

Question 1

(1) Short-term load

The design load consisting of the long-term load (such as dead and live loads) that acts continuously, combined with one of the following variable actions: snow load, wind pressure, or seismic force. It is used for allowable stress design. The snow load, wind pressure, and seismic force are assumed to represent a heavy snowfall, strong wind, or moderate earthquake that is likely to occur at least once during the building's service life (typically 50 years).

(2) *Zenshuyo* Style

An architectural style established in medieval Japan under the influence of Chinese architecture. Characteristic features include securing pillars with nuki, techniques such as intermediate bracket complexes and ougi-daruki (fan rafters), and the use of components like taiheizuka (bottle-shaped strut), ebi-koryo (s-shaped tie beam), and soban (footing stone). Representative examples include the Shari-den Hall at Engaku-ji Temple. It was also widely used in architecture other than Zen temples.

(3) Garden city

Ebenezer Howard (UK) authored "Garden Cities of Tomorrow" in 1898, the Garden City concept he proposed there became one of the most influential urban planning philosophies of the 20th century. As a response to the overcrowding of large cities, the idea of building "Garden Cities" that combined the strengths of both urban and rural areas had a significant impact on urban policies worldwide, leading to the construction of suburban housing areas and new towns around major cities.

(4) Cross rib vault

A type of ceiling generalized in Gothic architecture. Its basic form is a cross vault created by intersecting two pairs of semi-cylindrical (tunnel) vaults at right angles, reinforced along its ridgeline with linear members called ribs. Because the load concentrates on the four corner pillars supporting the ribs, large openings can be created in the walls between the pillars.

(5) Territory

Unlike "personal space", "territory" refers to a non-moving area that belongs to the environment in which someone has certain rights. A territory does not disappear even when its owner is not present, and is often marked by the placement of possessions.

(6) Asbestos

Asbestos is a fibrous mineral formed through the alteration of serpentine and amphibole rocks. It possesses excellent heat, chemical, and wear resistance. Because of its high tensile strength and low cost, it was widely used as a spray-on material for fireproofing, thermal insulation, and sound absorption. However, since inhalation into the lungs causes severe health hazards, its import, manufacture, and use are currently prohibited.

(7) Landscape Act in Japan

The Landscape Act is a law enacted in 2004 (Heisei 16) that establishes a system to promote the good landscapes in cities, agricultural areas, mountain villages, and fishing villages. This law enables the formulation of landscape plans, the designation of landscape districts, and

regulations on the form and color of buildings. Local governments can enact ordinances and give legal effect to residents' agreements, thereby aiming to form a beautiful national land that harmonizes with the region's nature, culture, and history.

(8) Plane (tool)

A type of woodworking tool used to shave thin layers from the surface of wood to achieve a smooth finish. In Japan, yari-ganna, a tool with a spear-like blade used to shave surfaces, was used in ancient times, while the dai-ganna, which fixes the blade to a base, appeared around the 16th century. While most planes worldwide are pushed to shave, Japanese planes are pulled.

(9) Law for the Protection of Cultural Properties (Japan)

The Law for the Protection of Cultural Properties was enacted in 1950.

It was newly established through the integration of three earlier laws: the Historic Sites, Places of Scenic Beauty, and Natural Monuments Preservation Law of 1919, the National Treasures Preservation Law of 1929, and the Law Concerning the Preservation of Important Works of Fine Arts of 1933.

Under the current law, the following categories of cultural properties are defined: tangible cultural properties, intangible cultural properties, folk cultural properties, treasure trove (buried cultural properties), monuments, cultural landscapes, groups of traditional buildings preservation districts, and techniques for the conservation of cultural properties.

Based on this law, important cultural properties may be designated or selected.

The law also provides for the establishment of local councils for the protection of cultural properties.

(10) Marine pollutant

Substances that are released into the ocean primarily as a result of human activity and cause pollution. These cause the problems that include the mass death of farmed fish due to eutrophication, the impact on ecosystems of crude oil spills due to tanker accidents, damage caused by the accumulation of toxic chemicals in living organisms, and, more recently, the adverse effects of trace amounts of plastic.

(11) City park

City parks are public green spaces, including park facilities such as pathways, plazas, playground equipment, and sports facilities, that are established and managed by local governments or the national government within city planning areas based on the Urban Park Act. These facilities serve diverse purposes, including providing citizens with places for relaxation, recreation, disaster prevention, and environmental conservation. There are also various types such as historical parks and athletic parks, and technical standards for their establishment and management are stipulated by government ordinances and local ordinances.

(12) Crowd

In architectural planning, a crowd refers to a condition in which a large number of people simultaneously occupy a space at a specific time or under particular circumstances, exhibiting patterns of movement, stay, and collective behavior. It is analyzed through indicators such as crowd density (degree of concentration) and crowd flow (speed, volume, and effective width

of movement paths), and constitutes a fundamental concept in evaluating spatial safety, comfort, and evacuation planning.

(13) Conservation of *satoyama*

In its narrow sense, *satoyama* refers to secondary forests, mixed woodlands, and agricultural forests created by thinning and cutting natural forests and growing coppiced or planted trees to form mature forests. These areas have traditionally been used as sites for producing firewood, charcoal, green manure, shiitake mushrooms, and other products. In its broad sense, the term can also include coniferous plantations, residential lots, and farmland, referring to the entire system where material circulation takes place. *Satoyama* is a concept that involves achieving harmony with the natural environment through people's lifestyles and maintenance practices, conserving biodiversity, and preserving local culture in a sustainable manner.

(14) Brutalism

An architectural movement that spread internationally from the 1950s to the 1970s, characterized by the “raw” expression of materials and construction methods, particularly exposed concrete. It originated in the concept of “New Brutalism” proposed by Peter and Alison Smithson and was later theorized by the architectural historian Reyner Banham.

(15) Habitat 67

The residential complex designed by Moshe Safdie for the Montreal World Expo. Employing an industrialised construction method involving factory-produced precast reinforced concrete units. By combining and stacking these units, it overcame the weakness of industrialisation to achieve innovative architecture featuring diverse, independent dwellings with terraces.

(16) La Ville Radieuse

Le Corbusier's ideal urban model proposed in the 1930s. The city was divided into four functions: “residence,” “work,” “leisure,” and “transportation.” Emphasis was placed on creating a comfortable environment through high-rise construction and surrounding greenery, along with separating pedestrians and vehicles and improving traffic efficiency. Designed using the Modulor, a human-scale standard, it aimed to solve the challenges of modern cities. This concept significantly influenced urban planning worldwide, with the Unité d'Habitation serving as a representative example of its implementation.

(17) Art nouveau

Around 1900, An artistic style that flourished primarily in European cities such as Brussels and Paris. Characterized by organic forms modeled after nature, particularly plants, rather than historical styles. The architecture uses extensively decorative elements made from cast iron and glass. Representative architects include Victor Horta, Hector Guimard, and Antoni Gaudí.

(18) Other effective area-based conservation measures (OECM)

One of the targets adopted at the COP10 to the CBD in 2010. A means to achieve the conservation targets of 17% of terrestrial areas and 10% of marine areas. Areas outside current protected areas where ecosystem functions and services are maintained and managed over the long term. The Ministry of the Environment certifies these as Nationally Certified Sustainably

Managed Natural Sites.

(19) Heat pump

A heat transfer device that utilizes a refrigerant cycle to transport heat from a low-temperature source to a high-temperature destination. It consists of a compressor, condenser, expansion valve, and evaporator. The refrigerant vapor condenses in the condenser, releasing heat, while the refrigerant liquid evaporates in the evaporator, absorbing heat. By switching the refrigerant circuit, this system can be used for both cooling and heating applications.

(20) Carbon negative

Carbon negative refers to a state in which the amount of greenhouse gases (CO₂, water vapor, etc.) absorbed by forests, oceans, etc. is greater than the amount emitted into the atmosphere through economic activity. In order to prevent global warming, which is a cause of abnormal weather, the development of technology to capture and fix CO₂ in the atmosphere and remove it is expected.

Question 2

- (1) This question evaluates the ability to calculate bending moments based on the force equilibrium of an elastic beam, and to calculate displacements using methods such as the unit load method.

Sample answer: $PL^3/3EI$

- (2) This question evaluates the ability to calculate axial forces based on the force equilibrium of an elastic truss, calculate the maximum load, and calculate displacements using methods such as the unit load method.

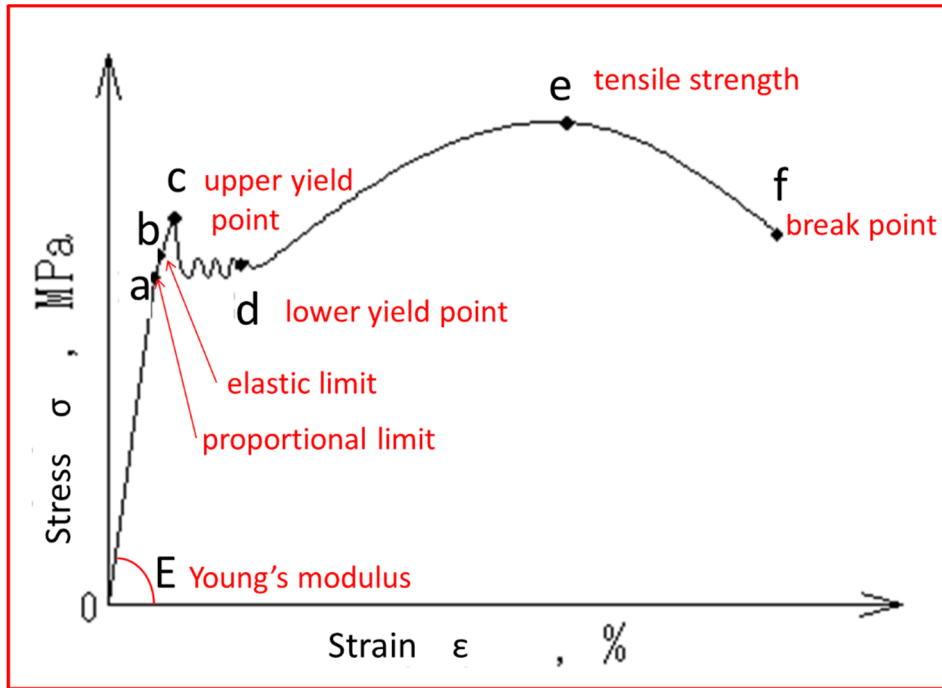
Sample answer: $28fA/15E$

Question 3

- (1) Granite possesses high compressive strength and excellent durability. It is used for building interiors, exteriors, and flooring. Since quartz undergoes a phase transformation and expands at temperatures around 570°C, which can cause surface spalling (explosive fracturing), care must be taken to prevent exposure to direct flames.

Marble is a type of metamorphic rock and is primarily used for building interiors. It is composed of colorless or white calcite, with calcium carbonate (CaCO₃) as its main component. Because it loses its surface luster when exposed to acid rain outdoors, its use is generally restricted to interior applications.

- (2)



- (3) In the atmosphere, wood begins to burn at 240°C to 270°C if an ignition source (pilot flame) is present (flashpoint). At 430°C to 500°C, combustion will begin even without an ignition source (auto-ignition).

During combustion, the wood chars, forming a carbonized layer (char layer) on the surface. This carbonized layer acts as a thermal barrier, delaying the combustion of inside the wood. In "sacrificial charring design", large cross-sections are engineered by pre-calculating a charring allowance that accounts for the thermal insulation provided by this layer during a fire.

- (4) a Water-Cement Ratio

$$173/294 \approx 59 \text{ [\%]}$$

b Unit Mass of Fresh Concrete

$$173 + 294 + 767 + 1049 = 2283 \text{ [kg/m}^3\text{]}$$

c Air Content of Concrete

$$\{1000 - (173 + 93 + 295 + 396)\} \times 100/1000 = 4.3 \text{ [\%]}$$

d Density of Cement

$$294/93 \approx 3.16 \text{ [kg/L] or [g/cm}^3\text{]}$$

e Fine Aggregate Ratio

$$295/(295 + 396) \approx 43 \text{ [\%]}$$

Question 4

- (1) With an air temperature of 20.0 °C and a relative humidity of 90%, the dew point temperature of the air is 18.3 °C, as determined from an air psychrometric chart. Since only the thickness of the glass wool can be varied, let the thickness of the glass wool be δ [m]. Given a thermal transmittance K [$\text{W} \cdot \text{m}^{-2} \cdot \text{K}^{-1}$] and a steady-state heat flux q [$\text{W} \cdot \text{m}^{-2}$], the surface temperature θ_{is} on the inner side of the wall must satisfy the following condition:

$$K = \frac{1}{\frac{1}{10.0} + \frac{0.09}{1.50} + \frac{\delta}{0.04} + \frac{0.015}{0.15} + \frac{1}{25.0}} = \frac{1}{0.1 + 0.06 + \frac{\delta}{0.04} + 0.1 + 0.04} = \frac{0.04}{0.012 + \delta} \text{ [W} \cdot \text{m}^{-2} \cdot \text{K}^{-1}\text{]}$$

$$\theta_{is} = \theta_i - \frac{q}{\alpha_i} = \theta_i - \frac{K(\theta_i - \theta_o)}{\alpha_i} = 20.0 - \frac{K \times 20.0}{10.0} = 20.0 - 2K \geq 18.3 \text{ [}^\circ\text{C]}$$

$$K \leq 0.85 \text{ [W} \cdot \text{m}^{-2} \cdot \text{K}^{-1}\text{]}$$

$$K = \frac{0.04}{0.012 + \delta} \leq 0.85 \text{ [W} \cdot \text{m}^{-2} \cdot \text{K}^{-1}\text{]}$$

$$\frac{0.04}{0.85} - 0.012 = 0.035 \leq \delta \text{ [m]}$$

Therefore, surface condensation will not occur if the glass wool thickness exceeds 0.035 m (35 mm).

- (2) In the direct water supply and direct pressure system, the following pressure requirements must be met:

$$P \geq P_1 + P_2 + P_3$$

P [kPa]: Water pressure in the main water supply line

P_1 [kPa]: Pressure equivalent to the hydrostatic pressure corresponding to the height from the water main to the highest water outlet or fixture

P_2 [kPa]: Pressure equivalent to the frictional pressure loss head caused by metering devices, valves, fittings, straight pipes, and other components between the water main and the highest water outlet or fixture

P_3 [kPa]: Minimum required pressure at the highest water outlet or fixture

Therefore, if we denote the height from which water can be supplied as h ,

$$250 \text{ [kPa]} \geq \rho gh + 10h + 120 \text{ [kPa]}$$

using water's density $\rho = 1000 \text{ [kg/m}^3\text{]}$ and gravitational acceleration $g = 9.8 \text{ [m/s}^2\text{]}$,

$$250 \text{ [kPa]} \geq \frac{1000 \times 9.8 \times h}{1000} + 10h + 120 \text{ [kPa]}$$

$$h \leq 6.57 \text{ [m]}$$

- (3) Dry air consists primarily of nitrogen (78%) and oxygen (21%), with trace amounts of other atoms and molecules. When calculating the molecular weight of dry air components using a volume-weighted average, the result is approximately 29. In contrast, the molecular weight of water vapor is 18.

Avogadro's Law states that under identical temperature and pressure conditions, equal volumes of gases contain the same number of molecules. To introduce water vapor into a space filled with dry air, it is necessary to remove as many dry air molecules as there are water vapor molecules. When dry air is considered as a molecular entity, its molecular weight is 29, while water vapor has a molecular weight of 18. Therefore, as water vapor molecules become increasingly abundant compared to dry air molecules, more dry air molecules must be removed, resulting in wetter air being lighter than drier air.

- (4) The solar constant represents the average normal-incident solar radiation energy reaching Earth's atmosphere from the sun, measured at 1366 W/m^2 . Since Earth's orbit is an elliptical

path, the average distance from Earth to the sun is 1 unit, with perihelion at 0.98 units and aphelion at 1.02 units. Due to the inverse square law of radiation, at perihelion the intensity becomes $\frac{1}{0.98^2} = 1.04$, while at aphelion it decreases to $\frac{1}{1.02^2} = 0.96$, resulting in $\pm 4\%$ variations.

Question 5

- (1) In order to prevent the recurrence of red yeast rice problems, it is considered that it's necessary to strengthen the quality control system, thoroughly implement governance, and change the awareness of employees.
- (2) Examples of the use of AI in the field of environmental chemistry include: 1. Measuring water and air by using chemical sensors and identify the unknown harmful pollutants and the source of pollution from the data; 2. Creating a diffusion prediction model for pesticides in ground water; and 3. Designing materials for environmental purification and nanomaterials for removing microplastics.
- (3) PFAS was widely used for Teflon coating, foam fire extinguishing agents, and others. However, due to their resistance to decomposition and high accumulation, their manufacture and import are regulated. Water purifiers using activated carbon filters and reverse osmosis membranes are considered effective.