DETAILS EXPLANATIONS

[PART : A]

1. It is the property of a material which permits the material to be extended in all directions without rupture.

2. By increasing carbon-percentage strenth increases but ductility decreases.

3. 'Modulus of Rigidity' is the ratio of shear-stress and shear-strain.

4. Longitudinal-stress in thin cylinder is

$$\sigma_L = \frac{pD}{4t}$$

Where p = internal pressure

D = Diameter of cylinder

t = thickness of walls

5. Torsion means Twisting of a structural member when it is subjected to couple that produces rotation about longitudinal axis.

6. Since, brittle material is weak in 'tension' as compared to 'shear' so it will fail to a plain at 45° from longitudinal-axis.

7. Shear center is a point from which a concentrated load passes then there will be only bending and no twisting.

8. **Open Coil Spring :** If the helix-angle is greater than 10°.

Close Coil Spring : If the helix-angle is less than or equal to 10°.

9. It is the ratio of effective length of any column to the least Radius of gyration.

10. Auto frittage is used for prestressing the cylinder for example - in pipe of a gun, wire winding (Auto-frittage) is done.

11. There is always crookedness in the column and the load may not be exactly-axial.

12. Bending moment and shear-force mainly depend upon the cross-sectional area and flexural rigidity of the members.

13. External Static indeterminacy is related with the support system while internal static indeterminacy refers to the geometric stability of the structure i.e. internal members.

14. Some major types of beams are :-

(i) Simply supported beam

(ii) Continuous Beam

(iii) Fixed Beam

(iv) Cantilever Beam and

(v) Over hang Beam

15. I.L.D. represents variation in the values of a particular stress function such as SF, BM, Axial-force, slope and/or deflection etc.

16.
$$H = \frac{wR}{2}$$

where w = intensity of load

R = Radius of the arch

17. There are two methods of structural analysis.

(i) Force-method

(ii) Displacement method

18. Stiffness is the force/moment required to be applied at a joint so as to produce unit deflection/rotation at that point.

19. The flexibility of a structure is defined as the displacement caused by a unit-force.

$$f = \frac{\delta}{P} \text{ or } f = \frac{\theta}{M}$$

20. **For Bending Moment**

+ve = clockwise

–ve = Anti-clockwise

For Slope

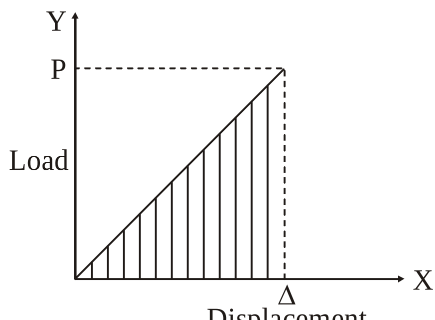
+ve = clockwise

–ve = Anti-clockwise

[PART : B]

21. **Strain Energy :** It is the energy absorbed by any material of any shape/size, when the material is strained.

*** For gradually applied load**



Strain Energy

$$U = \text{Area under the curve}$$

$$U = \frac{1}{2} \times P \times \Delta$$

By Hooke's law

$$\Delta = \frac{P \cdot l}{A \cdot E}$$

$$U = \frac{1}{2} \cdot P \cdot \frac{Pl}{AE}$$

$$U = \frac{P^2 l}{2AE}$$

22. Principal Stresses : Stresses on the principal-planes are called principal-stresses.

Principal planes are the planes for which the shear stress or tangential stress is zero.

$$\frac{\sigma_n}{\sigma_{n_2}} = \left(\frac{\sigma_1 + \sigma_2}{2}\right) \pm \sqrt{\left(\frac{\sigma_1 + \sigma_2}{2}\right)^2 + q^2}$$

23. Assumptions is Euler's theory:-

(i) Axis of column is perfactly straight when unloaded.

(ii) Load passes through axis.

(iii) Stress in the structure are within elastic limit.

(iv) Flexural Rigidity is constant.

(v) Material is homogeneous, Isotropic and linear-elastic.

(vi) Column is long and prismatic and it fails only in buckling.

24. Due to combined effect of bending and torsion

$$\text{Principal-stress} = \frac{16}{\pi D^3}\left[M \pm \sqrt{M^2 + T^2}\right]$$

$$\text{Maximum Shear Stress} = \frac{16}{\pi D^3}\sqrt{M^2 + T^2}$$

25. Creep : Creep is a permanent deformation which is recorded with passes of time at constant loading. It is a plastic deformation (permanent and non-recovarable) in nature.

Homologous Temperature : The temperature at which creep is uncontrollable is called Homogous-temperature.

26. (i) Maximum principal stress theory (Rankine's Theory)

(ii) Maximum principal strain theory (St. Venant Theory)

(iii) Maximum shear stress-theory (Guest and Tresca Theory)

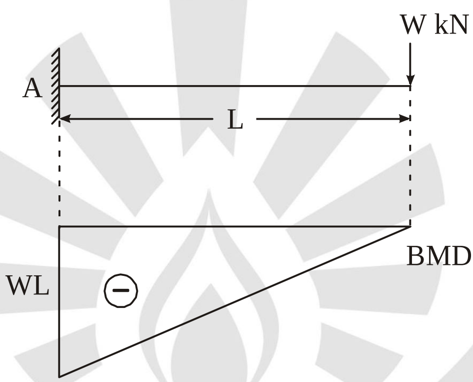
(iv) Maximum strain energy theory (Haigh's Theory)

(v) Maximum shear strain energy/distortion energy theory (Mises henky theory)

→ Above all these theories most safe results are produced by 'Maximum shear strain energy theory.

→ For uni-axial loading all theories will give same results.

27.



By Moment area method

$$\text{Slope} = \frac{\text{Area of BMD}}{EI}$$

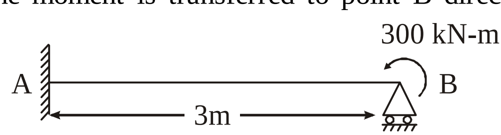
$$\text{Slope} = \frac{1}{2}\frac{(WL).L}{EI}$$

$$\text{Slope } \theta = \frac{WL^2}{2EI}$$

28. Types of pressure vessels:-

1. **Thin - Shells :** If the thickness of the wall of the shell is less than 1/10 to 1/15 of it's diameter, then shell is called 'thin-shell.'
2. **Thick-shells :** If the wall thickness of the wall of the shell is greater than 1/10 to 1/15 of it's diameter, then shell is called thick-shells.

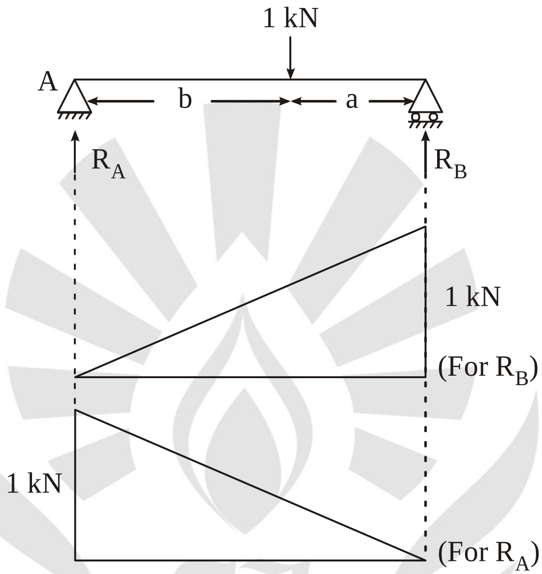
29. The moment is transferred to point B directly.



If $M_{BA} = 300$ kN-m

$M_{AB} = \frac{1}{2}\times 300 = 150$ kN-m as the carry-over factor for beams is $\frac{1}{2}$. The direction of moment will be anticlock wise i.e. hogging.

30.



Load is moving from 'B' to 'A'.

$$R_B \cdot l = l.b$$

$$R_B = b/l$$

$$R_A = 1 - R_B = \frac{a}{l}$$

31. (a) Formula for the curvature of parabolic Arch.

$$y = \frac{4hx}{l^2}(l - x)$$

Where, y = distance from X-axis

h = center dip/Rise

l = length/span of arch

(b) **Horizontal Thrust**

$$H = \frac{wl^2}{2(\sqrt{h_1} + \sqrt{h_2})}$$

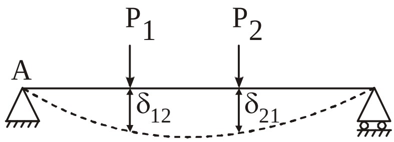
w = load intensity

l = span

h_1 = center rise of parabola 1.

h_2 = center rise of parabola 2.

32.



According to Maxwell's Reciprocal - Theorem.

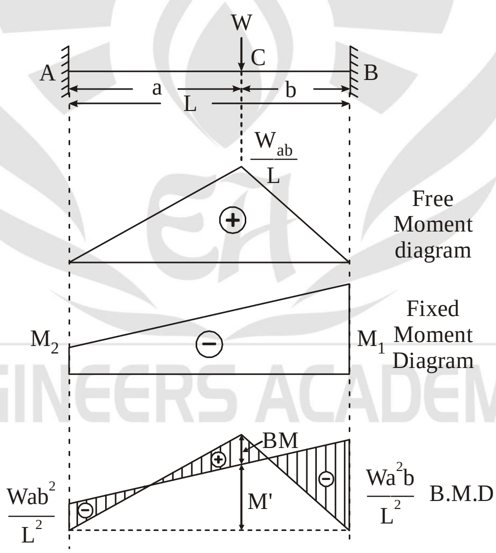
$\delta_{12} = \delta_{21}$

Where δ_{12} = deflection in direction (2) due to applied load in direction (1).

δ_{21} = deflection in direction (1) due to applied load in the direction (2).

[PART : C]

33.



As per the requirement Bending moment at C.

$$BM = \frac{W_{ab}}{L} - M'$$

Where, M' = Negative moment due to fixed supports at point 'C' (which can be calculated from the trapezoidal diagram of fixed end moments.

$$\Rightarrow \quad M' = \left\{\frac{Wab^2}{L^2} + \frac{\left(\frac{Wa^2b}{L^2} - \frac{Wab^2}{L^2}\right)\times a}{L}\right\}$$

$$\Rightarrow \quad M' = \frac{WabL^2}{L^2} + \frac{Wa^2b}{L^3}(a-b)$$

$$\Rightarrow \quad M' = \frac{Wab^2L + Wa^2b(a-b)}{L^3}$$

$$\Rightarrow \quad M' = \frac{Wab^2(a+b) + Wa^2b(a-b)}{L^3}$$

$$\Rightarrow \quad M' = \frac{Wa^2b^2 + Wab^3 + Wa^3b - Wa^2b^2}{L^3}$$

$$\Rightarrow \quad M' = \frac{Wab(a^2+b^2)}{L^3}$$

Now required 'BM' at 'C' is

$$BM = \frac{Wab}{L} - M'$$

$$BM = \frac{Wab}{L} - \frac{Wab(a^2+b^2)}{L^3}$$

$$BM = \frac{WabL^2 - Wab(a^2+b^2)}{L^3}$$

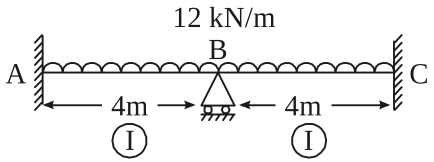
$$BM = \frac{Wab(a^2+b^2) - Wab(a^2+b^2)}{L^3}$$

$$BM = \frac{Wab(a^2+b^2+2ab) - Wab(a^2+b^2)}{L^3}$$

$$BM = \frac{Wa^3b + Wab^3 + 2Wa^2b^2 - Wa^3b - Wab^3}{L^3}$$

$$BM = \frac{2Wa^2b^2}{L^3}$$

34.



Fixed end Moments

$$M_{FAB} = -\frac{\omega l^2}{12} = -\frac{12\times 4^2}{12} = -16 \text{ kN-m}$$

$$\text{So, } M_{FBA} = +\frac{\omega l^2}{12} = +\frac{12\times 4^2}{12} = +16 \text{ kN-m}$$

$$M_{FBC} = -\frac{\omega l^2}{12} = -\frac{12\times 4^2}{12} = -16 \text{ kN-m}$$

$$M_{FCB} = +\frac{\omega l^2}{12} = +\frac{12\times 4^2}{12} = +16 \text{ kN-m}$$

Using Slope deflection equation :-

$$M_{AB} = M_{FAB} = \frac{2EI}{L}\left(2\theta_A + \theta_B - \frac{3\delta}{L}\right)$$

$$M_{AB} = -16 + \frac{2EI}{L}(\theta_B)$$

$$M_{AB} = -16 + \frac{2EI\theta_B}{4}$$

Since there is fixed end at 'A'. So. [$\theta_A = 0$] and there is no sinking of support [$\delta = 0$]

$$M_{AB} = M_{FBA} + \frac{2EI}{L}\left(2\theta_B + \theta_A - \frac{3\delta}{L}\right)$$

$$M_{BA} = +16 + \frac{2EI}{L}\left(2\theta_B + 0 - 0\right)$$

$$M_{BA} = 16 + EI\theta_B$$

Doing the same for the next span where [$\delta = 0$] and also [$\theta_C = 0$]

$$M_{BC} = M_{FBC} + \frac{2EI}{L}\left(2\theta_B + \theta_C - \frac{3\delta}{L}\right)$$

$$M_{BC} = -16 + \frac{2EI}{L}\left(2\theta_B + 0 - 0\right)$$

$$M_{BC} = -16 + EI\theta_B$$

and $$M_{CB} = M_{FCB} + \frac{2EI}{L}\left(2\theta_C + \theta_B - \frac{3\delta}{L}\right)$$

$$M_{CB} = M_{FCB} + \frac{2EI}{L}\left(0 + \theta_B - 0\right)$$

$$M_{CB} = 16 + \frac{2EI\theta_B}{4}$$

For equilibrium of joint 'B' equilibrium equation

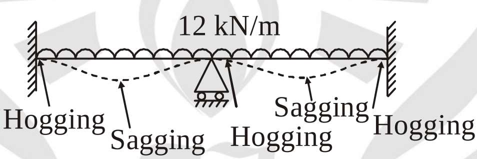
$$M_{BA} + M_{BC} = 0$$

$\Rightarrow (16 + EI\theta_B) + (-16 + EI\theta_B) = 0$

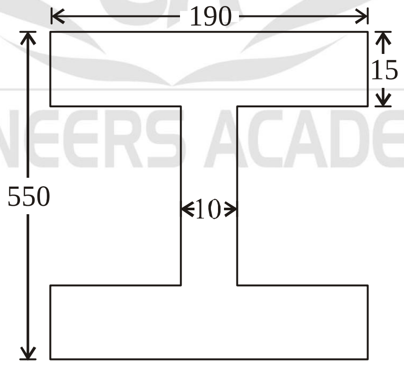
$\Rightarrow \quad 2EI\theta_B = 0$

So, $\quad \theta_B = 0$

So, the slope at B is '0'.



35. (i) For the given beam



(all dimensions in mm)

Since the section is symmetric about both axes, So the Neutral-axes will pass through geometrical-center.

Moment of Inertia of the section.

$$I_{xx} = \frac{190\times550^3}{12} - \frac{(190-10)\times520^3}{12}$$

I_{xx} = 525150833.3 mm^4

Bending stress

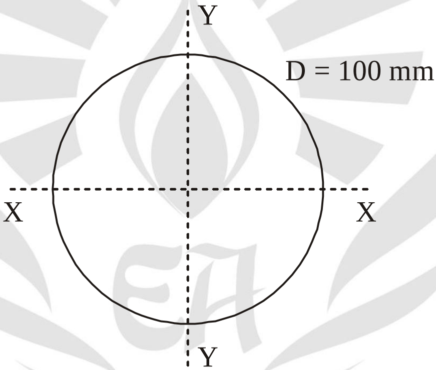
$$f = \frac{M}{I}\cdot y$$

So, $$M = \frac{f\cdot I}{y}$$

So, moment of Resistance of the Beam is

$$M = \frac{100\times525150833.3\times10^{-6}}{\left(\frac{550}{2}\right)} = 190.96\ \text{kN-m}$$

(ii)



Moment of Inertia $I_{XX} = \frac{\pi}{64}D^4$

$$I_{XX} = \frac{\pi}{64}\times(100)^4 = 4908738.52\ \text{mm}^4$$

Since bending stress

$$f = \frac{M}{I}\cdot y$$

So, moment of resistance

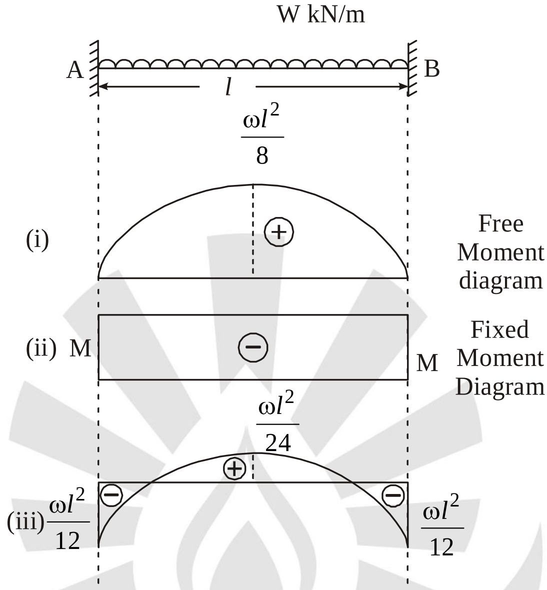
$$M = \frac{f\cdot I}{y} = \frac{100\times4908738.52}{\left(\frac{100}{2}\right)}$$

Given maximum stress

$$f = 100 \text{ N/mm}^2$$

$$M = 9.81 \text{ kN-m}$$

36. Bending moment diagram for the given beam.



Since the loading is symmetric the fixed end moments will be same at both the ends (say M).

Free end moment diagram is as per diagram (i).

Now as per moment area method, the difference of the slopes at two points of any beam will be equal to the area of (M/EI) - diagram between those two points.

$(\theta_A - \theta_B)$ = Difference of slopes at ends due to free moments.

$$\theta - (-\theta) = \frac{2}{3} \times \frac{Wl^2}{8EI} \times l$$

$$2\theta = \frac{Wl^3}{12EI}$$

$$\theta = \frac{Wl^3}{24EI}$$

Here, loading is symmetric so $[\theta_1 = \theta_2 = \theta]$ and for clockwise rotation $\theta \rightarrow$ positive and for Anticlockwise rotation $\theta \rightarrow$ negative.

Now, $\theta_1' - \theta_2'$ = Difference of slopes at ends due to fixed end moments.

$$\theta_1' - \theta_2' = \frac{M \cdot l}{EI}$$

$$\theta' - (-\theta') = \frac{Ml}{EI}$$

$$2\theta' = \frac{Ml}{EI}$$

$$\theta' = \frac{Ml}{2EI}$$

Since in the fixed beam slope at fixed end is zero. So, the slope due to free end moment will be restricted/opposed by fixed end moment.

$$\theta = \theta'$$

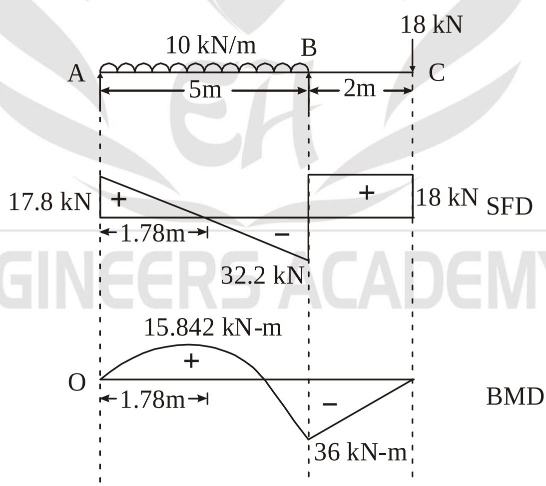
or $$[\theta' = \theta]$$

$$\Rightarrow \quad \frac{Ml}{2EI} = \frac{Wl^3}{24EI}$$

$$\Rightarrow \quad M = \frac{Wl^2}{12}$$

Putting the value of M is figure (ii) we can get the B.M.D. as shown by figure (iii).

37.



For reactions at A and B.

$$\Sigma M_A = 0$$

$$\Rightarrow \quad 5R_B = 251$$

$$R_B = 50.2 \text{ kN}$$

$$R_A + R_B = (10 \times 5) + 18$$
$$R_A = 68 - 50.2$$
$$R_A = 17.8 \text{ kN}$$

Now for shear force

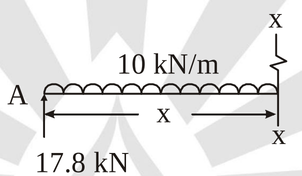
(i) In BC section

$SF_C = + 18$ kN

$SF_B = +18$ kN

+ve sign because clockwise direction.

(ii) SF in AB Section



$$SF_A = 17.8 \text{ kN}$$
$$SF_X = 17.8 - 10.x \text{ (Linear)}$$

at $x = 0$

$\Rightarrow$ $SF_A = 17.8$ kN

at $x = 5$

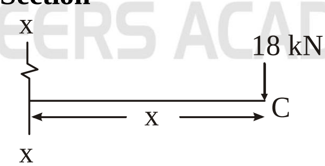
$\Rightarrow$ $SF_B = 17.8 - (10 \times 5)$

$SF_B = -32.2$ kN

So, the shear force diagram is shown in fig.

Now for Bending moment :

(i) BM in BC - Section



$$BM_X = -18.x \text{ (Linear)}$$

Negative sign is due to hogging B.M.

at $x = 0;$

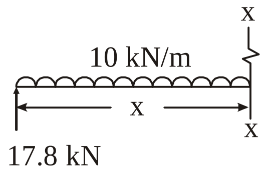
$\Rightarrow$ $(BM)_C = 0$

at $x = 2;$

$\Rightarrow$ $(BM)_B = -18 \times 2$

$(BM)_B = -36$ kN-m

(ii) For AB-Section



$$BMX = 17.8x - 10.x.\frac{x}{2} \quad (2^o\text{-parabola})$$

at $x = 0;$

$\Rightarrow \quad (BM)_A = 0$

at $x = 5M;$

$\Rightarrow \quad (BM)_C = -36$ kN-m

So, BMD is shown by fig.

For maximum BM

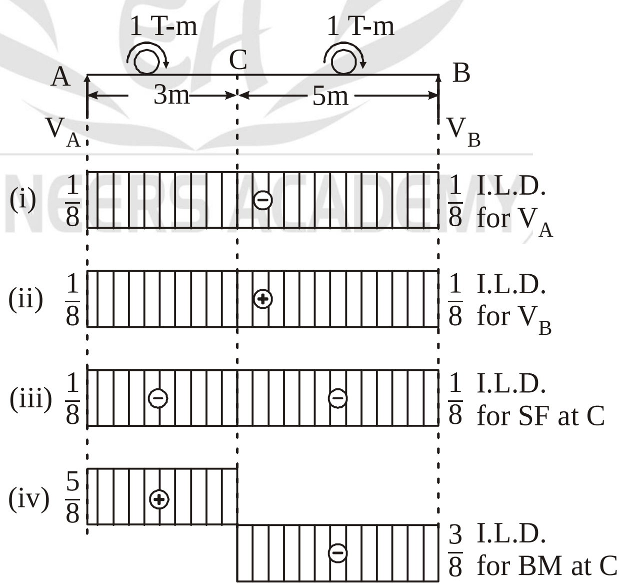
$$\frac{dM}{dx} = 0 \Rightarrow 17.8 - 5 \times 2x = 0$$

at $$x = \frac{17.8}{(5\times 2)} = 1.78 \text{ m}$$

$$(BM)_{max} = (17.8\times 1.78) - (10\times 1.78\times \frac{1.78}{2})$$

$$= 15.84 \text{ kN-m}$$

38.



1. For I.L.D. of VA(Reaction at A)

When load is between A and B

$$\Sigma M_B = 0$$

$$V_A.8 + 1 = 0$$

$$V_A = -\frac{1}{8} \text{ Ton}$$

here (–) sign represents that the direction of V_A is downward I.L.D. is in fig. (i).

2. I.L.D. of V_B (Reaction at B)

$$V_A + V_B = 0$$

$$V_B = -V_A$$

So, the (+) sign represents the upward direction of reaction at B. Fig. (ii)

$$VB = +\frac{1}{8} \text{ Ton}$$

(iii) I.L.D. for shear force at 'C'

(a) When the moment is between A and C

SF at C $\Rightarrow F_C = -V_B$

here negative sign is due to anticlockwise direction.

$$F_C = -\frac{1}{8}\text{Ton}$$

(b) When the moment is between B and C

SF at C $\Rightarrow F_C = -V_A$

$$F_C = -\frac{1}{8}\text{kN}$$

So, I.L.D. is given in figure (iii).

(iv) I.L.D. for Bending Moment at 'C'

(a) When the moment is between A and C

$$BM_C = V_B \times 5$$

$$(BM)_C = +\frac{5}{8} \text{ Ton-m}$$

(b) When the moment is between B and C

$$(BM)_C = V_A \times 3$$

$$= -\frac{1}{8} \times 3 = (-)\ \frac{3}{8} \text{ Ton-m}$$

So, I.L.D. is given in figure (iv).

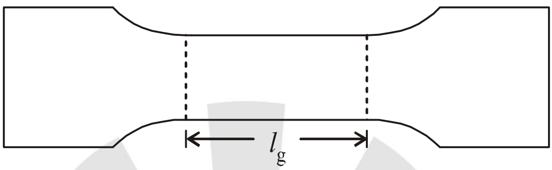
39. Tensile strength test of mild steel :

This test is of static type i.e. load is increased comparatively slowly from zero to a certain value.

Standard specimens are used for the tensile test. There are two types of specimens used for this purpose.

(i) Circular cross-section.

(ii) Square/Rectangular cross section



l_g = gauge length

The gauge length to diameter/size ratio is generally kept as 4 : 1. This test is carried out on Tensile testing machine and the following steps are performed to conduct this test.

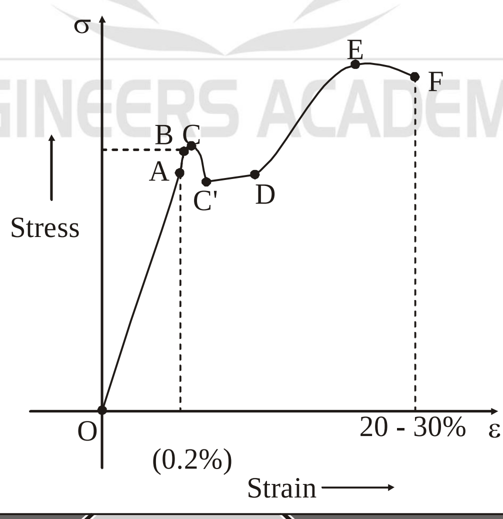
(i) The end of specimens are secured in the grips of the testing machine.

(ii) There is a unit of applying a load to the specimen with a hydraulic or mechanically drive.

(iii) There must be a some recording device by which you should be able to measure the final output in the form of load or stress. So the testing machines are often equipped with the pendulum type lever pressure gauge and hydraulic capsule and the stress v/s.

Strain diagram is plotted which has the following shape.

The stress-strain curve for mild-steel has been shown below :



In the above diagram:

OA $\rightarrow$ limit of proportionality

$\rightarrow$ linear Elastic Range

OB $\rightarrow$ Elasticity limit

AB $\rightarrow$ Non Linear Elastic Range

C $\rightarrow$ Upper Yield Point

C' $\rightarrow$ Lower yield point

(Due to slip of carbon atoms)

CD $\rightarrow$ Yield-Pleatau

DE $\rightarrow$ Strain hardening Range

E $\rightarrow$ Ultimate Stress

F $\rightarrow$ Failure point / Rupture Point

EF $\rightarrow$ Necking Zone.

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