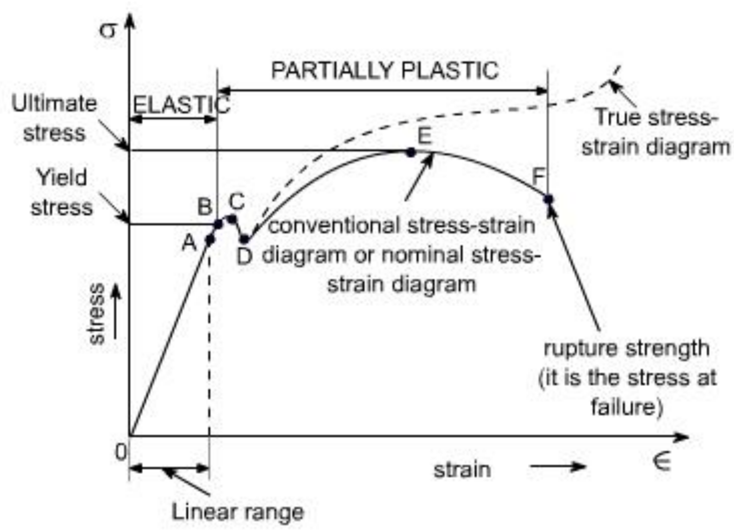
BWDB-2018
Assistant Engineer (CIVIL)
Exam Venue: BUET

1. Draw the mild steel stress-strain diagram with all point and how the ductility of mild steel is determined?

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. Two measures of ductility are elongation and reduction of area. The conventional means by which these measures are obtained is by pulling a specimen in tension until fracture.

Percent elongation or engineering strain at fracture can be written as:

$$\%EL = \frac{L_f - L_o}{L_o} \text{ x } 100$$

Percent reduction in area can be written as:

$$\%EA = \frac{A_f - A_o}{A_o} \text{ x } 100$$

2. An engineer wishing to obtain the speed characteristics on a bypass around her city at a confidence level of 95%, and an acceptable limit of ± 1.0 mi/h collected a total of 130 spot speed samples and determined that the variance is 25 $(mi/h)^2$. Has the engineer met with all of the requirements of the study?

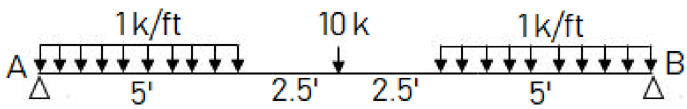
Solution:

$$N = \left(\frac{Z\,\sigma}{d}\right)^2 = \frac{Z^2 \text{ x } \sigma^2}{d^2}$$

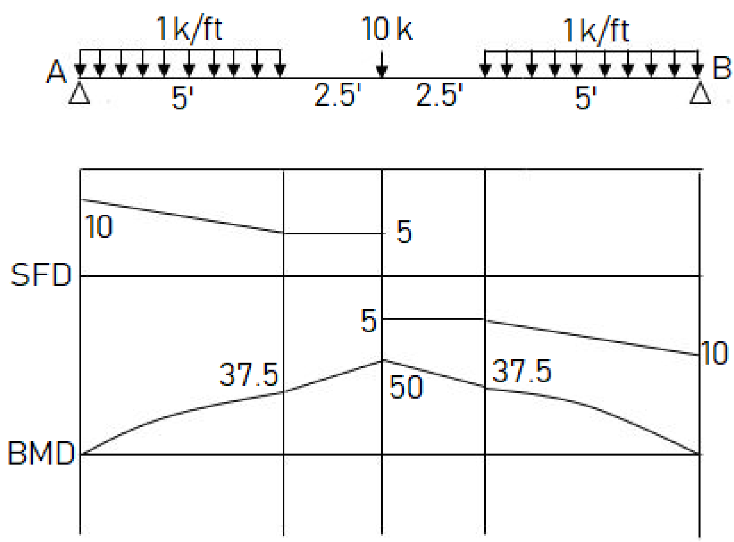
$$= 1.962 \text{ x } \frac{25}{1^2} \quad [\text{For 95\% confidence level}, Z = 1.96]$$

$$= 96.04 < 130, \text{the engineer met the requirement}$$

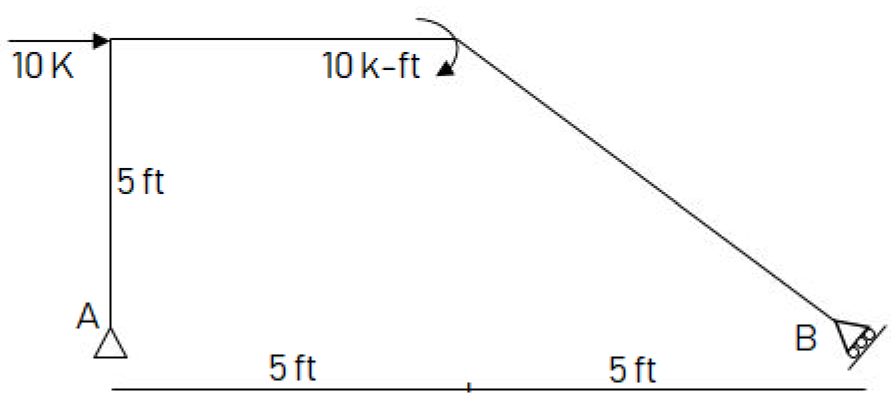
3. Draw SFD and BMD for the following beam.



Solution:



4. Find the reactions at supports for the following structure.



Solution:

$\sum M_A = 5 \times 10 + 10 - R_B \sin 45 \times 10 = 0$
$R_B = 6\sqrt{2}$ k

$\sum F_Y = 0$
$R_{AY} + R_B \sin 45 = 0$
$R_{AY} = 6$ k

$\sum F_x = 0$
$R_{AX} + 10 - R_B \cos 45 = 0$
$R_{AX} = -4$ k

5. From which harmful ray's stratospheric ozone layer save us? Which substances harm ozone layer? Write down the problems behind ground-water exploration in BD.

Solution:

The ozone layer absorbs ultraviolet radiation rays and prevents them from coming to the surface of the earth thus saving the human beings from harmful rays. Halocarbon refrigerants, solvents, propellants and foam-blowing agents [chlorofluorocarbons (CFCs), HCFCs, halons] referred to as ozone-depleting substances (ODS).

Bangladesh is a country of rivers and floods but groundwater is still a vital resource because it provides bacterially safe water and helps produce food for millions of people. Availability of groundwater has not been a constraint to agricultural development. But this resource is increasingly facing various problems including quality hazards in many areas where the exposure to pollution from agriculture, urbanized areas and industrial sites as well as arsenic contamination in shallower groundwater aquifers makes the water unfit for human consumption and in some cases even for irrigation purposes. High rates of pumping for irrigation and other uses from the shallow aquifers in coastal areas may result in widespread saltwater intrusion, downward leakage of arsenic concentrations and the general degradation of water resources. Besides, use of agrochemicals may cause contamination of shallow groundwater and sediments. Continuous decline of groundwater tables due to over-withdrawal has also been reported from some areas. Thus the overall situation calls for urgent groundwater management for sustainable development. Groundwater management must adopt an integrated approach taking into account a wide range of ecological, socio-economic and scientific factors and needs.

6. If the BOD_5 is 102.5 mg/L and k = 0.23/day at 20°C temperature. Determine the ultimate BOD.

Solution:

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

$$BOD_u = \frac{BOD_5}{(1 - e^{-k\,t})} = \frac{102.5}{(1 - e^{-5 \times 0.23})} = 150 \text{ mg/L}$$

7. 100 MLD water is to be supplied from a water treatment plant which containing 0.4 ppm Cl_2, if bleaching powder contains 25% available chlorine by weight find out the amount of bleaching powder in kg/day.

Solution:

Waste water to be treated = 100 Mld = 100000000 L/day

$$\text{Amount of chlorine required per day} = \frac{100000000 \times 0.4}{1000 \times 1000} = 40 \text{ kg}$$

$$\text{Amount of bleaching powder required} = \frac{40 \times 100}{25} = 160 \text{ kg/day}$$

8. Compute consolidation settlement of a 2.5 m thick clay layer due to an increase of 30 KN/m^2 pressure at the mid height of the layer. If vertical stress at the mid height of the layer is 40 KN/m^2. The value of initial void ratio is 0.7 and compression index is 0.28.

Solution:

$$S_c = \frac{C_c\ H}{1+e_0}\log\frac{\sigma_0+\Delta\sigma}{\sigma_0} = \frac{0.28 \text{ x } 2.51}{1+0.7}\log\frac{40+30}{40} = 0.100 \text{ m}$$

9. A nine pile group consisting of 18" diameter concrete pile was cast in situ in a clayey soil whose unconfined compressive strength is 1000 lb/ft^2. Each pile is 60ft long and the pile spacing is 2.5 times the pile diameter. Using an adhesion factor α=0.5 and factor of safety is 3, calculate allowable skin friction of single pile.

Solution:

$$\text{Here,} c_u = \frac{q_u}{2} = \frac{1000}{2} = 500 \ \text{kN/m}^2$$

$$Q_s = \alpha\ c_u\ A_s = \alpha\ c_u\ \pi\ D\ L$$

$$= 0.5 \text{ x } 500 \text{ x } 3.14 \text{ x } 1.5 \text{ x } 60$$

$$= 70676 \text{ lb} = 70.686 \text{ kip}$$

$$\text{Allowable skin friction} = \frac{70.686}{3} = 23.56 \text{ kN}$$

10. A wood of 5 kg weight flows in water; if the wood contain 60% of its volume at the time of floating then G_s=?

Solution:

For equilibrium, weight of wooden block = weight of water displaced

$$\gamma_{wood} \text{ x } V_{wood} = \gamma_{water} \text{ x } V_{water}$$

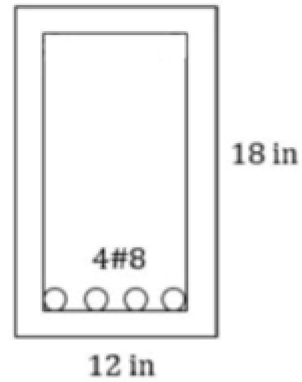
$$\rho_{wood} \text{ x } V_{wood} \text{ x } g = \frac{60}{100} \text{ x } V_{wood} \text{ x } 1000$$

$$\rho_{wood} = 600 \ \text{kg/m}^3$$

$$G_s = \frac{\gamma_{wood}}{\gamma_{water}} = \frac{600}{1000} = 0.6$$

11. Determine the ultimate moment for the beam shown below, where $fc' = 4$ ksi, $f_y = 60$ ksi, Clear cover = 1.5"

Solution:



$A_s = 4 \text{ x } 0.79 = 3.16 \text{ in}^2$

$$\rho = \frac{A_s}{b\ d} = \frac{4}{12 \text{ x } 16.5} = 0.02 > \rho_{min} = 0.0033$$

$$a = \frac{A_s\ f_y}{0.85\ f_c'\ b} = \frac{3.16 \text{ x } 60}{0.85 \text{ x } 4 \text{ x } 12} = 4.65 \text{ in}$$

$\beta_1 = 0.85$ for 4000 psi concrete

$$c = \frac{a}{\beta_1} = \frac{4.65}{0.85} = 5.47 \text{ in}$$

$$\varepsilon_t = \frac{d-c}{c}(0.003) = \frac{16.5 - 5.47}{5.47}(0.003) = 0.00605 > 0.005$$

$\varepsilon_t > 0.005$, So tension controlled section and $\varphi = 0.9$

$$M_u = \varphi\ A_s\ f_y\left(d - \frac{a}{2}\right) = 0.9 \text{ x } 3.16 \text{ x } 60\left(16.5 - \frac{4.65}{2}\right) = 2418.82 \text{ k} - \text{in}$$

12. Precipitation 9 cm, runoff 5 cm, Rainfall data is given to the time. Find the value of Ø-index.

Time	1	2	3	4	5	6
Rainfall	0.4	2.2	4	2.2	1.4	0.9

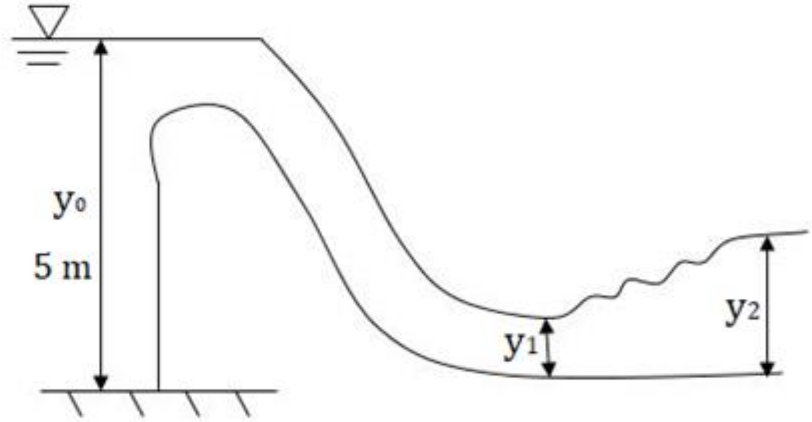
Solution:

If infiltration is assumed constant, $\varphi - \text{index} = \frac{P\ -\ R}{t} = \frac{11.1\ -\ 5}{6} = 1.017$ cm

But this infiltration rate can't be possible throughout the time period of 6 hours, because 1 hour and 6 hour rainfall rate is lesser and infiltration rate can never be more than rainfall rate. φ-index will be somewhere between 0.9 cm/hour to 1.4 cm/hour.

$$\varphi - \text{index} = \frac{11.1 - 5 - 0.4 - 0.9}{4} = 1.2 \text{ cm/hour}$$

13. A spillway discharge 2.5 $m^3/s/m$ width. For occurring hydraulic jump, what should be the value of Y_2. Neglect energy loss.



Solution:

By energy equation,

$$y_0 = y_1 + \frac{V_1^2}{2\ g} = y_1 + \frac{q^2}{2\ g\ y_1^2}$$

$$5 = y_1 + \frac{2.5^2}{2 \text{ x } 9.8 \text{ x } y_1^2}$$

$$19.62 y_1^2 - 98.1\ y_1^2 + 6.25 = 0$$

By trial and error, $y_1 = 0.259$ m

$$\text{Now}, V_1 = \frac{q}{y_1} = \frac{2.5}{0.259} = 9.65\ \text{ m/s}$$

$$Fr_1 = \frac{V_1}{\sqrt{g\ y_1}} = \frac{9.65}{\sqrt{9.81 \text{ x } 0.259}} = 6.05$$

$$\frac{y_2}{y_1} = \frac{1}{2}\left(\sqrt{1 + 8\ Fr_1^2} - 1\right)$$

$$y_2 = \frac{y_1}{2}\left(\sqrt{1 + 8\ Fr_1^2} - 1\right) = \frac{0.259}{2}\left(\sqrt{1 + 8 \text{ x } 6.05^2} - 1\right) = 2.09 \text{ m}$$

14. A storm with 10 cm precipitation has direct runoff 60,000 m^3 in 1 km^2 catchment area. Calculate runoff coefficient and effective rainfall.

Solution:

$$\text{Effective rainfall} = \text{direct runoff} = \frac{60{,}000}{1 \text{ x } 1000 \text{ x } 1000} = 0.06 \text{ m} = 6 \text{ cm}$$

$$\text{Runoff co} - \text{efficient} = \frac{\text{Runoff}}{\text{Rainfall}} = \frac{6}{10} = 0.6$$

15. Eight cube of 6" x 6" is made of concrete with ratio 1:3:6. How many bags of cement is required.

Solution:

$$\text{Wet volume} = 8 \text{ x } \frac{6}{12} \text{ x } \frac{6}{12} \text{ x } \frac{6}{12} = 1 \text{ cft}$$

$$\text{Dry volume} = 1.54 \text{ x } 1 = 1.54 \text{ cft}$$

$$\text{Amount of cement required} = \frac{1}{1\ +\ 3\ +\ 6} \text{ x } 1.54 = 0.154 \text{ cft} = 0.123 \text{ bags}$$

16. A sample of dry sand was tested in direct shear apparatus under a normal load of 36 kg. The sample failed under a shearing load of 58 lb. The sample size was 2" x 2". What is the angle of internal friction?

Solution

For cohesionless soil, c = 0

Shear stress, $\tau = \frac{R}{A} = \frac{58}{2 \text{ x } 2} = 14.5$ psi

Normal stress, $\sigma = \frac{N}{A} = \frac{36 \text{ x } 2.205}{2 \text{ x } 2} = 19.84$ psi

Shear strength, $\tau = c + \sigma \tan \varphi$

$14.5 = 0 + 19.84 \tan \varphi$

$\varphi = tan^{-1}\left(\frac{14.5}{19.84}\right) = 36.16^0$

17. Let the cycle time of an intersection is 60 seconds. The green time for a phase is 27 seconds and the corresponding yellow time is 4 seconds. If the saturation headway is 2.4 seconds per vehicle, the startup lost time is 2 seconds per phase and the clearance lost time is 1 second/phase, find the capacity of the movement per lane?

Solution:

Total lost time, l_i = 2 + 1 = 3 seconds

Saturation flow rate, $S_i = \frac{3600}{h} = \frac{3600}{2.4}$ = 1500 vehicle per hour

Effective green time, $g_{ei} = G_{ai} + y_i - l_i$ = 27 + 4 – 3 = 28 seconds

Capacity of the green phase, $C_i = \frac{g_{ei}}{C} \text{ x } S_i = \frac{28}{60}$ x 1500 = 700 vehicle per hour per lane

18. 2" x 2" cube load test. Fill the box. (BWDB – 2018)

Observed load	Actual load	Compressive strength	Avg. compressive strength
36.7 KN			
37.3 KN		2209 psi	

Solution:

Observed load	Actual load	Compressive strength	Avg. compressive strength
36.7 KN	38.54 KN	2166 psi	2188 psi
37.3 KN	39.30 KN	2209 psi	

Actual load on specimen two = 2209 x 2 x 2 = 8836 lb = $\frac{8836}{224.8}$ = 39.30 kN

Load ratio = $\frac{39.3}{37.3}$ = 1.05

Actual load on specimen one = 36.7 x 1.05 = 38.54 kN

Compressive load on specimen one = $\frac{38.54 \text{ x } 224.8}{2 \text{ x } 2}$ = 2166.04 psi

19. A pipe discharge 40 m³/s. Head loss is 10% of the difference of velocity head. Find out the pressure at point B.

	Point P	Point Q
Elevation	1011 m	1050 m
Pipe dia.	50 cm	100 cm
Pressure	50 kpa	???

Solution:

Area of pipe at point P, $A_1 = \frac{\pi}{4} \text{ x } 0.5^2 = 0.196 \text{ m}^2$

Area of pipe at point Q, $A_2 = \frac{\pi}{4} \text{ x } 1^2 = 0.785 \text{ m}^2$

Velocity at point P, $V_1 = \frac{Q}{A_1} = \frac{40}{0.196} = 203.72 \text{ m/s}$

Velocity at point P, $V_2 = \frac{Q}{A_2} = \frac{40}{0.785} = 50.93 \text{ m/s}$

Difference of velocity head $= \frac{V_1^2}{2\,g} - \frac{V_2^2}{2\,g} = \frac{1}{2 \text{ x } 9.81}(203.7^2 - 50.93^2) = 1983 \text{ m}$

Head loss, $h_L = 1983 \text{ x } 0.1 = 198.3 \text{ m}$

$$Z_1 + \frac{P_1}{\gamma} + \frac{V_1^2}{2\,g} = Z_2 + \frac{P_2}{\gamma} + \frac{V_2^2}{2\,g} + h_L$$

$$1011 + 2115.28 + 5.09 = 1050 + 132.2 + \frac{P_2}{\gamma} + 198.3$$

$P_2 = 17176.03 \text{ kPa}$

20. A stream of 130 liters per second was diverted from a canal and 100 liters per second were delivered to the field. An area of 1.6 hectares was irrigated in 8 hours. The effective depth of root zone was 1.7 m. The runoff loss in the field was 420 m3. Available moisture holding capacity of the soil is 20 cm per meter depth of soil. It is required to determine the, (a) water application efficiency, (b) water storage efficiency.

Solution:

(a) Water application efficiency $= \dfrac{\text{Water stored in the root zone during irrigation}}{\text{Water needed in the root zone prior toirrigation}}$

Water supplied to field during 8 hours @ 100 liters per second = 100 x 8 x 60 x 60 liters
= 2.88 x 10^6 liters
= 2.88 x 10^6 /10^3 m^3 = 2880 m^3

Runoff loss in the field = 420 m^3

The water stored in the root zone = 2880 – 420 m^3 = 2460 m^3

Water application efficiency $(\eta_a) = \dfrac{2880}{2460}$ x 100 = 85.4%

(b) Water storage efficiency $(\eta_s) = \dfrac{\text{Water needed in the root zone prior to irrigation}}{\text{Water stored in the root zone during irrigation}}$ x 100

Moisture holding capacity of soil = 20 cm per m length x 1.7 m height of root zone = 34 cm

Moisture already available in root zone at the time of start of irrigation $= \dfrac{50}{100}$ x 34 = 17 cm

Additional water required in root zone = 34 – 17 = 17 cm

Amount of water required in root zone = Depth x Plot area $= \dfrac{17}{100}$ x (1.6 x 10^4) m^3 = 2720 m^3

But actual water stored in root zone = 2460 m^3

Water storage efficiency $(\eta_s) = \dfrac{2460}{2720}$ x 100 = 90% (say)