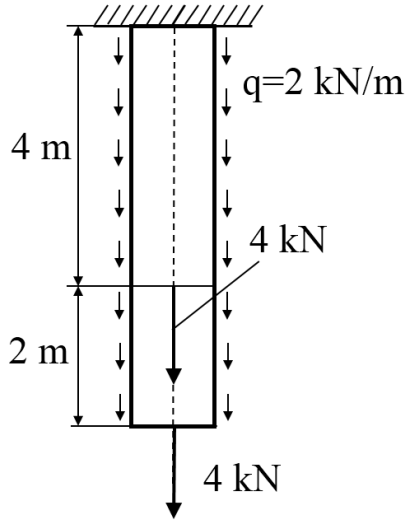
Urbanism & Civil Engineering: second-round sample tasks

The demo test serves as an illustrative sample that illustrates the evaluation criteria, maximum scores, and correct answers for the tasks. In tasks necessitating manual verification, a solution is provided.

Section 1. Strength of materials

Problem 1 (2 points)

The bar in the given figure is subjected to the action of two forces and a distributed axial loading. The cross-sectional area of the bar is 2 cm^2. Calculate the maximum average normal stress in the bar.

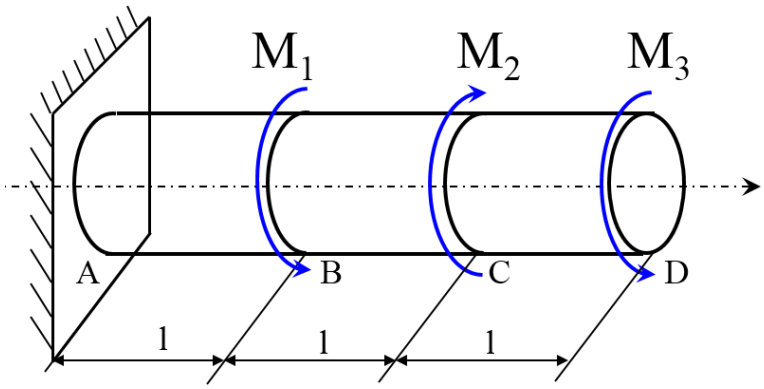


a. 60 MPa
b. 80 MPa
c. 100 MPa
d. 120 MPa

Answer: 100 MPa

Problem 2 (2 points)

Determine the maximum shear stress developed in the shaft subjected to torques M_1=2 kNm, M_2=4 kNm, M_3=6 kNm. The diameter of the shaft is 110 mm.



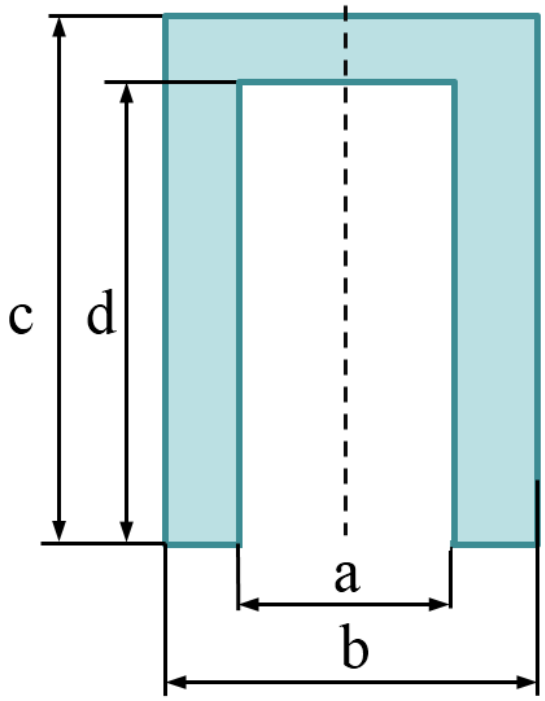
a. 15 MPa

b. 23 MPa
c. 31 MPa
d. 46 MPa

Answer: 23 MPa

Problem 3 (3 points)

Determine the moment of inertia of the cross-sectional area of the T-beam about the z-axis shown in the figure if a=8 см, b=12 см, c=20 см, d=18 см.

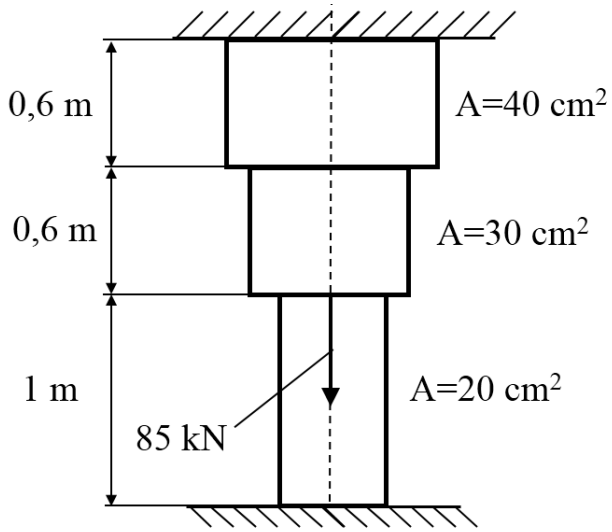


a. 1624 cm^4
b. 3752 cm^4
c. 4588 cm^4
d. 5682 cm^4

Answer: 3752 cm^4

Problem 4 (5 points)

The bar submitted to the action of a force is clamped at both ends. Determine the maximum average normal stress.

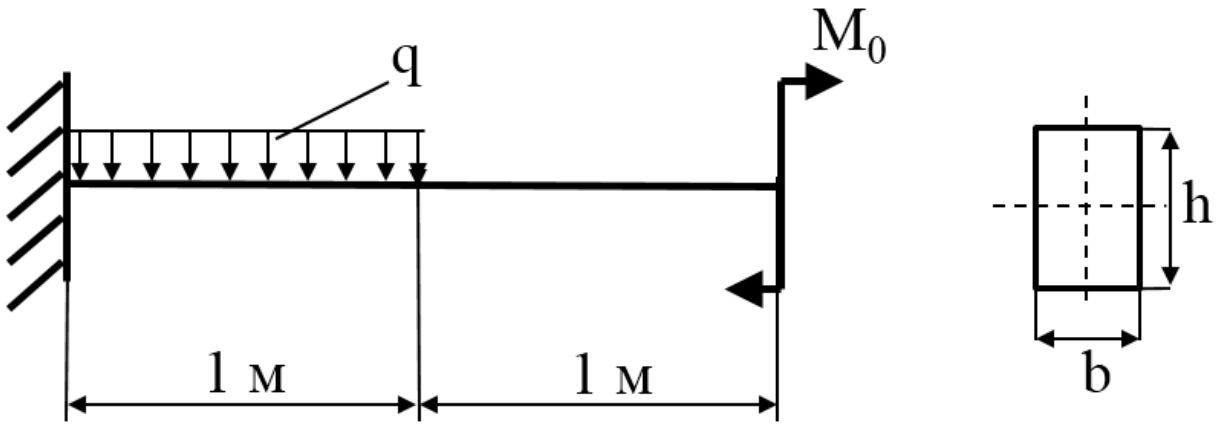


a. 12.5 MPa
b. 13.3 MPa
c. 17.5 MPa
d. 20.5 MPa

Answer: 17.5 MPa

Problem 5 (5 points)

Draw the shear and moment diagrams for the beam shown in Fig.5 if q=10 kN/m and M_0=20 kNm, *h*=0,2 m, *b*=0,1 m. Determine the absolute maximum bending stress.



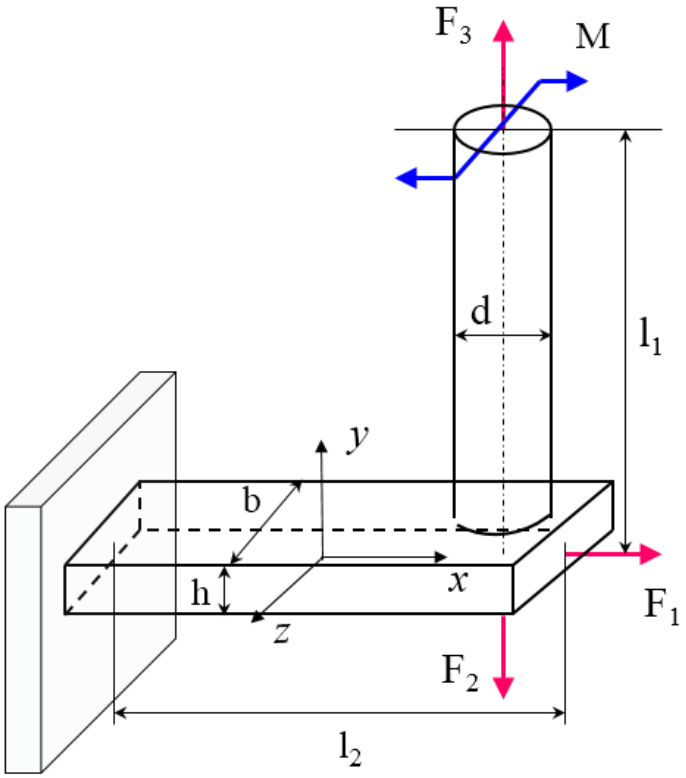
a. 15.5 MPa
b. 22.5 MPa
c. 37.5 MPa
d. 42.5 MPa

Answer: 37.5 MPa

Problem 6 (7 points)

The rectangular cross section is subjected to the loading shown. Determine the absolute maximum normal stress if F_1=150 kN, F_2=20 kN, and F_3=5 kN, *d*=0,2 m, *h*=0,1 m, *b*=0,3 m, l_1=l_2=1 m

FYI: When evaluating this task, the process of task completion will be considered. Merely offering an answer is not enough.



Solution

Internal loadings

The internal axial force in the rectangular bar is

$N_x = F_1 = 150\,\text{kN}$

The moments at x=l=1 m are

$M_y = -M = -15\,\text{kN}\cdot\text{m}$

$M_z = -F_2 \cdot l_2 + F_3 \cdot l_1 = -20\cdot 1 + 5\cdot 1 = -15\ \text{kN}\cdot\text{m}$

Area

The cross-sectional area of the bar is

$A = b\cdot h = 0.3\cdot 0.1 = 0.03\,\text{m}^2$

Section properties

The moments of inertia about the y and z axes are

$$I_y = \frac{h\cdot b^3}{12} = \frac{0.1\cdot(0.3)^3}{12} = 225\cdot 10^{-6}\ \text{м}^4$$

$$I_z = \frac{b\cdot h^3}{12} = \frac{0.3\cdot(0.1)^3}{12} = 25\cdot 10^{-6}\ \text{м}^4$$

Stress components

Normal force

The uniform normal-stress distribution acting over the cross section is produced by the normal force. Here $\sigma = \dfrac{N_x}{A} = \dfrac{150\cdot 10^3\,(\text{N})}{0.03\left(\text{m}^2\right)} = 5\,\text{MPa}$

Bending moment

The resultant normal stress at any point is

$$\sigma = \frac{M_y z}{I_y} - \frac{M_z y}{I_z}.$$

Point *A* is located at *y*=0.05 m from axis *z* and *z*= -0.15 m from the *y* axis. Hence,

$$\sigma_{max} = \frac{(-15\cdot 10^3\ \text{N}\cdot\text{m})(-0.15\ \text{m})}{225\cdot 10^{-6}\ \text{m}^4} - \frac{(-15\cdot 10^3\ \text{N}\cdot\text{m})(0.05\ \text{m})}{25\cdot 10^{-6}\ \text{m}^4} = 10 + 30 = 40\ \text{MPa}$$

Superposition

Adding the normal stresses determined above, we have

$\sigma_{max} = 40 + 5 = 45$ MPa

Answer: 45 MPa

Evaluation criteria:

Correctly calculated internal force and bending moments - 3 points.
Correctly calculated normal stresses in tension or bending - 5 points.
Completely solved problem – 7 points.

Section 2. Civil engineering materials

Problem 1 (1 point)

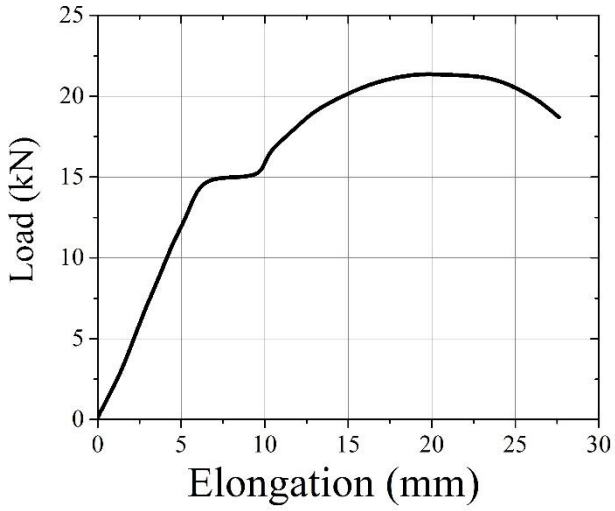
The bulk volume of a wooden beam is 18,000 cm³. The beam weighs 12 kg when saturated with water. When dried, the beam weighs 10 kg. What is the density of the solid material within the beam?

a. 0.505 g/cm3
b. 0.625 g/cm3
c. 0.875 g/cm3
d. 1.05 g/cm3

Answer: 0.625 g/cm^3

Problem 2 (1 point)

In the provided figure, there is a load-elongation curve for a steel bar with a diameter of 8.4 mm. The task is to determine the yield stress based on the information available from the curve.



a. 222.4 MPa
b. 270.8 MPa
c. 466.6 MPa
d. 527.2 MPa

Answer: 270.8 MPa

Problem 3 (2 points)

During the testing of 10 specimens, the following results were obtained, as shown in the table below. What is the standard deviation?

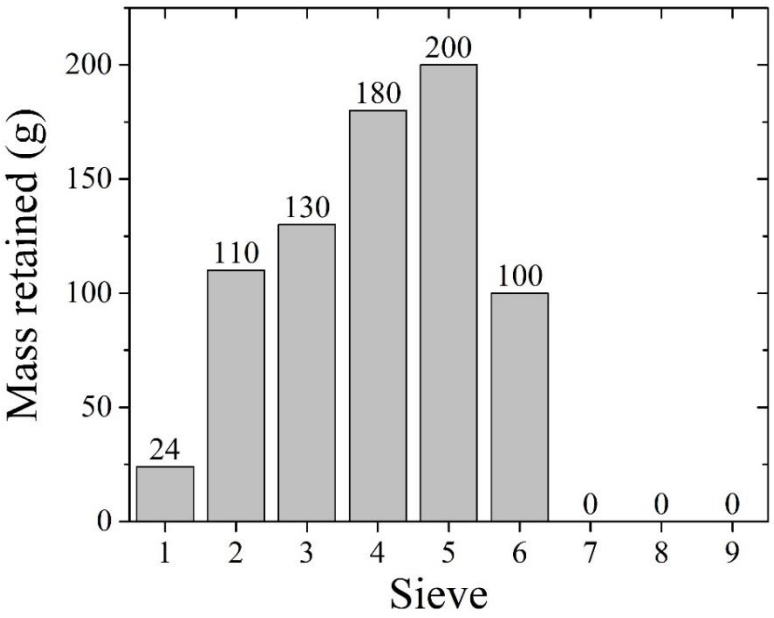
No	1	2	3	4	5	6	7	8	9	10
Strength (MPa)	35.1	42.2	40.1	37.3	44.0	37.2	48.0	35.1	46.8	34.4

a. 4.4 MPa
b. 4.8 MPa
c. 5.0 MPa
d. 5.6 MPa

Answer: 5.0 MPa

Problem 4 (3 points)

A sample of aggregates is subjected to sieving in order to establish the grading curve using a set of sieves. The amounts retained in each sieve are given in the table below. Calculate the percentage that passes through the 0.5 mm sieve.



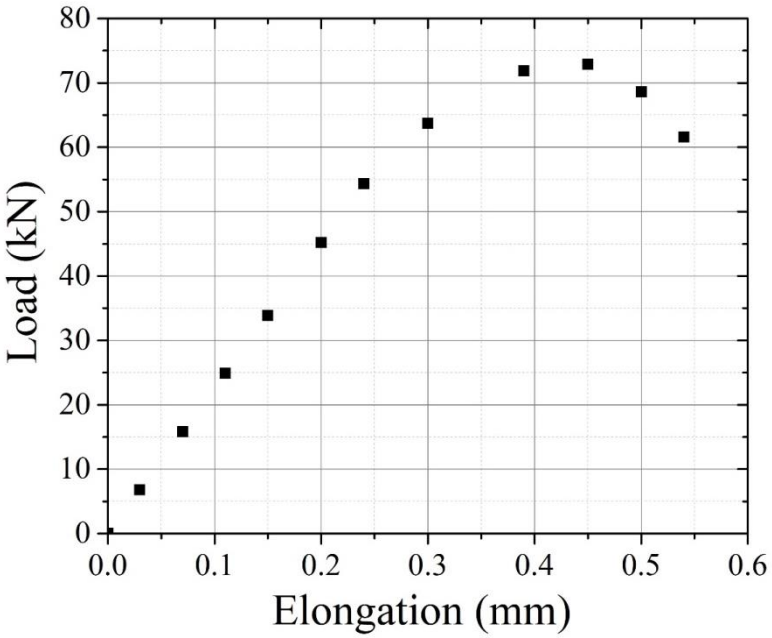
No	1	2	3	4	5	6	7	8	9
Sieve (μm)	31.5	63	125	250	500	1000	2000	4000	8000

a. 39.81
b. 56.68
c. 71.58
d. 79.93

Answer: 59.68

Problem 5 (3 points)

A tension test was performed on a specimen having a diameter of 12 mm. The elongations were measured over a gauge length of 100 mm. The results of the test are reported in the table. Determine the modulus of elasticity.



a. 68 GPa
b. 112 GPa
c. 200 GPa
d. 240 GPa

Answer: 200 GPa

Problem 6 (6 points)

Calculate the quantities for a 1 m^3 concrete mix if the mean compressive strength is 48 MPa; coarse aggregate: 10 mm uncrushed (2600 kg/m^3); percentage of fine aggregate is 45; target slump is 50 mm. Use the graphs below.

FYI: When assessing this task, the process of completing the task will be taken into account. Simply providing an answer is not sufficient.

Figure 1.
Relationship between compressive strength and water/cement ratio.

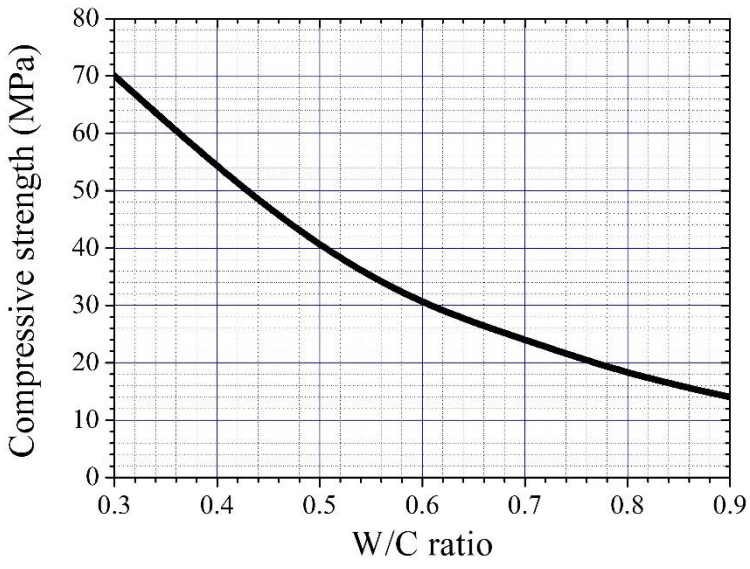


Figure 2. Relationship between water content and aggregate size depending on the level of workability of concrete.

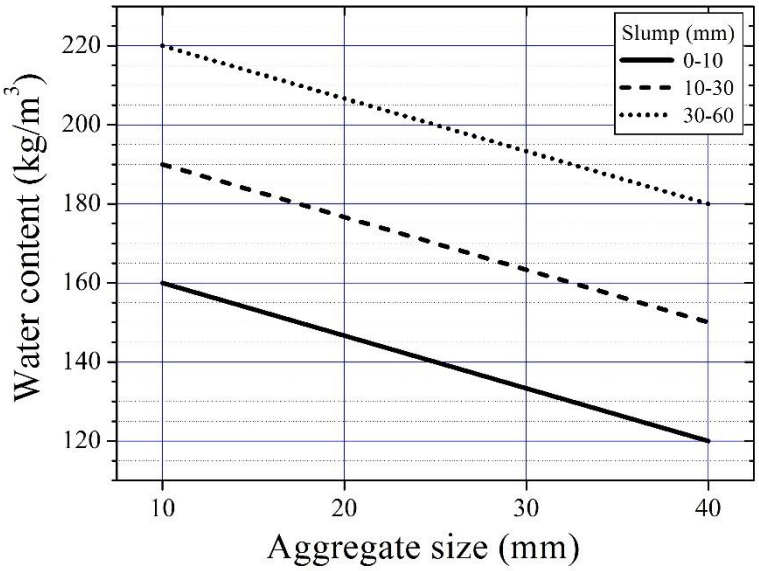
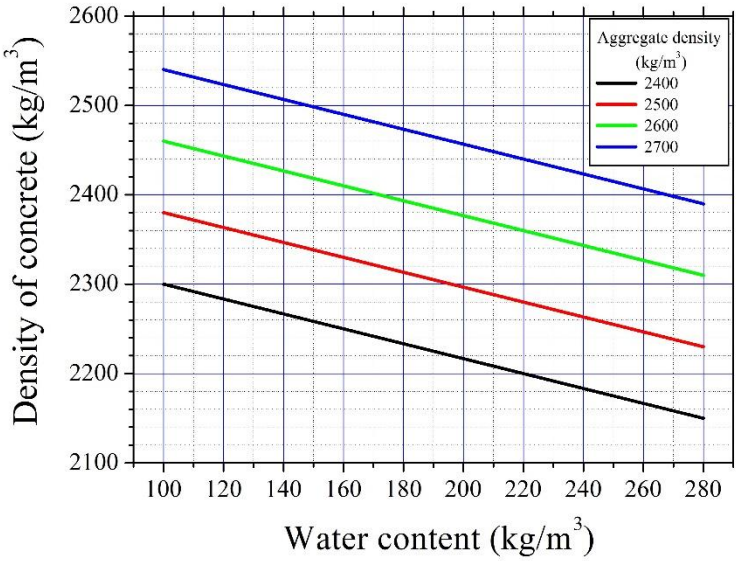


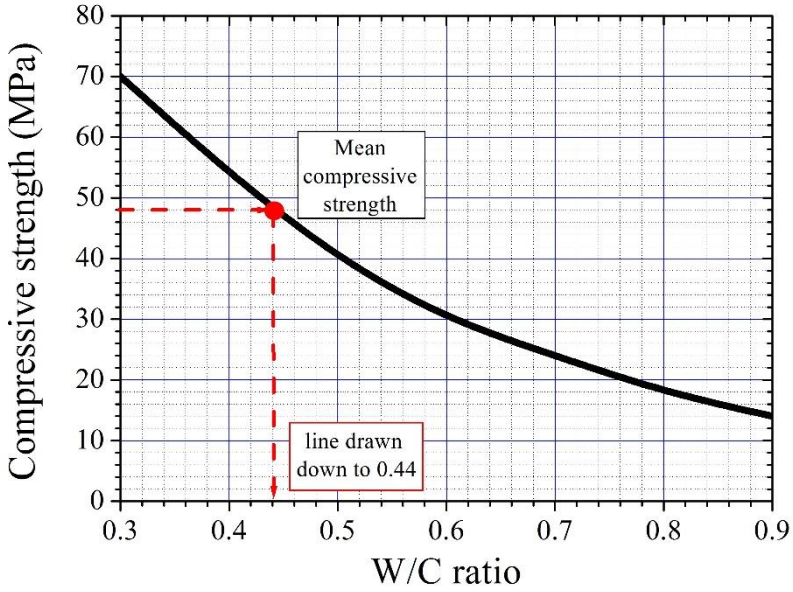
Figure 3. Relationship between the density of concrete and water content depending on the aggregate density.



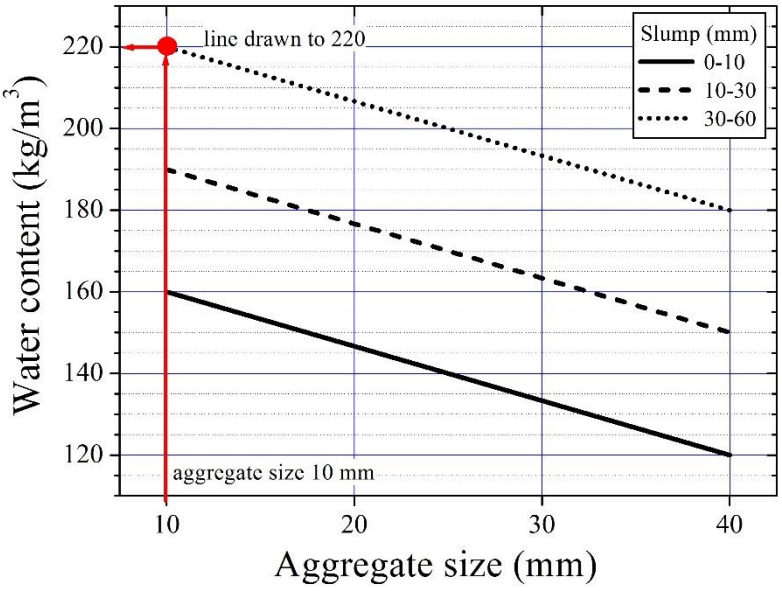
Solution

Step 1: Begin by calculating the water/cement ratio in the concrete mix, using Figure 1 as a reference. Refer to the figure below. Given that the compressive strength of the concrete is 48 MPa, we start from this point on the graph. Next, draw a vertical line from this point down to the

x-axis. This action yields a water/cement ratio of 0.44.

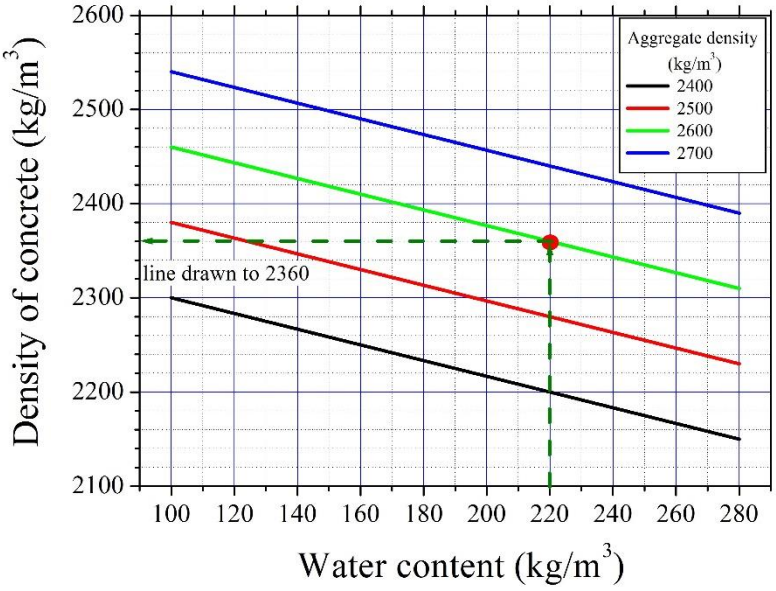


Step 2: Referencing Figure 2, ascertain the water content by following the steps detailed below. Please refer to the figure provided. Initiate from the 10 mm mark on the x-axis. Then, draw a line upwards to intersect the target slump of 50 mm (represented by the short and dotted line). This process yields a water content of 220 kg/m³.



Step 3. Cement content=220/0.44=500 kg/m^3.

Step 4. Using Figure 3, we determine the density of concrete. See Figure below. The starting point is 220 kg/m^3 on *x* axis. Then, a line is drawn up to the aggregate density line (green line). Thus, the density of concrete is 2360 kg/m^3.



Step 5. Aggregate content=2360-220-500=1640 kg/m^3
Fine aggregate content=1640·0.45=738 kg/m^3
Coarse aggregate content=1640-738=902 kg/m^3

Answer: The quantities for a 1 m^3 concrete mix

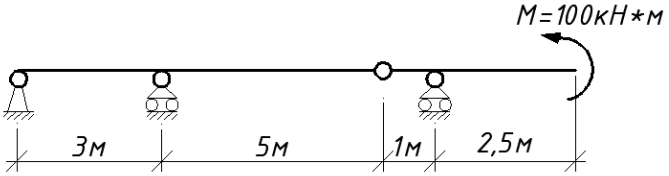
Water	Cement	Fine aggregate	Coarse aggregate
220	500	738	902

Evaluation criteria:
Correctly determined water-cement ratio - 2 points.
Correctly determined the content of water and cement - 3 points.
Correctly determined the density of concrete - 4 points.
Completely solved problem - 6 points.

Section 3. Structural mechanics

Problem 1 (3 points)

Determine the absolute maximum value of normal stress in the beam of the symmetrical section with a height of 200 mm represented in the figure. The moment of inertia is 15880 cm^4

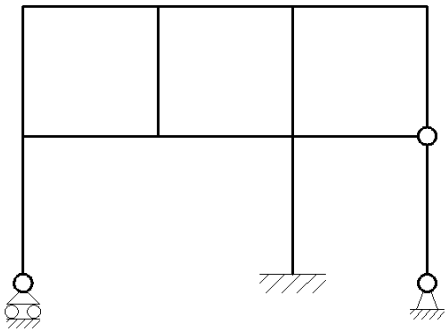


a. 245.7 MPa
b. 314.9 MPa
c. 53.16 MPa
d. 31.5 MPa

Answer: 314.9 MPa

Problem 2 (2 points)

Which of the methods is preferable to analyze the rod system in terms of the degree of static/kinematic indeterminacy? Loading is random; tensile-compressive strains are not taken into account.

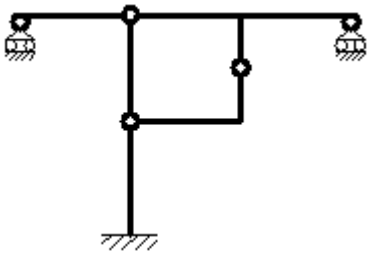


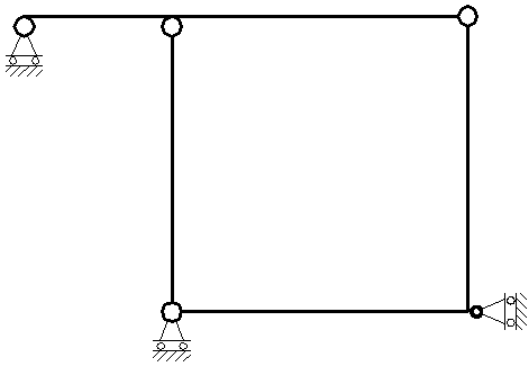
a. force method
b. displacement method
c. both methods give the same number of equations
d. none of the methods applies to this problem (the system is geometrically unstable, etc.)

Answer: force method

Problem 3 (2 points)

What types of frame systems are represented below?



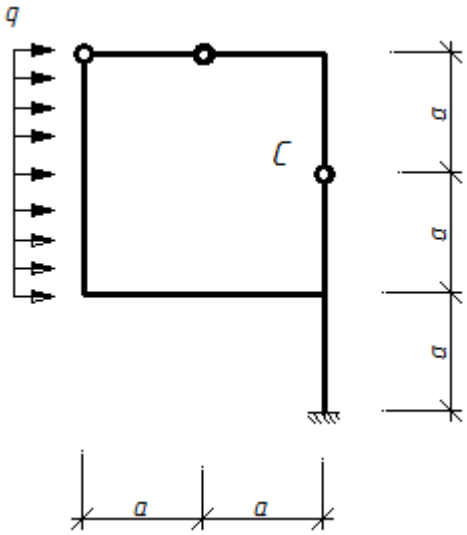


a. both are statically determinate
b. both are statically indeterminate
c. both are geometrically unstable
d. one structure is statically determinate, another one is statically indeterminate
e. one structure is statically determinate, another one is geometrically unstable
f. one structure is statically indeterminate, another one is geometrically unstable

Answer: both are statically determinate

Problem 4 (3 points)

Determine the absolute value of internal force in the hinge C. Load is q=15kN/m; a=3m.

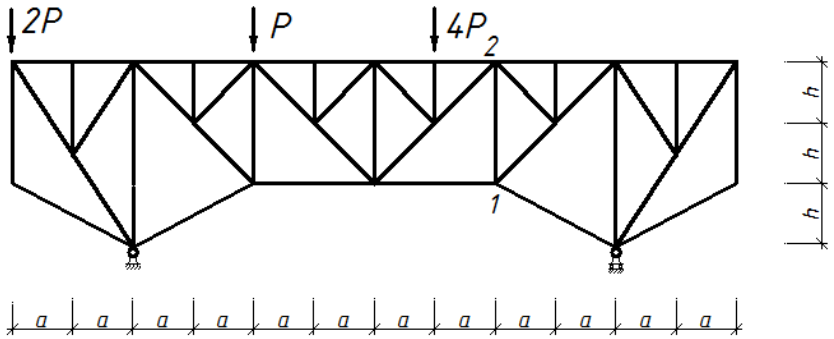


a. 0 kN
b. 2 kN
c. 5 kN
d. 8 kN

Answer: 0 kN

Problem 5 (5 points)

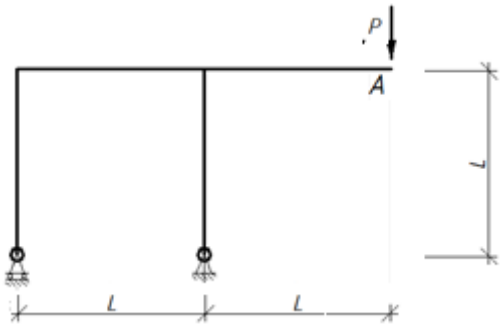
Determine the value of the axial force in the truss member 1-2. Loads P=4 kN, a=3m, h=4m. The answer should be given in kN (taking into account positive or negative sign).



Answer: -9 kN

Problem 6 (5 points)

Determine the value of the vertical displacement (**in mm**) at the point A (at the end of the structure) of the structural frame system if the following is known: P=100kN, L=3m, EI=360,000 kN*m^2



Answer: 5 mm

Section 4. Building structures

Problem 1 (2 points)

How does the value of the critical force for an eccentrically compressed reinforced concrete column change with an increase in the steel reinforcement content while maintaining all other parameters?

a. decreases
b. does not change
c. increases
d. the question doesn't make sense

Answer: increases

Problem 2 (3 points)

The supports of a continuous reinforced concrete beam with five spans are indicated by the letters A, B, C, D, E, F (from left to right). Which uniformly distributed load location results in the greatest longitudinal tensile reinforcement near the second support (B support)?

a. only the first and the third spans are loaded
b. only the first, the second and the fourth spans are loaded
c. only the second, the third and the fifth spans are loaded
d. only the first, the third and the fifth spans are loaded

Answer: Only the first, the second and the fourth spans are loaded

Problem 3 (2 points)

What is the estimated stress in the tensile steel reinforcement before cracking, assuming the ultimate tensile strain of the surrounding concrete is 0.0002? The bond between the concrete and reinforcement remains intact.

a. 40 MPa
b. 60 MPa
c. 15 MPa
d. 80 MPa
e. 400 MPa

Answer: 40 MPa

Problem 4 (3 points)

A solid steel rod with a circular cross-section and a diameter of 120 mm is subjected to eccentric tension with an eccentricity of 30 mm. The design strength (resistance) of the steel is 600 MPa. What is the maximum value of the tensile force that ensures the strength of the rod, *considering only the linear-elastic stage of work, without any additional coefficients?*

a. 300 kN
b. 2000 kN
c. 4500 kN
d. 1200 kN

Answer: 2000 kN

Problem 5 (6 points)

The bending moment in the cross section of a reinforced concrete rectangular beam is 200 kN*m, width b = 250 mm, effective (useful) depth h_0 = 450 mm, distance from the center of the compressed reinforcement to the edge of the concrete a′ = 50 mm; the design strength (resistance) of concrete in compression is 11.9 N/mm^2, the area of compressed reinforcement is 4.53 cm^2 (design tensile and compressive strength are 360.0 N/mm^2). Consider that the shape of the block of compressive stresses is rectangular. No additional coefficients should be introduced to the design resistances or the shape of the block of compressive stresses. Select from the proposed options all values of the tensile reinforcement area at which the strength condition is satisfied:

a. 24.5 cm2
b. 14.8 cm2
c. 8.3 cm2
d. 9.9 cm2
e. 18.7 cm2

Answer
a. 24.5 cm2
b. 14.8 cm2
e. 18.3 cm2

Problem 6 (4 points)

At what values of the uniformly distributed load q does the formation of normal cracks occur in section 1-1 of a concrete column without reinforcement?
As a criterion for the formation of cracks, take the excess of the maximum value of tensile stresses from the loads P and q over the tensile strength (resistance) of concrete equal to 1.95 N/mm^2 (serviceability limit state). The effect of deflection on the moment from external loads, the own weight of concrete and plastic deformations should not be taken into account. The height of the column is 5 m, the lower end is fixed in the foundation, the upper end is free, and the dimensions of the cross section are: height 50 cm (dimension in the bending plane), width 20 cm, P = 5 kN, a = 60 cm.

a. 410 kN/m
b. 330 kN/m
c. 300 kN/m
d. 380 kN/m
e. 210 kN/m

***Answer*:**

a. 410 kN/m
b. 330 kN/m
d. 380 kN/m

Section 5. Urbanism

Problem 1 (1 point)

Which of the modern urban concepts includes ensuring the safety and favorable living conditions, limiting the negative impact on the environment and ensuring the protection of natural resources for the benefit of present and future generations?

a. New Urbanism
b. Sustainable development
c. Landscape urbanism
d. Cluster analysis (Clustering)

Answer: Sustainable development

Problem 2 (1 point)

Specify the components of the concept of sustainable development of territories.

a. Economic, environmental and social
b. Economic and territorial
c. Social and cultural
d. Environmental, cultural and social

Answer: Economic, environmental and social

Problem 3 (1 point)

What type of residential development is shown in the photo?

a. Townhouse
b. Individual residential development
c. Sectional residential development
d. Mixed residential development

Answer: Individual residential development

Problem 4 (4 points)

From the principles listed below mark those that relate to the concept of New Urbanism that emerged in the early 1980s in the United States

a. Pedestrian accessibility
b. Road transport development
c. Mixed use (multifunctionality)
d. Functional division of territories

Answer:

a. pedestrian accessibility
c. mixed use (multifunctionality)

Problem 5 (4 points)

Match questions (1-4) and images (A-F).
There may be some extra images.

1. Which image shows point-type development.
2. Which image shows perimeter-type development.
3. Which image shows linear-type development.
4. Which image shows terraced-type development.

Format of the answer:
1A-2C-3D-4B, where 1A means question 1, the answer is image A, etc.

A

B

C

D

E

F

Answer: 1B-2C-3A-4 F

Problem 6 (9 points)

Give a description of the concept of a Smart City.

You must enter a short description in the response field.

Answer:
Smart City is a concept of a new generation city, which provides for effective management and ensures a high standard of living for the population through the use of **innovative technologies**. The main technological, economic and environmental changes have caused the emergence of interest in smart cities.
The main idea of a smart city is the joint use of information and **communication technologies** and the **Internet of Things**. The use of **sensors** and sensor networks allows for **real-time monitoring**. The information comes from the citizens themselves or public devices, after which it is processed and analyzed.
Megacities all over the world are making more and more efforts every year to create a **'smart environment'** for the population. Megacities in question include Singapore, London, San Francisco, New York, Amsterdam, Stockholm, Zurich, Copenhagen, Moscow. For example, thanks to the use of smart transport in Singapore, traffic jams occur rarely even though the city has a high population density. To date, Singapore is an example of using the largest number of **'smart systems'.** Most cities following the Smart City concept are using fewer innovative technologies so far.

Evaluation criteria:

1. Compliance with the question topic (4 points max.)

- The respondent correctly and consistently reveals the topic of the question, discusses the proposed topic and gives examples **(4 points)**
- The respondent discusses the proposed topic, but the answer is incomplete (does not fully disclose the topic) **(2-3 points)**
- The respondent discusses a topic close to the proposed one **(1 point)**

- The answer does not correspond to the topic of the question **(0 points)**

2. Key terms and concepts usage (5 points max.)

Keywords: *'Smart City', information technologies, innovative technologies, info-communication technologies (ICT), 'Internet of Things' (IoT solutions), sensors, real-time monitoring, smart environment, 'smart systems', interactivity, Big Data).*

- The participant can use terminology, correctly elucidates and employs key terms and definitions (3 or more terms/definitions) (5 points).
- The participant aptly utilizes terminology, including 2-3 terms/definitions in the text with minor inaccuracies (3-4 points).
- The participant exhibits partial proficiency in employing terminology, using 1-2 terms/definitions in the text with some inaccuracies or errors (1-2 points).
- The participant lacks the ability to use terminology and does not employ relevant terminology (0 points).