MADE EASY

India's Best Institute for IES, GATE & PSUs

ESE 2018 : Mains Test Series

UPSC ENGINEERING SERVICES EXAMINATION

Civil Engineering

Test 2 : Transportation Engineering + Surveying and Geology
Geo-technical & Foundation Engineering-1 + Environmental Engineering-1

Name : AMBAREESH SINGH

Roll No : C E 1 8 M B D L A 6 1 0

Test Centres					Student's Signature
Delhi ✓	Bhopal ☐	Noida ☐	Jaipur ☐	Indore ☐	Singh
Lucknow ☐	Pune ☐	Kolkata ☐	Bhubaneswar ☐	Patna ☐	
Hyderabad ☐					

Instructions for Candidates

1. Do furnish the appropriate details in the answer sheet (viz. Name & Roll No).
2. Answer must be written in English only.
3. Use only black/blue pen.
4. The space limit for every part of the question is specified in this Question Cum Answer Booklet. Candidate should write the answer in the space provided.
5. Any page or portion of the page left blank in the Question Cum Answer Booklet must be clearly struck off.
6. Last two pages of this booklet are provided for rough work. Strike off these two pages after completion of the examination.

FOR OFFICE USE	
Question No.	Marks Obtained
Section-A	
Q.1	48
Q.2	
Q.3	
Q.4	34-3
Section-B	
Q.5	42+10
Q.6	
Q.7	50+2
Q.8	50
Total Marks Obtained	224+9 = 233

Signature of Evaluator ..... Cross Checked by .....

1) Very neat / clear presentation.
2) Done excellent / Do practice of above org. questions
Tougher

Excellent!!

Section A : Transportation Engineering + Surveying & Geology [All topics]

Q.1 (a) Two platoons of cars are timed over a distance of 0.5 km. Their flows are recorded. The first group is timed at 40 seconds with the flow at 1350 vehicle/hour. The second group takes 45 seconds, with the flow of 1800 vehicles per hour.
Determine the maximum flow of traffic stream using linear relationship between speed and density as per Greenshield's model.

[12 marks]

As per greenshield model velocity & density are related as

$$v = v_{sf}\left[1 - \frac{k}{k_j}\right] \quad \text{—— (I)}$$

& as we know $q = kv$, where, k = density

so $k = \frac{q}{v}$ —(II) put in (I)

$$v = v_{sf}\left[1 - \frac{q}{v \times k_j}\right] \quad \text{—— (A)}$$

Now for the first platoon

$$v_1 = \frac{d}{t} = \frac{0.5\ km \times 60 \times 60}{40\ hr} = 45\ kmpH$$

$$q_1 = 1350\ veh/hrs$$

So put in (A)

$$45 = v_{sf}\left[1 - \frac{1350}{45 \times k_j}\right] \quad \text{—— (B)}$$

Now for 2nd platoon of car

$$v_2 = \frac{0.5}{45} \times 60 \times 60 = 40\ kmpH$$

$$q_2 = 1800\ veh/hr$$

so Put in eq (A)

$$40 = v_{sf}\left[1 - \frac{1800}{40 \times k_j}\right] \quad \text{— (C)}$$

(B)/(C)

$$\frac{45}{40} = \frac{\left(1 - \frac{1350}{45 k_j}\right)}{\left(1 - \frac{1800}{40 k_j}\right)} \Rightarrow k_j = 165\ veh/km$$

put the value of K_j in eqn (B)

$$u_s = v_{sf}\left[1 - \frac{13.5}{u_s \times 165}\right]$$

$\boxed{v_{sf} = 55 \text{ kmph}}$ = free mean speed

K_j = jam density = 165 veh/km

So max flow possible = $q_{max} = \frac{v_{sf} \times K_j}{4}$

$\boxed{q_{max} = 2268.75 \text{ veh/hr}}$ Ans

12

Q.1 (b) Write a short note on:

(i) Photogrammetry

(ii) Map vs Aerial photographs.

[12 marks]

(i) Photogrammetry

- Photogrammetry is the process of depicting the topographical features of an area in systematic way.
- High resolution Cameras are used for this purpose which may be mounted on aircraft for survey.

(ii) Maps & aerial photographs

- Maps are generally taken from satelite & have a uniform scale throughout
- Maps are provided by Survey of India.

5

- Aerial photographs are the picture taken from the camera mounted on a aircraft.
- Their scale may vary depending upon the topography of area.

Q.1 (c) The following staff readings were taken with a level, the instrument having been shifted after the 4th, 7th and 10th readings. The RL of the starting benchmark (A) is 123.450 m. The third reading was taken with an inverted staff on point *B*, and the 4th, 7th and 10th readings were taken on points *C*, *D* and *E*. The last reading was taken on benchmark *F*. The readings (in m) are:
2.650, 3.740, (–2.830)(B), 4.270(C), 4.640, 0.380, 0.960(D), 1.640; 2.840. 3.480(E), 4.680 and 4.260(F).

(i) Tabulate the readings in the form of a level-book page. Reduce the readings and apply the usual checks.

(ii) Calculate the R.L's of *B*, *C*, *D*, *E* and *F*. Use height of collimation method.

[12 marks]

Stations	BS	IS	FS	HI	RL	Remarks
BM	2.650			126.1	123.45	BM
		3.740			122.36	
B		−2.830			128.92	
C	4.640		4.270	126.47	121.83	C.P.
		0.38			126.09	
D	1.640	——	0.960	127.15	125.51	C.P
		2.840			124.31	
E	4.680		3.480	128.35	103.67	C.P
F			4.260		124.09	
	ΣBS = 13.61		ΣFS = 12.97			

Check

RL of last pt − RL of Ist pt

= 124.09 − 123.45

= 0.64 — (I)

$\Sigma BS - \Sigma FS = 0.64$ — (II)

(I) = (II) so ok

(II) From the Table

RL of B = 128.93 m

" " C = 121.83 m

" " D = 125.51 m

" " E = 123.67 m

" " P = 124.09

Ans.

Q.1 (d) Determine the stopping sight distance on a highway for a level stretch having design speed of 80 kmph.
Also, calculate percentage change in SSD for 2% descending gradient on the same highway.
Data may be assumed suitably as per IRC recommendations.

[12 marks]

design speed = 80 kmph = $\frac{80}{3.6}$ = 22.22 m/sec

Stopping S.D = $\underbrace{v \times t}_{\text{lag distance}} + \underbrace{\frac{v^2}{2gf}}_{\text{Braking distance}}$

Now assuming reaction time = t = 2.5 sec
& coeff of friction = 0.35

$$SSD = 22.22 \times 2.5 + \frac{(22.22)^2}{2 \times 9.81 \times 0.35}$$

$$\boxed{SSD = 127.468 \text{ m}}$$ For one way traffic

SSD = 2 × 127.468 = 254.94m ✓ two way traffic

If descending gradient of 2% is provided then
Breaking distance is given as

$$B.D = \frac{v^2}{2g(f - \eta)}$$

$$SSD = 22.22 \times 2.5 + \frac{22.22^2}{2g\left(0.35 - \frac{2}{100}\right)}$$

$$SSD = 131.827 \text{ m}$$

% change in SSD = $\frac{131.827 - 127.468}{127.468} \times 100 = 3.42\%$

Ans.

Q.1 (e) What factors are considered in selection of gauge in Railways? Write advantages of uniformity of gauges?

[12 marks]

→ Factor considered for selection of gauges

(i). Speed of the train - more speed is permitted on Broad gauge & lesser on other gauge.

(ii) loads to be Carried. For Heavier loads Broad gauge is selected.

- Feeder gauge can be used for less developed area for Connectivity purpose.

(iii) Economy - B/C ratio shall be calculated before the selection.

7

Advantage of Uniformity of gauge.

(i) Smooth movement of trains
(ii) lesser amount of fatigue
(iii) lesser amount of joint (which are weakest point in track)
(iv) Higher speed.
(v) Better elasticity.
(vi) lesser maintenance required.

Q.4 (a) A branch curve of 7° diverges from main curve of 3° in an opposite direction in a layout of BG track. Calculate the superelevation and the speed on the branch track, if the maximum speed permitted on main line is 70 kmph.

[20 marks]

for Broad gauge $G = 1.676\,m$

max allowed cant deficient $= 76\,cm = 7.6\,cm$

so for Broad gauge (main Track)

$$R = \frac{1720}{D^\circ} = \frac{1720}{3^\circ} = 573.33\,m$$

wrong formula

so eq b cant $= \frac{GV^2}{127R}$

$= \frac{1.676 \times 70^2}{127 \times 573.33}$

$= 0.11278\,m$

$e = 11.278\,cm$

So for max allow

now for max allowable speed $V = 70\,kmph$

$e_{actual} + CD = e_{theoratical} = \frac{GV^2}{127R}$

$e_{actual} + CD = \frac{1.676 \times 70^2}{127 \times 573.33} \times 100\,cm$

$e_{actual} = 11.278 - CD$

$e_{actual} = 11.278 - 7.6$

$e_{actual} = 3.678\,cm$

This will act as (-ve superelevation) for Branch Track.

so $(e_{branch})_{actual} = -(e_{main})_{actual}$

$e_{branch\,actual} = -3.678$ cm

so Theoratical $e_{branch} = -3.678 + \underbrace{7.6}_{CD}$

$= 3.922$ cm $= e_{branch\,theoratical}$

so $(e_{theoratical})_{branch} = \frac{GV_b^2}{127R} = 3.922$

$R_{branch} = \frac{17.2}{7} = 245.714$ m

$$\frac{1.676 \times V_b^2}{127 \times 245.714} = \frac{3.922}{100}$$

$$\boxed{V_{b_{max}} = 27 \text{ kmph}} \quad \text{— (I)}$$

Check from martin formula

$$V_{max} = 4.67\sqrt{R_b - 67}$$

$$= 4.67\sqrt{245.714 - 67} = 62.43 \text{ kmph} \quad \text{— (II)}$$

so adopt minof ((I)& (II))

so $\boxed{V_{branch} = 27 \text{ kmph}}$ max speed.

from.

Q.4 (c) (i) What do you understand by airborne and space borne remote sensing?

(ii) Points *A* and *B* are at elevations 273 m and 328 m above datum, respectively. The photographic coordinates of their images on a vertical photograph are:

x_a = 68.27 mm, x_b = –87.44 mm

y_a = –32.37 mm, y_b = 26.81 mm

What is the horizontal length of the line *AB* if the photo was taken from 3200 m above datum with a 21 cm focal length camera?

[8 + 12 = 20 marks]

Airborne remote Sensing

- It is done by sensor mounted by on Aircraft.
- Areal survey is required to get the information about the geographical area. with help of sensor without coming in physical contact with area.

Space Borne Sensing

- It is done with the Help of Satellite placed in predetermined orbit.
- Satellites are equipped with sensors which send the information to ground based main stations.
- Different frequency band are utilised by sensors mounted on satelite

Point A ⇒ $h_a = 243\,m$ $x_a = 68.27\,mm$

$H = 3200\,m$ $y_a = -32.37\,mm$

So $X_A = \left(\frac{t}{H-h_a}\right)^{-1} x_a = \frac{3200-243}{21\times10} \times 68.27 = 951.55\,m.$

$Y_A = \left[\frac{H-h_a}{f}\right] \times y_a = \left[\frac{3200-243}{21\times10}\right](-32.37) = -451.176\,m$

Point B ⇒ $h_b = 328\,m$, $x_b = -87.44\,mm$

$H = 3200\,m$ $y_b = 26.81\,mm$

$X_B = \left[\frac{H-h_b}{f}\right] x_b = \left[\frac{3200-328}{210}\right] \times (-87.44) = -1195.846m$

$Y_B = \left[\frac{H-h}{f}\right] \times y_b = 366.66m$

So $AB = \sqrt{(X_A - X_B)^2 + (Y_A - Y_B)^2}$

$= \sqrt{(951.55+1195.846)^2 + (-451.176-366.66)^2}$

$AB = 2297.86m$ Ans.

Section B : Geo-technical & Foundation Engg-1 + Environmental Engineering-1

Q.5 (a) An unconfined compression test was carried out on a saturated clay sample. The maximum (peak) load the clay sustained was 127 N and the vertical displacement was 0.8 mm. The size of the sample was 38 mm in diameter and 76 mm long. Determine the undrained shear strength of soil.

[12 marks]

$$A_{actual} = \frac{A_T}{(1-\epsilon_L)}(1-\epsilon_v)$$

$$A_T = \frac{\pi}{4} \times 38^2 = 1133.54\ mm^2$$

$$H = 76mm, \quad \epsilon_L = \frac{0.8}{76} \Rightarrow \epsilon_L$$

ϵ_v = Not given $= 0$

$$\text{So } A_{actual} = \frac{1133.54}{\left(1-\frac{0.8}{76}\right)} = 1145.6\ mm^2 = A_f$$

So Unconfined Compressive strength $= \frac{P}{A_f}$

$$= \frac{127}{1145.6} = 0.11086\ N/mm^2$$

$$q_u = 110.86\ kN/m^2$$

So undrained shear strength of soil

$$C = \frac{q_u}{2} = 55.429\ kN/m^2$$ Ans.

Q.5 (b) A water sample has the following composition:
Calcium = 80 mg/*l*, Magnesium = 33 mg/*l*, Sodium = 14 mg/*l*
Bicarbonate = 280 mg/*l*, Sulphate = 82 mg/*l* and Chloride = 36 mg/*l*
Calculate the carbonate hardness, non-carbonate hardness and total hardness, all in terms of mg/*l* of $CaCO_3$. Also construct an equivalent bar diagram.

[12 marks]

$Ca^{+2} = 80\ mg/L = \frac{80}{20} = 4\ meq.$

$Mg^{+2} = 33\ mg/L = \frac{33}{12} = 2.75\ meq.$

$Na^{+} = \frac{14}{23} = 0.61\ meq.$

Total hce = 7.36 meq/l.

$HCO_3^{-} = 280\ mg/L = \frac{280}{61} = 4.59\ meq.$

$SO_4^{-2} = 82\ mg/L = \frac{82}{48} = 1.708\ meq.$

$Cl^{-} = 36\ mg/L = \frac{36}{35.5} \simeq 1\ meq.$

Total hce = 7.3 meq

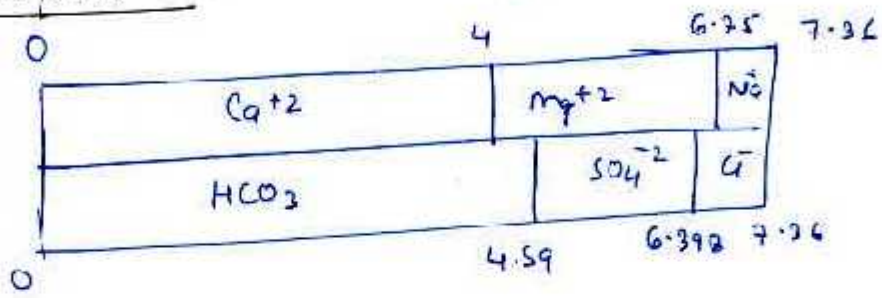
Alk = 4.59 mleq = 4.59 × 50 = 229.5 mg/L as $CaCO_3$

TH = (4 + 2.75) × 50 = 337.5 mg/L as $CaCO_3$ Ans

CH = min (Alk & TH) = 229.5 mg/L as $CaCO_3$ Ans

NCH = 337.5 − 229.5 = 108 mg/L as $CaCO_3$ Ans

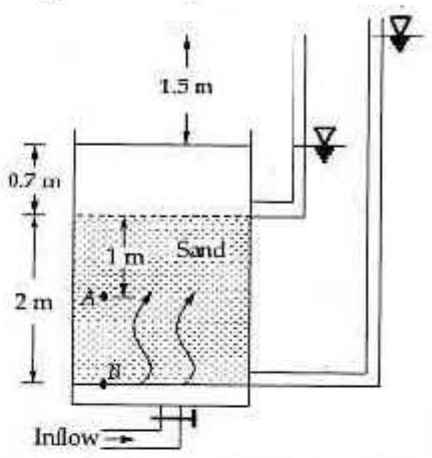
Bar diagram



Q.5 (c) Consider the upward flow of water through a layer of sand in a tank as shown below. For the sand, the following data are given:

Void ratio (e) = 0.520 and specific gravity of solids, G_s = 2.670

(i) Calculate the total stress, pore water pressure and effective stress at points A and B.



(ii) What is the upward seepage force per unit volume of soil?

[6 + 6 = 12 marks]

(1) $\Delta H = 1.5m$, $L = 2m$

$i = \frac{\Delta H}{L} = \frac{1.5}{2} = 0.75$

Consider point B as datum.

$DH_B = 0$

$PH = 2 + 0.7 + 1.5 = 4.2m$

$TH_B = 4.2m$

For soil $e = 0.52$, $G_s = 2.670$

$\gamma_{sat} = \left(\frac{G+e}{1+e}\right)\gamma_w = \frac{2.67+0.52}{1.52} \times 9.81$

$= 20.59\ KN/m^3$

So Total pressure at $B = 20.59 \times 2 + 0.7 \times 9.81$

Total stress $= \sigma = 48.347\ KN/m^2$

Pore water $P = u = PH \times \gamma_w = 4.2 \times 9.81 = 41.207\ KN/m^2$

So effective stress $= \bar{\sigma}_B = \sigma - u$

$= 6.845\ KN/m^2$ Ans.

For A ⇒ DH = 1m. $TH_A = TH_B - i(x) = 4.2 - 0.75 \times 1 = 3.45\,m$

So $pH_A = 3.45 - 1 = 2.45\,m$

So Total stress at A = $0.7 \times 9.81 + 20.59 \times 1 = 27.457\ kN/m^2$

Pore water p = $u = \gamma_w \times pH_A = 9.81 \times 2.45 = 24.0345\ kN/m^2$

so effective stress = $\sigma - u = \bar{\sigma} = 27.457 - 24.0345$

$\bar{\sigma}_A = 3.42255\ kN/m^2$ Ans

(11)

(12)

Upward seepage force per unit volume

$= i\gamma_w = 0.75 \times 9.81$

$= 7.3575\ kN/$ unit volume

Ans.

Q.5 (d) **(i)** What is corrosion in metal pipes?

(ii) Write a short notes on Gate Valves and Butterfly Valves.

[6 + 6 = 12 marks]

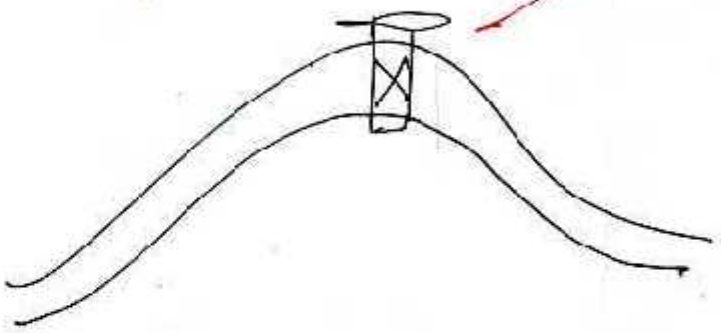
When metal pipes are used, then due to present of oxigen & other metalic element (present in water) oxidation of one metal starts which leads to the formation of metal oxides. This process is called as corrosion of metal pipes.

This is the reason why treated metal pipes are used for water Transmission which are corrosion resistant.

(4)

Gate value

- These are control value provided to control the flow of fluid in the pipe by changing the gate opening.
- They are generally provided at summit point because of pressure head is lesser at summit point.



(3)

Butterfly valve

- These value are provided for the inlet or exit of air from the pipe.
- These values are provided next to gate value.

Q.5 (e) (i) Two soil samples tested in a soil mechanics laboratory gave the following results:

	Sample No. 1	Sample No. 2
Liquid limit	50%	40%
Plastic limit	30%	20%
Flow index, I_f	27	17

(a) Determine the toughness indices of both the soil samples.

(b) Comment on the type of each soil.

(ii) A sample of sand, 5 cm in diameter and 15 cm long was prepared at a porosity of 60% in a constant head apparatus. The total head was kept constant at 30 cm and the amount of water collected in 5 seconds was 40 cm^3. The test temperature was 20°C. Calculate the hydraulic conductivity and the seepage velocity.

[6 + 6 = 12 marks]

Sample (I) $w_L = 50\%$. $w_p = 30\%$.

$I_f = 27$, $I_p = w_L - w_p = 50 - 30 = 20\%$.

So Toughness Index of (I) $= \frac{I_p}{I_f} = \frac{20}{27} = 0.741$ Ans

sample (II) $\Rightarrow w_L = 40\%$. $w_p = 20\%$.

$I_f = 17$. $I_p = 40 - 20 = 20$

Toughness index of (II) $= \frac{20}{17} = 1.176$ Ans

Comment → (I) Sample (II) has more strength at plastic limit than that of sample (I)

$(TI)_{II} > (TI)_I$

(II) Sample (II) is less compressible than Sample (I)

as $(w_L)_{II} < (w_L)_I$

(11)

$H = 30\,cm, \quad V_w = 40\,cm^3, \quad t = 5\,Sec$

$\theta \qquad\qquad\qquad\qquad n = 0.6$

In Constant Head Test

$$q = kiA$$

$$\frac{V}{t} = k \times \frac{H}{L} \times \frac{\pi}{4}(D)^2$$

$$\frac{40}{5} = k \times \frac{30}{15} \times \frac{\pi}{4}[5]^2$$

$$\boxed{k = 0.2038\ cm/sec}$$ = Hydraulic Conductivity

Seepage velocity $= \dfrac{kxi}{n}$

$$= \frac{0.2038 \times \left(\frac{30}{15}\right)}{0.6}$$

(10)

$$\boxed{v_s = 0.6794\ cm/sec}$$

7 (a) (i) An earth dam requires 1 million cubic meters of soil compacted to a void ratio of 0.80. In the vicinity of the proposed dam, three borrow pits were identified as having suitable materials. The cost of purchasing the soil and the cost of excavation are the same for each borrow pit. The only cost difference is transportation cost. The table below provices the void ratio and the transportation cost for each borrow pit. Which borrow pit would be the most economical?

Borrow pit	Void Ratio	Swell factor	Transportation cost (Rs/m^3)
1.	1.8	1.10	Rs. 0.60
2.	0.9	1.20	Rs. 1.00
3.	1.5	1.10	Rs. 0.75

(ii) A fine grained soil has a liquid limit of 300% and a plastic limit of 55%. The natural water content of the soil in the field is 80% and the clay content is 60%.

(a) Determine the plasticity index, the liquidity index and the activity.

(b) What is the soil state in the field?

(c) What is the predominant mineral in this soil?

(d) If this soil were under a concrete slab used as foundation for a building and water were to seep into it from watering of a lawn, what would you expect to happen to the foundation?

[10 + 10 = 20 marks]

(1)

keeping volume of solid same in dam & borrow pit soil

$$\left(\frac{V}{1+e}\right)_{dam} = \left(\frac{V}{1+e}\right)_{Borrow\,pit}$$

$V_{dam} = 1\times10^6\ m^3$, $e_{dam} = 0.8$.

for Borrow pit (1)

$$\frac{V_{BP}}{1+e} = \frac{1\times10^6}{1+0.8} \Rightarrow V_{BP} = \frac{10^6\times(1+1.8)}{1.8}$$

$$V_{BP} = 1.555\times10^6\ m^3$$

Composeting for swelling $\Rightarrow V_{BP_r} = V_{BP}\times 1.1 = 1.711\times10^6\ m^3$

So Transportation cost = $0.6 \times V_{BP_r} = 1.0267\times10^6$ Rs/— most economical

For Pit (2)

$$V_{BP} = \frac{10^6\times(1+0.9)}{1.8}\times SF = \frac{10^6\times1.9}{1.8}\times1.2$$

$$V = 1.267\times10^6\ m^3$$

So Transportation Cost = $V\times1 = 1.2667\times10^6$ Rs/—

Pit ②

$$V_{BP} = \frac{10^6 \times (1+1.5)}{1.8} \times 1.1 = 1.5278 \times 10^6 \ m^3$$

Tramp. Cost $= V_{BP} \times 0.75 = 1.1458 \times 10^6$ Rs/-

So from economical point of view

Borrow pit ① excavation will be selected

(B.P.1) — most economical

(11) $w_L = 300\%$, $w_p = 55\%$, $w_n = 80\%$

Clay Content $= 60\%$

(a) Plasticity index $= w_L - w_p = 300 - 55 = \boxed{245 = I_p}$

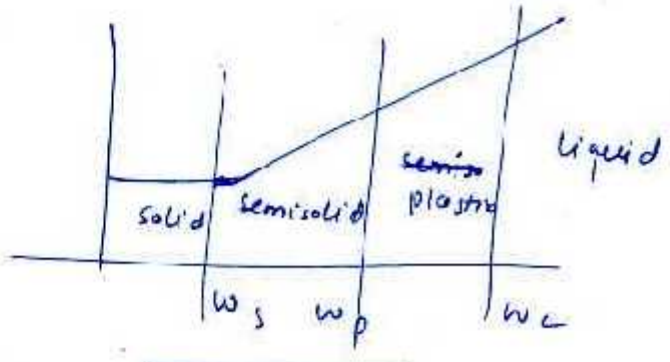
i Liquidity index $= \dfrac{w_n - w_p}{w_L - w_p} = \dfrac{80 - 55}{245}$

$$\boxed{I_L = 0.1020}$$

17

Activity $= \dfrac{I_p}{\%\text{ Clay Conten}} = \dfrac{245}{60} = 4.08$

(b)



Since $\boxed{w_n > w_p}$

So soil is in Plastic state in the field

(c) Montmorlinite is the predominating mineral.

(d) if this soil is used as fdn & water seeps through it, it will expand vigourously causing cracking fdn & uneven settlement.

Q.7 (b) (i) Define hardness of water alongwith its classification.

(ii) List out methods of determining hardness of water in laboratory and briefly describe any one of them.

(iii) Discuss lime-soda process of removing hardness.

[20 marks]

Hardness :-

- Hardness is prop of water by virtue of which it prevents the formation foam / lather. Or it destroy the surfactant prop of substance.
- It is caused by multivalent cations like Ca^{+2}, Mg^{+2}, Al^{+3}

Classification :-

① Temporary Hardness

- Caused by HCO_3^- & CO_3^{-2} of multivalent cations.
- Can be removed by boiling or by addition of lime.

② Permanent Hardness

- Cause by Cl^-, SO_4^-, NO_3^- etc of multivalent cations
- Can not be removed by boiling.

③ Pseudo Hardness

- Caused by Na^+

13+

Method of finding Hardness in lab

By Versanate sol^n

- given sample is treated (titrated) by 0.01 m EDTA solution with Eriochrome Black T. (EBT) as an indicator.

Ca^{+2}/Mg^{+2} + EBT (indicator) ⟶ Ca – EBT (Vinered color complex)

↓ 0.01 m EDTA

Ca/Mg – EDTA (complex) (more stable) + EBT (Blue Black)

- Titration is stopped at the point when vine red sol^n starts to become Blue Black.

∴ Quantity of Ca^{+2}/Mg^{+2} & other multivalent cations can be found by $(NV)_{\text{multivalent cation}} = (NV)_{\text{EDTA sol}^n}$

(iii) Lime Soda process

Lime has 3 function - (a)

(i) Lime reacts with CO_2 present in water & gets wasted out (a)

$$Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 \downarrow$$

(a)

(ii) Lime removes all the carbonate Hardness (d)

$$Ca(OH)_2 + MgCO_3 \longrightarrow Mg(OH)_2 \downarrow + CaCO_3$$

$$Ca(OH)_2 + Ca(HCO_3)_2 \longrightarrow CaCO_3 \downarrow + 2CO_2 \uparrow + H_2O$$

(iii) Lime converts all the Non carbonate Hardness of Mg^{+2} into Non carbonate Hardness of Ca^{+2} (β)

$$Ca(OH)_2 + MgCl_2 \longrightarrow CaCl_2 + Mg(OH)_2\downarrow$$

$$Ca(OH)_2 + MgSO_4 \longrightarrow Mg(OH)_2\downarrow + CaSO_4$$

So Total lime added = $\alpha + \beta + \gamma$

(iv) Soda reacts with all Non Carbonate Hardness and removes them. (δ)

$$Na_2CO_3 + CaCl_2 \longrightarrow 2NaCl + CaCO_3\downarrow$$

$$Na_2CO_3 + CaSO_4 \longrightarrow Na_2SO_4 + CaCO_3\downarrow$$

(Soda)

\# 40 mg/L of Hardness as $CaCO_3$ & 10 mg of Hardness as $Mg(OH)_2$ form very slowly so if they are not converted into soluble form, they will cause tuberculation in pipe.

So CO_2 is added to make them into soluble form

$$CaCO_3 + CO_2 + H_2O \longrightarrow Ca(HCO_3)_2$$

This process is called Recarbonation.

\# By this method zero Hardness water can not be achieved.

A retaining wall with a smooth vertical back retains sand backfill for a depth of 6 m. The backfill has a horizontal surface and has the following properties:

$$c' = 0,\ \phi' = 28°;\ \gamma = 16\ kN/m^3;\ \gamma_{sat} = 20\ kN/m^3$$

Calculate the magnitude of the total thrust against the wall for the conditions given below:

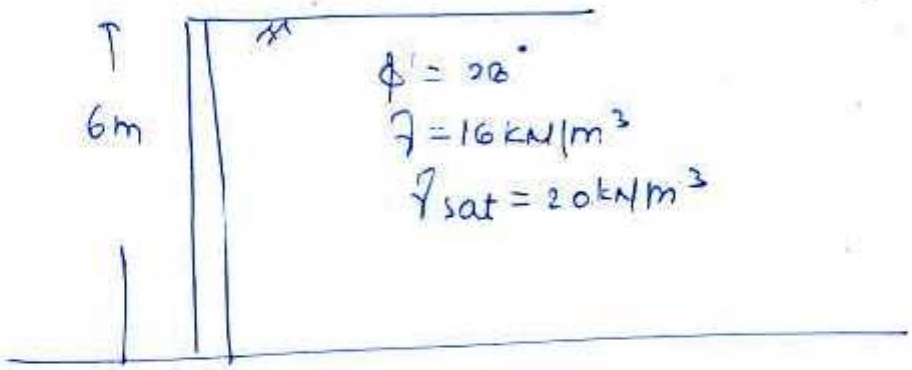
(i) Backfill fully drained but the top of the wall is restrained against yielding.

(ii) Backfill fully drained and the wall is free to yield.

(iii) Wall free to yield, water table at 3 m depth and there is no drainage.

Determine the point of application of the resultant thrust for case (iii).

[20 marks]

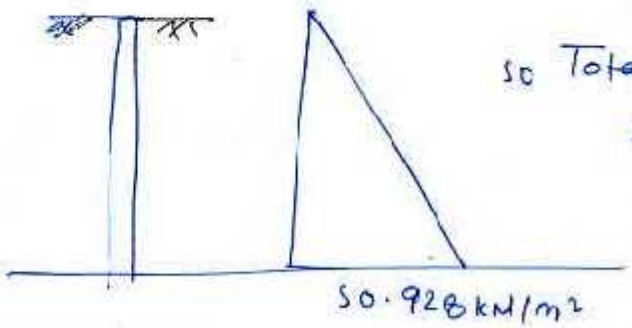


(i) if Top of wall is restrained against yielding then Earth pressure at rest will be effective.

$k_o = 1 - \sin\phi = 0.5305$ (fully drained)

so lateral pressure dist^n is given as

$p_a = k_a \gamma z = 16 \times 0.5305 \times z$



So Total Thrust

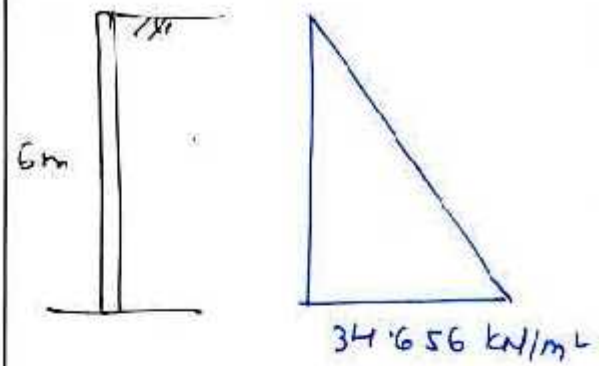
$= \frac{1}{2} \times 50.928 \times 6$

$= 152.784$ kN/m length of wall

Ans.

(ii) where free to yield then active earth pressure will be effective

$k_a = \frac{1 - \sin\phi}{1 + \sin\phi} = 0.361$



So $p_a = k_0 \times \gamma \times z$ at Bottom

$= 0.361 \times 16 \times 6$

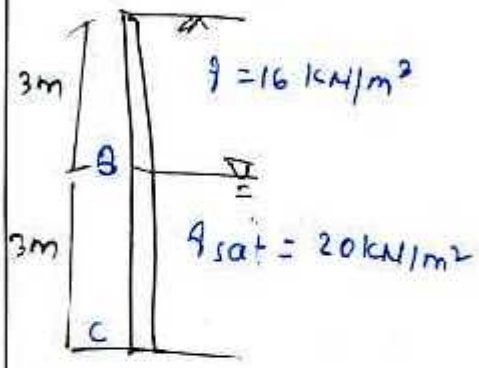
$= 34.656$ kN/m²

so Total active Thrust

$= \frac{1}{2} \times 34.656 \times 6$

$P_a = 103.968$ kN/m length of wall

(14)



$k_a = 0.361$

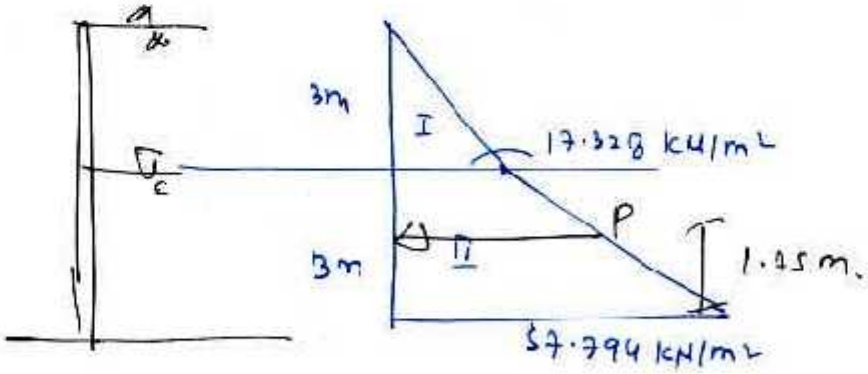
$p_B = k_0 \gamma z$

$= 0.361 \times 16 \times 3$

$= 17.328$ kN/m²

$p_C = k_a [16 \times 3 + (20 - 9.81) \times 3] + \gamma_w \times 3$

$= 57.794$ kN/m²



So Total active Earth P = Area of ① + ②

$= \left[\frac{1}{2} \times 3 \times 17.328\right] + \left[\frac{57.794 + 17.328}{2} \times 3\right]$

$= 25.992 + 112.683$

$P_a = 138.675$ kN/m length of wall

For point of App.

CG of (II) from Base $= \left(\frac{57.794 + 2 \times 17.328}{57.794 + 17.328} \right) \times \frac{3}{3}$

$= 1.231\ m$

CG of (I) from Base $= 3 \times \frac{3}{3} = 4m$

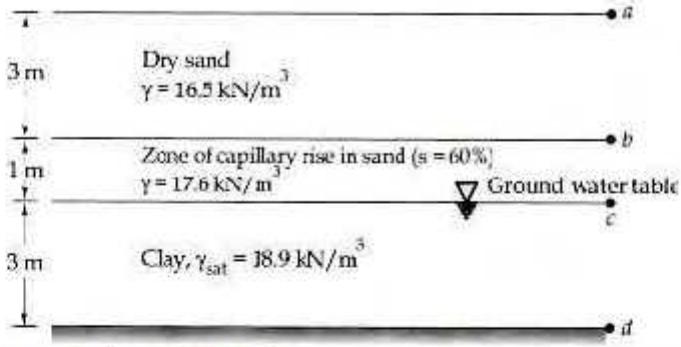
so

CG of Pa from base $= \frac{25.992 \times 4 + 112.682 \times 1.231}{138.675}$

$= 1.75\ m$ from base Ans

20

Q.8 (a) A soil profile is shown below. The zone of capillary rise is in the sand layer overlaying clay. In this zone, the average degree of saturation and moist unit weight are 60% and 17.6 kN/m^3 respectively. Calculate and plot the variation of σ, u and $\bar{\sigma}$ with depth.



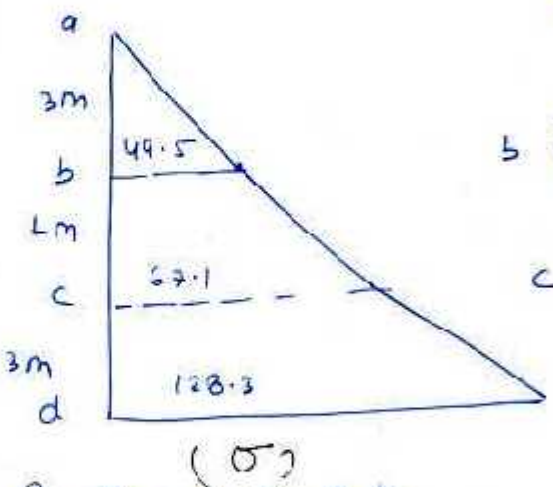
[20 marks]

Total stress at a = 0

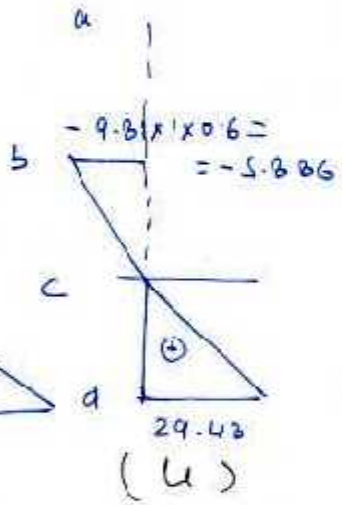
Total stress at b = 16.5 × 3 = 49.5 kN/m²

" " " c = 16.5 × 3 + 17.6 × 1 = 67.1 kN/m²

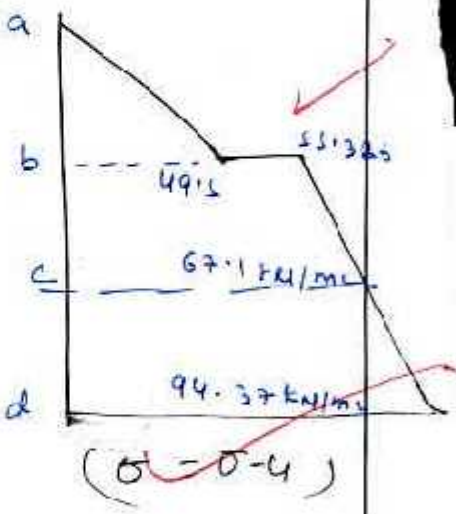
" " " d = 16.5 × 3 + 17.6 × 1 + 18.9 × 3 = 123.8 kN/m²



(σ)



(u)



(σ − σ-u)

Pore Press at a = 0

Pore press at b = -9.81 × 1 × 0.6 = -5.886 kN/m²

" " " c = 0

" " d = 9.81 × 3 = 29.43 kN/m²

effective stress at a = 0

" " b = 49.5 − (−5.886) = 55.386 kN/m²

" " c = 67.1 kN/m²

" " d = 128.3 − 29.43 = 94.37 kN/m²

Q.8 (b) (i) Briefly discuss the various Noise Rating System?

(ii) Write a short note on:

(a) Classification of Natural Ecosystems.

(b) Components of an Ecosystem.

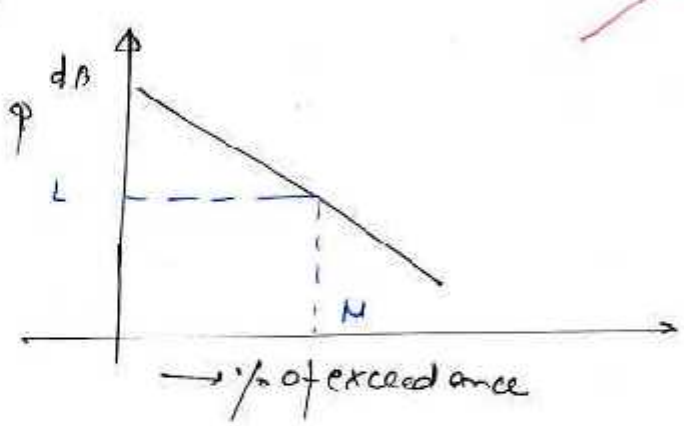
[10 + 10 = 20 marks]

(1) Noise Rating System

(i) L_N Concept

It is represented as L_N means

L dB of sound level is exceeded on N% of gauging time.



(ii) Leq/Equivalent Concept

If there are several sound level L_1, L_2, L_3, L_4 ... are present for t_1, t_2, t_3, t_4 time fraction then same amount of Energy is created by Leq P given by

$$L_{eq} = 10 \log \left[10^{L_1/10} \times t_1 + 10^{L_2/10} \times t_2 + \cdots \right]$$

Where t_1, t_2, t_3 ... are the fraction time

Classification of Natural ecosystem

Lithosphere - land ecosystem

Hydrosphere - water based ecosystem — ocean, lake, river

Atomsphere - air ecosystem. — troposphere, Stratosphere, Thermosphere, mesosphere.

(III) Component of Ecosystem

(I) Biotic Components -

All the living organics combinally form the Biotic component of ecosystem. Ex - animal, plants

→ Categorised into — Flaura (plants), Fauna (Animals)

(II) Abiotic Component.

All the non living component like - air, land water etc.

In an ecosystem there is an interaction b/w Biotic & Abiotic components -

Q.8 (c) (i) A filter unit has plan dimensions of 4.88 m width and 9.144 m length. After filtering 10900 m^3 for 50 hours, the filter is backwashed at a rate of 0.65 m/min for 15 minutes. Find

(a) the average filtration rate (in m/day).

(b) the quantity of washwater.

(c) percent of washwater to be treated.

(d) the flow rate of washwater each of the four troughs (in m^3/min).

(ii) A quantity of 50 m^3/s of air flows from a cement manufacturing facility. It contains cement particles whose settling velocity is 0.12 m/s. If 99 percent removal efficiency is required, calculate the surface area of the electrostatic precipitator.

[10 + 10 = 20 marks]

(a) avg rate of filtration $= \dfrac{10900\ m^3}{\frac{50}{24}\ day \times 4.88 \times 9.144}$

$= 117.2499\ m^3/m^2/day$ Ans.

(b) quantity of wash water

$= [0.65 \times 4.88 \times 9.144] \times 15$

$= 435.07152\ m^3$

avg rate of filtration $= \frac{\text{Total filtered water}}{\text{Total time} \times \text{Area}}$

$= \frac{10900 + 435.07152}{\left(\frac{50 + \frac{15}{60}}{24}\right) \times 4.88 \times 9.144} = 12.323 \text{ m/day}$ Ans.

(d) Flow rate of wash water through 4 trough

$= \frac{435.07152}{4 \times 15} = 7.2512 \text{ m}^3/\text{min}$ Ans.

(c) % of washwater to be treated

$= \frac{435.07152}{10900 + 435.07152} \times 100 = 3.84\%$ Ans

8. (11)

$Q = 50 \text{ m}^3/\text{sec}$

$v_s = 0.12 \text{ m/sec}$

$\eta = 99\%$

$\left[\eta = 1 - e^{-\frac{Av}{Q}}\right]$ = efficiency of ESP

$.99 = 1 - e^{-Av/Q}$

$e^{-\frac{Av}{Q}} = 1 - 0.99$

$-\frac{Av}{Q} = -4.60517$

$A = \frac{4.60517 \times 50}{0.12}$

$A = 1918.82 \text{ m}^2$ Area required of plate of ESP Ans.