Internal Assessment Test 1– Sep- 2019

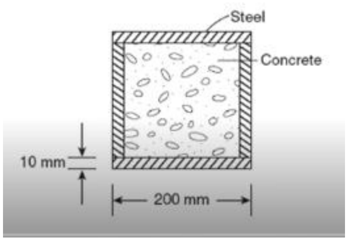
(solution and scheme of valuation)

Sub:	**Strength of Materials**					Sub Code:	**18CV32**	Branch:	Civil
Date:	6/9/2019	Duration:	90 min	Max Marks:	50	Sem/Sec:	III – A & B		marks

Answer any 5(five) questions

1 A short column is made by welding steel plates into a square section and then filling inside with concrete. The side of square column is 200mm and the thickness of steel plate is t = 10mm as shown in figure. The steel has an allowable stress of 140N/mm^2 and the concrete has an allowable stress of 12 N/mm^2. Determine the allowable safe compressive load on the post. 10

E_s = 200 GPa, E_c = 20 Gpa.



Ans Given data:

Area of column A = 200mm X 200mm = 40000mm^2

Area of concrete A_c = 180mm X180mm = 32400mm^2

Area of steel A_s = 40000-32400 = 7600mm^2

σ_s= allowable stress in steel = 140N/mm^2

σ_c= allowable stress in concrete = 12 N/mm^2

E_s = 200 Gpa = 200 x 10^3 N/mm^2

E_c = 20 Gpa = 20 x 10^3 N/mm^2 2

Since the composite post is subjected to compressive load, both concrete and steel tube will shorten by the same extent. Using this condition following relationship between stresses in concrete and steel can be established. 10

Strain in steel = strain in concrete

$\sigma_s / E_s = \sigma_c / E_c$

let us consider concrete is stressed to its maximum capacity σ_c = 12N/mm^2 then

$\sigma_s = (E_s / E_c)\ \sigma_c$ = (200/20) 12 4

σ_s = 120 N/mm^2 (< 140N/mm^2)

<u>allowable safe compressive load on the post</u>

P = $\sigma_s A_s + \sigma_c A_c$ = 120x7600 + 12x32400 = **1300800 N** 4

2 a) Define stress and strain. Explain different types of stresses and strains developed in a member.

Ans <u>Stress:</u> The force of resistance offered by a body against the deformation per unit area is called the **stress.** The external force acting on the body is called **load.** The stress will be induced in the body only if external load is acting on it. It is denoted by σ .

<u>Types of stress and strain :</u> 1) tensile stress and strain

2) Compressive stress and strain 2

3) shear stress and strain

1) <u>tensile stress</u> and strain

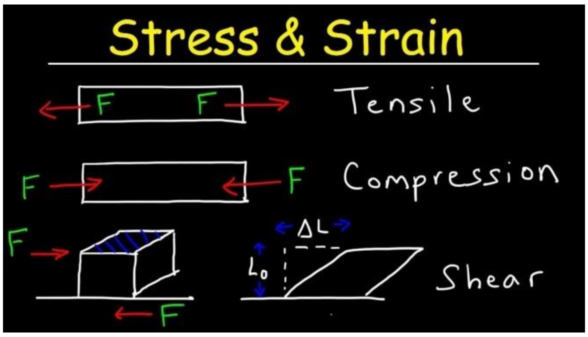
_ the stress developed in a member when it is applied with a pulling force causing elongation in it is known as tensile stress. The corresponding strain in length is called tensile strain Ex: a stressed rubber band 5

2) <u>Compressive stress</u> and strain 3

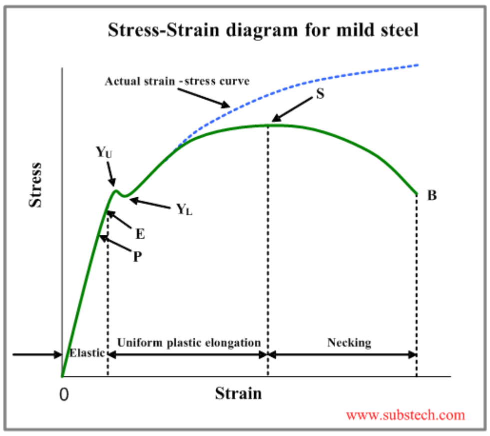
: the stress developed in a body when forces are applied towards it is known as compressive stresses. The corresponding strain in length is called compressive strain Ex: stresses developed in wall foundation

3) <u>Shear stress</u> and strain

: the stress induced in a body when subjected to tangential or surface force is known as shear stress. And corresponding strain is known as shear strain. Example : steel bold used to fix two flat plates



b) Draw stress - strain curve for a ferrous material. Explain with salient features.



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<u>Proportionality limit (p):</u> it is the maximum stress level up to which the stress is

directly proportional to strain. For some materials elastic limit is slightly above the proportional limit. However for practical purpose the two points may coincide.

Elastic limit(E): In this range the material is elastic in nature. The greatest stress up to which the material exhibits the characteristics of regaining its original shape and dimensions on removal of loads is known as elastic limit(E). 5

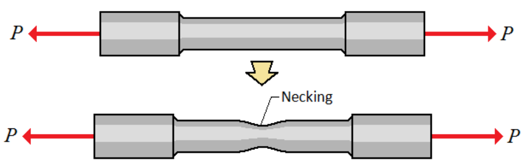
Yield stress: It is the value of the stress at which the material continues to deform at constant load condition. The two distinct points shown in curve are the highest stress preceding extensive strain known as Upper yield point (Y_u) and relatively constant runout value known as lower yield point (Y_L). 3

Ultimate stress: (S) It is the maximum stress induced in the specimen and is occurs in the plastic region.

Break point: (B) the load at which the member breaks.

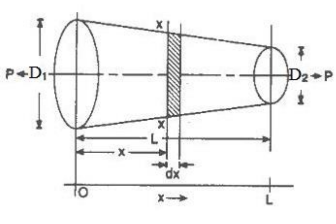
Plastic range: After the elastic range the specimen undergoes deformation which cannot be regained with the removal of load. This deformation is known as plastic deformation. The region starting from yield point to the end of the curve is known as plastic region. In this region deformation is no more directly proportional to strain. For any material plastic deformation is very large when compared to elastic deformation.

Phenomenon of Necking: weaker section in the specimen undergoes reduction in area which continues from ultimate point to the fracture point. This reduction in cross section area is known as necking. This phenomenon of necking does not occur in brittle materials.



3 a) Derive an expression for elongation of circular tapering rod.

Ans: Proof: Consider an elemental length dx of the bar at a distance ‘x’ from the larger end. Let the diameter of bar be ‘d’ at distance ’x’ from the larger end.



5 5

$$d = D_1 - ((D_1 - D_2)/L)\,X$$

$$d = D_1 - K\,X \qquad \text{where } K = (D_1 - D_2)/L$$

Therefore cross sectional area at distance X from the larger end.

$$A = \pi (D_1 - K X)^2/4$$

Extension of the elemental strip = $Pdx/(\pi (D_1 - K X)^2/4)E$

Total extension = $\int_0^L Pdx/(\pi (D1 - K X)2/4)E$

$= 4Pl/\pi E d_1 d_2$

b) A hollow steel column of external diameter 250mm has to support an axial load of 2000KN. If the safe stress for the steel column is 120 N/mm², find the internal diameter of the column.

Ans: external diameter = d_1 = 250mm

Load = (P) = 2000KN 1

Safe stress = 120N/mm²

Internal diameter = ?

$A = P/\sigma = 2000\times10^3 N/120N/mm^2$

$=16666.66mm^2$ 2 5

$A = \pi/4*(d_1^2 - d_2^2)$

$16666.66 = \pi/4*(250^2 - d_2^2)$ 2

$d_2 = 203.17mm$

4 a) Determine the elongation of the bar of length 'l', area of cross section 'A', young's modulus E and subjected to a pull of P.

Ans: $\sigma = P/A$

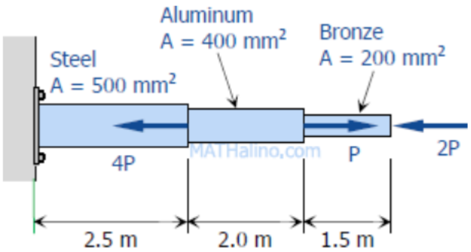
$e = dl/l$

$E = \sigma/e = (P/A)/(dl/l)$ 3 3

$dl = Pl/AE$

b) An aluminum rod is rigidly attached between a steel rod and a bronze rod as shown in fig. Axial loads are applied at the positions indicated. Find the stresses induced in each segment and extension/contraction of the bar for P=10KN.

Take $E_s = 2.1 \times 10^5$ N/mm², $E_a = 0.7 \times 10^5$ N/mm², $E_b = 1.14 \times 10^5$ N/mm²



Ans: load in steel 50000N

Load in aluminum = 10000N 2

Load jin bronze = 20000N

Stress in steel = 50000/500 = 100 N/mm²

Stress in aluminum = 10000/400 = 25 N/mm² 2

Stress in Bronze = 20000/200 = 100 N/mm²

Contraction in steel = $100*2.5*1000/2.1*10^5 = 1.19$mm

Contraction in aluminum = 25*2*1000/0.7*10^5 = 0.71mm   2   7
Contraction in bronze = 100*1.5*1000/1.14*10^5 = 1.31mm

Total elongation = 3.21mm   1

5 a) State and explain Hooke's law.   3   3

Ans: when the member is subjected to a load within elastic limit, stress is proportional to strain.

b) A 15mm diameter steel rod passes centrally through a copper tube 50mm external diameter and 40mm internal diameter. The tube is closed at each end by rigid plates of negligible thickness. If the temperature of the assembly is raised by 60°C, calculate the stresses developed in copper and steel.

Ans: condition 1:

Tension in steel = compression in concrete

$\sigma_s A_s = \sigma_c A_c$

$\sigma_s = 4\sigma_c$ ----------------- 1   2

$\sigma_s / E_s + \sigma_c / E_c = (\alpha_c - \alpha_s)t$

$\sigma_s + 2\sigma_c = 69.3$ -----------------2   3   7

from 1` and 2

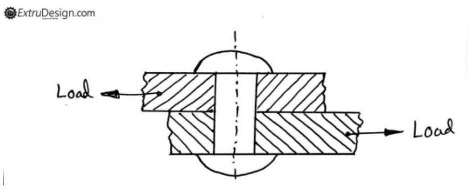
$\sigma_c = 11.55 N/mm^2$

$\sigma_s = 46.2 N/mm^2$ 2

6 a) State and explain with neat figure the shear stress and shear strain.

Ans:

Shear stress is defined as the ratio of shear force to the surface area.   2



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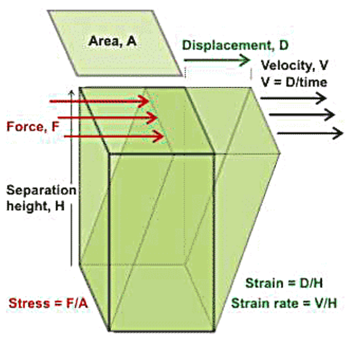
Shear strain is the ratio of the change in deformation to its original length perpendicular to the axes of the member due to **shear stress**   3



b) Calculate the diameter of steel rod needed to carry a load of 8KN, if the extension is not to exceed 0.04 percent. Assume $E=210GN/m^2$.

Ans: P = 8KN = 8000N

e = 0.04% = 0.0004 3

$E = 210GN/m^2 = 2.1 \times 10^5\ N/mm^2$

D =?

$E = \sigma/e = P/Ae$ 5

$A = P/Ee = 8000/2.1\times10^5 * .0004 = 95.23mm^2$

$\Pi d^2/4 = 95.23mm^2$

D=11.011mm 2

7 a) State and explain saint - venant's principle.

Ans: The **Saint-Venant principle** states that the effects of loading with the same magnitude but different distributions dissipate quickly as distance increases. In other words, as the distance from the point of loading becomes greater, the local effects are reduced such that they can be considered not to be present 3 3

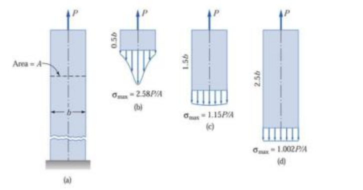


FIG. 1.7 Normal stress distribution in a strip caused by a concentrated load

ILLUSTRATING ST. VENANT'S PRINCIPLE

b) The following data refers to a tensile test conducted on a mild steel bar

i) Diameter of steel bar = 30mm
ii) Gauge length = 200mm
iii) Extension at a load of 100KN = 0.139mm
iv) Load at elastic limit = 230KN
v) Maximum load = 360KN
vi) Total extension = 56mm
vii) Diameter of rod at failure = 22.25mm

Calculate the young's modulus, stress at elastic limit, the percentage elongation, percentage decrease in area and ultimate stress

Ans: E=Pl/Adl

$=10000\times200\times4/\pi(30)^2*0.139 = 2.035\times10^5\ N/mm^2$ 2

Stress at elastic limit = $230000/\ \pi(30)^2/4 = 325.38\ N/mm^2$ 1

% elongation = (56/200) *100 = 28% 1 7

% decrease in area = $\pi/4(30^2 - 22.25^2)/\ \pi/4*30^2 * 100 = 44.92\%$ 1

Ultimate stress = $360000/\ \pi/4*22.25^2 = 925.87\ N/mm^2$ 2