SSC JE CONVENTIONAL 2016

GENERAL ENGINEERING (CIVIL)

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Q1. (A) A town on the bank of river Ganga discharges 18000 m³/day of treated waste water into the river. The treated wastewater has a BOD_5 of 20 mg/L and a BOD decay constant of 0.12 day^{-1} at 20°C. The river has a flow rate of 0.43 m³/sec and an ultimate BOD of 5.0 mg/L. The DO of the river is 6.0 mg/L and the DO of the wastewater is 0.4 mg/L. Compute the DO and initial ultimate BOD in the river, immediately after mixing. [15 Marks]

Solution :

Discharge of treated wastewater,

$Q_t = 18000 m^3/day$

5 day BOD of treated wastewater,

$BOD_5 = 20 \text{ mg}/l$

Ultimate BOD of treated wastewater,

$$BOD_t = \frac{BOD_{5t}}{(1-10^{-kt})} = \frac{20}{(1-10^{-0.12\times5})} = 26.77 mg/l$$

DO of treated wastewater, $DO_t = 0.4 \text{ mg}/l$

Discharge of river Ganga, $Q_R = 0.43 m^3/s$

$= 0.43 \times 3600 \times 24^2/day$

$= 37152^2/day$

Ultimate BOD of river, $BOD_R = 5.0 \text{ mg}/l$

DO of water, $Do_R = 6.0 \text{ mg}/l$

Ultimate BOD of the mix, $BOD_{mix} = \frac{Q_R BOD_R + Q_t BOD_t}{Q_R + Q_t}$

$$= \frac{37152 \times 5.0 + 18000 \times 26.77}{37152 + 18000}$$

DO of the mix, $DO_{mix} = \frac{Q_R DO_R + Q_t DO_t}{Q_R + Q_t}$

$$= \frac{37152 \times 6.0 + 18000 \times 0.4}{37152 + 18000} = 4.17 mg/l$$

(B) A sample of normally consolidated clay was subjected to a xonsolidated undrained triaxial compression test that was carried out until the specimen failed at a deviator stress of 50 kN/m². The pore water pressure at failure was recorded to be 20 kN/² and confining pressure of 50 kN/m² was used in the test. Determine the consolidated undrained friction angle. [15 Marks]

Solution :

Undrained condition

1. $\sigma_d = 50$

$u = 20$

$\sigma_3 = 50$

$\sigma_1 = \sigma_3 + \sigma_d = 50 + 50 = 100$ kN/m.

$$\sin\theta_{cv} = \frac{\sigma_1 - \sigma_3}{\sigma_1 + \sigma_3} = \frac{100-50}{100+450} = \frac{50}{150} = \frac{1}{3}$$

θ_{cv} = 19.47°.

2. Undrained condition

$$\bar{\sigma}_1 = \sigma_1 - u = 80$$

$$\sigma_3 = \sigma_3 - u$$
$$= 50 - 20 = 30$$

$$\sin\theta_{CD} = \frac{\bar{\sigma}_1 - \bar{\sigma}_3}{\bar{\sigma}_1 + \bar{\sigma}_3} = \frac{80-30}{80+30} = \frac{50}{110}$$

= 27°04'

(C) Using Lacey's theory, design an irrigation channel carrying 30 m³/sec. Take silt factor as 1.0. [15 Marks]

Solution :

Q_d = 30 m³/sec

(f) = 1

(a) Calculation of velocity.

$$V = \left(\frac{Qf^2}{140}\right)^{1/6}$$

$$= \left(\frac{30\times1^2}{140}\right)^{1/6} = .7\text{m/sec.}$$

(b) Calculation of hydraolic meon depth

$$R_s = \frac{s}{2}\times\frac{v^2}{f}$$

$$= \frac{s}{2}\times\frac{(1.7)^2}{1} = 1.4m$$

R = 1.4m

(c) Calculation of area

$$A = \frac{Q}{v} = \frac{30}{.7} = 42.9m^2$$

(d) Perimeer $p = 4.75\sqrt{Q}$

$$= 4.75\sqrt{30} = 26m$$

∴ For trapezoidal section

Assume $\frac{1}{2}H:V$ we get

A = (B + my) y

42.9 = By + .5y² ....(i)

Perimeter

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$p = B + 2y\sqrt{.5^2 + 1} = 26$

B + 2.23y = 26

B = 26 – 2.23y ....(ii)

Put value of B in eq ....(i)

$42.9 = 26\,y - 2.23y^2 + 5.y^2$

y = 1.89m

Puting value of y in eq (ii)

we ge

B = 21m

Calculation of bed slope.

$$F = \frac{f^{5/3}}{3340(30)^{1/6}} = \frac{1}{659.4}$$

(D) Discuss the various causes of disintegration and the major faults occurring in WBM and surface-treated (asphalt roads) in India. [15 Marks]

Solution :

Following are the chief causes of disintegration or failure of WBM and surface treated roads in India:

(i) Improper stability or strength: Poor mix proportioning or inadequate thickness are main reasons for the lack of stability or strength of sub base layer. Soft varieties of stone aggregates also make the base course layer weak. Improper quality control during the construction results in poor base course.

(ii) Loss of binding action: Due to internal movements of aggregate in sub base or base course layers under the repeated stress applications, the composite structure of the layers gets disturbed. This results in loosening of the total mass and formation of alligator cracks on the bituminous surfacing of flexible pavements.

(iii) Inadequate wearing course: Absence of wearing course or inadequate thickness or stability of wearing course exposes the base course to the damaging effects of climatic variations mainly due to rains, frost action and traffic. Bullock cart traffic affects the surface course.

(iv) Use of inferior materials: Many failures mainly structural failures are attributed due to the use of inferior materials in the paving jobs. Some materials exhibit satisfactory characteristics initially, but show rapid deterioration due to weathering.

(v) Failure of wearing course: Failure of wearing course is observed due to lack of proper mix design, improper gradation of aggregates, inadequate binder content and inferior type of binder result in a poor bituminous surfacing.

Some major faults occurring in flexible pavements are:

(a) Alligator (map) cracking

(b) Consolidation of pavement layers

(c) Shear failure and cracking

(d) Longitudinal cracking

(e) Frost heaving

(f) Lack of binding with lower layer:

(g) Reflection cracking

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Q2. (A) Differentiate between the following with reference to bituminous construction:

[15 Marks]

(i) Prime coat and tack coat

(ii) Bituminous concrete and Bituminous macadam.

Solution :

(1) Prime Coat: A prime coat is a coating applied directly to a prepared base before additional layers of support. Prime coat asphalt preparation is a vital element, as it directly affects the shear strength of the final asphalt product.

A prime coat.is mainly responsible for protecting the substrate of a construction project before additional "layers are added. In asphalt preparation, they can also act as a binder with secondary and tertiary , compounds, creating a better adhesion between the layers. Prime coat asphalt acts as an initial sealer in the asphalt laying process to block the other iayers from moisture, dust and debris before additional coating installations.

Tack Coat: A tack coat is applied after the prime coat, to form an adhesive bond between the tack coat and the next layer of coating. The tack coat prevents slippage and may sometimes function as a more long-term sealer to protect the substrate from moisture and bacteria. For asphalt prime coat systems, the tack coat is one of the most vital parts of the process, as it connects the subsequent layers and forms the base of those layers' strength.

(2) Bituminous Macadam (BM):- Bitumen Bound Macadam is a premixed construction method consisting of one or more courses of compacted crushed aggregates premixed with bituminous binder, laid immediately after mixing. The BM is laid in compacted thickness of 75 mm or 50 mm and three different gradations of aggregates have been suggested for each thickness to provide open graded and semi-dense constructions. The BM is essentially a base course or binder course and hence should be covered by a suitable surfacing course before exposing to traffic. BM base course is considered to be much superior than other types of base course materials such as WBM with respect to load dispersion characteristics and durability.

Bituminous Concrete or Asphaltic Concrete (AC):- It is a dense graded premixed bituminous mix which is well compacted to form a high quality pavement surface course. The AC consists of a carefully proportioned mixture of coarse aggregates, fine aggregates, mineral filler and bitumen and the mix is designed by an appropriate method such as the Marshal method to fulfil the requirements of stability, density, flexibility and voids. The thickness of bituminous concrete surface course layer usually ranges from 40 to 75 mm. The IRC has provided specification for 40 mm thick AC surface course for highway pavements.

(B) A road is to be xconstructed with a uniform rising gradient of 1 in 100. Determine the staff readings required for setting the tops of the two pegs on the given gradient at 30 meters interval from the last position of the instrument. The RL of the first peg is 384.500 m. A fly levelling was carried out from a BM of RL 387.000 m. The following observations (in m) were recorded.

Backsight	**1.625**	**2.345**	**2.045**	**2.955**
Foresight	**1.315**	**3.560**	**2.355**	

[15 Marks]

Solution :

B.S.(m)	**F.S.(m)**	**H.I.(m)**	**R.L. (m)**
1.625		388.625	387.0
2.345	1.315	389.655	387.31
2.045	3.56	388.14	386.095
2.955	2.355	388.74	385.785

H.I. at last position of instrument = 388.74 m

R.L. of first peg = 384.50 m

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Staff reading at first peg = 388.74 – 384.5 = 4.24 m

Therefore,

Staff reading at second peg = $4.24 - 30 \times \frac{1}{100} 3.94m$

(C) What are the errors induced in theodolite survey? [15 Marks]

Solution :

The errors which occur in theodolite survey may be classified into three types depending upon their sources:

(i) Instrumental errors:

These may occur due to imperfect adjustments of the theodolite, due to constructional defects in the instrument or due to wear of the various components. The errors due to imperfect adjustments are most common and some of them are as follows:

(a) Errors due to imperfect adjustments of the plate level

(b) Error due to line of collimation not being perpendicular to horizontal axis.

(c) Error due to horizontal axis not being perpendicular to the vertical axis.

(d) Error due to eccentricity of inner and outer axes.

(e) Error due to eccentricity of verniers.

(f) Error due to imperfect graduations on the horizontal scale.

(g) Vertical index error.

(h) Vertical cross hair not perpendicular to the horizontal axis.

(i) Error due to defective tripod.

(ii) Personal errors:

These can be classified into two categories:

(a) Errors in manipulation: These can occur due to inaccurate centring, inaccurate levelling, slip in screws and improper use of tangent screws.

(b) Errors in sighting and reading: These errors occur due to inaccurate vernier reading, inaccurate sighting and parallax.

(iii) Errors due to natural causes:

These errors occur due to temperature effect, wind effect, refraction effect and settlement of tripod.

(D) A solid shaft transmits 250 kW at 100 r.p.m. If the shear stress is not to exceed 75 N/mm², what should be the diameter of the shaft?

If this shaft is to be replaced by a hollow shaft whose internal diameter shall be 0.6 times the outer diameter, determine the size and percentage saving in weight, maximum stresses being the same. [15 Marks]

Solution :

$$p = \frac{2\pi NT}{60}$$

$$T = \frac{250 \times 10^3 \times 60}{2\pi \times 100}$$

1. $\frac{T}{J} = \frac{\tau}{R}$

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$T = Z_{p(solid)} \times \tau \quad \left(Z_{p(solid)} = \frac{\pi D3}{16}\right)$

$23873.24 = \frac{\pi D^3}{16} \times 80$

D = 11.49

For Hollow shaft

$T = Z_{P(hollow)} \times \tau \qquad Z_{p(hollow)} = \frac{\pi}{16D}\left(D^4 - d^4\right)$

d = .6D

$23873.24 = \frac{\pi}{16D}\left(D^4 - \left(.6D^4\right)\right)80$

D = 12.46

d = 7.476

$\% \; saving = \frac{Area\,of\;solid - Area\,of\;hollow}{Area\,of\;solid} \times 100$

$= \frac{\frac{\pi}{4}(11.49)^2 - (12.46^2 - 7.476)^2}{\frac{\pi}{4} \times 11.49^2} \times 100$

= 24.6%

Q3. (A) Design a circular column with helical reinforcement subjected to a working load of 1500 kN. Diameter of the column is 450 mm. The column has unsupported length of 3.5 m and is effectively held in position at both ends but not restrained against rotatin. Use limit state design method. Use M-25 concrete and HYSD Fe-415 steel.

[25 Marks]

Solution :

(a) pu = 1.5 × 1500 = 2250 kN

left = 1 × 3.5 = 3.5 m = 3500 mm

$\frac{l_{eff}}{450} = 7.78 \angle 12$ Short col.

(b) Min eccentricity

$e_{min} = \frac{L_{eff}}{500} + \frac{D}{30} = \frac{3500}{500} + \frac{450}{30} = 22mm$

or

20 mm

22 mm < .05D

22 < 22.5 ok

(c) $Pu = 1.05\,(.40\, f_{ck}\, A_c + .67 + f_y\, A_{sc})$

$2250 \times 10^3 = 1.05\,(.40 \times 25 \times \frac{\pi}{4}(450^2) + (.67 \times 415 - .4 \times 25\, A_{sc})$

$A_{sc} = 2061\ mm^2$.

Use 16 mm ϕ

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No of bars = $\dfrac{2061}{\frac{\pi}{4}(16)^2} = 10.25 = 11$

(d) Design of helical R/F

(1) $A_g = \dfrac{\pi}{4}(450)^2 = 159043\ mm^2$

(2) $A_c = \dfrac{\pi}{4}(450-50)^2 = 107521\ mm^2$

(3) $V_c = 1000 \times Ac = 107521000$

$$V_n = \frac{1000}{p} \times (\pi \times (370-8)) \times \frac{\pi}{4}(8)^2$$

$$= \frac{57164749}{p}$$

$$.36\frac{f_{ck}}{f_y}\left(\frac{Ag}{Ac}-1\right) \le \frac{v_h}{v_c}$$

$$.36 \times \frac{25}{415} \times \left(\frac{159043}{107521}-1\right) \le \frac{57164749}{p \times 107521000}$$

p = 51mm

Check = 1. p $\ngtr$ 75 mm

2. p $\ngtr \dfrac{\phi c}{6} = \dfrac{370}{6} = 61mm$

3. p $\nless$ 25

4. p $\nless$ (3×8)

(B) Design a constant thickness footing for a reinforced concrete column of 300 mm × 300 mm. The column is carrying an axial working load of 600 kN. The bearing capacity of soil is 200 kN/m². Use M-25 concrete and HYSD Fe-415 bars. [15 Marks]

100 (Ast/bd)	**0.15**	**0.25**	**0.50**	**0.75**	**1.0**
τc (N/mm²)	**0.19**	**0.36**	**0.49**	**0.57**	**0.64**

Solution :

$P_f = 600$

$q_u = 200\ kN/m^2$

Total load $P = 1.1p_f$

$= 1.1 \times 600$

$= 660$ kN

Area of footing

$$Ac = \frac{w}{qu} = \frac{660}{200} = 3.3m^2$$

Assume zquare footing

$B^2 = 3.3\ m^2$

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$B = 1.81$ m²

adopt $B = 2 \times$m

1. Check for one-way shear

$$w_o = \frac{P}{A} = \frac{1.5\times600\times10^3}{2000\times2000}$$

$= .225$ N/mm².

$$\alpha = \frac{B-300}{2} - d = 850 - d$$

$$\tau_v = \frac{w_o \alpha B}{B\times d} \qquad B = 1m$$

$$\tau_v = \frac{.225(850-d)}{d}$$

$\tau_v < \tau_c$

Assume Pst = .15% $\qquad \because \tau_c = .19$

$$\frac{.225(850-d)}{d} \le .19$$

$191.25 - .225d \le .19d$

$d > 460.84$ mm

$d = 470$ mm

2. Check for two way shear

$x = 300 + d$

$y = 300 + d$

$$\tau_v = \frac{.225\times\left((2000)^2-(300+d)^2\right)}{2\left(2(300+d)\right)d}$$

$\tau_v < k_s \tau_c \qquad k_s = 1$

$\tau_v < .25\sqrt{25} \qquad \tau = .25\sqrt{f_{ck}}$

$\tau_v \le 1.25$

$.225 \times (2000 - (300+d)^2) \le 1.25 \times 4\,(300+d)d$

$d \ge 282.64$

3. Check from B.m Consideration

$$\alpha = \frac{2000-300}{2} = 850$$

$$BM = \frac{wo\,d^2}{2} = \frac{.225\times850^2}{2}$$

$$BM \le .138\, f_{ck}\, Bd^2$$

$$\frac{.225\times850^2}{2} \le .138\times25\times1000\times d^2$$

$d > 23.55$

$\because$ Take d max from (1), (2) & (3)

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d = 470 mm.

(C) State and discuss different factors influencing compaction of soil in the field. **[20 Marks]**

Solution :

There are four main factors which influence compaction and they are as follows:

(i) Water Content:- As the water content increases, the dry density increases and air voids are decreased till the optimum water content is reached, a stage when lubrication effect is maximum. With further increase in moisture content, however the water starts to replace the soil particles and since $\gamma_w << \gamma_s$, the dry unit weight starts decreasing.

(ii) Compactive Effort:- For a given type of compaction, the higher the compactive effort, the higher the maximum dry unit weight and lower the OMC.

(iii) Types of Soil:-

(a) Coarse grained, well graded soils compact to high dry unit weight especially if they contain some fines.

(b) Poorly graded sands lead to lowest dry unit weight values.

(c) In clay soils, the maximum dry unit weight tends to decrease as plasticity increases.

(d) Cohesive soils have generally high values of OMC/

(e) Heavy clays with high plasticity have very low maximum dry density and very high OMC.

(iv) Methods of Compaction:- Ideally speaking, the laboratory test must reproduce a given field compaction procedure, because the mode of compaction does influence somewhat the shape and the position of the 'γ_d' vs 'w' plot. Since the field compaction is essentially a kneading type compaction or rolling type compaction and the laboratory tests use the dynamic impact type compaction, one must expect some divergence in the OMC and $\gamma_{d(max)}$ in the two cases.

Q4. (A) Classify the solid wastes, giving suitable example for each of them. Also explain the different methods of disposal of solid wastes. **[15 Marks]**

Solution :

Type of solid waste

1. Municipal wastes
2. Industrial wastes
3. Hazardous wastes

Refuse represents the dry wastes or solid wastes of the society except human excreta and sullage.

Classification of refuse

(i) Garbage includes all sorts of putrescible organic wastes obtained from kitchens, hotels, restaurants, etc. All waste food articles, vegetable peelings, fruit peelings, etc., are thus included in this term.

(ii) Ashes denote the incombustible waste products from hearths and furnaces, and houses or industries.

(iii) Rubbish includes all non-putrescible wastes except ashes. It, thus includes all combustible and non-combustible wastes such as rags, paper pieces, broken pieces of glass and furniture, card boards, broken crockery, etc.

Besides the technical classification based on the type of wastes, the refuse may also be classified, depending on its source, as: (i) House refuse; (ii) Street refuse and (iii) Trade refuse.

Disposal of refuse:

The refuse can be disposed of by various methods, such as

(a) Sanitary land filling: In this method of refuse disposal, refuse is carried and dumped into

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the low lying area under an engineered operation, designed and operated according to the acceptable standards, as not to cause any nuisance or hazards to public health or safety.

(b) **Burning or incineration:** Burning of refuse at high temperatures in furnaces called incinerators is quite a sanitary method of refuse disposal.

(c) **Barging it out into the sea:** This method may be used to dispose of refuse by throwing it away into the sea, after carrying it at reasonable distance from the coast. The sea depth at such disposal point should not be less than 30 m or so, and the direction of the currents should be as not to bring it back towards the shore.

(d) **Pulverization:** In this method refuse is pulverized in grinding machines, so as to reduce its volume and to change its physical character. The grinded or pulverized refuse becomes practically odourless and unattractive to the insects.

(e) **Composting:** It is a biological method of decomposing solid wastes. This decomposition can be effected either under aerobic or anaerobic conditions or both. The final end product is manure called compost or humus, which is in great demand as fertilizer for farms.

(B) Estimate for 1:20 model of a spillway (i) prototype velocity corresponding to a model velocity of 2 m/sec, (ii) prototype discharge per unit width corresponding to a model discharge per unit width of 0.3 m³/sec, (iii) pressure head in the prototype corresponding to a model head of 5 cm of mercury at a point (iv) the energy dissipated per second in the model corresponding to a prototype value of 1.5 kW. **[15 Marks]**

Solution :

Length ratio, $L_r = \frac{L_m}{L_p} = \frac{1}{20}$

(i) Prototype velocity for model velocity of 2 m/sec.

Velocity ratio, $V_r = \sqrt{L_r}$

$$\frac{V_m}{V_p} = \sqrt{\frac{1}{20}}$$

$$V_p = V_m\sqrt{20} = 2\sqrt{20}$$

$$V_p = 8.994 \text{m/s}$$

(ii) Prototype discharge per unit width for model discharge per unit width of $0.3\text{m}^3/\text{s/m}$.

Discharge intensity ratio $q_r = \frac{V_r A_r}{L_r} = \frac{\sqrt{L_r} \times L_r^2}{L_r} = L_r^{3/2}$

$$\frac{q_m}{q_p} = \left(\frac{1}{20}\right)^{3/2}$$

$$q_p = q_m (20)^{3/2} = 0.3 \times (20)^{3/2}$$

$$q_p = 26.83 \text{m}^3/\text{s/m}$$

(iii) Prototype pressure head for model pressure head of 5 cm of Hg.

$$\left(\frac{p}{\rho g}\right)_r = L_r$$

$$\frac{p/\rho g_m}{\rho g/\rho g_{p\,r}} = \frac{1}{20}$$

$$(\rho/\rho g)_p = 20 \times (\rho/\rho g)_m$$

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= 20 × 5 = 100 cm of Hg

(iv) Energy dissipated per second in model for 1.5 kW. Energy dissipated in prototype.

Energy dissipated /sec. = Work done/sec. = Power

$$P_r = F_r V_r$$

$$= \rho_r L_r^3 \times g_r 5\sqrt{L_r}$$

$$= L_r^{7/2}$$

$$\frac{P_m}{P_p} = \left(\frac{1}{20}\right)^{7/2}$$

$$P_m = 1.5 \times \left(\frac{1}{20}\right)^{7/2}$$

$$P_m = 4.19 \times 10^{-5} \text{ kW} = 0.042 \text{W}$$

(C) A centrifugal pump having an impeller of 35 cm outside diameter rotates at 1050 r.p.m. The vanes are radial at exit and are 7.0 cm wide. The velocity of 1050 radial flow through the impeller is 3 m/sec. The velocity in the suction and delivery pipes are 2.5 m/sec and 1.5 m/sec respectively. Neglecting frictional losses, determine the height through which pump lifts and the horse-power of the pump. [15 Marks]

Solution :

D_1 = 35 cm = .35 m

N = 1050 rpm

B_1 = .07 m

V_d = 1.5 m/s

V_s = 2.5m/sec.

Tanqential velocity $v_1 = \frac{\pi \times D_1 N}{60}$

$$= \frac{\pi \times .35 \times 1050}{60}$$

= 19.24 m/se.

Vanes are radial = $V_{w1} = V_1$ = 19.24 m/s

$$H_m = \frac{V_{w_1} v_1}{g} \eta_{mano} \left[V_{w1-v1}\right]$$

$$H_m = \frac{v_1^2}{g} = \frac{(19.24)}{9.81} = 37.735m$$

$$H_m = h_s + h_d + h_f \times d + \frac{vd^2}{2g}$$

$$H_m = H_m \times \left(H_m - \frac{vd^2}{2g}\right) = 37.735 - \frac{1.5^2}{2 \times 9.81} = 37.62m$$

Power $= \frac{\rho g Q Hm}{75 \times 90}$ $\quad Q = \pi DBV_f$

$$= \frac{100 \times 9.81 \times (\pi \times .35 \times .07 \times 3) \times 37.735}{75 \times 9.81}$$

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= 116.177 Hp

Q5. (A) A retaining wall with a smooth vertical back is 9 m high and retains a two-layer sand backfill with the following properties :

0 – 3 m depth : c' = 0.0, φ = 30°, γ = 18 kN/m³

3 – 9 m depth : c' = 0.0,φ = 35°, γ = 20 kN/m³

Show the active earth pressure distribution and determine the total active thrust on the wall. Assume that the water table is well below the base of the wall.

[20 Marks]

Solution :

I layer – (0 – 3m)

Conesion c' = 0

$\phi = 30$

unit wt γ = 18 kN/m²

2– layer (3 – 9)

C = o, $\phi = 35^o$ $\gamma = 20$ kN/m³

$$k_a = \frac{1-\sin\phi}{1+\sin\phi} = \frac{1-\sin 30}{1+\sin 30} = 0.33$$

$$ka_2 = \frac{1-\sin 35}{1+\sin 35} = .271$$

Total eorth pressure on wall.

$$pa = \frac{1}{2} \times ka_1 \times y_1 \times z_1^2$$

$$(Pa)_{Top} = \frac{1}{2} k_{a1} \times y_1 \times 0 = 0$$

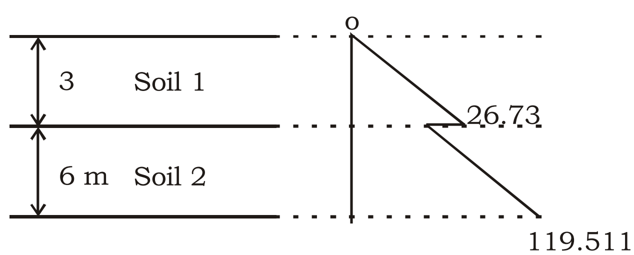
$$(Pa)_{a+3m} = \frac{1}{2} \times k_a \times y_1 \times 3^2 = 26.73 kN/m$$

For layer (3 –9m)

$$\sigma_{at}\ 9\text{ m} = \frac{1}{2} k_{az} + y_1 z_1^2 + \frac{1}{z} k_{az} y_2 z_2^2$$

= .5 ×.271 × 18 × 9 + .5 × .271 × 20 × 36

= 119.511 kN/m.



(B) A layer of sand 6.0 m thick lies above a layer of clay soil. The water table is at a depth of 2.0 m below the ground surface. The void ratio of the sand layer is 0.6 and the degree of saturation of the sand layer above the water table is 4%. The void ratio of the clay layer is 0.7. Determine the total stress, neutral stress and effective stress at a point 10 below the ground surface. Assume specific gravity of the sand and clay soil respectively as 2.65 and 2.7. **[20 Marks]**

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Solution :

$(\gamma_b)_{sand} = \dfrac{(G+es)\gamma_w}{1+e}$ let rw = 9.81 kN/

$= \dfrac{(2.65+0.6\times 0.4)\times 9.81}{1+0.6} = 17.72\,km$

$(\gamma_{sat})_{sand} = \dfrac{(G+e)\gamma_w}{1+e}$

$= \dfrac{(2.65+0.6)\times 9.81}{1+0.6} = 19.93\,KN/m^3$

$(\gamma_{sat})_{clay} = \dfrac{(2.7+0.7)9.81}{1.7} = 19.62\,KN/m^3$

Total stess

$\sigma_A = 0$

$\sigma_B = \gamma_b \times 2 = 17.72 \times 2 = 35.44 kN/m^2$

$\sigma_C = \gamma_b \times 2 + [\gamma_{sat}]_{sand} \times 4$

$= 17.72 \times 2 + 19.93 \times 4 = 115.16\ KN/m^2$

$\sigma_D = \gamma_b \times 2 + (\gamma_{sat})$ sand $\times 4 + (\gamma_{sat})$clay $\times 4$

$= 115.16 + 19.62 \times 4$

$= 193.64\ KN/m^2$

Neutral Stress

$u_A = 0$

$u_B = 0$ (NOT saturated)

$u_C = \gamma_W \times 4 = 9.81 \times 4 = 39..\ 24\ KN/m^2$

$u_d = \gamma_w \times 8 = 78.48\ KN/m^2$

Effective Stresss

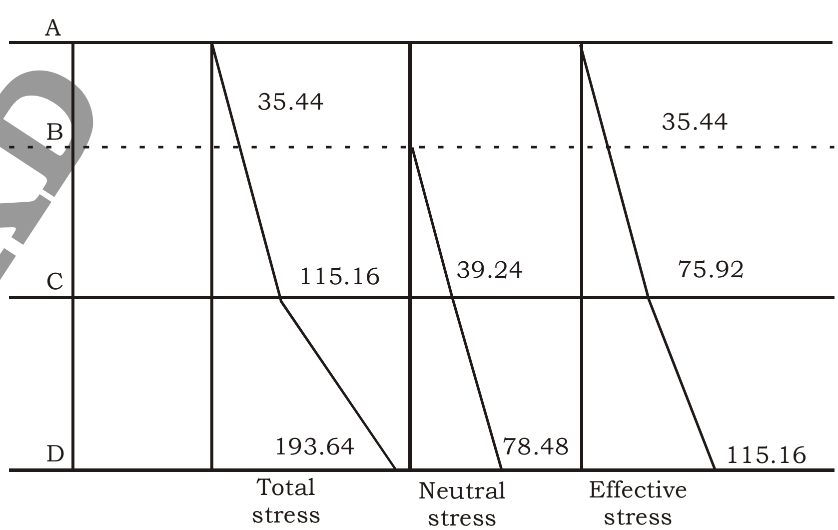
$\bar{\sigma}$ = Total st. – Neutral st

$\bar{\sigma}_A = 0 - 0 = 0$

$\bar{\sigma}_B = 35.44 - 0 = 35.44\ KN/m^2$

$\bar{\sigma}_C = 115.16 - 39.24 = 75.92\ KN/m^2$

$\bar{\sigma}_n = 193.64 - 78.48 = 115.16\ KNm/m^2$



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(C) What is grit? Why should grit be removed from wastewater? What is the basic principle behind the design of grit chambers? What is the reason to have constant velocity of flow have constant velocity of flow in a grit chamber (conventional horizontal flow) and how is it achieved? [20 Marks]

Solution :

Grit chambers or Grit channels, as they are usually called, are the sedimentation basins placed usually after the fine screens and certainly, before the primary sedimentation tank. The grit chamber removes the inorganic grit such as sand, gravel, and other mineral matter that has a nominal diameter of 0.15 to 0.20 mm or more. Grit removal basins, such as Grit chamber or Grit channels or Detritus tank are the sedimentation basins placed in front of the wastewater treatment plant to remove the inorganic particles such as sand, gravel, grit, shells, bones and other non-putresible materials that may clog channels or damage pumps due to abrasion and to prevent their accumulation in sludge digestors.

Grit chambers are infact, nothing but like sedimentation tanks designed to separate the intended heavier inorganic materials by the process of sedimentation due to gravitation forces and to pass forward the lighter organic materials.

The basic principle in the design of the grit chambers is that the flow velocity should neither be too low as to cause the settling of lighter matter organic matter, nor should it be so high as not to cause the settlement of the entire silt and grit present in sewage.

If there are large variations in discharge, then the grit chamber is designed for generating optimum velocity at peak discharge and a velocity control section, such as a properly designed modified weir, called a proportional flow weir or a sutro weir, is provided at the lower end of the rectangular grit channel, which helps in varying the flow area of the section in direct proportion to the flow, and thus, helps to maintain a constant velocity in the channel (within the permissible limits of ± 5 to 10% over the designed value), even at varying discharges.

Q6. (A) Design riveted splices for a tie of a steel bridge, 20 cm wide, 20 mm thick, carrying an axial tensile force of 50,000 kg. use 12 mm thick cover plates and 22 mm dia rivets.

Permissible stresses:

Tension in plates = 1500 kg/cm²

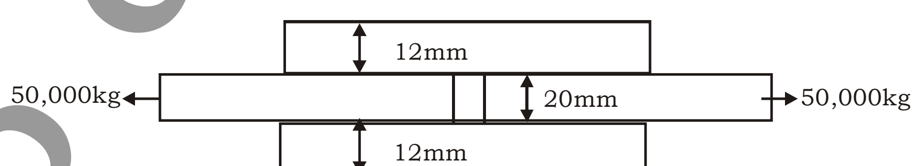
Shear in rivets = 1000 kg/cm²

Bearing in rivets = 3000 kg/cm²

Given a neat sketch of the arrangement. [25 Marks]

Solution :

Designing the splice as a double cover but joint as it will given maximum efficiency



Thickness of cover plate = 12 mm
Thickness of main plate = 20 mm
Width of cover plate = 200 mm
Nominal dia of rivets = 22 mm
Gross dia = 22 + 1.5 = 23.5 m = 2.35 cm

Calculation of number of rivets required,

Shear strength of rivet in double shear $= \left(\frac{\pi}{4} \times d_n^2\right) \times 2 \times \sigma_s$ = (0.7854 × (2.35)² ×2 1000)

= 8674.723 kg

Bearing strength of rivet $= d_n \times t \times \sigma_{bt}$

where, t = {min (combined thickness of two cover plate, mian plate thickness)}

t = {min (12 + 12, 20)}

t = 20 mm = 2 cm

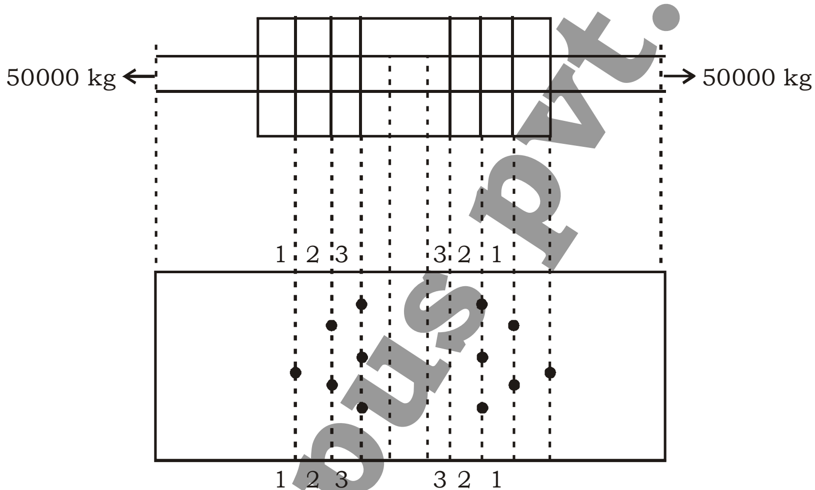
Bearing strength = (2.35 × 2 × 3000) N

= 14100 kg

R_v (rivet value) = min {shear strength, bearing strength) = 8674.723 kg

Number of rivet required $= \frac{50000}{8674.723} = 5.76 = 6\, rivets$

6 numbers of rivets can be arranged in various pattems. However, diamond pattern is generally most economical.



Check for safety of joint in tearing

For main plate:

At see (1) – (1)

$(B - d_h) \times t \times \sigma_{at} \geq 50000$ kg

$(20 - 2.35) \times 2 \times 1500 \geq 50000$ kg

$52950 \geq 50000$ kg

Hence see (1) –(1) for main plate is safe in tearing.

At see (2) – (2)

$R + (B - 2d_h) + \sigma_{at} \geq 50000$ kg

$8674.723 + (20 - 2 \times 2.35) \times 2 \times 1500 \geq 50000$ kg

$54574.723 \geq 50000$ kg

Hence section (2)- (2) for main plate is safe in tearing.

At see (3) – (3)

$(B - 3d_h)\, t\, \sigma_{at} + 3R_v \geq 50000$ kg

$(20 - 3 \times 2.35) \times 2 \times 1500 + 3 \times 8674.923 \geq 50000$ kg

$64874.169 \geq 50000$ kg

Section (3) - (3) for main plate is safe in tearing.

For cover plate: For cover plate the most critical section is 3-3

Assuming width for plat to be same as that for main plate.

i.e., $(B - 3d_h) \times t \times \sigma_{at}$ should be > 50000 kg

$(20 - 3 \times 2.35) \times 2.4 \times 1500 \geq 50000$ kg

46620 kg ≤ 50000 kg

Hence cover plate is not safe.

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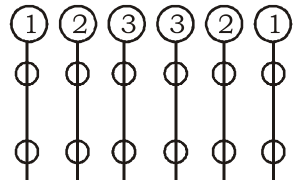
Note that as section (3)-(3) is the 1st line of rivet encountered for cover plate, we do not ………… rivet values for tearing strength of cover plate.

……………. chain rivet



Section (1–1) of main is plate checked for the safety

$(B - 2d_h) \times t \times \sigma_{at}$ should be ≥ 50000 kg

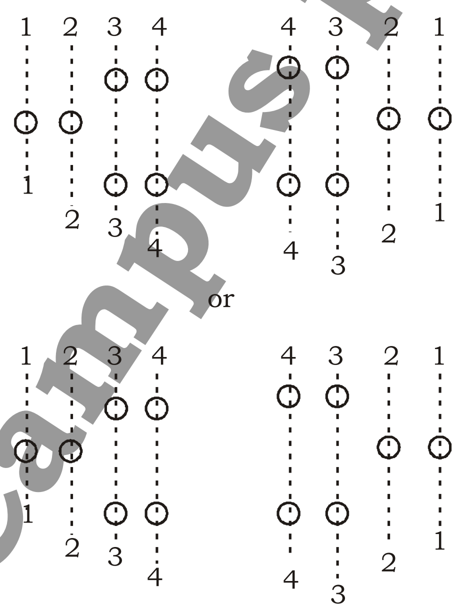
$(20 - 2 \times 2.35) \times 20 \times 1500 \geq 50000$

$45900 \geq 50000$

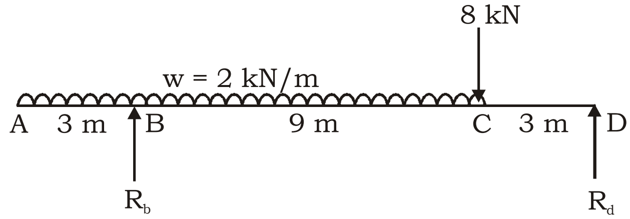
Chain riveting is not safe for main plate.

Conclusion: At section 1 – 1 we can apply two rivets

So, the two possible design is as follows.



(B) Draw BMD and SFD for the beam shown below. **[25 Marks]**



Solution :

1. Support r_x^n.

$R_B + R_d = 8 + (2 \times 12) = 32m$

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7 apking moment along B u zero

ε mo = 0

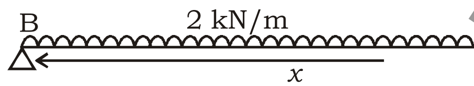
$R_B \times 12 = 8 \times 3 + 18 \times 75 + 6 \times 13.5$

$R_B = 240/12 = 20$ kN

$\therefore$ $R_d = 32.20 = 12$ kN

2. Point of zero S.F

Let S.F. is zero at a distance x from B



Sf at B = $2x$

14 = $2x$

x = $7m$

3. SFD

(i) From AB

$V_B = V_A - W_B$

But, $V_A = 0$

$V_B = V^O - 6 = -6$kN

But due to support x^n, at B

V_B fmal = – 6+ 20 = 14 kN

(ii) Span oc

$V_c = V_B - W_C$

$= .14 - 18 = -4$

V_C fmal = – 4 – 8 = –12

(iii) Span CD

$V_D = V_C - W_D$

V_D final = –12 +12 = 0

BMD -

(i) Span AB

M_B = MA = –9

MB = – 9kNm

(ii) Span BE

ME – MB = 49

ME = 49.9

= 40 kNm

(iii) Span EC

$M_C - M_E = -4$

$M_C = -4 + 40$

= 36 kNm

(iv) Span CD

$M_D - M_C = -36$

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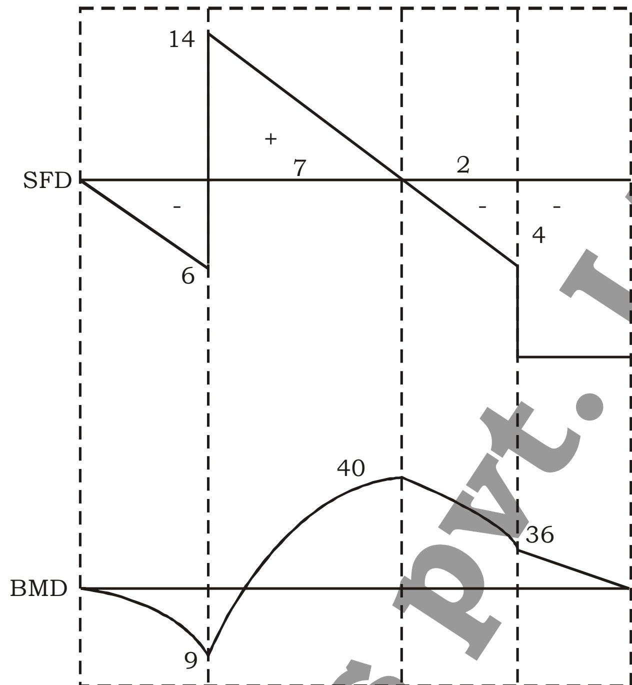
MD = – 36+36

= 0 kNm

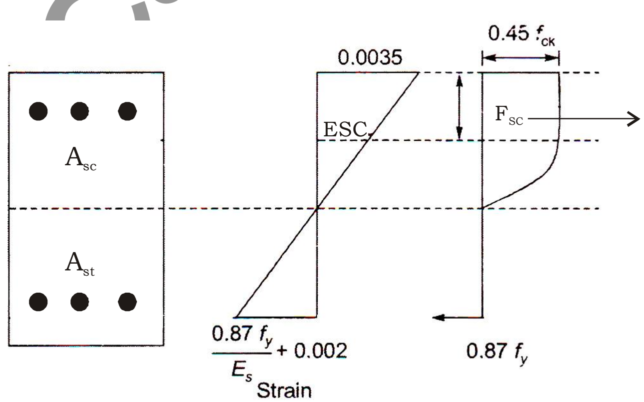


(C) Enumerate the situation in which doubly reinforced concrete beams become necessary. What is the role of compression steel? [10 Marks]

Solution :

Whein reinforcement are provided on compression side also, it is called a doubly reinforced section.

- To increase the moment of resistonce of the section, If size of beam is restricted or limiting depending on area of steel provided.
- It may be under reinforced/ over reinforced or limiting depending on area of steel provided.
- Doubly reinforced section is alsway desiqned for limiting section



- Compression steel is takes the extra tension generated due to restricted depth of beam in compression side.
- It increases the load carrying capacity of beam.
- It prevents brittle failure.

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