube 2, r_2, was doubled. When the valve was rapidly opened under this condition, explain how many times larger the following quantities will be: the drag force; the inertia force and the static friction force. Then judge whether the cube 2 moves or not under this condition. Here, assume that the density of these two cubes do not change and the doubled r_2 does not affect the drag and the inertia coefficients and the fluid velocity in the pipe.

b) Return to the initial state of (5). This time, r_2 was doubled as was (5) a) and then the length of the pipe, L, was shortened to a half of its original length. Under this condition, the valve was rapidly opened. Judge whether the cube 2 starts to move or not and explain the reasons.

Question 2

Answer the following questions on water related disasters.

(1) Write appropriate words in 【1】【2】【4】【5】 and an appropriate sentence in 【3】 to complete the text below. If you do not know proper names, you can write descriptive text instead.

"It is a national priority to protect national land as well as citizens' lives, livelihoods, and property from natural disasters. The turning point for strengthening the disaster management system came into effect in response to the immense damage caused by 【1】 in 1959, and led to the enactment of 【2】 in 1961, which formulates a comprehensive and strategic disaster management system."

"Japan is prone to a variety of water and wind-related disasters including flooding, landslides, tidal waves and storm hazards, owing to meteorological conditions such as typhoons and active weather-front systems and geographical conditions such as 【3】, as well as settlement conditions in which many of cities are built on river plains. One-half of the population is concentrated in possible inundation areas, which account for about 10% of the national land."

"In order to reduce damage caused by severe weather disasters, structural measures such as 【4】 and non-structural measures such as 【5】 must be promoted in an integral manner."

Reference: "Disaster Management in Japan", Cabinet Office, Government of Japan, 2015. http://www.bousai.go.jp/1info/pdf/saigaipamphlet_je.pdf

(2) After the 2011 Tohoku Earthquake, the Japanese government has classified tsunami hazards into two major categories; L1 and L2. Explain the difference of L1 and L2, including the difference of disaster countermeasures within 7 lines.

(3) The idea "design high-water level should be planned as low as possible" is a basic principle of Japanese river management. Explain why this basic principle has been adopted within 7 lines.

(4) Below is an abstract of the paper "American and Dutch Coastal Engineering: Differences in Risk Conception and Differences in Technological Culture" by Dr. Wiebe E. Bijker in 2007. Read the following paragraphs and then explain in 20 lines, which flood protection standard is suitable for Tokyo; American or Dutch.

"How is it possible that the USA failed to keep New Orleans dry, when large parts of the Netherlands can exist below sea level? This question, with all its implicit rhetoric about the big and mighty Americans and the small and weak Dutch, generated a flock of American expeditions to the Netherlands in the aftermath of the flooding of New Orleans by hurricanes Katrina and Rita in 2005. The big US television networks, channels such as National Geographic, and political delegations, including the Louisiana governor and members of the US Congress, visited the Netherlands within a few months after the flooding, and all parties returned with spirited reports of how the Americans could learn from the Dutch. Does this suggest that the US Army Corps of Engineers is less able than the Rijkswaterstaat engineers in the Netherlands? I will argue that something else is going on: that the difference is not one of expertise and competence.
In this paper I compare the styles of US and Dutch coastal engineering, and argue that they express different conceptions of risk management in relation to flooding. These differences can, perhaps, be explained by reference to the wider technological cultures of both countries, rather than to the specific engineering cultures. The core of my analysis, however, is aimed at the styles of coastal engineering. In this paper I am not interested in blaming artefacts or humans - levees/dikes and warning systems – or politicians or engineers involved in their design or maintenance. My conjecture is that even had everyone and everything functioned effectively, the historical style of American coastal engineering would encourage accepting the kind of flooding that occurred after Katrina."

Difference between America and Netherlands is written in the main text as follows:

"The key phrase in the USA is 'flood hazard mitigation', and the key ideas in this discourse are 'prediction' and 'insurance', which suggest that the very fact of flooding is accepted. The risk criterion that is used in designing levees and other coastal defense structures in the USA is a 1:100 chance, or a 'hundred year flood'. This criterion is a technical norm, carrying important professional 'weight' among coastal engineers, but it carries no legal authority.
How different is the practice in the Netherlands. The water should be kept out. In the Deltaplan law, the criterion of 1:10,000 was specified: not merely as a technical norm, but as an obligation embedded in the 'Delta Law', unanimously approved by parliament. The 1:10,000 criterion specifies that levees in central Holland have to be designed 'for a surge level and wave condition occurring with a 1:10,000 probability'. Under these conditions, the defense system should not fail."

Reference: American and Dutch Coastal Engineering: Differences in Risk Conception and Differences in Technological Culture, Wiebe E. Bijker, Social Studies of Science, 37, pp. 143-151, 2007. (http://www.jstor.org/stable/25474506)

Field 5 (Land, Urban, Transportation and Landscape Planning)

Question 1

Assuming that there are two routes (route 1 and route 2) from point O to point D and the traffic volume in one direction is in total 10,000 veh/hr as illustrated in Figure 1, answer the following questions.

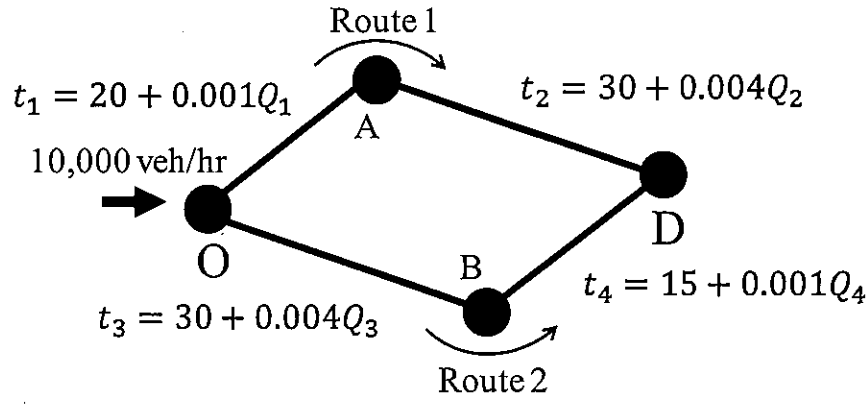

Figure 1 Setting of the transportation network

(1) Explain Wardrop's first principle in traffic assignment in about three lines.

(2) If the relationships between each link's traffic volume in one direction Q [veh/hr] and its travel time t [min] are as illustrated in Fig. 1, calculate the traffic volume of the route 1 in one direction according to Wardrop's first principle.

(3) Because of severe traffic congestion, a new one-way link was constructed from the node A to B. Explain in about three lines what phenomenon will be observed after that.

(4) Instead of constructing a new link, the traffic flow in the route 2 is now controlled by road pricing. Assuming the total traffic volume of 10,000 veh/hr is constant, calculate the amount charged to the traffic in the route 2 so as to control the traffic flow in the route 2 as 2,000 veh/hr. Here, the value of time is defined as 2,400 yen/hr.

(5) Read the following paragraph about road pricing and judge whether each of the underlined descriptions (a) – (f) is True or False.

Road pricing usually has two kinds of charging principles: charging on a particular road and charging in a fixed area in a city. With regard to the former principle, we can expect (a)more congestion reduction in general when pricing on uncongested road rather than pricing on congested road. In Tokyo metropolitan area, (b)route-based pricing service was started due to the enhancement of alternative routes as a result of ring roads development. In the future, dynamic optimization of traffic assignment would be possible by utilizing ETC2.0 such as (c)toll discount in detour routes. With regards to the latter principle, there are mainly two methods of charging; (d)toll-ring method to charge vehicles that are crossing borderlines around a city center and (e)area-wide method to charge vehicles that are running inside an area of a city. Charging amount can be flat whole day or can be changed based on peak/off-peak hours. In London, congestion charge with (f)toll-ring method was introduced to improve environment and reduce congestion in the city center.

Question 2

Answer the following questions.

(1) The German word "Landschaft" originally means a state of local lands organized by human activities; and it implies a region distinguished from the peripheral area by the characteristics of its appearance.

a) In General, characteristics of a region's appearance are given by the lifestyle of inhabitants, patterns of space or topography, common land use and so on. Give a concrete example of "Landschaft" in seven lines specifying the characteristics of its appearance.

b) Only controlling land use by zoning is not sufficient for preserving "Landschaft". Show the reason in seven lines.

(2) Figure 2 shows the streetscape of Ginza Street (27 m width), the main street of Ginza Brick Town completed in 1877, Tokyo. Figure 3 shows the topographical map of the area around Ginza Brick Town in 1909.

a) Ginza Street is the first modern style street in Japan. Give three features of space or furniture which show it's a modern style street by referring to Figure 2. Explain each of them in one line.

b) The street network of Ginza Brick Town was planned systematically as shown in Figure 3. The width of streets was categorized into 27 m, 18 m, 14.4 m and 5.4 m, and eaves height of buildings along the streets were restricted depending on the streets' width as shown in Table 1. Discuss in 10 lines what kind of impressions each category of the streets gives us, by using the Maertens's law and relation between sensation of being surrounded and angles of elevation.

Figure 2 Ginza street (completed in 1877)

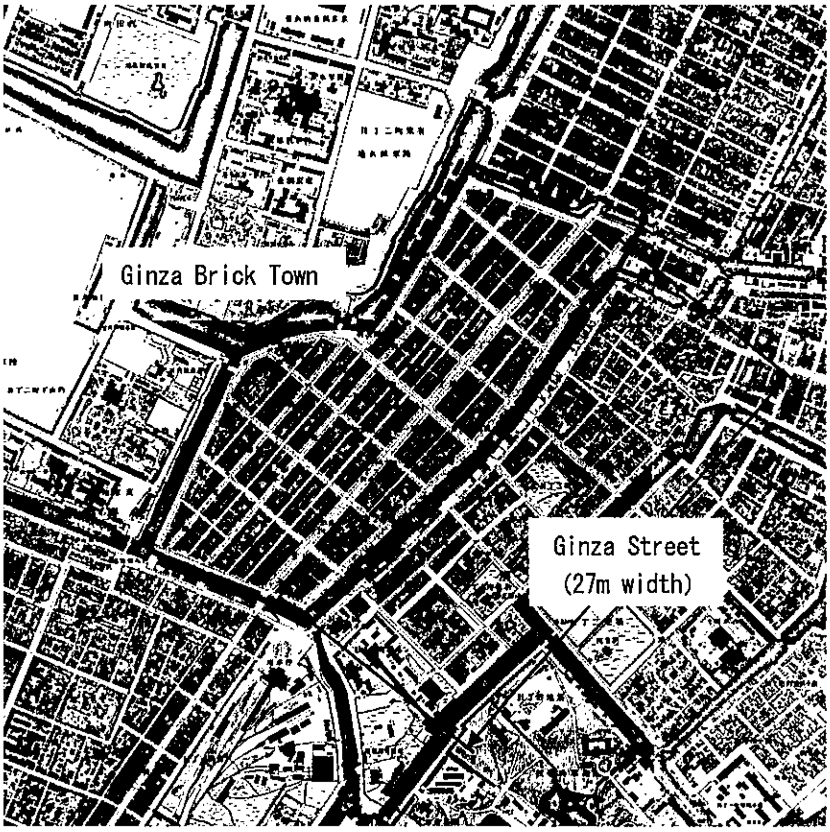

Figure 3 Topographical map of the area around Ginza Brick Town in 1909

Table 1 Street width and restriction of eaves height in Ginza Brick Town

Street width (D)	Restriction of eaves height (H)	D : H	Angle of elevation (arctan H/D)
27 m	9 m	3 : 1	approx. 18°
18 m	9 m	2 : 1	approx. 27°
14.4 m	7.5 m	1.9 : 1 (≒2 : 1)	approx. 27°
5.4 m	6 m	0.9 : 1 (≒1 : 1)	approx. 45°

Field 6 (International Project and Management)

Question 1

Read the following paragraphs on management of a road construction project in an urban area and answer questions on the underlined parts.

This is a project which constructs a 4-lanes road infrastructure including a temporary support for existing buildings and a relocation of underground lifelines. At its approval, this project was planned to be performed as a model project utilizing Information and Communication Technology (ICT) and 3-dimensional data model in order to promote construction productivity.

At its start, the project owner hired a project manager for the whole project①. And the project manager made contracts with a design firm, a construction company and a maintenance company ② concurrently, so as to put know-hows in a construction stage and a maintenance stage into a design.

At its design stage, the project manager consulted the design with stakeholders of the project, assessed risks③ which were predicted to occur during the project and conducted Value Engineering (VE)④, so as to make the project within a budget and a planned construction period which were stated at its approval.

At its construction stage, a three-dimensional virtual model developed in the design stage was renewed to a definite model⑤ based on measured quality and the amount of work done at the site. The project manager examined bills submitted according to the amount of work done, and the construction company was paid its necessary expenses⑥.

The designer, the constructor and the maintenance manager always shared information of the project and collaborated with each other having a common goal to complete the project successfully.

(1) Regarding the underlined part ①, explain the requirements to be considered in the selection of the project manager and their reasons in about 5 lines.
(2) Regarding the underlined part ②, explain an appropriate selection method for the construction company and its reason in about 3 lines.
(3) Regarding the underlined part ③, explain risk responses, that is, avoidance, mitigation and acceptance, using a concrete example in about 3 lines each.
(4) Regarding the underlined part ④, explain what is Value Engineering in about 3 lines.
(5) Regarding the underlined part ⑤, explain how to utilize the definite model effectively in the project in about 3 lines.
(6) Regarding the underlined part ⑥, explain issues to be considered in the contract with the construction company to make such a payment in about 5 lines.

Question 2

Answer the following questions regarding the recent situation of infrastructure development in Asian developing countries:

(1) In addition to Official Development Assistance (ODA), private participation has been increasing in infrastructure development in Asian developing countries. Answer the following questions:

a) Explain the benefits of private participation for developing countries, comparing to ODA, in about 5 lines.

b) Japan has been one of the major donors of ODA in Asia. Explain why the amount of Japan's ODA has recently been decreasing, in about 3 lines.

(2) With ample funds from the Japanese private sector and ODA, Japanese private companies are expected to actively participate in infrastructure development business in developing countries. Explain possible ODA measures to encourage Japanese private companies to engage in infrastructure development, in about 5 lines.

(3) Japanese companies and the government are expected to produce innovative products and services in future international projects; a good example is the "Cool Japan" strategy of the government. Explain the role of innovation in this context, in about 4 lines.