

**19YEARS**  
PREVIOUS SOLVED PAPERS

# GATE 2020

## CIVIL ENGINEERING

**(Fully Solved with Explanations)**

*By  
Team of  
Engineers Academy*



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# CIVIL ENGINEERING

## STRENGTH OF MATERIALS

### GATE PREVIOUS YEARS TOPICWISE SOLVED QUESTIONS

*Fully Solved with Explanations*

#### Syllabus

Solid Mechanics: Bending moment and shear force in statically determinate beams; Simple stress and strain relationships; Theories of failures; Simple bending theory, flexural and shear stresses, shear centre; Uniform torsion, buckling of column, combined and direct bending stresses.

Everyone has

a talent

and so do you.

Let it shine out,





# SIMPLE STRESSES

## OBJECTIVE QUESTIONS

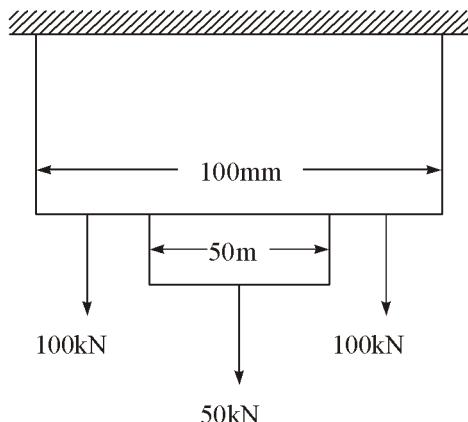
1. The shear modulus ( $G$ ), modulus of elasticity ( $E$ ) and the Poisson's ratio ( $\mu$ ) of a material are related as,

- (a)  $G = E/[2(1 + \mu)]$       (b)  $E = G/[2(1 + \mu)]$   
 (c)  $G = E/[2(1 - \mu)]$       (d)  $G = E/[2(\mu - 1)]$

**NOTES**

[1 Mark : GATE-2002]

2. A bar of varying square cross-section is loaded symmetrically as shown in the figure. Loads shown are placed on one of the axes of symmetry of cross-section. Ignoring self weight, the maximum tensile stress in  $\text{N/mm}^2$  anywhere is



- (a) 16.0      (b) 20.0      (c) 25.0      (d) 30.0

[2 Marks : GATE-2003]

3. For an isotropic material, the relationship between the young's modulus ( $E$ ), shear modulus ( $G$ ) and poison's ratio ( $\mu$ ) is given by

- (a)  $G = \frac{E}{(1+\mu)}$    (b)  $G = \frac{E}{2(1+\mu)}$    (c)  $G = \frac{E}{(1+2\mu)}$    (d)  $G = \frac{E}{2(1+2\mu)}$

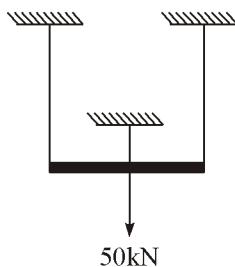
[1 Mark : GATE-2007]

4. A metal bar of length 100 mm is inserted between two rigid supports and its temperature is increased by  $10^\circ\text{C}$ . If the coefficient of thermal expansion is  $12 \times 10^{-6}$  per  $^\circ\text{C}$  and the Young's modulus is  $2 \times 10^5$  MPa, the stress in the bar is

- (a) zero      (b) 12 MPa      (c) 24 MPa      (d) 2400 MPa

[2 Marks : GATE-2007]

5. A rigid bar is suspended by three rods made of the same material as shown in the figure. The area and length of the central rod are  $3A$  and  $L$ , respectively while that of the two outer rods are  $2A$  and  $2L$ , respectively. If a downward force of  $50\text{kN}$  is applied to the rigid bar, the forces in the central and each of the outer rods will be

**NOTES**

- (a)  $16.67\text{ kN}$  each      (b)  $30\text{ kN}$  and  $15\text{ kN}$   
 (c)  $30\text{ kN}$  and  $10\text{ kN}$       (d)  $21.4\text{ kN}$  and  $14.3\text{ kN}$

**[2 Marks : GATE-2007]**

6. The number of independent elastic constants for a linear elastic isotropic and homogeneous material is

- (a) 4      (b) 3      (c) 2      (d) 1

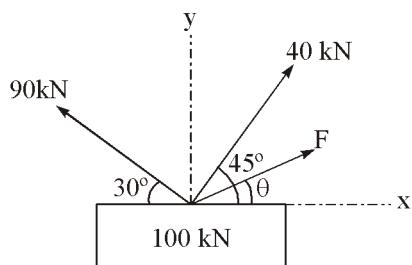
**[1 Mark : GATE-2010]**

7. The Poisson's ratio is defined as

- (a)  $\left| \frac{\text{axial stress}}{\text{lateral stress}} \right|$       (b)  $\left| \frac{\text{lateral strain}}{\text{axial strain}} \right|$   
 (c)  $\left| \frac{\text{lateral stress}}{\text{axial stress}} \right|$       (d)  $\left| \frac{\text{axial strain}}{\text{lateral strain}} \right|$

**[1 Mark : GATE-2012]**

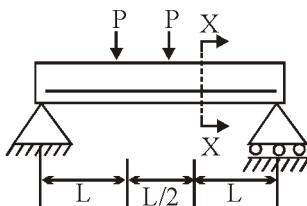
8. A box of weight  $100\text{ kN}$  shown in the figure is to be lifted without swinging. If all forces are coplanar, the magnitude and direction ( $\theta$ ) of the force ( $F$ ) with respect to  $x$ -axis should be



- (a)  $F = 56.389\text{ kN}$  and  $\theta = 28.28^\circ$     (b)  $F = -56.389\text{ kN}$  and  $\theta = -28.28^\circ$   
 (c)  $F = 9.055\text{ kN}$  and  $\theta = 1.414^\circ$     (d)  $F = -9.055\text{ kN}$  and  $\theta = -1.414^\circ$

**[2 Marks : GATE-2014]**

9. Consider the singly reinforced, beam in the figure below:

**NOTES**

At cross-section XX which of the following statements is TRUE at the limit state?

- (a) The variation of stress is linear and that of strain is non-linear
- (b) The variation of strain is linear and that of stress is non-linear
- (c) The variation of both stress and strain is linear
- (d) The variation of both stress and strain is non-linear

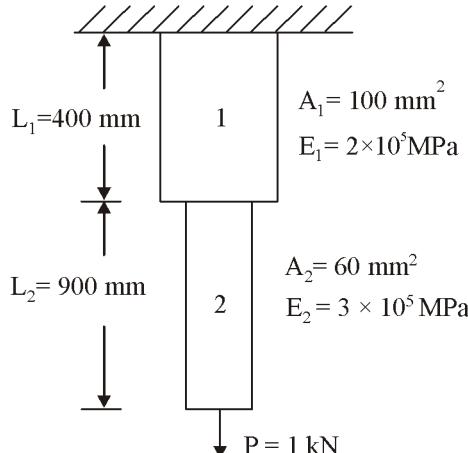
**[1 Mark : GATE-2015]**

10. An elastic bar of length L, uniform cross sectional area A, coefficient of thermal expansion  $\alpha$  and Young's modulus E is fixed at the two ends. The temperature of the bar is increased by T, resulting in an axial stress  $\sigma$ . Keeping all other parameters unchanged, if the length of the bar is doubled, the axial stress would be

- (a)  $\sigma$
- (b)  $2\sigma$
- (c)  $0.5\sigma$
- (d)  $0.25 \alpha\sigma$

**[1 Mark : GATE-2017]**

11. Consider the stepped bar made with a linear elastic material and subjected to an axial load of 1 kN as shown in the figure



Segments 1 and 2 have cross sectional area of  $100 \text{ mm}^2$  and  $60 \text{ mm}^2$  Young's modulus of  $2 \times 10^5 \text{ MPa}$  and  $3 \times 10^5 \text{ MPa}$  and length of 400 mm and 900 mm respectively. The strain energy in N-mm up to one decimal place in the bar due to the axial load is \_\_\_\_\_

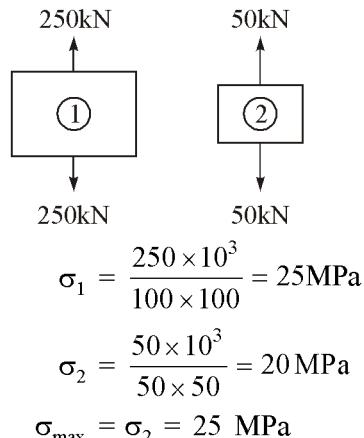
**[2 Marks : GATE-2017]**

## ANSWERS AND EXPLANATIONS

1. *Ans. (a)*

$$E = 2G(1 + \mu)$$

2. *Ans. (c)*



3. *Ans. (b)*

$$E = 2G(1 + \mu), G = \frac{E}{2(1 + \mu)}$$

4. *Ans. (c)*

$$\sigma = \alpha t E = (12 \times 10^{-6})(10)(2 \times 10^5) \\ = 24 \text{ MPa}$$

5. *Ans. (c)*

$$2P_{\text{out}} + P_{\text{center}} = 50 \text{ kN} \rightarrow (1)$$

$$(\delta l)_{\text{out}} = (\delta l)_{\text{center}}$$

$$\frac{(P_o)(2L)}{(2A)(E)} = \frac{P_c(L)}{(3A)(E)}$$

$$P_c = 3P_o$$

$$P_c = 30 \text{ KN}$$

$$P_o = 10 \text{ KN}$$

6. *Ans. (c)*

For homogeneous isotropic material independent elastic constants are two

7. *Ans. (b)*

$$\mu = \frac{\text{lateral strain}}{\text{linear strain}}$$

8. *Ans. (a)*

For no swinging

$$\Sigma F_H = 0$$

$$90 \cos 30^\circ = F \cos \theta + 40 \cos 45^\circ$$

$$F \cos \theta = 49.658$$

$$100 = 90 \sin 30^\circ + 40 \sin 45^\circ + F \sin \theta$$

$$F \sin \theta = 26.715$$

$$F = 56.389 \text{ kN}$$

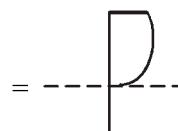
$$\theta = 28.28^\circ$$

9. *Ans. (b)*

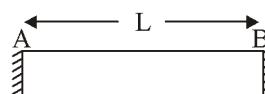
Strain varies linearly



While stress has recto-parabolic variation and no tension in concrete is to be considered. Hence variation of stress



10. *Ans. (a)*



Effect of temperature increase



Effect of restraining force generated

From compatibility

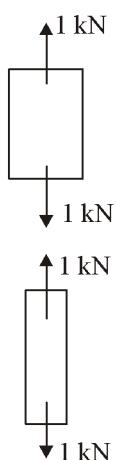
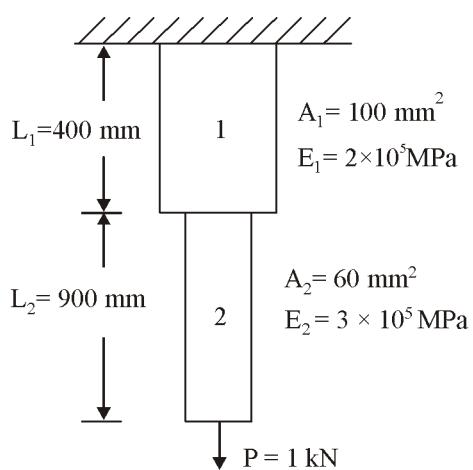
$$\delta_T = \delta_R \\ = 0$$

$$\Rightarrow L \propto \Delta T = \frac{RL}{AE}$$

$$\Rightarrow \sigma = \frac{R}{A} = \text{Stress} \\ = E \propto \Delta T$$

Hence stress is independent of length of bar.

11. Ans. (34.9 to 35.8)



$$U = \sum \frac{P^2 L_i}{2A_i E_i}$$

$$= \frac{(1000)^2 \times 400}{2 \times 100 \times 2 \times 10^5} + \frac{(1000)^2 \times 900}{2 \times 60 \times 3 \times 10^5}$$

$$= 10 + 25$$

$$= 35 \text{ N-mm}$$

○○○