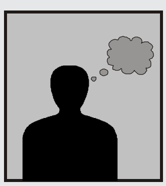
ESE GATE PSUs

State Engg. Exams

MADE EASY WORKBOOK 2025



Detailed Explanations of Try Yourself *Questions*

Civil Engineering

Railway, Airport, Tunneling, Dock and Harbour Engineering

MADE EASY PUBLICATIONS

2 Track Stresses, Traction and Tractive Resistances

Detailed Explanation *of* Try Yourself Questions

T1 : Solution

Number of wagons in the train = 20

Weight of each wagon = 18 tonnes

∴ Total weight of wagons = $18 \times 20 = 360$ tonnes

Also, weight of locomotive = 120 tonnes

∴ Weight of train = $360 + 120 = 480$ tonnes

Now, number of driving axles in a 2-8-2 locomotive, $n = \dfrac{8}{2} = 4$

and load on each driving axle = 22.5 tonnes (given)

∴ Hauling capacity = $\mu n W$

where μ = coefficient of friction which has a value = $\dfrac{1}{6}$

n = number of driving axles in locomotive

W = load on each driving axle

∴ Hauling capacity = $\dfrac{1}{6} \times 4 \times 22.5 = 15$ tonnes

Tractive effort of locomotive = 15 tonnes

We know that total resistance = $RT_1 + RT_2 + RT_3 + W \tan\theta$

where RT_1 = Rolling resistance independent of speed

RT_2 = Resistance dependent on speed

RT_3 = Atmospheric resistance

Now, RT_1 = RT_1 for locomotive + RT_1 for wagons

= $3.5 \times 120 + 2.5 \times 360 = 420 + 900 = 1320$ kg or 1.32 tonnes

RT_2 = 2.65 tonnes (given)

RT_3 = $0.0000006\, WV^2$

where W = Total weight of train = 480 tonnes

V = Speed of train in kmph

∴ $RT_3 = 0.0000006 \times 480 \times (50)^2 = 0.72$ tonnes

Now, Hauling capacity = Total resistance

But Total resistance = $RT_1 + RT_2 + RT_3 + W \tan\theta$

$\Rightarrow$ $15 = 1.32 + 2.65 + 0.72 + 480 \tan\theta$

$$\Rightarrow \quad \tan\theta = \frac{10.31}{480}$$

$$\Rightarrow \quad \tan\theta = \frac{1}{46.56}$$

Thus the steepest gradient will be 1 in 47 (approx.)

T2 : Solution

Total weight of train = Weight of locomotive + Weight of wagons

= 120 + 20 × 18 = 480 tonnes

Rolling resistance of each wagon = 2.5 × 18 = 45.0 kg

Rolling resistance of all wagons = 45 × 20 = 900 kg

Rolling resistance of locomotive = 120 × 0.35 = 42 kg

Therefore total resistance of locomotive and wagon

= 942 kg = 0.942 tonnes

Atmospheric resistance = $0.0000006\, wV^2$

$= 0.0000006 \times 480 \times 50^2 = 0.72$ tonne

Resistance depending upon speed = $0.00008\, wV$

$= 0.00008 \times 480 \times 50 = 1.92$ tonnes

Train resistance = Rolling resistance + Resistant depending on speed + Atmospheric resistance + Resistance due to gradient

$$= 0.942 + 1.92 + 0.72 + \frac{1}{g} \times 480$$

where the gradient required is 1 in g.

Equating the resistance with tractive effort of locomotive

$$12 = 3.582 + \frac{480}{g}$$

$$\Rightarrow \quad g = \frac{480}{8.418} = 57 = 60\,(\text{say})$$

∴ Steepest gradient permissible is 1 in 60.

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3 Geometric Design of Track

Detailed Explanation of Try Yourself Questions

T1 : Solution

(a)

For Main Track,

$$D = 3^\circ$$

$$R = \frac{1750}{3} = 583.33 \text{ m}$$

$$\because \quad (e_{th})_{MT} = (e_{act})_{MT} + CD$$

$$\Rightarrow \quad \frac{G(V_{max})^2_{MT}}{127R} = (e_{act})_{MT} + \left(\frac{7.6}{100}\right)$$

$$\Rightarrow \quad \frac{1.750(70)^2}{127 \times 583.33} = (e_{act})_{MT} + \left(\frac{7.6}{100}\right)$$

$$\Rightarrow \quad (e_{act})_{MT} = 0.03974 \text{ m} = 3.975 \text{ cm}$$

For Branch Track, ($D = 5^\circ$)

$$\because \quad (e_{th})_{BT} = (-e_{act})_{MT} + CD$$

$$\Rightarrow \quad \frac{1.750(V_{max})^2_{BT}}{127 \times \left(\frac{1750}{5}\right)} = \left(\frac{-3.975 + 7.6}{100}\right)$$

$$\Rightarrow \quad (V_{max})_{BT} = 30.3438 \simeq 30.345 \text{ kmph}$$

(b)

For Branch Track, (D = 5°)

$$\because \quad (e_{th})_{BT} = -(e_{act})_{MT} + CD$$

$$\Rightarrow \quad \frac{1.750 \times (V_{max})^2_{BT}}{127 \times \left(\frac{1750}{5}\right)} = -(e_{act})_{MT} + \left(\frac{7.6}{100}\right)$$

$$\Rightarrow \quad \frac{1.750 \times 40^2}{127 \times \left(\frac{1750}{5}\right)} = -(e_{act})_{MT} + \left(\frac{7.6}{100}\right)$$

$$\Rightarrow \quad (e_{act})_{MT} = 0.013 \text{ m} = 1.3 \text{ cm}$$

For Main Track, (D = 3°)

$$\because \quad (e_{th})_{MT} = (e_{act})_{MT} + CD$$

$$\Rightarrow \quad \frac{1.750 \times (V_{max})^2_{MT}}{127 \times \left(\frac{1750}{3}\right)} = \left(\frac{1.3 + 7.6}{100}\right)$$

$$\Rightarrow \quad (V_{max})_{MT} = 61.38 \text{ kmph}$$

T2 : Solution

Given: Actual cant, C_a = 9 cm

Cant deficiency, C_d = 10 cm

V_{max} = 145 kmph

Check for maximum speed,

$$\because \quad e_{th} = e_{act} + CD$$

$$\Rightarrow \quad \frac{G(V_{max})^2}{127R} = C_a + C_d$$

$$\Rightarrow \quad \frac{1.750(V_{max})^2}{127 \times \left(\frac{1750}{2}\right)} = \left(\frac{9 + 10}{100}\right)$$

$$\Rightarrow \quad V_{max} = 109.84 \text{ kmph}$$

Based on transition curve,

$$\because \quad V_{max} = \frac{198L}{C_a} \text{ or } \frac{198L}{C_d}$$

$$\Rightarrow \quad V_{max} = \frac{198 \times 125}{9 \times 10} \text{ or } \frac{198 \times 125}{10 \times 10}$$

$$\because \quad V_{max} = (275 \text{ or } 247.5) \text{ kmph}$$

So, V_{max} adopted = minimum of (145 kmph, 109.84 kmph, 275 kmph, and 247.5 kmph)

= 109.84 kmph

T3 : Solution

$$V_{avg} = \frac{n_1V_1 + n_2V_2 + n_3V_3 + n_4V_4}{n_1 + n_2 + n_3 + n_4}$$

$$\Rightarrow \quad V_{avg} = \frac{15(35)+12(60)+8(90)+3(95)}{15+12+8+3}$$

$$\Rightarrow \quad V_{avg} = 59.21 \text{ kmph}$$

$$\therefore \quad (e_{act}) = \frac{GV^2}{127R}$$

$$= \frac{1.750 \times 59.21^2}{127 \times \frac{1750}{3}} = 0.0828 \text{ m} = 8.28 \text{ cm}$$

For maximum permissible speed,

$$\frac{GV_{max}^2}{127R} = (e_{act}) + CD$$

$$\frac{1.750 \times V_{max}^2}{127 \times \frac{1750}{3}} = (8.28 + 7.5) \times 10^{-2}$$

$$\therefore \quad V_{max} = 81.73 \text{ kmph}$$

Check for cant excess required

$$\text{Cant for slowest train} = \frac{GV_{slow}^2}{127R} = \frac{1.750 \times 35^2}{127 \times \frac{1750}{3}} = 0.0289 \text{ m}$$

$$= 2.89 \text{ cm}$$

$$\text{Provided cant} = 8.28 \text{ cm}$$

$$\therefore \quad \text{Cant excess} = 8.28 - 2.89$$

$$= 5.39 \text{ cm} < 7.5 \text{ cm} \qquad \text{(OK)}$$

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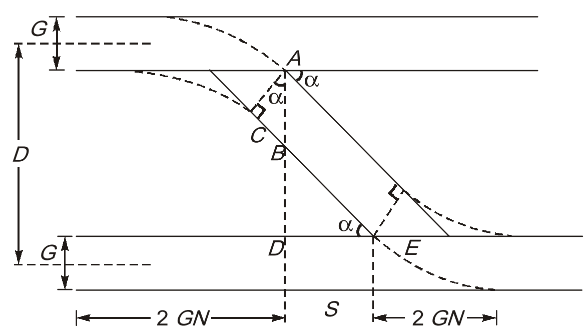
4 Points and Crossings

Detailed Explanation of Try Yourself Questions

T1 : Solution



Let
N = Number of crossing
α = Angle of crossing
G = Gauge distance (1.676 m in case of *BG*)
D = Centre to centre distance between two tracks
$2GN$ = Length of turnouts
S = Straight horizontal portion between the turnouts
$N = \cot\alpha$

From ΔBDE, $S = DE = BD\cot\alpha$

$= (AD - AB)\cot\alpha$

$= [(D-G) - G\sec\alpha]\cot\alpha \qquad \left[\because \cos\alpha = \frac{AC}{AB} \text{ and } AC = G\right]$

$$= \left[(D-G) - G\sqrt{1+\tan^2\alpha}\right]N$$

$$= \left[(D-G) - G\sqrt{1+\frac{1}{\cot^2\alpha}}\right]N$$

$$= \left[(D-G) - \frac{G}{N}\sqrt{1+N^2}\right]N$$

$$\Rightarrow \quad S = (D - G)\,N - G\sqrt{1 + N^2}$$

But overall length of cross over $= 4\,GN + S$

$$= 4\,GN + (D - G)\,N - G\sqrt{1 + N^2}$$

Given that $G = 1.676$ m, $N = 8.5$, $D = 5$ m

$\therefore$ Overall length of cross over $= 4 \times 1.676 \times 8.5 + (5 - 1.676) \times 8.5 - 1.676\sqrt{1 + (8.5)^2}$

$$= 70.89 \text{ m}$$

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