COMBINED BANK – 2020
Post: Senior Officer (Civil)

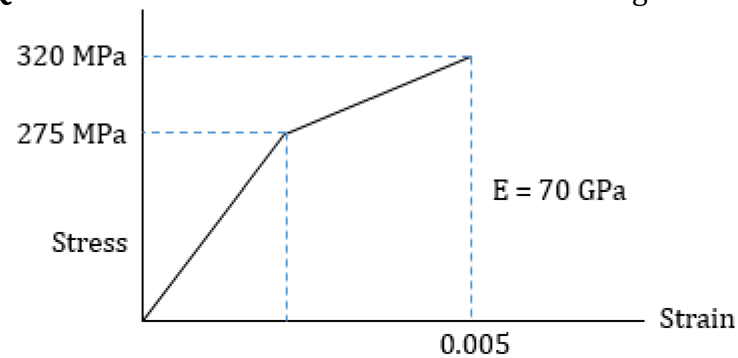
Question: The amount of BOD_5 in a sewage found 200 mg/L at temperature 20°C. If k = 0.22/day, then determine the ultimate BOD.

Solution:

$$BOD_5 = BOD_u\ (1 - e^{-k\,t})$$

$$BOD_u = \frac{BOD_5}{(1 - e^{-k\,t})} = \frac{200}{(1 - e^{-0.22 \times 5})} = 299.79\ \text{mg/L}$$

Question: Find the modulus of resilience & toughness modulus from the following data.



Solution:

Strain at 275 MPa, $\varepsilon_{yield} = \frac{\sigma_{yield}}{E} = \frac{275 \text{ x } 10^6}{70 \text{ x } 10^9} = 0.00392$

Modulus of resilience $= \frac{1}{2} \text{ x } \sigma_{yield} \text{ x } \varepsilon_{yield} = \frac{1}{2} \text{ x } 275 \text{ x } 10^6 \text{ x } 0.00392 = 539000\ \text{J/m}^3$

Modulus of toughness $= \frac{1}{2} \text{ x } 275 \text{ x } 0.00392 + \frac{275 + 320}{2} \text{ x } (0.005 - 0.00392) = 0.86\ \text{MPa}$

Question: A rectangular channel is 10 ft width and 3 ft depth. Determine the velocity & rate of flow if manning's coefficient is, n = 0.015 and bed slope of the channel is, S = 0.003.

Solution:

Area, $A = b\ h = 10 \text{ x } 3 = 30\ \text{ft}^2$

Wetted perimeter, $P = b + 2\ h = 10 + 2 \text{ x } 3 = 16\ \text{ft}$

Hydraulic radius, $R = A/P = 30/16 = 1.875\ \text{ft}$

Velocity, $V = \frac{1}{n}\ R^{2/3}\, S^{1/2} = \frac{1}{0.015} \text{ x}(1.875)^{2/3}(0.003)^{1/2} = 5.56\ \text{ft/s}$

Discharge, $Q = A\ V = 30 \text{ x } 5.56 = 16.68\ \text{ft}^3/\text{s}$

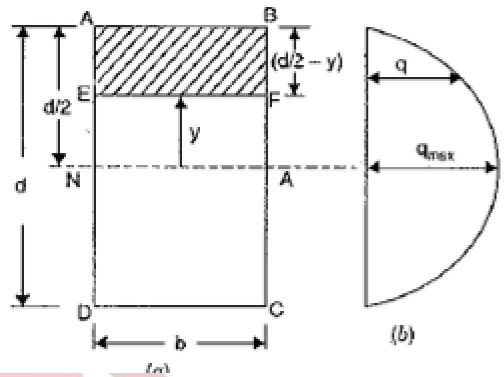
Question: Show that shear stress of a rectangular beam along the section in neutral axis is 1.5 times of average shear stress.

Solution:

Figure shows a rectangular section of a beam of width b and depth d. Let F is the shear force acting at the section. Consider a level EF at a distance y from the neutral axis.

The shear stress at this level, $\tau = \dfrac{A\,\bar{y}}{b \text{ x } I}$

Where, $A =$ area of the section above (shaded area $ABFE$) $= \left(\dfrac{d}{2} - y\right) b$



$\bar{y} =$ Distance of the C.G of area A from neutral axis

$= y + \dfrac{1}{2}\left(\dfrac{d}{2} - y\right) = y + \dfrac{d}{4} - \dfrac{y}{2} = \dfrac{y}{2} + \dfrac{d}{4} = \dfrac{1}{2}\left(y + \dfrac{d}{2}\right)$

$b =$ Actual width of the section at the level EF

$I = M.O.I$ of the whole section at the level EF

Now, $\tau = \dfrac{F\,\left(\frac{d}{2} - y\right) \text{ x } b \text{ x } \frac{1}{2}\left(y + \frac{d}{2}\right)}{b \text{ x} I} = \dfrac{F}{2\,I}\left(\dfrac{d^2}{4} - y^2\right)$

we see that τ increases as y decreases, the variation of τ with respect to y is parabola.

At the top edge, $y = \dfrac{d}{2}, \tau = \dfrac{F}{2\,I}\left[\dfrac{d^2}{4} - \left(\dfrac{d}{2}\right)^2\right] = \dfrac{F}{2\,I} \text{ x } 0 = 0$

At the neutral axis, $y = 0, \tau = \dfrac{F}{2\,I}\left(\dfrac{d^2}{4} - 0\right) = \dfrac{F}{2\,I} \text{ x } \dfrac{d^2}{4} = \dfrac{F\,d^2}{8\,I}$

$\tau = \dfrac{F\,d}{8 \text{ x } \frac{b\,d^3}{12}} = \dfrac{12}{8} \text{ x } \dfrac{F}{b\,d} = 1.5\,\dfrac{F}{b\,d}$

Average shear stress, $\tau_{avg} = \dfrac{\text{Shear force}}{\text{Area of section}} = \dfrac{F}{b\,d}$

So, $\tau = 1.5\,\tau_{avg}$

Which gives the shear stress at the neutral axis where $y = 0$, this stress is also the maximum shear stress.

$\tau_{max} = 1.5\,\tau_{avg}$

Question: From a direct shear test, the value of normal stress of two sample is found 100 & 200 kip/ft^2 respectively. The value of shear stress of two sample is 80 & 120 kip/ft^2 respectively. What is the value of c & φ value?

Solution:

Here, $\sigma_1 = 100\ \text{kip/ft}^2, \sigma_2 = 200\,\text{kip/ft}^2, \tau_1 = 80\,\text{kip/ft}^2, \tau_2 = 120\ \text{kip/ft}^2$

Now, $\tau_1 = c + \sigma_1 \tan\varphi$

$80 = c + 100\tan\varphi$

Again, $\tau_2 = c + \sigma_2 \tan\varphi$

$120 = c + 200\tan\varphi$

Solving the two equations, $\varphi = 21.80^0$ & $c = 40\ \text{kip/ft}^2$

Question: Define ductility. Why it is important in earthquake resistant structures?

Solution:

Ductility indicates the ability of a material to deform in the plastic range without breaking, which may be expressed as percent elongation or percent area reduction from a tensile test.

Ductility describes the extent to which a material or structure can undergo large deformations without failing. The term is used in earthquake engineering to designate how well a building will endure large lateral displacements imposed by ground shaking. In the simplest of terms, a ductile structure will bend and not break, which greatly reduces the risk of a catastrophic failure.

You can, however, have too much of a good thing. A structure that is too stiff (often referred to as *brittle*) will be prone to failure under relatively small deformation demands. An example of a brittle structure is an unreinforced masonry building, which will tolerate very little displacement before the onset of damage and failure.

A ductile structure's ability to contort and dissipate energy during an earthquake is, therefore, also advantageous as it will keep deforming without reaching ultimate failure or collapse. An example of a ductile structure is a properly detailed steel frame with a degree of elasticity that will enable it to undergo large deformations before the onset of failure.

Question: Specific gravity of cement, CA & FA are 2.9, 2.67 & 2.6. Air content is 2%.

(a) Find the unit weight of CA,
(b) W/C ratio,
(c) Unit weight of concrete
(d) If water is increased what will be the effect on compressive strength and workability.

Weight (kg)			
Water	Cement	CA	FA
187	397	-	636

Solution:

(a) Volume of water, $V_w = \dfrac{W_w}{G_s\,\gamma_w} = \dfrac{187}{1 \text{ x } 1000} = 0.187 \text{ m}^3$

Volume of cement, $V_c = \dfrac{W_c}{G_s\,\gamma_w} = \dfrac{397}{2.9 \text{ x } 1000} = 0.136 \text{ m}^3$

Volume of FA, $V_{FA} = \dfrac{W_{FA}}{G_s\,\gamma_w} = \dfrac{636}{2.6 \text{ x } 1000} = 0.245 \text{ m}^3$

Volume of CA, $V_{CA} = 1 - (0.187 + 0.136 + 0.245 + 0.02) = 0.412 \text{ m}^3$

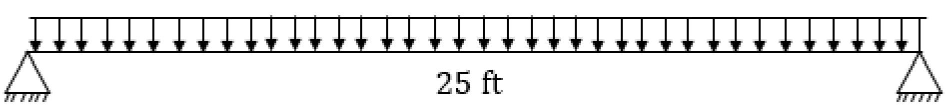
Weight of CA, $W_{CA} = V_{CA}\,G_s\,\gamma_w = 0.412 \text{ x } 2.67 \text{ x } 1000 = 1100.04 \text{ kg}$

(b) Water cement ratio $= \dfrac{187}{397} = 0.47$

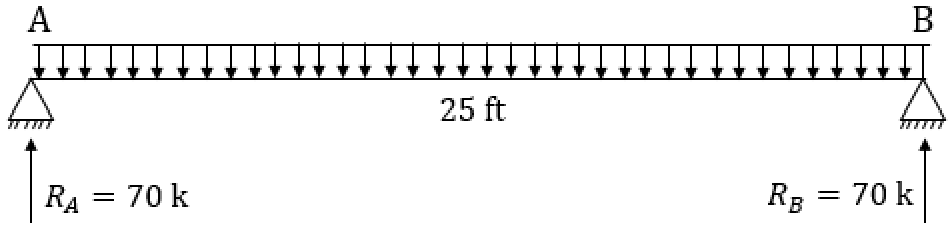
(c) Unit weight of concrete, $\gamma_c = \dfrac{W}{V} = \dfrac{187 + 397 + 636 + 1100.04}{0.187 + 0.136 + 0.245 + 0.412 + 0.02} = 2320.04 \text{ kg/m}^3$

(d) If water is increased the concrete compressive strength will decrease and workability will increase.

Question: A rectangular beam of section 12” x 24” carries $DL = 2$ k/ft and $LL = 2$ k/ft. If the value of $f_c' = 4$ ksi, $f_y = 60$ ksi & $d' = 1.5"$, design the reinforcement at 10 ft from the support for the following beam.



Solution:



Factored load, $W = 1.2\ DL + 1.6LL = 1.2 \text{ x } 2 + 1.6 \text{ x } 2 = 5.6$ k/ft

Moment at 10 ft from support, $M_u = 70 \text{ x } 10 - 5.6 \text{ x } 10 \text{ x } 5 = 420$ k − ft

$$M_u = \varphi\, A_s\, f_y \left(d - \frac{a}{2}\right)$$

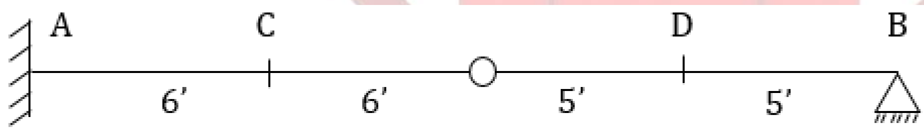
$$420 \text{ x } 12 = A_s \text{ x } 0.9 \text{ x } 60 \text{ x } \left(22.5 - \frac{7.28}{2}\right) \qquad [\text{Assume, } a = 7.28 \text{ in}]$$

$A_s = 4.94 \text{ in}^2$

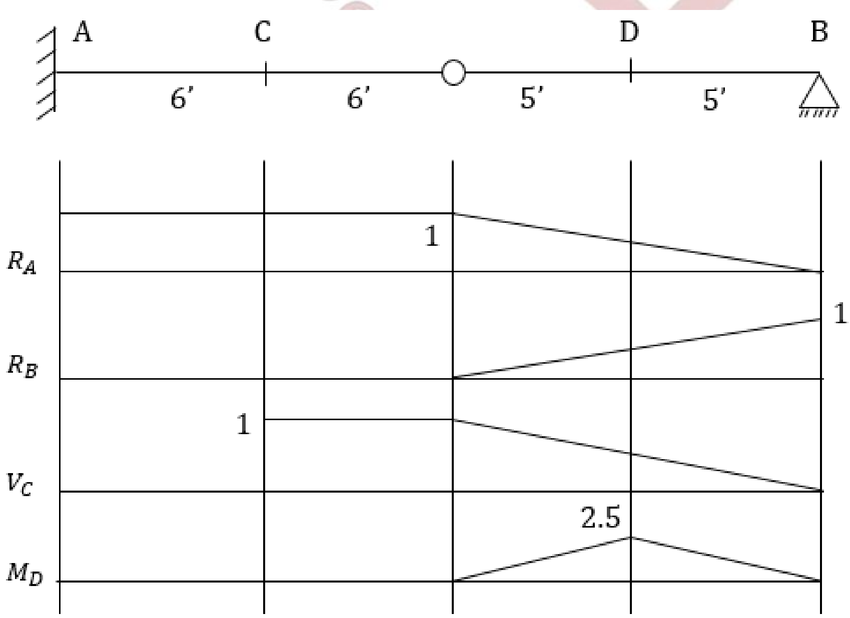
$$\text{Check, } a = \frac{A_s\, f_y}{0.85\, f_c'\, b} = \frac{4.94 \text{ x } 60}{0.85 \text{ x } 4 \text{ x } 12} = 7.28 \text{ in} \rightarrow \text{as assumed (ok)}$$

Provide 5#9 bar as main reinforcement ($A_s = 5.00 \text{ in}^2$)

Question: Draw influence line of reaction at A & B, shear at C & moment at D. What will be moment at D if 100 kip load act on the hinge.



Solution:



If 100 kip load act on the hinge the moment at D will be zero.

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