ESE GATE PSUs

State Engg. Exams

MADE EASY Workbook 2026

Detailed Explanations of Try Yourself *Questions*

Civil Engineering

Highway Engineering

MADE EASY PUBLICATIONS

1 Geometric Design of Highway

Detailed Explanation of Try Yourself Questions

47 : Solution

$$\text{Braking distance} = \frac{V^2}{2g(f \pm n)} = \frac{(0.278V)^2}{2 \times 9.81(f \pm n)} = \frac{V^2}{254(f \pm n)}$$

Here, V = Speed in kmph = 65 kmph

f = coefficient of friction between type and pavement = 0.4

n = grade of pavement [+ for upgrade; – for downgrade]

As, vehicle travelling towards upgrade requires 10 m. Less than travelling towards downgrade with same grade.

So,
$$\frac{V^2}{254(f+n)} = \frac{V^2}{254(f-n)} - 10$$

$$\Rightarrow \quad \frac{65^2}{254(0.4+n)} = \frac{65^2}{254(0.4-n)} - 10$$

$$\Rightarrow \quad 16.63\left(\frac{1}{0.4-n} - \frac{1}{0.4+n}\right) = 10$$

$$\Rightarrow \quad \frac{2n}{0.4^2 - n^2} = 0.6$$

$$\Rightarrow \quad 3.33\,n = 0.4^2 - n^2$$

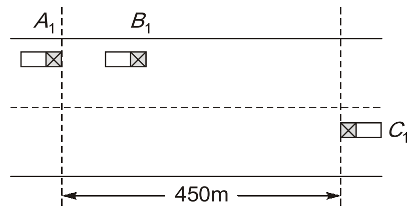
$$\Rightarrow \quad n^2 + 3.33\,n - 0.4^2 = 0$$

$$\Rightarrow \quad n = 0.0474$$

So, grade of pavement in percent = 4.74%

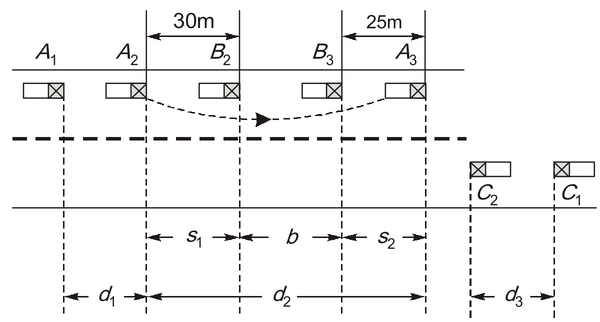
48 : Solution

Before Overtaking



Assume, length of a vehicle = 6 m

Overtaking operation



$$s_1 = 30 \text{ m}$$

$$s_2 = 25 \text{ m}$$

Before overtaking and overtaking operation is as shown above in the figures.

Total distance travelled by A during the overtaking operation,

$$D_A = d_1 + d_2$$

where, d_1 = distance travelled in reaction time

d_2 = distance travelled in overtaking

Now, reaction time, $t_R = 2$ sec

$\therefore$ $d_1 = V_A \times t_R$

$$= \left(40 \times \frac{5}{18}\right) \times 2$$

$$\ldots V_A = V_B = 40 \text{ kmph}$$

$$d_1 = 22.22 \text{ m}$$

Time taken during overtaking operation

$$T = \sqrt{\frac{2(s_1 + s_2)}{a}}$$

where, a = acceleration = 1.2 m/s^2

Now, $$T = \sqrt{\frac{2(30+25)}{1.2}}$$

$$T = 9.5743 \text{ sec}$$

Now, $$d_2 = s_1 + b + s_2 = 30 + V_B \times T + 25 = 55 + \left(40 \times \frac{5}{18}\right) \times 9.5743$$

$$d_2 = 161.38 \text{ m}$$

Thus, $$D_A = d_1 + d_2 = 22.22 + 161.38 = 183.6 \text{ m}$$

During overtaking distance travelled by vehicle C

$$d_3 = V_c (t_R + T)$$

$$d_3 = 80 \times \frac{5}{18}(2 + 9.5743)$$

$$d_3 = 257.2 \text{ m}$$

Hence remaining distance between front bumpers of vehicles A & C

$$= 450 - (d_1 + d_2 + d_3)$$

$$= 450 - (183.6 + 257.2) = 9.2 \text{ m}$$

and remaining distance between front bumpers at vehicles B & C

$$= s_2 + 9.2 = 25 + 9.2 = 34.2 \text{ m}$$

49 : Solution

Given: $n_1 = 2\%$, $n_2 = -5\%$; $N = n_1 - n_2 = 2 + 5 = 7\%$

(a) Requirements of stopping sight distance:

$$\text{SSD} = 180 \text{ m}$$

Assume $L >$ SSD then

$$L = \frac{NS^2}{4.4} = \frac{7 \times 180^2}{100 \times 4.4} = 515.45 \text{ m}$$

As this length is greater than SSD, the assumption is correct.

So, the length of summit curve required is about 516 m. which is less than the prescribed maximum limit of 1550 m. of vertical curve.

(b) Requirement of overtaking sight distance:

$$\text{OSD} = 600 \text{ m}$$

Assume, $L >$ OSD

$$\therefore \quad L = \frac{NS^2}{9.6} = \frac{7 \times 600^2}{100 \times 9.6} = 2625 \text{ m}$$

As the length obtained is higher than OSD, the assumption is correct and length of summit curve should be 2625 m.

But as suggested, length of summit curve is restricted to a value less than 1550 m, it is not possible to provide the required OSD of 600 mtr.

Therefore, to provide limited opportunities for overtaking, Intermediate Sight Distance (ISD) equal to twice the SSD of 180 × 2 = 360 m. may be provided if possible.

Now, if $L >$ SSD; $S = 360$ m

$$L = \frac{NS^2}{9.6} = \frac{7 \times 360^2}{9.6 \times 100} = 945 \text{ m}$$

As this value is greater than ISD of 360 m., the assumption is correct.

It is possible to provide the ISD of 945 m. to allow limited overtaking operations and the length of summit curve in this case is also less than the maximum available length of 1550 m.

50 : Solution

Given : R = 484 m, V = 80 kmph (Rolling terrain), N = 150, l = 6 m

Case (i) : Based on rate of change of centrifugal acceleration

$$C = \frac{80}{75+V} = \frac{80}{75+80} = 0.516 \text{ m/s}^3$$

$$L_T = \frac{V^3}{CR} = \frac{\left(\frac{5}{18}\times 80\right)^3}{0.516\times 484} = 43.94 \text{ m}$$

Case (ii) : As per rate of introduction of superelevation.

Design of superelevation

$$e = \frac{V^2}{225R} = \frac{80^2}{225\times 484} = 0.0587 < 0.07 \quad \text{(Safe)}$$

$$e = 5.87\%$$

Assume rotation about centreline

(For radius R > 300 m extra widening is not required for 2 lane road)

$$L_T = \frac{1}{2}eN(W+W_e)$$

$$= \frac{1}{2}\times 0.0587\times 150\times 7 = 30.81 \text{ m}$$

Case (iii) : Minimum length

$$L_T = 2.7\frac{V^2}{R} = 2.7\times\frac{80^2}{484} = 35.70 \text{ m}$$

Length of tranection curve, $$L_T = \max\begin{cases}43.94\\30.81 = 43.94 \text{ m}\\35.70\end{cases}$$

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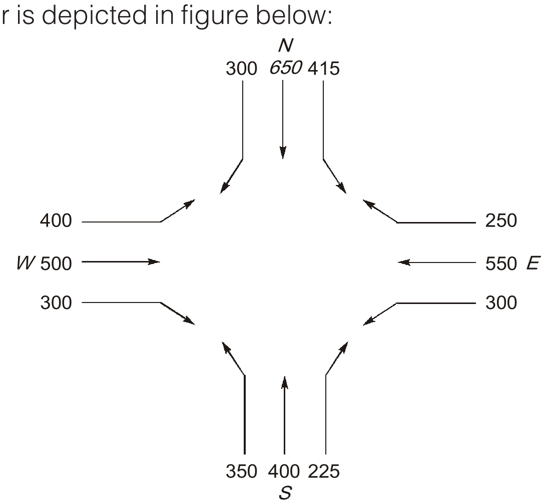
2 Traffic Engineering

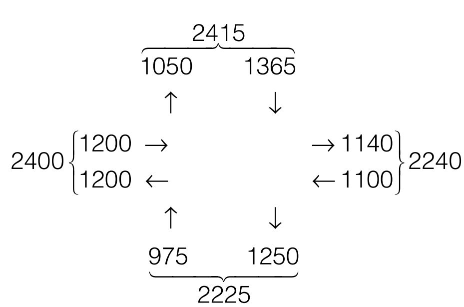
Detailed Explanation *of* Try Yourself Questions

T1 : Solution

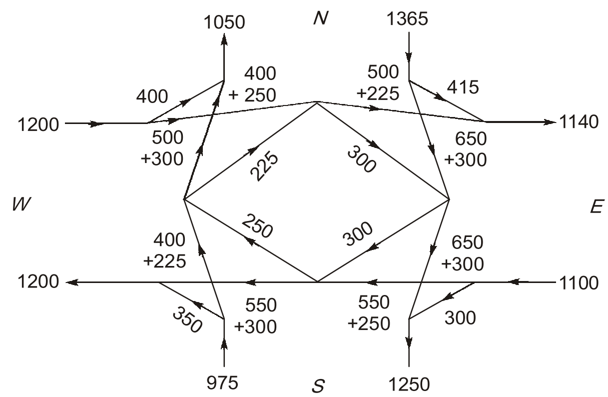
The traffic in PCU per hour is depicted in figure below:



The traffic in PCU per hour on each leg is depicted below:



The traffic assigned to the network is shown in figure below:



The maximum 2 way flow in the intersection leg (North) is 2415 PCU/hr and the maximum in one direction is 1365 PCU/hr.

For a carriageway width of 15 m, width of carriageway at entry and exit is taken as 10.0 m. The width of non-weaving section is also kept as 10.0 m

Width of weaving section, $W = \dfrac{e_1 + e_2}{2} + 3.5 = \dfrac{10 + 10}{2} + 3.5 = 13.5\ m$

As per IRC, the weaving length L is taken between 30 m to 60 m for 30 kmph design speeds so that W/L = 0.12 to 0.4

∴ Let us take $L = 50$ m

The maximum weaving occurs in $E - S$ direction, therefore proportion of weaving traffic is given by

$$p = \frac{(650 + 300) + (550 + 250)}{(650 + 300) + (550 + 250) + 300 + 300} = 0.745$$

Average width of entry (e_1) and width of non-weaving section (e_2) is given by

$$e = \frac{e_1 + e_2}{2} = \frac{10 + 10}{2} = 10\text{ m}$$

$$\therefore \quad Q_p = \frac{280\, W\,(1 + e/W)(1 - p/3)}{(1 + W/L)} = \frac{280 \times 13.5 \times \left(1 + \frac{10}{13.5}\right)\left(1 - \frac{0.745}{3}\right)}{1 + \frac{13.5}{50}}$$

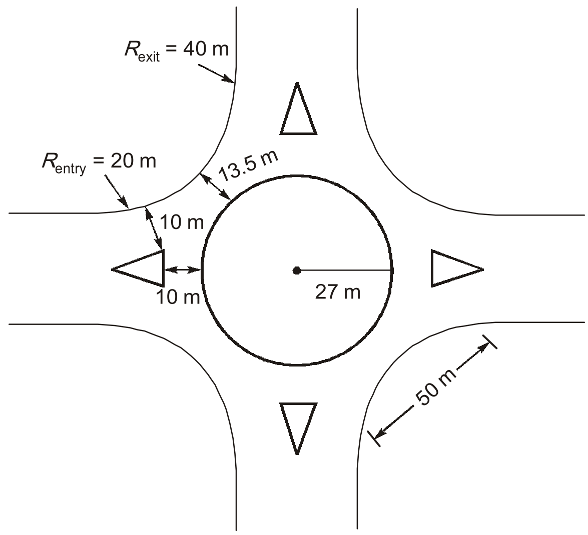
$$= 3894.46 \text{ PCU per hour } (> 2415;\ \text{Hence OK})$$

IRC recommends radius at entry as 15 to 25 m for 30 kmph speed.

IRC recommends minimum radius of central island as 1.33 times the radius at entry.

Let us assume radius at entry as 20 m

∴ Radius of central island = 1.33 × 20 = 26.6 = 27 m


R_{exit} = 40 m
R_{entry} = 20 m
13.5 m
10 m
10 m
27 m
50 m

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