2024年8月26日14時~16時30分 14:00-16:30, August 26, 2024

# B 都市工学専門B Urban Engineering Subjects

# 受験番号

修

(Examination I.D.)

- (1) すべての答案用紙の所定の欄に、問題番号、受験番号を記入し なさい。<u>氏名を記入してはならない。</u>
   Write the question number and your examination I.D. on all the answer sheets. <u>Do not write your name.</u>
- (2) 問題冊子に受験番号を記入しなさい。Write your examination I. D. on this sheet.
- (3) B-1~B-15の15問の中から<u>5問を選択</u>し、解答しなさい。ただし、5問の解答の中で以下の条件を満たすこと。
  ・専攻分野として「都市環境工学」を希望するものは、B-1~
  B-7のうちから3問以上選択しなければならない。
  - ・専攻分野として「都市計画」を希望するものは、<u>B-8~B-</u> <u>15のうちから3問以上</u>選択しなければならない。

Answer five questions out of the 15 questions (B-1 to B-15) following the instruction below:

- If your major field of study is "Urban Environmental Engineering," then select at least three questions from B-1 to B-7.
- If your major field of study is "Urban Planning," then select at least three questions from B-8 to B-15.
- (4) <u>答案用紙は1問につき1枚(裏を含む)</u>とし、問題毎に用紙を 変えなさい。

Use one answer sheet for each question. You may write your answers overleaf.

2024年8月26日14時~15時 14:00-15:00, August 26, 2024

# B 都市工学専門B Urban Engineering Subjects

# 受験番号

博

(Examination I.D.)

- (5) すべての答案用紙の所定の欄に、問題番号、受験番号を記入しなさい。
  氏名を記入してはならない。
  Write the question number and your examination I.D. on all the answer sheets. <u>Do not write your name.</u>
- (6) 問題冊子に受験番号を記入しなさい。Write your examination I. D. on this sheet.
- (7) B-1~B-15の15問の中から2<u>問を選択</u>し、解答しなさい。ただし、以下の条件を満たすこと。

・専攻分野として「都市環境工学」を希望するものは、<u>B-1~</u> <u>B-7のうちから2問</u>選択しなければならない。

・専攻分野として<u>「都市計画」</u>を希望するものは、<u>B-8~B-</u> <u>15のうちから2問</u>選択しなければならない。

Answer two questions out of the 15 questions (B-1 to B-15) following the instruction below:

- If your major field of study is "Urban Environmental Engineering," then select two questions from B-1 to B-7.
- If your major field of study is "Urban Planning," then select two questions from B-8 to B-15.
- (8) <u>答案用紙は1問につき1枚(裏を含む)</u>とし、問題毎に用紙を 変えなさい。

Use one answer sheet for each question. You may write your answers overleaf.

## B-1 Water and Wastewater Engineering

- Q.1 Answer the following questions on disinfection of drinking water.
- (1) In Japan, Article 17, Paragraph 1, Item 3 of the Ordinance for Enforcement of the Water Supply Act stipulates that the residual free chlorine concentration detected at the tap must be maintained at 0.1 mg/L or higher. Explain the reason why chlorine should be detectable at the tap.
- (2) Even in a properly chlorinated drinking water system meeting the conditions described in(1), health problems due to contamination of drinking water with *Cryptosporidium* may occur. Explain the major reason and propose a possible countermeasure.
- (3) Explain the relationship between chlorine dosage and residual free chlorine concentration by drawing graphs in the following two cases: "(i) pure water" and "(ii) water containing oxidizable substances (Fe<sup>2+</sup>, Mn<sup>2+</sup>, H<sub>2</sub>S, organic matter, etc.)".
- (4) Explain the principle of breakpoint chlorination. If needed, a figure may be used for explanation.
- (5) Monochloramine may be used as a disinfectant. Explain the advantages of monochloramine over free chlorine as a disinfectant.

#### Q.2 Answer the following questions on sewage facilities.

- (1) Explain the difference between combined sewer and separate sewer, and describe the problems or issues associated with the combined sewer.
- (2) Explain the role of the primary sedimentation tank and the final sedimentation tank in the conventional activated sludge process.
- (3) Explain the functions and features of stormwater detention and infiltration facilities for preventing urban inundation.

#### B-2 Hydraulics

- Q.1 Explain the following terms.
- (1) Critical slope
- (2) Cavitation
- (3) Piezometric head
- (4) Coefficient of viscosity
- (5) Critical Reynolds number
- Q.2 Explain what is determined by Venturi meter and draw its structure. Also give the equation to show the principle of determination by the Venturi meter. The symbols in the equation should be shown in the drawing.
- Q.3 Answer the following questions on the relationship between water level and flow rate at a triangular weir as shown in the figure below.
- (1) Derive the flow rate dQ through the elemental rectangular section at water depth z. Assume the elemental section as an orifice and use a coefficient of discharge c.
- (2) Derive the total flow rate Q through the weir as a function of water level H, integrating the obtained dQ in Question (1) by water depth.



#### B-3 Water Environment

- Q.1 Among the environmental water quality standard items established for river, lake, sea and groundwater, answer a water quality standard item which is unique to each water body. In addition, explain the reason for each answered item why it is uniquely applied to the water body. Answer "none" if there is no such a unique item.
- Q.2 Wastewater from a factory containing pollution load is being discharged into River A at Point X located in the midstream of the river. Curve (a) in Figure 1 shows the profile of dissolved oxygen concentration in River A at a certain time on a certain day. Assume that BOD concentration and discharge flow rate of the wastewater are constant regardless of the period and time. Answer the questions below.
- As shown in Figure 1, a curve representing the profile of dissolved oxygen concentration along the flow distance, plotted with dissolved oxygen concentration on the vertical axis and the flow distance on the horizontal axis, is called (i). Answer a term that fits in (i).
- (2) Answer how the shape of Curve (a) changes if the flow rate of River A increased. Draw the curve together with Curve (a). In addition, explain how the two curves differ and its reason(s).
- (3) Curve (b) represents the dissolved oxygen concentration profile at a different time on the same day as Curve (a). Explain possible reason(s) why Curve (b) differs from Curve (a). Assume that the river flow rates are same.



Figure 1 Profile of dissolved oxygen concentration in River A

- Q.3 Concisely explain the terms below on water environment, respectively.
- (1) Ecotone
- (2) Saltwater wedge

#### B-4 Environmental Microbiology

- Q.1 Explain the following terms concisely.
- (1) Glycolysis
- (2) Active transport
- (3) Plasmid
- Q.2 Answer the following questions on the modified Ludzack-Ettinger biological nitrogen removal process for municipal wastewater treatment.
- (1) The growth of nitrifying bacteria is generally slow. To promote nitrification, it is necessary to retain a sufficient biomass of nitrifying bacteria in an aerobic tank. Explain how to operate the process to achieve that condition.
- (2) Nitrifying bacteria perform nitrification reaction using enzymes. Explain the general mechanism of how bacteria synthesize enzymes from genes.
- (3) Methanol (CH<sub>3</sub>OH) is sometimes added to an anoxic tank to accelerate denitrification reaction. Describe the catabolic reaction equation in which methanol is used to convert nitrate ion ( $NO_3^-$ ) to nitrogen gas ( $N_2$ ). In addition, state the electron donor and the electron acceptor in this reaction.
- (4) In the modified Ludzack-Ettinger biological nitrogen removal process, explain why an aerobic tank should be placed after an anoxic tank with respect to the water quality of municipal wastewater and the characteristics of denitrifying bacteria.
- Q.3 In enhanced biological phosphorus removal process for municipal wastewater treatment, competition between polyphosphate-accumulating organisms and glycogen-accumulating organisms can decrease the removal ratio of phosphorus. Explain how competition between them affects phosphorus removal.

#### B-5 Environmental Chemistry and Reaction

Q.1 Consider a reaction in which the enzyme E and substrate S produce the product P via the enzyme-substrate complex ES, as expressed in following equation:

$$E + S \stackrel{k_1}{\rightleftharpoons} ES \stackrel{k_3}{\to} E + P$$
$$k_2$$

where the concentrations of E, S, and ES are denoted by [E], [S], and [ES], respectively, the total enzyme concentration  $[E_0]$  is constant, and [ES] is assumed constant. Answer the questions below.

- (1) Express [E] using [ES], [S],  $k_1$ ,  $k_2$ , and  $k_3$ .
- (2) Express [ES] using  $[E_0]$ , [S],  $k_1$ ,  $k_2$ , and  $k_3$ .
- (3) When the production rate  $r_1$  of P is given by the following equation, express  $V_{\text{max}}$  and  $K_m$  using [E<sub>0</sub>],  $k_1$ ,  $k_2$ , and  $k_3$ .

$$r_1 = \frac{V_{\max}[S]}{K_m + [S]}$$

Next, consider the case of contamination with antagonistic inhibitor I. The binding of the enzyme to the antagonistic inhibitor I is reversible and forms the enzyme-inhibitor complex EI, where the concentrations of I and EI are denoted by [I] and [EI], respectively. The reaction between the enzyme and the inhibitor is expressed as follows.

$$E + I \rightleftharpoons EI \\ k_5$$

- (4) Express [EI] using [E], [I],  $k_4$  and  $k_5$ .
- (5) Express [E] using [E<sub>0</sub>], [S], [I],  $k_1$ ,  $k_2$ ,  $k_3$ ,  $k_4$  and  $k_5$ .
- (6) When the production rate  $r_2$  of P is expressed by the following equation, express X using the other symbols.

$$r_2 = \frac{V_{\max}[S]}{K_m \cdot (1+X) + [S]}$$

- Q.2 Answer the following questions regarding the use of ammonia as an energy source.
- (1) Give two ways to generate electrical energy using ammonia.
- (2) Concisely describe the advantages and disadvantages of the use of ammonia compared to hydrogen.

#### B – 6 Global Environment Engineering

Q.1 Figures below are the graphical representation of nitrous oxide and methane emissions by source shown in "National Greenhouse Gas Inventory Document of Japan 2024" (National Institute for Environmental Studies, Japan). Answer the following questions regarding these figures.



- (1) Answer which figure shows the methane emissions.
- (2) Answer the emission sources that correspond to A and B in Fig.(a), and explain the mechanism by which this gas is generated, respectively.
- (3) Explain the mechanism by which this gas is generated from the source of C "Agricultural soils" in Fig.(b).

Q.2 Answer the following questions regarding climate change adaptation.

- (1) Explain what climate change adaptation is and how it differs from mitigation.
- (2) Three stages are sometimes shown in climate change adaptation, namely "Protect", "Accommodate", and "Retreat". Explain this with a specific example.
- (3) Explain about soft adaptation limit and hard adaptation limit, respectively.
- Q.3 Explain the following pairs of terms in environmental issues by clarifying the difference of two terms.
  - (1) "RCP scenario" and "SSP scenario"
  - (2) "Background data" and "Foreground data" in LCA
  - (3) "Virtual water" and "Water footprint"
  - (4) "Green hydrogen" and "Blue hydrogen"

## B-7 Waste Management and Material Cycles

- Q.1 Describe the contents of each term below and explain its impacts on waste management and material cycle policies so far.
- (1) Waste disposal site and remaining years for landfill
- (2) Marine plastic pollution
- Q.2 Waste incineration facilities are getting attention as important decentralized local energy sources. As waste incineration facilities tend to be located far away from energy demand sites, effective energy utilization is not easy to realize. Explain implementation policies to locally utilize recovered energy toward decarbonized regions using three points below.

Location management of energy demand facilities Co-supply of heat and electric energy Eco-industrial park

- Q.3 Answer the following questions about circular economy practices.
- (1) Provide one example of circular economy practices which is related with multiple stages among production, consumption, and waste management systems and explain its contents.
- (2) Explain environmental, economic, and societal effects of the circular economy practice you answered in (1).

# B-8 Urban Planning

- Q. Answer to the following questions regarding planning and development of urban facilities under the City Planning Act of Japan.
- (1) Name 10 urban facility types out of 15 listed in the Article 11 of the City Planning Act that can be designated in urban planning.
- (2) Explain in about 100 words the reasons why various urban facilities must be designated in urban planning.
- (3) What is the "Regulations on Building in Areas of City Planning Facilities"? Explain in about 150 words.
- (4) Explain in about 100 words the reasons why there are urban facilities that have not been developed for a long time since the urban planning designation.

#### B-9 Urban Design

Q.1 Describe the concepts of the following urban design terms and their application to urban design in about 5 lines each.

(1) D/H

- (2) Rain garden
- (3) Authenticity
- Q.2 Various tools (institutions, mechanisms, and initiatives) are used to create high quality urban spaces. These tools can be divided into those that formally influence the design decision-making process for urban spaces, such as district plans, building agreements, and design guidelines (formal tools), and those that informally influence the process (informal tools). Based on this understanding, answer the following questions.
- (1) List in bullet points three informal tools in urban design.
- (2) Give an example of an urban design in which high quality urban space is created by using both the formal and informal tools, and explain in about 10 lines an overview of the tools used and the relationship between them.

#### B - 1 0 Urban Housing

Q.1 Answer the following questions regarding condominiums (condos).

(1) Fill in the blanks [A] to [J] in the following sentences with the appropriate words.

The acts on the management and reconstruction of condos were amended in 2020. Now, local governments can formulate plans based on [A], certify [B] that meets certain criteria, and provide advice, guidance, and [D] to [C]. Additionally, to promote demolition and reconstruction, not only condos lacking [E] but also condos with peeling exterior walls that may cause harm and condos that lack [F] are now eligible for the special exception of relaxed floor area ratios for reconstruction.

The Tokyo Metropolitan Government enacted an ordinance in 2019 to promote proper management of condos. The ordinance designates responsibilities for [C], such as setting [G], holding [H], and determining the amount to be collected for management and [I]. Additionally, [C] of condos with a certain number of units and years after construction are required to [J] regarding the management status.

- (2) Explain the background of the above acts and ordinance in 2-3 lines.
- Q.2 For the prediction of the housing demand of a municipality, estimate the future population using the cohort change ratio method based on the population data in the table on the next page. The birth rate is defined as the number of children born to women in each age group per year divided by the number of women in that age group. The sex ratio at birth is assumed to be 1:1.
- (1) Estimate the female population aged 25-29 and 30-34 in 2025, respectively.
- (2) Estimate the number of boys aged 0-4 in 2025 born to women aged 20-34 in 2020.
- (3) Explain the difference between the cohort change ratio method and the cohort component method. Additionally, provide an example of a municipality with specific characteristics where the latter method would be more suitable.

Table: Population Data

Age group	2015 Female Population	2020 Female Population	Birth Rate
20-24	8200	8000	0.08
25-29	8800	7500	0.1
30-34	9900	8400	0.12

## B – 1 1 Disaster Management

- Q.1 Explain the history of the enactment of the Urban Renewal Act in the context of making cities fireproof in about three lines.
- Q.2 Explain the "mainstreaming disaster risk reduction" which has been used by the organizations related to the United Nations since around 2000 in about three lines.
- Q.3 In the urban reconstruction following the Great Kanto Earthquake, new spatial elements were created that had never existed before. Pick up two representative ones and explain their outlines and modern significance in about two lines each.
- Q.4 The present high-density wooden housing areas in Tokyo were formed during the two periods: during the post-disaster of the Great Kanto Earthquake in 1923 and during the process of rapid urbanization in the period of high economic growth from the 1960s until the 1970s. Explain the characteristics of both in contrast in about four lines.

#### B-1 2 Urban Analysis

- Q.1 Consider the analysis of visitors' circulation in a shopping street with a mathematical model for the policy discussion to enhance the circulation. This shopping street has two spots to visit, A and B, and we consider the visitors' circulation between them. The ratio of the population in A to that in B at the time t is  $x_t: 1 x_t$ . People in spot A at the time t move to spot B in the next time t + 1 with the probability  $p_{AB}$ , and stay A with the probability  $1 p_{AB}$ . People in spot B at the time t move to spot A in the next time t + 1 with the probability  $1 p_{BA}$ . We can ignore any human flows to other spots and outside of the shopping street. Answer the following questions.
- (1) Find a conditional equation among  $x, p_{AB}, p_{BA}$  when  $x_t$  converges to x.
- (2) Find the general term of  $x_t$  when the initial condition  $x_0$  is given.
- (3) Consider an improvement of this mathematical model. Give a specific example of the model modification and discuss it with its reason in approximately four lines.
- Q.2 Public chairs have been placed since last year in a plaza in the T university. However, some people argued that these chairs are not necessary, so we conducted a questionnaire for the plaza users. The question was whether they positively evaluated the chairs or not, and the users answered with "Yes" or "No." The number of respondents were n, and we recorded  $x_i = 1$  when the *i*th answer was "Yes," and  $x_i = 0$  when "No." Answer the following questions.
- (1) We refer to the ratio of people who answered "Yes" as "approval rate" of chairs. Show the formula of the approval rate of respondents m.
- (2) Fill in the blanks A and B with the most suitable words.

When n is large enough, applying A, we can approximate the distribution of m with the B distribution. Therefore, we can conduct the statistical test about the approval rate.

(3) The questionnaire is not sufficient to conclude whether "the chairs are beneficial for students" or not. List and discuss three reasons within eight lines.

## B-1 3 Urban Transportation Planning

Q.1 A binary logit mode choice model was estimated yielding the following results. For each of the statements below, answer ○ (circle) for a correct statement and × (cross) for an incorrect statement. Furthermore, for each of the incorrect statements, explain in 3~4 lines why it is incorrect.

Variable	Coefficient	t-value	p-value
Public transport constant	0		_
Car constant	-0.5	-1.96	0.05
Travel cost (JPY)	-0.003	-1.65	0.10
Travel time (min)	-0.03	-2.58	0.01
Final log-likelihood	-980		
$LL(\hat{eta})$			

- (1) In the logit model, the error term of the utility follows a Gumbel distribution.
- (2) By including J 1 alternative specific constants in the model, it is guaranteed that the estimated market shares and the observed shares of each alternative match. Here, J represents the number of alternatives.
- (3) The statistical significance of the travel cost coefficient, indicated by its p-value, reflects the practical importance of travel cost.
- (4) The travel time coefficient captures its effect size on choice probability.
- (5) Using only the final log-likelihood, the model's goodness of fit can be evaluated.
- Q.2 Answer the following questions related to contemporary road planning and design.
- (1) Explain what a "road diet" is, and list three of its merits. Answer in 4~5 lines in total.
- (2) Name three main approaches to use road space in a flexible manner, in order to make it human-centric, and explain under which situations it is appropriate to use each approach. Answer in about 12 lines in total.

#### B-14 Regional Planning

- Q. 1 Gentrification caused by redevelopment is progressing around the world recently. Answer the following questions in three to five lines each.
- (1) Explain the mechanism of gentrification caused by redevelopment concretely.
- (2) Propose two specific countermeasures to effectively cope with the gentrification caused by redevelopment.
- Q. 2 Read each of the statements regarding urban and regional policy in the age of depopulation, answer "o" (a circle) if the statement is correct and "×" (a cross) if it is incorrect.
- As of April 2024, there are no "*municipalities with the potential to disappear*" in Tokyo Metropolitan Government jurisdiction, according to the prediction of Japan in 2050 published by the "Population Strategy Council" in April 2024.
- (2) As of April 2024, none of the municipalities in Tokyo Metropolitan Government jurisdiction have formulated a "*Location Normalization Plan*", which is expected to be utilized in a municipality facing with significant population decline.
- (3) In the 2020s, the overall population of the countries of the Global South, including Asia, Africa, and Latin America, has begun to decline.
- (4) In the 2020s, the population of the U.S. is increasing, and the social increase is larger than the natural increase.
- Q. 3 Explain each of the following terms related to national and regional planning in Japan briefly in two to three lines.
- (1) Megacity
- (2) Act on Development of Infrastructures for Wide-Area Revitalization
- (3) Technopolis
- (4) Comprehensive Management Plan for Public Facilities

## B-1 5 Landscape Planning and Environmental Design

- Q.1 Briefly explain the following four terms related to landscape planning in 3 to 4 lines each.
- (1) 30by30
- (2) Garden Residential Zone (Denen-jyukyo-chiiki)
- (3) River basin management (Ryuiki-chisui)
- (4) Tokyo Green Plan (Tokyo-ryokuchi-keikaku)
- Q.2 Answer the following three questions about cultural landscapes.
- (1) Briefly explain the concept and characteristics of cultural landscapes in 3 to 4 lines.
- (2) "Important Cultural Landscapes" are selected under the Act on ( A ) in Japan. Write the words that apply to ( A ).
- (3) Describe two advantages and two disadvantages of the areas selected as "Important Cultural Landscapes" becoming tourist destinations. Answer in a total of 6 to 8 lines.