2 CHAPTER

Highway Geometric Design

Q.1 Given that
Speed of a vehicle = V kmph
Brake reaction time = t sec
Efficiency of the brakes = η%
Then the stopping distance of the vehicle is

(a) $0.28V^2t + \dfrac{V}{0.01\eta}$

(b) $28V^2t + \dfrac{V}{0.01\eta}$

(c) $0.28Vt + \dfrac{0.01V^2}{2g\eta f}$

(d) $0.28V^2t \div 0.01\eta V^2$

Q.2 Consider the following pairs with reference to highway geometric design
1. Camber for cc pavement
   — (1 in 33) to (1 in 40)
2. Roadway for motion with for two lane NH in plain terrain
   — 12 m
3. Height of object while calculating stopping sight distance
   —0.15 m
4. Reaction time of driver in the calculation of the overtaking sight distance
   — 2.5 S

Which of these pairs are correct?
(a) 2 and 3 (b) 1 and 3
(c) 2 and 4 (d) 3 and 4

Q.3 Consider the following steps involved in the design of superelevation in practice as recommended by IRC:
1. Calculation of the allowable speed for maximum 'e' and design value of 'f'
2. Calculation of the superelevation for 75% of the design speed.
3. Calculation of the value of 'e' and recheck.
4. Calculation of the value of 'f' and recheck.

The correct sequence of these steps is
(a) 1-2-3-4 (b) 3-4-1-2
(c) 2-3-4-1 (d) 4-3-2-1

Q.4 What is the superelevation for a horizontal highway curve of radius 500 m and speed 100 kmph in mixed traffic condition?
(a) 8.9% (b) 6.2%
(c) 0 (d) 7%

Q.5 Consider the following statements:
1. An ascending gradient of 1 in 100 meets an ascending gradient of 1 in 120 to form a valley curve.
2. A falling gradient of 1 in 75 meets a falling gradient of 1 in 50 to form a summit curve.
3. The length of summit curve is determined on the basis of headlight sight distance.

Which of the above statement/s is/are correct?
(a) 1 and 2 (b) 2 and 3
(c) 1 and 3 (d) 2 only

Q.6 Match List-I (Highway survey) with List-II (Outcome) and select the correct answer using the codes given below the lists:

List-I
A. Map study
B. Reconnaissance
C. Preliminary survey
D. Detailed survey

List-II
1. Best alignment of road
2. Grade line and central line of road
3. Cross-drainage locations
4. Obligatory points

Codes:

	A	B	C	D
(a)	1	2	4	3
(b)	4	3	1	2
(c)	1	3	4	2
(d)	4	2	1	3

Q.7 Match List-I (Type of road surface) with List-II (Percentage of camber in areas of heavy rainfall) and select the correct answer by using the codes given below the lists:

List-I	List-II
A. Cement concrete	1. 4.0%
B. Thin bituminous surface	2. 3.0%
C. Water-bound macadam	3. 2.0%
D. Earth road	4. 2.5%

Codes:

	A	B	C	D
(a)	4	3	2	1
(b)	3	2	1	4
(c)	4	3	2	1
(d)	3	4	2	1

Q.8 Match List-I (Road surface) with List-II (Percentage of camber for light rain fall) select the correct answer by using the codes given below the lists:

List-I	List-II
A. Earth road	1. 1.7%
B. Water bound macadam	2. 3.0%
C. Thin bituminous surface	3. 2.5%
D. Cement concrete	4. 2.0%

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	3	4	2	1
(c)	1	4	3	2
(d)	2	3	4	1

Q.9 Match List-I (Type of road) with List -II (Width of carriage way) and select the correct answer by using the codes given below the lists:

List-I	List-II
A. Single lane road	1. 7.0 m
B. Two lanes road without raised kerbs	2. 7.5 m
C. Two lanes with raised kerbs	3. 3.75 m
D. Multi-lane pavements /lane	4. 3.5 m

Codes:

	A	B	C	D
(a)	3	1	2	4
(b)	1	2	3	4
(c)	3	4	2	1
(d)	1	3	4	1

Q.10 Match List-I with List-II and select the correct answer by using the codes given below the lists:

List-I

A. Width of single lane carriage way
B. Minimum width for medians of rural high ways
C. Width of median on long bridge
D. Kerb used as high speed barrier

List-II

1. 0.45 m
2. 1.5 m
3. 5.0 m
4. 3.75 m

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	2	4	3	1
(c)	4	3	2	1
(d)	1	3	4	2

Q.11 Match List-I with List-II and select the correct answer by using the codes given below the lists:

List-I

A. Transverse slope at the horizontal curve
B. The centrifugal force acting horizontally outwards towards the centre of gravity
C. Coefficient of lateral friction
D. Equilibrium superelevation

List-II

1. $\frac{Wv^2}{gR}$
2. 0.15
3. Superelevation
4. $\frac{V^2}{127R}$

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	3	1	2	4
(c)	3	4	2	1
(d)	1	4	3	2

Q.12 Match List-I with List-II and select the correct answer by using the codes given below the lists:

List-I

A. Mechanical widening
B. Total widening of road
C. Radius of curve exceeding 300 m
D. Psychological widening

List-II

1. $\frac{V}{9.5\sqrt{R}}$
2. $\frac{V}{9.5\sqrt{R}}+\frac{nl^2}{2R}$
3. No widening
4. $\frac{n(\text{wheel base})^2}{2R}$

Codes:

	A	B	C	D
(a)	1	3	4	2
(b)	2	3	1	4
(c)	4	2	3	1
(d)	1	3	2	4

Q.13 Match List-I with List-II and select the correct answer by using the codes given below the lists:

List-I

A. Length of transition curve based on rate of change of centrifugal acceleration
B. Length of transition curve for plain and rolling terrain according to IRC
C. Shift of the transition curve
D. Rate of change of centrifugal acceleration

List-II

1. $\frac{2.7V^2}{R}$
2. $\frac{L_s^2}{24R}$
3. $\frac{80}{(75+V)}$
4. $\frac{0.0215V^3}{CR}$

Codes:

	A	B	C	D
(a)	3	4	2	1
(b)	1	4	2	3
(c)	1	3	4	2
(d)	4	1	2	3

Q.14 Match List-I with List-II and select the correct answer by using the codes given below the lists:

List-I

A. General equation for stopping distance at level
B. General equation for length of parabolic curve
C. Stopping distance on descending slope
D. Stopping distance on ascending slope

List-II

1. $\left[0.278Vt+\frac{V^2}{254(f+0.01n)}\right]$
2. $\left[0.278Vt+\frac{V^2}{254(f-0.01n)}\right]$
3. $\left[0.278Vt+\frac{V^2}{254f}\right]$
4. $\frac{NS^2}{\left(\sqrt{2H}+\sqrt{2h}\right)^2}$

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	3	4	2	1
(c)	3	4	1	2
(d)	1	3	4	1

Q.15 Match List-I with List-II and select the correct answer by using the codes given below the lists:

List-I

A. Length of summit curve exceeding overtaking sight distance
B. Length of summit curve exceeding stopping sight distance
C. Length of summit curve less than stopping sight distance
D. Length of summit curve less than overtaking sight distance

List-II

1. $\frac{NS^2}{4.4}$ 2. $2S-\frac{4.4}{N}$
3. $\frac{NS^2}{9.6}$ 4. $2S-\frac{9.6}{N}$

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	3	1	2	4
(c)	3	4	2	1
(d)	1	2	4	3

Q.16 Match List-I (Type of road) with List-II (recommended camber)

List-I	List-II
A. Water bound macadam	1. 1 in 72
B. Bituminous concrete	2. 1 in 60
C. Earth road	3. 1 in 48
D. Rigid pavement	4. 1 in 25

Codes:

	A	B	C	D
(a)	3	2	4	1
(b)	2	3	1	4
(c)	4	3	2	1
(d)	1	4	3	2

Q.17 Assuming the rate of superelevation to be 1 in 400, the length of the transition curve required to attain a maximum superelevation of 15 cm will be
(a) 60 m (b) 600 m
(c) 25.67 m (d) 26.57 m

Q.18 The full width of land acquired before finalizing a highway, is known as
(a) width of formation
(b) right of way
(c) carriage way
(d) roadway

Q.19 The minimum width of the pavement of a National Highway should be
(a) 4.7 m (b) 5.7 m
(c) 6.7 m (d) 7.7 m

Q.20 On concrete roads, the camber generally provided, is
(a) 1 in 20 to 1 in 24
(b) 1 in 30 to 1 in 48
(c) 1 in 36 to 1 in 48
(d) 1 in 48 to 1 in 60

Q.21 An exceptional gradient may be provided upto 1 in 12 along hill roads, if the length does not exceed
(a) 45 m per km
(b) 60 m per km
(c) 75 m per km
(d) 90 m per km

Q.22 If W is the weight of a vehicle negotiating an upgrade 1:S along a track having coefficient of resistance μ, the tractive force T is given by
(a) $T=\frac{P}{\mu+S}$ (b) $P=\frac{T}{\mu+S}$
(c) $S=\frac{P}{\mu+T}$ (d) $\mu=\frac{P}{S+T}$

Q.23 For a vehicle moving with a speed of 80 km per hour, the brake reaction time, in ordinary cases, is
(a) 1 sec (b) 1.5 sec
(c) 2.0 sec (d) 2.5 sec

Q.24 Widening of the roads on curves in hilly region, is done
(a) on the outer side
(b) on the inner side
(c) on the outer and inner sides equally
(d) less on outer side and more on inner side

Q.25 If $x\%$ is the gradient of an alignment and $y\%$ is the gradient after proper superelevation along a curved portion of a highway, the differential grade along the curve, is
(a) $(x-y)\%$ (b) $(x+y)\%$
(c) $(y-x)\%$ (d) $(x\times y)\%$

Q.26 The standard equation of a cubical spiral transition curve provided on roads, is
(a) $y=\frac{l^3}{6RL}$ (b) $y=\frac{x^3}{6RL}$
(c) $y=\frac{x^2}{6RL}$ (d) $y=\frac{l^2}{6RL}$

Q.27 The standard equation of a cubic parabolic transition curve provided on roads, is
(a) $\frac{x^3}{6RL}$ (b) $\frac{x^2}{6RL}$
(c) $\frac{l^2}{6RL}$ (d) $\frac{l^3}{6RL}$

Q.28 The standard equation of a Lemniscate curve, is
(a) $\frac{x^3}{6RL}$ (b) $\frac{l^3}{6RL}$
(c) $\frac{x^2}{6RL}$ (d) None of these

Q.29 In a right angled bend of a road provided with a transition throughout, the maximum polar angle will be
(a) 10° (b) 15°
(c) 20° (d) 30°

Q.30 If the rate of change of grade permitted along a vertical curve is r and total change of grade is $g\%$, then the length L of the curve to be provided, is
(a) $L=\frac{r\times 100}{g}$m
(b) $L=\frac{g\times 100}{r}$m
(c) $L=(r+g)\times 100$ m
(d) $L=\frac{100}{r+g}$m

Q.31 Alignment of highways in hilly regions, is decided on
(a) long stretch of very hard cutting
(b) number of river crossings
(c) natural unstable areas
(d) All of the above

Q.32 The usual width of parapet walls along highways in hilly region, is
(a) 50 cm (b) 60 cm
(c) 70 cm (d) 80 cm

Q.33 The usual slope of side drains along highways in hilly region, is
(a) 2.2% (b) 2.5%
(c) 3.0% (d) 3.5%

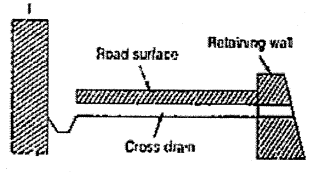
Q.34 Maximum superelevation on hill roads should not exceed
(a) 5% (b) 7%
(c) 8% (d) 10%

Q.35 Superelevation on roads in snow bound areas, should generally not exceed
(a) 15% (b) 12%
(c) 10% (d) 7%

Q.36 The type of transition curve of a National Highway or State highway in hilly region free from snow, is kept as
(a) circular (b) cubic parabola
(c) lemniscate (d) spiral

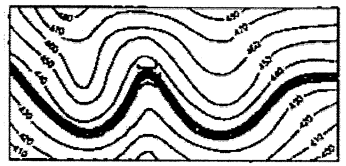
Q.37 Ruling gradient on hill roads 3000 m above M.S.L. is kept at
(a) 4% (b) 5%
(c) 6% (d) 7%

Q.38 Cross-section of a hill road is shown in figure wherein 1 represents



(a) retaining wall (b) parapet wall
(c) breast wall (d) road wall

Q.39 In the figure shown below '1' represents



(a) convex curve
(b) concave curve
(c) spur curve
(d) re-entrant curve

Q.40 The head light of vehicles should be such that its lower beam illuminates objects at
(a) 10 m (b) 20 m
(c) 30 m (d) 40 m

Q.41 From the point of tangency before an intersection, route markers are fixed at a distance of
(a) 15 m to 30 m (b) 20 m to 35 m
(c) 40 m to 50 m (d) 50 m to 75 m

Q.42 As per IRC, minimum length of transition curve is
(a) 39 m (b) 25.1 m
(c) 35.1 m (d) 30 m

Q.43 Maximum axle load of vehicles for single axle as per I.R.C. is
(a) 9.0 tonnes (b) 8.17 tonnes
(c) 12.5 tonnes (d) 14.5 tonnes

Q.44 For a National Highway, the minimum formation width is
(a) 12 m (b) 9.5 m
(c) 7.5 m (d) 6 m

Q.45 As per I.R.C. recommendations, the maximum width of a road vehicle is limited to
(a) 1.75 m (b) 2.0 m
(c) 2.44 m (d) 2.5 m

Q.46 As per I.R.C. recommendations, the maximum height of a design truck is
(a) 2.7 m - 3.2 m (b) 3.8 m - 4.2 m
(c) 4.0 m - 5.0 m (d) 5.2 m - 5.5 m

Q.47 As per I.R.C. recommendations, the camber on the Water Bound Macadam (WBM) road is
(a) 1 in 33 (b) 1 in 40
(c) 1 in 50 (d) 1 in 25

Q.48 PIEV time depends upon
1. speed of the vehicle
2. physical characteristics of driver
3. psychological factors
4. environmental conditions and purpose of trip
The correct answer is
(a) 1, 2 and 3 (b) both 2 and 4
(c) 2, 3 and 4 (d) 1, 2, 3 and 4

Q.49 As per IRC recommendations, the ruling design speed on a national highway in plain terrain should be
(a) 120 kmph (b) 100 kmph
(c) 80 kmph (d) 65 kmph

Q.50 As per IRC recommendations, the ruling minimum radius of horizontal curve is computed by increasing the design speed by
(a) 8 kmph (b) 10 kmph
(c) 16 kmph (d) 25 kmph

Q.51 For the design of superelevation for mixed traffic conditions, the speed is reduced by
(a) 15% (b) 75%
(c) 25% (d) 50%

Q.52 Which slope of camber suits most for cement concrete pavements?
(a) Parabolic (b) Circular
(c) Straight line (d) Elliptical

Q.53 In case of divided carriage-ways, the super elevation can be achieved in the following ways:
1. the two carriage-ways and the median are superelevated as a plane section
2. the median is kept level and the two carriage-ways are rotated about the edge of the median
3. the two carriage-ways are separately super elevated, resulting in the median having its edges at different levels
The correct answer is
(a) Only 2 (b) Only 3
(c) Both 1 and 2 (d) 1, 2 and 3

Q.54 Widening should
1. be equally distributed on inner and other sides except in case of sharp curves of radius less than 50 meters
2. start at the beginning of the transition curve
3. be provided by means of offset radial to the centre line
The correct answer is
(a) Both 1 and 2 (b) Both 1 and 3
(c) Both 2 and 3 (d) 1, 2 and 3

Q.55 The transition curve used in the hilly regions is
(a) lemniscate (b) spiral
(c) cubic parabola (d) both (a) and (c)

Q.56 Assumptions in the design of vertical curves are:
1. the curve is so flat that the length of the curve is equal to the length of the chord
2. the portions of the curve along the two tangents on either side of the point of intersection are equal
3. the angles subtended by the tangents with the horizontal are so small that the tangents of these angles are equal to the angles in radians themselves
The correct answer is
(a) Only 1 (b) Only 2
(c) Both 2 and 3 (d) 1, 2 and 3

Q.57 Valley curves are designed as
(a) cubic parabola (b) spiral
(c) lemniscate (d) both (b) and (c)

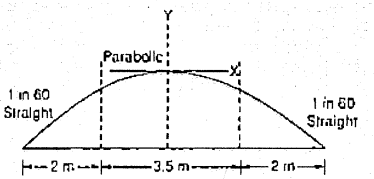
Q.58 The length of the valley curve is determined with following assumptions:
1. head light height is 0.75 m
2. upward divergence of the light beam from the longitudinal axis of the vehicles is 1^0
3. stopping sight distance is 25 m
The correct answer is
(a) Only 1
(b) Only 2
(c) Both 1 and 2
(d) Both 1 and 3

Q.59 The maximum impact factor for valley curves is equal to
(a) $\frac{NV^2}{L}$ (b) $1.58\frac{NV^2}{L}$
(c) $1.58\frac{NV}{L}$ (d) $1.58\frac{N^2V}{L}$

Q.60 The maximum design speed for hair pin bends in hill roads is taken as
(a) 30 kmph (b) 40 kmph
(c) 20 kmph (d) 15 kmph

Q.61 If b is the wheel track of a vehicle and h is the height of centre of gravity above road surface, then to avoid overturning and lateral skidding on a horizontal curve, the centrifugal ratio should always be
(a) less than $b/2h$ and greater than coefficient of lateral friction
(b) less than $b/2h$ and also less than coefficient of lateral friction
(c) greater than $b/2h$ and also less than coefficient of lateral friction
(d) greater than $b/2h$ and also greater than coefficient of lateral friction

Q.62 A road camber is given in figure.



For designing this camber, the equation to be used is
(a) $y = \frac{x^2}{60}$ (b) $y = \frac{x^2}{120}$
(c) $y = \frac{x^2}{210}$ (d) $y = \frac{x^2}{225}$

Q.63 Which one of the following is associated with "Limiting Gradient" on highways?
(a) Requirement of maximum tractive effort for a short distance
(b) Requirement of minimum tractive effort on the whole gradient
(c) Efficient drainage conditions
(d) Alignment design in general

Q.64 The advantages of super elevation are
1. it allows design speed to be maintained on a curve as on a straight portion
2. helps in keeping the vehicles to their correct side
3. lessens the danger of skidding at bends
4. keeps the pressure on the wheels as equally distributed

The correct answer is
(a) 1, 2 and 3 (b) 1, 3 and 4
(c) 2, 3 and 4 (d) 1, 2, 3 and 4

Q.65 Consider the following statements
1. Psychological extra widening depends on the speed of the vehicle
2. Psychological extra widening depends on the number of traffic lanes
3. Psychological extra widening depends on the length of the wheel base

The correct statement(s) is(are):
(a) Only 1
(b) Only 3
(c) Both 1 and 2
(d) Both 2 and 3

Q.66 Assuming the safe stopping sight distance to be 60 m on a flat highway section and with a setback distance of 10 m, what would be the radius of the negotiable horizontal curve?
(a) 70 m (b) 80 m
(c) 800 m (d) 100 m

Q.67 For a road with a camber of 3% at a design speed of 80 kmph, find out the minimum radius beyond which no superelevation is provided
(a) 280 m (b) 948 m
(c) 240 m (d) 740 m

Q.68 As per IRC, the minimum length of transition curve for a mountainous terrain road with radius of curvature 100 m and design speed of vehicle 100 kmph is
(a) 270 m (b) 200 m
(c) 100 m (d) 170 m

Q.69 The compensated gradient provided at the curve of radius 60 m with a ruling gradient of 6 percent is
(a) 5.25% (b) 4.75%
(c) 4.5% (d) 3.75%

Q.70 For a design speed of 80 kmph, if the deviation angle of a valley curve is $\frac{1}{20}$, then the length of a curve for comfort consideration is nearly
(a) 30 m (b) 61 m
(c) 101 m (d) 122 m

Q.71 When the path travelled along the road surface is more than the circumferential movement of the wheels due to rotation, then it results in
(a) slipping (b) skidding
(c) turning (d) revolving

Q.72 Compared to a level surface, on a descending gradient the stopping sight distance is
(a) less
(b) more
(c) same
(d) dependent on the speed

Q.73 If the stopping distance is 60 metres, then the minimum stopping sight distance for two lane, two way traffic is
(a) 30 m (b) 60 m
(c) 120 m (d) 180 m

Q.74 The attainment of superelevation by rotation of pavement about the inner edge of the pavement
(a) is preferable in steep terrain
(b) results in balancing the earthwork
(c) avoids the drainage problem in flat terrain
(d) does not change the vertical alignment of road

Q.75 The off-tracking of a vehicle having a wheel base of 6.0 m and negotiating a curved path of mean radius 25 m is
(a) 0.82 m (b) 0.72 m
(c) 0.65 m (d) 1.44 m

Q.76 In the limiting case of overturning while traversing a simple circular curve by a vehicle, pressure below
(a) outer wheels will be zero
(b) outer wheels will be maximum
(c) outer and inner wheels will be same
(d) inner wheels will be maximum

Q.77 Which one of the following pairs is correctly matched? (Notations have their usual meanings)
(a) To avoid both skidding and overturning ... $\frac{P}{W} \le \frac{b}{2h} \le f$
(b) Allowable maximum super-elevation in plain region ... 0.15
(c) Allowable coefficient of lateral friction ... 0.07
(d) Attainment of superelevation ... $\frac{v^2}{2R}$

Q.78 The design speed of a highway is 80 km per hour. Assuming other data as per IRC recommendations, which one of the following is the approximate adopted lag distance?
(a) 55.6 m
(b) 66.7 m
(c) 61.2 m
(d) 44.5 m

Q.79 Roads provided to give access to properties along an important highway with controlled access as express way or freeway are
(a) drive ways (b) access roads
(c) parking lanes (d) frontage roads

Q.80 Which one of the following is associated with "limiting gradient" on highways?
(a) Requirement of maximum tractive effort for a short distance
(b) Requirement of minimum tractive effort on the whole gradient
(c) Efficient drainage conditions
(d) Alignment design in general

Q.81 What will be the ruling gradient for cement concrete road in heavy rainfall area if camber is 2%?
(a) 4% (b) 3.3%
(c) 2% (d) 0%

Q.82 If ruling gradient is 1 in 20 and there is also a horizontal curve of radius 75 m, then the compensated grade should be
(a) 3% (b) 4%
(c) 5% (d) 6%

Q.83 The maximum rate of change of radial acceleration in a transition curve which may pass unnoticed may be taken as
(a) 30 cm/sec^3 (b) 30 m/sec^3
(c) 3 cm/sec^3 (d) None of the above

Q.84 The ideal alignment of highway between two towns should be
(a) short
(b) easy
(c) safe and easy
(d) short, easy, safe and economical

Q.85 The perpendicular offsets from a tangent to the junction of a transition curve and circular curve is equal to
(a) shift 'S' (b) 2 × shift 'S'
(c) 3 × shift 'S' (d) 4 × shift 'S'

Q.86 A vertical curve is designated on the basis of the
(a) radius of the curve
(b) minimum sight distance
(c) change of gradient
(d) All of the above

Q.87 The design speed of traffic lane is 80 kmph. Average length of the vehicle is 6 m. The capacity of the road when reaction time of driver is 2 sec. is (Assuming longitudinal friction is 0.35)
(a) 523 veh/hr (b) 656 veh/hr
(c) 832 veh/hr (d) 932 veh/hr

Q.88 When a driver drives down the grade at speed of 30 kmph with coefficient of friction 0.40, the driver requires braking distance twice that required for stopping the vehicle when he travels up the same grade. The grade is
(a) 10.6% (b) 7%
(c) 33.3% (d) 13.3%

Q.89 The intermediate stopping distance for a design speed of 65 kmph assuming $f = 0.36$ and $t = 2.5$ seconds is
(a) 91 m (b) 273 m
(c) 182 m (d) 212 m

Q.90 The ruling design speed on a curve is 100 kmph, absolute minimum design speed is 80 kmph. The superelevation on curve and coefficient of lateral friction are 7% and 0.15 respectively. The ruling design radius and absolute minimum radius on curve respectively in m are:
(a) 230 m and 360 m (b) 360 m and 480 m
(c) 420 m and 980 m (d) 360 m and 230 m

Q.91 The gradient on the highway in 1 in 15 and radius of curve is 150 m. After grade compensation, the grade to be provided should be not less than 4%. The grade compensation is;
(a) 1.2% (b) 0.5%
(c) 2.1% (d) 1.5%

Q.92 The SSD (stopping sight distance) for a descending gradient of 2% for a design speed of 80 kmph is;
(Use data from IRS standard specification, coefficient of friction = 0.35)
(a) 92 m (b) 112 m
(c) 132 m (d) 122 m

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Answers Highway Geometric Design

1. (c)	2. (a)	3. (c)	4. (d)	5. (d)	6. (b)	7. (d)	8. (d)	9. (a)	10. (c)
11. (b)	12. (c)	13. (d)	14. (b)	15. (b)	16. (a)	17. (a)	18. (b)	19. (b)	20. (d)
21. (b)	22. (b)	23. (d)	24. (b)	25. (c)	26. (a)	27. (a)	28. (d)	29. (b)	30. (b)
31. (d)	32. (b)	33. (b)	34. (d)	35. (d)	36. (d)	37. (b)	38. (c)	39. (c)	40. (c)
41. (d)	42. (c)	43. (b)	44. (a)	45. (c)	46. (a)	47. (a)	48. (d)	49. (b)	50. (c)
51. (c)	52. (c)	53. (d)	54. (d)	55. (b)	56. (d)	57. (a)	58. (c)	59. (b)	60. (c)
61. (b)	62. (d)	63. (a)	64. (d)	65. (a)	66. (b)	67. (b)	68. (c)	69. (b)	70. (b)
71. (b)	72. (b)	73. (b)	74. (c)	75. (b)	76. (b)	77. (a)	78. (a)	79. (d)	80. (a)
81. (b)	82. (b)	83. (a)	84. (d)	85. (a)	86. (d)	87. (b)	88. (d)	89. (c)	90. (d)
91. (b)	92. (c)								

Explanations Highway Geometric Design

4. (d)

$$e = \frac{V^2}{225 \times R} = \frac{100 \times 100}{225 \times 500}$$

$$= 0.089 > 0.07$$

$$\therefore \quad e_{max} = 7\%$$

17. (a)
Length of transition curve to attain superelevation of 15 cm,

$$L = 400 \times 0.15 = 60 \text{ m}$$

Hence option (a) is correct.

18. (b)
Right of way is the area of land acquired for the road, along its alignment. The width of this acquired land is known as land width and it depends on the importance of the read and possible future development.

37. (b)
The ruling gradient in mountainous terrain over 3000 m height above MSL is 5%. The ruling gradient upto 3000 m height above MSL is 6%. At high attitudes (> 3000 m) as the pulling power of engines decrease due to reduction in oxygen supply. The design value of steepest gradient should be lower.

42. (c)

$$L_s = \frac{2.7V^2}{R} = \frac{2.7 \times 65^2}{325} = 35.1 \text{ m}$$

48. (d)
The PIEV time of a driver depends on several factors such as physical and psychological characteristics of the driver, type of the problem involved environmental condition and temporary factors (e.g., motive of trip, travel speed etc.).

57. (a)
At the valley curve, the centrifugal force acts downwards adding to the pressure on the springs and the suspensions of the vehicle in addition to that due to weight of the vehicle. The best shape of valley curve is a transition curve for gradually introducing and increasing the centrifugal force acting downwards.

58. (c)
The length of valley transition curve is designed based on the two criteria.
(i) The allowable rate of change of centrifugal acceleration of 0.06 m/sec^3.

(ii) The head light sight distance, and the higher of two values is adopted. Usually the second criterion of head light sight distance is higher and therefore governs the design also, the average height of the head light is taken as $h_1 = 0.75$ m and the beam angle $\alpha = 1°$.

61. (b)

For no skidding $f > \frac{P}{W}$

For no overturning $\frac{b}{2h} > \frac{P}{W}$

Where f = coefficient of lateral friction

$\frac{P}{W}$ = centrifugal ratio

To avoid overturning and skidding on horizontal curve

$\frac{P}{W} < \frac{b}{2h}$ and $\frac{P}{W} < f$

62 (d)

$$y = \frac{2x^2}{nW}$$

$W = 7.5$ m

$n = 60$

$$\therefore \quad y = \frac{2x^2}{60 \times 7.5} = \frac{x^2}{225}$$

65 (a)

Extra widening = Mechanical widening + Psychological widening

$$= W_m + W_{ps}$$

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

where V = speed of vehicle
l = length of wheel base
R = radius
n = no. of lanes

66. (b)

SSD = 80 m

Setback distance = 10 m

Radius of horizontal curve

$$= \frac{(SSD)^2}{8(\text{Setback distance})}$$

$$= \frac{80 \times 80}{8 \times 10} = 80\text{m}$$

67. (b)

$$e = \frac{V^2}{225 \times R}$$

$$\therefore \quad R = \frac{V^2}{225 \times e} = \frac{60^2}{225 \times 0.03}$$

$$= 948\text{ m}$$

68. (c)

Minimum length of Transition curve

$$= \frac{V^2}{R} = \frac{100 \times 100}{100} = 100\text{ m}$$

69. (b)

Grade compensation = $\frac{30+R}{R}$

$$= \frac{30+60}{60} = \frac{90}{60} = 1.5\%$$

Maximum allowable grade compensation

$$= \frac{75}{R} = \frac{75}{60} = 1.25\%$$

∴ Compensated gradient

$$= 6.0 - 1.25 = 4.75\%$$

70. (b)

$$L = 0.38(NV^3)^{1/2}$$

$$= 0.38\left(\frac{1}{20} \times 80^3\right)^{1/2}$$

$$= 60.8\text{ m} \simeq 61\text{ m}$$

71. (b)

Skid occurs when vehicles slide without revolving or when the wheels partially revolve i.e., when the path travelled along the road surface is more than the circumferential movements of the wheels due to their rotation. Slip occurs when a wheel revolves more than the corresponding longitudinal movement along the roads.

72. (b)

When there is a descending gradient the component of gravity is subtracted from the braking distance and hence the stopping sight distance is more.

73. (b)

The minimum stopping sight distance should be equal to the stopping distance in one-way traffic lanes and also in two-way traffic roads when there are two or more traffic lanes.

74. (c)

The method of rotating about inner edge is preferable in flat terrain in high rain fall area, when the road is not taken on embankment, in order to avoid the drainage problem.

75. (b)

$$\text{Off-tracking} = \frac{l^2}{2R} = \frac{6^2}{2 \times 25} = 0.72\text{ m}$$

76. (b)

If the pavement is kept horizontal across the alignment, the pressure on the outer wheels will be higher due to the centrifugal force acting outwards and hence the reaction at the outer wheel would be higher. When the limiting equilibrium condition for overturning occurs the pressure at the inner wheels becomes equal to zero and pressure at outer wheels will be maximum.

77. (a)

Centrifugal ratio $\frac{P}{W} = \frac{V^2}{gR}$

Case-1:

For overturning $\frac{P}{W} > \frac{b}{2h}$

To avoid skidding $f \geq \frac{P}{W}$

Thus for overturning without skidding

$f > \frac{P}{W} > \frac{b}{2h}$

Case-2:

For skidding $f > \frac{P}{W}$

To avoid overturning $\frac{P}{W} \leq \left(\frac{b}{2h}\right)$

For skidding without overturning $f < \left(\frac{b}{2h}\right)$

Allowable maximum superelevation in plane region = 0.07 or 7%

Allowable coefficient of lateral friction = 0.15

Mechanical widening of pavement = $\frac{nl^2}{2R}$

78. (a)

Lag distance = 0.278 Vt

Reaction time t = 2.5 sec

∴ Lag distance = 0.278 × 80 × 2.5 = 55.6 m

81. (b)

$$RG = 2 \times \text{camber}$$

$$= 2 \times 2 = 4\%$$

But max RG in plain and rolling terrain is = 3.3%

$$\therefore \quad RG = 3.3\%$$

82. (b)

Grade compensation

$$= \frac{30+R}{R}\% = \frac{30+75}{75}\% = 1.4\%$$

But can not greater than $\frac{75}{R} = 1\%$

Hence grade compensation = 1%

∴ Compensated grade = 5% – 1% = 4%

Hence option (b) is correct.

84. (d)

Ideal alignment of highway should be short, easy, safe and economical.

87. (b)

$$SSD = Vt + \frac{V^2}{2gf}$$

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

$$= 116 \text{ m}$$

$$S = SSD + L = 116 + 6 = 122 \text{ m}$$

$$C = \frac{1000V}{S} = \frac{1000 \times 80}{122}$$

$$= 656 \text{ veh/hr}$$

88. (d)

Braking distance for travelling upgrade

$$S_1 = \frac{V^2}{254(f + 0.01n)}$$

Braking distance for travelling downgrade

$$S_2 = \frac{V^2}{254(f - 0.01n)}$$

Given, $S_2 = 2S_1$

$$\Rightarrow \quad \frac{1}{(f - 0.01n)} = \frac{2}{(f + 0.01n)}$$

$$\Rightarrow \quad n = \frac{f}{0.03} = \frac{0.4}{0.03} = 13.3\%$$

89. (c)

Design speed = 65 kmph

$$SSD = vt + \frac{v^2}{2gf}$$

$$= 18 \times 2.5 + \frac{(18)^2}{2 \times 9.81 \times 0.36}$$

$$= 91 \text{ m}$$

Intermediate sight distance

$$= 2 \times SSD = 2 \times 91 \text{ m} = 182 \text{ m}$$

90. (d)

Ruling design radius,

$$V_r = \frac{5}{18} \times 100 \Rightarrow 27.77 \text{ m/s}$$

$$R = \frac{V_r^2}{g(e + f)}$$

$$= \frac{(27.77)^2}{9.81(0.07 + 0.15)}$$

$$= 357.32 \approx 360 \text{ m}$$

Absolute minimum radius

Maximum design speed,

$$V_m = \frac{5}{18} \times 80 = 22.22 \text{ m/s}$$

$$R_m = \frac{V_m^2}{g(e + f)}$$

$$= \frac{(22.22)^2}{9.81(0.07 + 0.15)}$$

$$= 228.81 = 230 \text{ m}$$

91. (b)

$$\text{Gradient} = \frac{1}{15} = \frac{1}{15} \times 100 = 6.67\%$$

Grade compensation

$$= \frac{30 + R}{R} = \frac{30 + 150}{150} = 1.2\%$$

or, maximum

$$= \frac{75}{R} = \frac{75}{150} = 0.5\%$$

Use minimum i.e. 0.5%

After grade compensation, gradient provided

$$= 6.67\% - 0.5 = 6.17\%$$

92. (c)

Design speed = 80 kmph = 22.22 m/s

$$SSD = vt + \frac{v^2}{2g(f - N)}$$

$$= 22.22 \times 2.5 + \frac{(22.22)^2}{2 \times 9.81(0.35 - 0.02)}$$

$$SSD = 132 \text{ m}$$

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