MADE EASY

RPSC AEn-2024 Main Test Series

CIVIL ENGINEERING | **Test 5**

Test Mode : • Offline • Online

Subjects : Transportation Engineering + Surveying

DETAILED EXPLANATIONS

1. Solution:

Camber is provided in pavements to drain rainwater quickly, prevent water ingress, and maintain pavement stability and skid resistance.

2. Solution:

Two fundamental principles of surveying are:

(i) To work from whole to part

(ii) To locate a point by at least two measurements

3. Solution:

Exceptional gradient is the very steep gradient permitted only for short stretches (not exceeding about 100 m) under unavoidable site conditions.

4. Solution:

Time headway is the time interval between the passages of two successive vehicles over the same point on a traffic lane, measured from front to front of the vehicles.

5. Solution:

Revolving the telescope in the horizontal plane, about its vertical axis is called the swinging of the telescope.

6. Solution:

Initial speed, $u = 30$ kmph

Braking distance, $L = 5.8$ m

We know, $L = \frac{u^2}{2gf}$

$$\Rightarrow \quad f = \frac{u^2}{2gL} = \frac{\left(30 \times \frac{5}{18}\right)^2}{2 \times 9.81 \times 5.8} = 0.61$$

7. Solution:

Height of observer and distance to visible horizon are related as:

$$h = 0.0673\, D^2$$

$$\Rightarrow \quad 80 = 0.0673\, D^2$$

$$\Rightarrow \quad D = 34.478 \text{ km}$$

Dip of the horizon,

$$\theta = \tan^{-1}\left(\frac{34.478}{6400}\right) = 0.3087° = 0°18'31.32''$$

8. Solution:

Azimuth is measured clockwise from north and hence azimuth of the line is 135°.

9. Solution:

The objective of tack coat is to ensure adequate bonding between the existing pavement surface and the new bituminous layer.

10. Solution:

Hypsometry is the determination of difference in elevations by observing boiling point of water at different altitudes using a hypsometer. It works on the principle that water boils when its vapour pressure is equal to the atmospheric pressure which is different at different elevations.

11. Solution:

PIEV theory explains total reaction time of a driver as the sum of four stages:

(i) Perception time to transmit sensations received from sensory organs to the brain.

(ii) Intellection time to understand the situation.

(iii) Emotion is the time elapsed during emotional sensations like fear, anger, etc.

(iv) Volition is time required for taking final action such as braking or steering.

12. Solution:

Superelevation required,

$$e = \frac{V^2}{225R} = \frac{75^2}{225 \times 300} = 0.083 > 0.07$$

$\because$ Maximum allowable superelevation = 0.07

$$\therefore \quad e = 0.07$$

$\therefore$ Friction developed,

$$f = \frac{V^2}{127R} - 0.07 = \frac{75^2}{127 \times 300} - 0.07 \approx 0.08 < 0.15 \text{ (Ok)}$$

$\therefore$ It is safe.

Superelevation to be provided = 0.07

13. Solution:

Temporary adjustments are the operations carried out at every instrument set-up before taking observations. These include:

(i) Setting up: The instrument is centred approximately over the station using tripod legs.

(ii) Levelling up: The vertical axis is made truly vertical by bringing the plate level bubble to the centre using foot screws.

(iii) Focussing: Eyepiece is focused to make cross-hairs clear, followed by focusing the objective to obtain a sharp image of the object.

14. Solution:

Ravelling is the progressive disintegration of a bituminous pavement surface due to loss of bond between aggregates and binder, leading to aggregate loosening under traffic. Two major causes of ravelling are:

(i) Insufficient bitumen binder content in the mix.

(ii) Improper coating or stripping of binder from aggregates due to moisture.

15. Solution:

Shrinkage factor, $SF = \frac{9.5}{10}$

Original area on plan,

$$A = \left(\frac{10}{9.5}\right)^2 \times 90.5 = 100.277 \text{ cm}^2$$

$\therefore$ Area on ground $= 100.277 \times (10)^2 = 10027.7 \text{ m}^2$

Original length of tape $= 30 - 0.09 = 29.91$ m

$\therefore$ True area of the field, $A' = \left(\frac{29.91}{30}\right)^2 \times 10027.7$

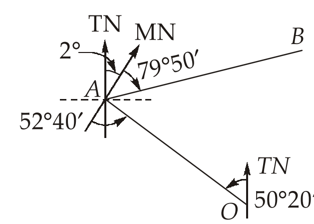
$\Rightarrow$ $A' = 9967.624 \text{ m}^2$

16. Solution:

Magnetic Declination, $\delta = 2°E$

Magnetic *FB* of *AB* = N 79°50′ E

To find local attraction at station *A*



As station *O* is free from local attraction

Hence *FB* of *OA* will be correct,

Correct *FB* of *OA* = N 50°20′ *W* = 309°40′

$\therefore$ Correct *BB* of *OA* = 129°40′

$\because$ Observed *FB* of *AO* = Observed *BB* of *OA* = S52°40′E = 127°20′

$\therefore$ Error at station *A* = Observed bearing – Correct bearing

= 127°20′ – 129°40′ = – 2°20′

$\therefore$ Correction required at station *A* = +2°20′

Local attraction at station *A* = +2°20′ = 2°20′ E

$\because$ Magnetic *FB* of *AB* = N 79°50′ E

δ = 2°E and local attraction = 2°20′E

$\therefore$ *TB* of *FB* of *AB* = 79°50′ + 2° 20′ + 2°

= N84°10′E

17. Solution:

(i) They are light structures and require no false work.

(ii) Materials of construction can be transported easily.

(iii) Time of construction is less.

(iv) Roadway is provided at low elevation and has low centre of wind pressure.

(v) They require no centering for construction.

(vi) They can be provided over long spans with fewer supports.

(vii) They require minimal work in running water thereby keeping the waterways open during construction.

18. Solution:

Horizontal distance,

$$D = K s \cos^2 \theta + C \cos \theta$$

Here, $K_1 = K_2 = 100, C_1 = 0, C_2 = 0.5, \theta = 9°46'$

$\therefore$ Difference in distances $= (C_2 - C_1) \cos \theta = 0.4928$ m

Original distance,

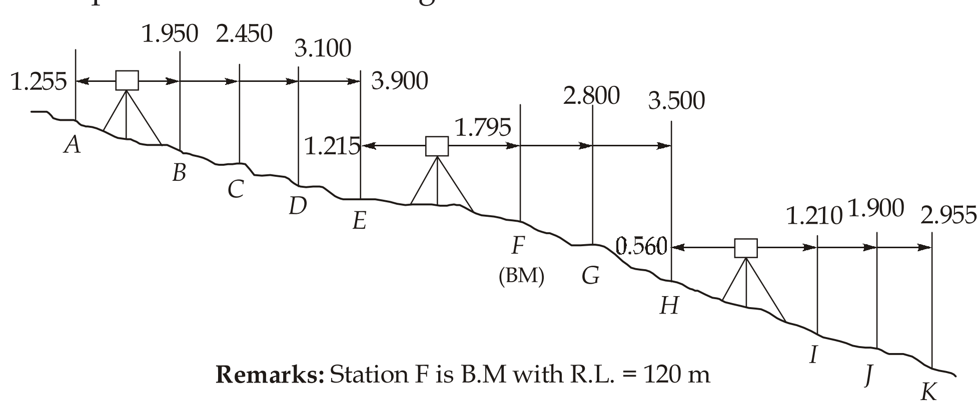
$$D = 100 \times 1.915 \cos^2 9°46' + 0.5 \cos 9°46'$$

$$= 186.482 \text{ m}$$

$\therefore$ Percentage error in computed distance $= \dfrac{0.4928}{186.482} \times 100 = 0.26\%$

19. Solution:

A schematic representation of levelling work is shown below.



Remarks: Station F is B.M with R.L. = 120 m

Staff station	Back sight (m)	Intermediate sight (m)	Fore sight (m)	Rise (m)	Fall (m)	R.L. (m)	Remarks
A	1.255	–	–	–	–	123.225	–
B	–	1.95	–	–	0.695	122.53	–
C	–	2.45	–	–	0.5	122.03	–
D	–	3.10	–	–	0.65	121.38	–
E	1.215	–	3.9	–	0.8	120.58	C.P.
F	–	1.795	–	–	0.58	120	R.L.
G	–	2.80	–	–	1.005	118.995	–
H	0.560	–	3.5	–	0.7	118.295	C.P.
I	–	1.210	–	–	0.65	117.645	–
J	–	1.900	–	–	0.69	116.955	–
K	–	–	2.955	–	1.055	115.9	–

Checks:

$$\text{Last R.L.} - \text{First R.L.} = 115.9 - 123.225 = -7.325 \text{ m}$$

$$\Sigma \text{ Rise} = 0$$

$$\Sigma \text{ Fall} = 7.325$$

$$\Sigma \text{ Back sights} = \Sigma \text{ B.S.} = 3.03 \text{ m}$$

$$\Sigma \text{ Fore sights} = \Sigma \text{ F.S.} = 10.355 \text{ m}$$

$$\Sigma \text{ B.S.} - \Sigma \text{ F.S.} = -7.325 \text{ m}$$

$$\therefore \quad \Sigma \text{ B.S.} - \Sigma \text{ F.S.} = \Sigma \text{ Rise} - \Sigma \text{ Fall}$$

$$= \text{Last R.L.} - \text{First R.L} = -7.325 \text{ m (Ok)}$$

20. Solution:

Given: Radius of curve, $R = 300$ m

Given design speed for highway in the built-up area is 80 kmph

(i) Super elevation:

For mixed traffic conditions, super-elevation is calculated for 75% of design speed neglecting the friction.

$$\therefore \quad e = \frac{(0.75V)^2}{127R} = \frac{V^2}{225R}$$

$$= \frac{80^2}{225 \times 300} = 0.095 > 0.04 \text{ (maximum for built up area)}$$

As the value of super-elevation is greater than the maximum permissible super-elevation of 0.04 and hence the actual super-elevation to be provided is restricted to 0.04.

Check for coefficient of lateral friction at full speed:

$$e_{max} + f = \frac{V^2}{127R}$$

$$\Rightarrow \quad f = \frac{80^2}{127 \times 300} - 0.04 = 0.128 < 0.15 \text{ (max)} \quad \text{(Ok)}$$

(ii) Extra widening of pavement:

Assuming highway pavement width, $W = 7\,\text{m}$

$\therefore$ No. of lanes, $n = 2$

Also assuming wheel base of vehicle, as per *IRC* as:

$$l = 6.1 \text{ m}$$

Extra widening,
$$E_W = \frac{nl^2}{2R} + \frac{V}{9.5\sqrt{R}} = \frac{2 \times 6.1^2}{2 \times 300} + \frac{80}{9.5\sqrt{300}}$$
$$= 0.124 + 0.486 = 0.61 \text{ m}$$

(iii) Length of transition curve:

(a) Based on rate of change in centrifugal acceleration:

Length of transition curve, $L_s = \dfrac{v^3}{RC}$

where
$$C = \frac{80}{75+V} = \frac{80}{75+80} = 0.516\,\text{m/s}^3$$ (which lies between 0.5 and 0.8) (Ok)

So,
$$L_s = \frac{\left(80 \times \frac{5}{18}\right)^3}{300 \times 0.516} = 70.89 \text{ m}$$

(b) Based on rate of introduction of superelevation:

Assuming that pavement is rotated about centre line.

Length of transition curve, $L_s = \dfrac{eN(W + E_w)}{2}$

where 1 in N is rate of introduction of superelevation i.e. 1 in 100 for built up areas.

So,
$$L_s = \frac{0.04 \times 100 \times (7 + 0.61)}{2} = 15.22 \text{ m}$$

(c) As per IRC

Length of transition curve, $L_s = \dfrac{2.7V^2}{R}$

$$= \frac{2.7 \times 80^2}{300} = 57.6 \text{ m}$$

Now L_s is maximum of lengths calculated in (a), (b), (c)

So, $L_s = 70.89 \text{ m} \simeq 71 \text{ m (say)}$

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