DETAILS EXPLANATIONS

[PART : A] *Surveying + Transport + Traffic*

1. In the plane survey, curvature of earth is neglected but it is considered in geodetic surveying.

2. It is so constructed that (n + 1) divisions of main scale is equal to 'n' divisions of vernier.

3. (i) R.F. = $\frac{1}{3000}$

(ii) R.F. = $\frac{1}{12\times12} = \frac{1}{144}$

4. Correction for pull in chain surveying :

$$C_P = \frac{(P - P_0)l}{AE}$$

5. In centesimal system of angle measurement :

- 1 Circumference = 400 grades
- 1 grade = 100 centigrade
- 1 centigrade = 100 centi-centigrade

6. If there is local-attraction present, the difference of fore-bearing and Back bearing would not be 180°.

7. In bowditch method, linear and angular measurements are equally precise.

- Error in linear measurements $\propto \sqrt{l}$
- Error in angular measurements $\propto \frac{1}{\sqrt{l}}$

8. ***Reduced-level :*** The elevation of a point with respect to either mean sea level (MSL) or with respect to a fixed point of known height is called 'Reduced-level.'

9. Sounding is the method to measure the depth below the water-surface.

10. Horizontal equivalent is the horizontal distance between two consecutive contour lines.

11. ***Normal Tension :*** The particular value of pull, at which pull correction neutrilize each other.

12. Simpson's formula :

$$V = \frac{d}{3}[(A_1+A_n)+4(A_2+A_4+...+A_{n-1}) + 2(A_3+A_5+...+A_{n-2})]$$

13. The development plans are :

- Nagpur Road plan
- Bombay Road plan
- Lucknow Road plan

14. The minimum sight distance available in a highway at any spot should be of sufficient length to stop a vehicle travelling as design speed, safely without collision.

15. Super elevation is the ratio of height of outer edge with respect to horizontal width.

$$e_{max} = \begin{cases} 0.07 \Rightarrow \text{for plain and Rolling terrain} \\ 0.10 \Rightarrow \text{for hilly area} \\ 0.04 \Rightarrow \text{for urban roads with frequent intersections} \end{cases}$$

16. PCU may be considered as a measure of the relative space-requirement of a vehicle class compared to that of passanger car.

17. Space mean speed

$$V_s = \frac{3.6\,d.n}{\sum_{i=1}^{n} t_i}$$

Where, d = Length of Road(m)

n = Number of individual vehicle-observation.

t_i = observed travel time(sec)

18. As per IRC, maximum legal axle load = 8170 kg.

19. Rigidity factor is the ratio of contact pressure and tyre pressure.

20. Glodback's formula for stress due to corner load:

$$S_c = \frac{3P}{h^2}$$

where, S_c = Stress due to corner load

P = Corner load assumed as a concentrated point load

h = Thickness of slab (cm)

[PART : B]

21. Corrected Area $= \left[\frac{L'}{L}\right]^2 A'$

Where, A' = Wrong measured Area
L = Designated length
L' = Wrong length of chain

$$A = \left[\frac{30.10}{30}\right]^2 \times 1210$$

$$A = 1218.08 \text{ m}^2$$

$$A = \frac{1218.08}{10^4} = 0.1218 \text{ ha}$$

22.

Line	W.C.B.	Q.B./R.B.
AB	$49^o35'$	N $49^o35'$ E
AC	155^o	S 35^o E
AD	190^o	S 10^o W
AE	$295^o10'$	N $64^o50'$ W

23. ***Transit Method for Balancing the traverse*** **:**

This method is suitable when angular measurements are more precise than the linear measurements.

According to this method :

Correction in lattitude of a line

$$C_L = \left(\frac{L}{L_T}\right)\Sigma L$$

Correction in departure of the line :

$$C_D = \left(\frac{D}{D_T}\right)\Sigma D$$

Where, ΣL = Total error in lattitude
ΣD = Total error in departure
L = Lattitude of a line.
D = Departure of the line
L_T = Arithmetic sum of all lattitudes
D_T = Arithmetic sum of all departures

24. ***Sensitivity of bubble tube :***

It is defined as the angular value of one-division of the bubble tube. (Expressed as 'α')

$$\alpha = \frac{l}{R}$$

$$\alpha = \frac{S}{nD}$$

Where, n = Number of division on bubble-tube.

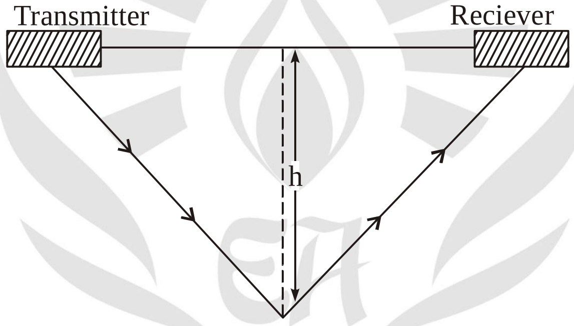
S = Staff intercept

R = Radius of curvature of bubble tube.

D = Distance between instrument and staff

25. ***Fathometer :***

A fathometer is used for ocean sounding where the depth of water is too much and to make a continuous and accurate record of the depth of water below the boat or ship at which it is installed.

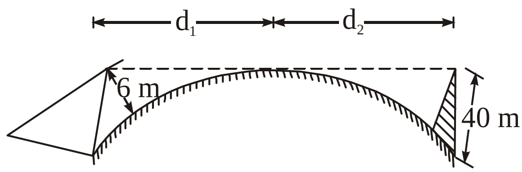


$$\text{Depth (h)} = \frac{Vt}{2}$$

where, V = Speed of sound in water

t = Time interval between transmitter and emitter

26. The net correction



$$C = 0.0672\ d^2$$

$$d \rightarrow (\text{km}) = 3.85\sqrt{C} \rightarrow (\text{m})$$

Distance

$$D = d_1 + d_2$$

$$d_1 = 3.85\sqrt{6} = 9.45 \text{ km}$$

$$d_2 = 3.85\sqrt{40} = 24.35 \text{ km}$$

So, distance

$$D = 9.45 + 24.35$$

$$D = 33.80 \text{ km}$$

27. Radius R = 160 m

Deflection Angle $\Delta = 60^o$

(i) Length of Curve

$$l = R.\Delta$$

$$l = 160 \times 60^o \times \frac{\pi}{180^o}$$

$$= 167.55 \text{ m}$$

(ii) Length of long-chord

$$L = 2R \sin\frac{\Delta}{2}$$

$$L = 2 \times 160 \times \sin\left(\frac{60^o}{2}\right) = 160 \text{ m}$$

(iii) Length of tangent

$$L_T = R \tan\frac{\Delta}{2}$$

$$L_T = 160 \tan\left(\frac{60^o}{2}\right) = 92.37 \text{ m}$$

28. ***Jayakar Committee Suggestions*** :

- Road development should be considered as a matter of national-interest.
- Tax on patrol should be levied for funding of Road-development. So central road fund was formed in 1928.
- A semi-official technical body should be formed to act as advisory body on various aspects of roads. IRC was formed.
- A research organisation should be instituted to carryout research and development work.

So, CRRI was formed in 1950.

29. Extrawidening on curve :

$$E_w = \frac{nl^2}{2R} + \frac{V}{9.5\sqrt{R}}$$

$$E_w = \frac{3\times(2.5)^2}{2\times 200} + \frac{75}{9.5\sqrt{200}}$$

$$E_w = 0.675 \text{ m}$$

Where, n = Number of lanes = 3 (for 10.5 m width)

l = Length of wheel base = 2.5 m

V = Design speed = 20.83 m/s

$\simeq$ 75 kmph

R = Radius of Curve = 200 m

30. Number of spaces :

(i) For 30° angle-parking

$$N = \frac{L - 0.85}{5.1}$$

(ii) For 45° angle-parking

$$N = \frac{L - 2.0}{3.6}$$

(iii) For 60° angle-parking

$$N = \frac{L - 2}{2.9}$$

(iv) For 90° angle-parking

$$N = \frac{L}{2.5}$$

Out of various angles used in angle parking, 45° angle is considered the best from all considerations discussed above.

31. ***Group-Index of Soil (G.I.)***

In order to classify the fine grained soils within one group and for judging their suitability as subgrade material.

Group Index is a function of percentage and is given by the equation

$$G.I. = 0.2a + 0.005\,ac + 0.01\,bd$$

Where, $a = (P - 35) \not> 40$

$b = (P - 15) \not> 40$

$c = (w_l - 40) \not> 20$

$d = (I_P - 10) \not> 20$

w_l = Liquid limit

I_P = Plasticity-Index

P = Percentage finer than 0.075 mm

$0 \leq G.I. \leq 20$

Lower the group Index → Best quality

32. Length of transition curve :

(i) As per Rate of change of centrifugal-Acceleration

$$L = \frac{0.0215V^3}{CR}$$

$$C = \frac{80}{75+V}$$

Where, V = Speed of Vehicle(kmph)

C = Allowable rate of change of Centrifugal-Acceleration (m/sec^3)

R = Radius of Curve

(ii) As per Empirical Formula :

$$L = \frac{2.7V^2}{R} \rightarrow \text{For plain and Rolling terrain}$$

$$L = \frac{V^2}{R} \rightarrow \text{For hilly Area}$$

(iii) According to Rate of change of Super Elevation

$$L = \begin{cases} 150x \rightarrow \text{For plain and Rolling Terrain} \\ 100x \rightarrow \text{For built up area} \\ 60x \rightarrow \text{For hilly area} \end{cases}$$

Where, x = Raise of Outer line of Road

[PART : C]

33. When the observations were taken from 'R' to 'P'

$h = b \tan \alpha = 127 \tan(15^o 11') = 34.47$ m

R.L. of P = R.L. of R + Height of Instrument at (R + h – r)

= 112.78 + 1.64 + 34.47 – 2 = 146.89 m

R.L. of instrument axis at P = R.L. of P + height of instrument at 'P'

= 146.89 + 1.87 = 148.76 m

Difference in elevation between the instrument axis = S

$= 148.76 - (112.78 + 1.64) = 34.37$ m

$$D = \frac{b\tan\alpha_2 - S}{\tan\alpha_1 - \tan\alpha_2}$$

$$= \frac{127\tan 21^o18' - 34.34}{\tan 38^o21' - \tan 21^o18'}$$

$D = 37.8$ m

$h_1 = D\tan\alpha_1$

$= 37.8 \tan 38^o21' = 29.92$ m

$\therefore$ R.L. of Q= R.L. of Instrument axis at P + h_1

$= 148.76 + 29.92 = 178.68$ m

Check :

R.L. of Q = R.L. of instrument axis at R + h_2

$= (112.78 + 1.64) + (b + D)\tan(21^o18')$

$= 114.42 + (127 + 37.8)\tan 21^o18'$

$= 114.42 + 64.26$

$(R.L.)_Q = 178.68$ m

34. ***Resection:***

It is the process of determining the plotted position of the station occupied by the plane table, by means of sights taken towards known points, locations of which have been plotted.

The method consists in drawing two rays to the two points of known locations on the plan after the plane table has been oriented. The rays drawn from the unplotted locations are called resectors, the intersection of which gives the required location of the instrument station. If the table is not correctly oriented at the station to be located on the map, the intersection of the two Re-sectors will not give the correct location of the station. So, the problem of orienting the table at the stations can be solved by the following four methods:

(i) Resection After Orientation by Compass:

The method is utilised only for small scale or rough mapping for which the relatively large errors due to orienting with the compass needle would not impair the usefulness of the map.

(ii) Resection After Orientation by Backsighting

If the table can be oriented by backsighting along a previously plotted backsight line, the station can be located by the intersection of the backsight line and the Re-sector drawn through another known point.

(iii) Resection After Orientation by Three Point Problem

Location of the position, on the plan, of the station occupied by the plane table by means of osbervations to three well defined points whose positions have been previously plotted on the plan.

(iv) Resection After Orientation

Location of position, on the plan, of the station occupied by the plane table by means of observation to two well defined points whose positions have been plotted on the plan.

35. Some operations with theodolite :

(i) To measure Magnetic bearing of a line:

In order to measure the magnetic bearing of a line, the theodolite should be provided with either a tubular compass or a trough compass.

(ii) To measure Direct Angles :

Direct Angles are the angles measured clockwise from the previous line to the next line. They are also known as angles to the right or azimuth from the back line and may vary from 0^o to 360^o.

(iii) To measure Direction angles :

A deflection angle which a survey line makes with the prolongation of the proceeding line. It is designated as Right (R) or Left (L) according as it is measured to the clockwise or to anticlockwise from the prolongation of the previous line. It's value may vary from 0^o to 180^o.

(iv) To prolong a straight line :

The theodolite can be used to prolong a straight line such as AB to a point P which is not already defined upon the ground and invisible from A and B.

(v) To run a straight line between two points

A theodolite may be used to run straight line between two points in any condition like both ends are visible or invisible from each other.

(vi) To locate the point of intersection of two straight lines.

The theodolite can be used to locate the point of intersection of two lines.

(vii) To lay off a horizontal angle.

(viii) To lay off a vertical angle.

36. ***The difference in level between A and B***

$$= \frac{(3.810 - 2.165) + (2.355 - 0.910)}{2} = 1.545 \text{ m}$$

Error due to curvature = 0.07849 d^2 m

$= 0.07849(1.53)^2 = 0.184$ m

$\therefore$ When the level is at A, corrected staff reading on

$B = 3.810 - (C_c - C_r) + C_1$

where, C_c = Correction due to curvature

$= 0.184$ m

C_r = Correction due to Refraction

C_1 = Correction due to collimation

$$= \frac{0.004}{100} \times 1530 = 0.0612 \text{ m}$$

$\therefore$ Corrected staff reading on B

$= 3.810 - (0.184 - C_r) + 0.0612$

$= 3.6872 + C_r$

$\therefore$ True difference in level between A and B

$= (3.6872 + C_r - 2.165)$

$= (1.5222 + C_r)$

But it is equal to 1.545 m

$1.5222 + C_r = 1.545$

$C_r = 1.545 - 1.5222 = 0.0228 \simeq 0.023$ m

37. ***Bridge Type Selection :***

Once a decision is made that a bridge needs to be replaced/new bridge is to be built, the type of bridge structure needs to be determined. Bridge type selection is dependent on the site characteristics, owner preferences and cost. If the bridge crosses over water then the hydraulic needs of the site and the profile grade will affect the bridge.

It is prudent to prepare a cost comparison study using several bridge type options to determine the best fit for the site and budget. Future maintenance, cost savings may not be reason enough to not choose the low cost structure(For procurement of bridge funds).
Bridge planning is typically done by an engineering consulting firm that is familier with the various types of bridges used in India.
Bridges that cross Railroads, Roadways, and/or trails have different factors that will decide the type.
Bridge substructure placement, clear height, profile grade and aesthetics are the main factors in deciding the bridge type.

(i) Pre-Cast Concrete Box-Culverts :

The use of precast concrete box culverts is a good choice if the sight conditions and hydraulic analysis allow for this structure type to be used.

In general, this structure type is used for smaller water way requirements that will have a minimal effect on the stage increase for the design flood.

(ii) Concrete Slab Span Bridges :

The concrete slab span(C-Slab) bridge type commonly has the lowest unit cost of the bridge types used on local roads. The contractor doesn't need to arrange beam delieveries to the site (and pay for those beams). So the bridge price goesdown as a result.

(iii) Pre-Stressed concrete beam bridges :

The Prestressed concrete beam (PCB) bridge type is the most common structure type on the local road system. This bridge type feature pre-cost concrete beams that meet abide array of span-length requirements. The unit cost is usually a little more than the C-Slab bridge type, but lower than other beam types (Steel, inverted T-Beams etc.)

(iv) Inverted-T-Prestressed Concrete Beam Bridge :

These INV-T type bridge is a good choice for when the false work of a C-slab bridge is not desired.

38. ***Trial-Cycle Method :***

$$X_A = \frac{n_A}{15 \times 60} \times T$$

$$X_B = \frac{n_B}{15 \times 60} T$$

Where, X_A = Number of vehicle accumulated in one cycle time on Road 'A'.

X_B = Number of vehicle accumulated in one cycle time on Road 'B'.

T = Cycle-time in 'Sec'(Assumed)

n_A = Traffic count on Road A in 15 min.

n_B = Traffic count on road B in 15 min.

∴ Green time on Road A

$$G_A = 2.5X_A$$

on Road B

$$G_B = 2.5X_B$$

∴ Total Cycle time

$$T' = (G_A + A_A) + (G_B + A_B)$$

Approximate Method :

$$R_A = G_{AP} = \left[7 + \frac{W_A}{1.2}\right]$$

$$R_B = G_{BP} = \left[7 + \frac{W_B}{1.2}\right]$$

where, R_A = Red time of Road 'A'.

R_B = Red time of Road 'B'

G_{AP} = Green time on road A for pedestrians.

G_{BP} = Green time on Road 'B' for pedestrians.

W_A = Width of Road A

W_B = Width of Road B

1.2 m/sec = Speed of pedestrians

$$G_A = R_B - A_A$$

$$G_B = R_A - A_B$$

Where, G_A and G_B are green times on Roads A and B. A_A and A_B are amber times on Roads A and B.

Webster's Method:

$$C_o = \frac{1.5L+5}{1-Y}$$

$L = 2n + R$

Where, C_o = Optimum cycle time

L = Total lost time

n = Number of phases

R = All Red time

$Y = y_1 + y_2$

$$y_1 = \frac{q_1}{S_1} \text{ and } y_2 = \frac{q_2}{S_2}$$

$$G_A = \frac{y_1}{Y}(C_o - L) \text{ and } G_B = \frac{y_2}{Y}(C_o - L)$$

Where, q_A = Normal flow on road A

q_B = Normal flow on road B

S_A = Saturation flow on road A

S_B = Saturation flow on road B

39. ***Assumption :*** The ruling design speed for NH passing through a Rolling terrain is 80 kmph as per IRC.

The co-efficient of lateral friction

$f = 0.15$

The maximum permissible super-elevation

$e = 0.07$

Case-(a) Radius = 450 m

Step-1 : Find 'e' for 75% of design speed, neglecting f,

i.e. $$e_1 = \frac{(0.75V)^2}{127R} = \frac{(0.75\times 80)^2}{127\times 450} = 0.0629$$

$V = 80$ kmph

Step-2 : $e_1 \leq 0.07$ hence the design is sufficient.

Answer : Design super-elevation

$e = 0.06$

Case-(b) Radius = 150 m

Step-1 : Find e for 75% of design speed, neglecting f′,

i.e. $$e_1 = \frac{(0.75\times80)^2}{127\times150} = \frac{(0.75\times80)^2}{127\times150}$$

$$= 0.1889$$

Step-2 : Maximum ‘e’ to be provided = 0.07

Step-3:Find ‘f_1’ for design speed and maximum e, i.e., $(e + f_1) = \frac{V^2}{127R} = \frac{80^2}{127\times150}$

$$f_1 = 0.3359 - 0.07 = 0.2659$$

Step-4 : Find allowable speed V_a for the maximum e = 0.07 and f = 0.15

$$V_a = \sqrt{0.22gR} = \sqrt{0.22\times9.81\times150}$$

$$V_a = 17.99 \text{ m/sec}$$

$$V_a = 64 \text{ kmph}$$

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