NPCBL – 2019
Post: Assistant Engineer
Venue: BUET

1. Define the following term

a. Initial Setting time
b. Soundness test of cement

Solution:

Initial Setting time: The time between the water is added to cement till it starts losing its plasticity is called as initial setting time. For OPC it should not be less than 30 minutes.

Soundness test of cement: The ability of cement to retain its volume after it gets hardened is known as Soundness of Cement. That means the cement should be at minimum volume change after it gets hardened. The test used for determining soundness of cement is known as "Le chatelier apparatus test."

2. Write down the short note on.

a. Quick lime

b. Fat lime

c. Hydraulic lime

d. Hydrated lime

e. Sacked lime

Solution:

Quick lime: Quicklime is a compound named calcium oxide which when added with water gives slake lime which is used for whitewashing. Quick lime is prepared by heating calcium carbonate or limestone to a temperature of 1200 celsius in kiln and then it decomposes into calcium oxide and gaseous carbon dioxide.

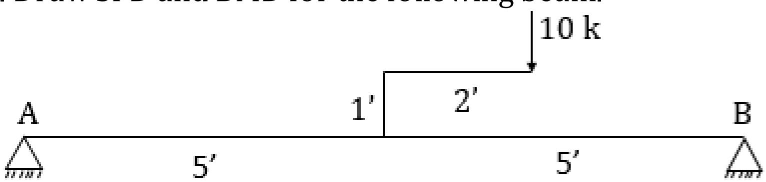
Fat lime: Fat lime is produced from sea shell, coral deposits etc or from lime stone containing impurities like free sand and soluble silica combined with alumina, magnesium, carbonate etc. Fat lime, therefore, does not possess much strength and is used for plastering walls, while washing etc in exposed positions.

Hydraulic lime: It is also known as water lime. This lime contains clay and some amount of ferrous oxide. It sets under water and hence also known as water lime.

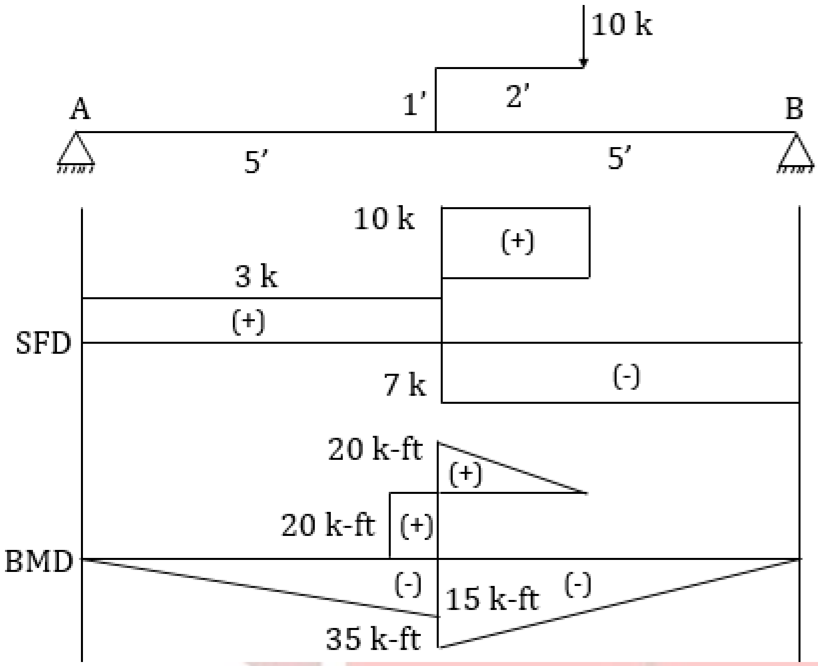
Hydrated lime: Hydrated lime is a dry powder manufactured by treating quicklime with sufficient water to satisfy its chemical affinity for water, thereby converting the oxides to hydroxides.

Sacked lime: It is also known as hydrate of lime. It is obtained by slaking (i.e. chemical combination of quick lime with water) of quick lime. It is ordinary pure lime, in white powder form, available in market. It has got the tendency of absorbing carbonic acid from the atmosphere in presence of water.

3. Draw SFD and BMD for the following beam.

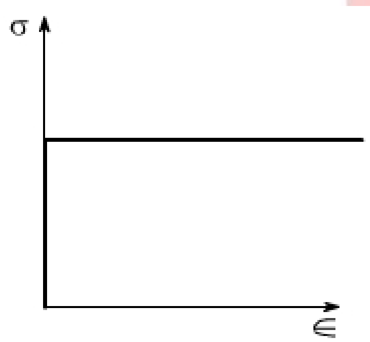


Solution:

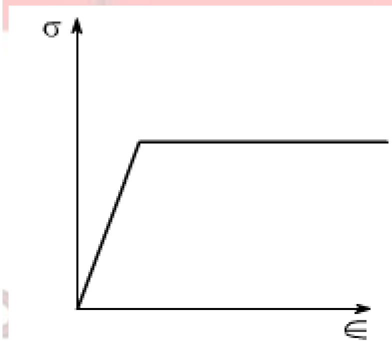


4. Write down the characteristics of the strain of plastic materials.

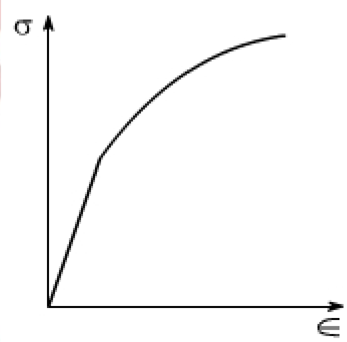
Solution:



Perfectly plastic



Elastic Perfectly Plastic material



Elastic – Plastic material

5. A clay layer of 2 m thick has a coefficient of volume compressibility 0.02 cm^2/kg. If effective stress increases to 2 kg/cm^2 what is the settlement of the clay layer?

Solution:

$H = 2 \text{ m} = 200 \text{ cm}, \Delta\sigma = 2 \text{ cm}^2/\text{kg}$

$S_c = m_v\, H\, \Delta\sigma = 0.02 \text{ x } 2 \text{ x } 200 = 8 \text{ cm}$

6. 100 gm H_2SO_4 mixed with 100L water, determine the value of pH [MW = 98]. Equation

$H_2SO_4 = 2\,[H^+] + SO_4^{2-}$

Solution:

$$\text{mol of } H_2SO_4 = \frac{\text{Weight}}{\text{Molecular Weight}} = \frac{100}{98} = 1.02 \text{ mol}$$

$$\text{Molarity}, M = \frac{\text{mol}}{\text{L}} = \frac{1.02}{100} = 0.0102\ M$$

$H_2SO_4 = 2\,[H^+] + SO_4^{2-}$

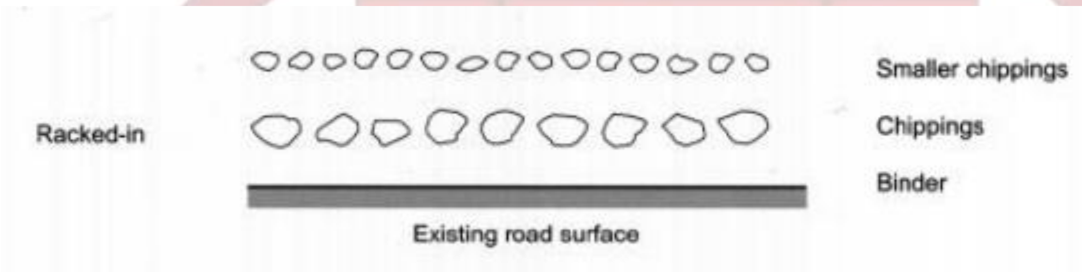
Concentration of $[H^+] = 2 \text{ x } 0.0102 = 0.0204\ M$

$pH = -\log\ [H^-] = -\log\ [0.0204] = 1.69\ M$

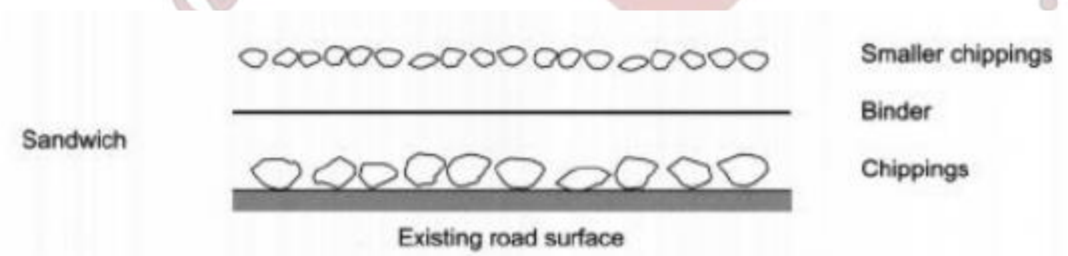
PH = -log [H^+] = -log [0.0204] = 1.69

7. Write down the definition of following: (i) Racked in surface dressing (ii) Sandwich surface dressing.

Solution:



(i) Racked in surface dressing: One application of binder, one layer of chippings at about 90% of what would be used in a single dressing system followed by a second layer of smaller chippings. The smaller chippings lock the larger chippings in position producing a stable matrix. It is used where the traffic is partially heavy and fast and where the stresses are high.



(ii) Sandwich surface dressing: A layer of chippings only is applied before a single dressing. The system is used in situations in which the road surface condition is binder rich, usually just in the wheel-paths.

8. You have planned to irrigate a garden by a dug well using a centrifugal pump at a rate of 10gpm through 1in plastic pipe. At the lowest point, the water level is 50ft below the garden level. You will need a 75ft long plastic pipe (including horizontal length).According to the chart, the frictional head loss per 100ft length of 1 inch plastic pipe is 6.3ft and the same one 90 degree below the connection loss is 16.655ft. Calculate Water horsepower and motor horse power for motor efficiency 0.5.

Solution:

$$\text{Friction loss} = 75 \text{ x } \frac{6.3}{100} + 16.665 = 21.39 \text{ ft}$$

$$\text{Total loss}, H = 21.39 + 50 = 71.39 \text{ ft}$$

$$\text{Water horsepower}, WHP = \frac{H\,Q}{3960} = \frac{71.39 \text{ x } 10}{3960} = 0.18 \text{ HP}$$

$$\text{Brake horsepower} = \frac{\text{Water horsepower}}{\text{efficiency}} = \frac{0.18}{0.5} = 0.36 \text{ HP}$$

9. Find the Time mean speed and space mean speed from the following data.

Distance (m)	Time (sec)
300	20
300	18
300	21
300	16
300	20
300	20

Solution:

$$U_1 = \frac{300}{20} = 15 \text{ m/s}$$

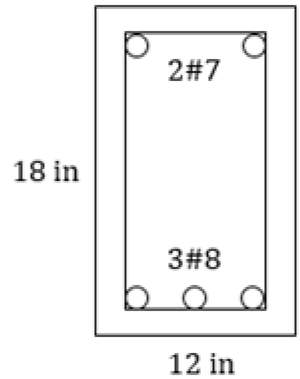
Similarly, $U_2 = 16.66$ m/s, $U_3 = 14.28$ m/s, $U_4 = 18.75$ m/s, $U_5 = 15$ m/s, $U_6 = 15$ m/s

$$\text{Time mean speed}, V_t = \frac{\sum U}{N} = \frac{15 + 16.66 + 14.28 + 18.75 + 15 + 15}{6} = 15.78 \text{ m/s}$$

$$\text{Space mean speed}, V_s = \frac{N}{\sum \frac{1}{U}} = \frac{6}{\frac{1}{15} + \frac{1}{16.66} + \frac{1}{14.28} + \frac{1}{18.75} + \frac{1}{15} + \frac{1}{15}} = 15.65 \text{ m/s}$$

10. Determine the ultimate moment capacity of the beam which clear cover is 1.5 inch. Consider $fc' = 4$ ksi and $f_y = 60$ ksi.

Solution:



$A_s' = 2 \text{ x } 0.6 = 1.2 \text{ in}^2$

$A_s = 3 \text{ x } 0.79 = 2.37 \text{ in}^2$

Assuming, $f_s' = f_y$

$$a = \frac{(A_s - A_s')\, f_y}{0.85\, f_c'\, b} = \frac{(2.37 - 1.2) \text{ x } 60}{0.85 \text{ x } 4 \text{ x } 12} = 1.72 \text{ in}$$

$$c = \frac{a}{\beta_1} = \frac{1.72}{0.85} = 2.02 \text{ in}$$

Computing strains in compression steel to verify assumption that it is yielding,

$$\varepsilon_s' = 0.003 \left(\frac{c - d'}{c}\right) = 0.003 \left(\frac{2.02 - 1.5}{2.02}\right) = 0.000772$$

$$\varepsilon_y = \frac{f_y}{E_s} = \frac{60}{29{,}000} = 0.0027 > \varepsilon_s' \rightarrow So\ f_s' \neq f_y$$

Since the assumption is not valid, we have to use the equilibrium equation that is based on f_s' not yielding.

$$A_s\, f_y = 0.85\, f_c'\, \beta_1\, c\, b + A_s' \left(\frac{c - d'}{c}\right) (0.003)\, E_s$$

$$2.37 \text{ x } 60 = 0.85 \text{ x } 4 \text{ x } 0.85 \text{ x } c \text{ x } 12 + 1.20 \left(\frac{c - 1.5}{c}\right) (0.003) \text{ x } 29{,}000$$

Solving the equation, $c = 2.74$ in

$$a = c\, \beta_1 = 2.74 \text{ x } 0.85 = 2.32 \text{ in}$$

$$\varepsilon_s' = 0.003 \left(\frac{c - d'}{c}\right) = 0.003 \left(\frac{2.74 - 1.5}{2.74}\right) = 0.00135 < \varepsilon_y$$

$$f_s' = \varepsilon_s'\, E_s = 0.00135 \text{ x } 29{,}000 = 39.15 \text{ ksi}$$

$$A_{s2} = \frac{A_s'\, f_s'}{f_y} = \frac{1.2 \text{ x } 39.15}{60{,}000} = 0.78 \text{ in}^2$$

$$A_{s1} = A_s - A_{s2} = 2.37 - 0.78 = 1.59 \text{ in}^2$$

$$\varepsilon_t = \frac{d - c}{c} (0.003) = \frac{16.5 - 2.74}{2.74} (0.003) = 0.015 > 0.005 \rightarrow \varphi = 0.90$$

The design moment strength is,

$$\varphi\, M_n = \varphi \left[A_{s1}\, f_y \left(d - \frac{a}{2}\right) + A_s'\, f_s' (d - d')\right]$$

$$\varphi\, M_n = 0.9 \left[1.59 \text{ x } 60 \left(16.5 - \frac{2.32}{2}\right) + 1.2 \text{ x } 39.15\ (16.5 - 1.5)\right]$$

$$= 1951.32 \text{ kip} - \text{in} = 162.61 \text{ kip} - \text{ft}$$