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DIRECTOR'S *Message*

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This book has been organized and executed with a lot of care, dedication and passion for lucidity. A conscious attempt has been made to simplify the concepts to facilitate better understanding of the subject.

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We would feel satisfied if the book meets the needs of the students for whom it is meant.

Lastly, we are thankful to all the engineers, authors whose work has been the source of enlightenment, inspiration and guidance in presenting this book.

It is hoped that the book in its new form will enjoy its ever increasing popularity.

Regards

Dr. Pankaj Goyal

Preface

This book has been written to meet the growing requirements of candidates appearing for BSNL, DRDO, ISRO, BARC, ECIL, TTA, RRB-JE, State and Public Sector Engineering Examinations. Though every candidate has ability to succeed but competitive environment, in-depth knowledge, quality guidance, time management and good source of study is required to achieve goals.

This book includes Multiple Choice Questions (MCQ) which works as a mock exam practice for the reader. Questions of all the subject have been organized in systematic, concepts oriented and error less manner so that it become easy and interesting for even a beginner to understand. It is a very convenient book and must be solved by candidate aiming for competitive exams.

After solving this booklet students can feel encouraged and develop confidence to attempt each and every type of numerical as well as theoretical problems. Each problems explains solving approach so that at the end, so the reader is well equipped to be able to apply any type of problem solving requirement and distinctly choose one strategy or type from the other.

We hope this book will be proved an important tool to succeed in BSNL, DRDO, ISRO, BARC, ECIL, TTA, RRB-JE, State and Public Sector Engineering Examinations.

It is earnestly hoped that with the extensive additions and revisions, the present edition will facilitate the students not only in preparing themselves for competitive examinations but also in preparing for their regular examinations and prove more useful to the students than the earlier editions.

Even though, enough readings were given for correcting the error and printing mistakes, due to human tendency there could be some minor types in the book. If any such types found, they will be highly appreciated and in corporated in the next edition. Also, please provide your valuable suggestions at : engineers.academy.india@gmail.com

Wish you all the best. Have a nice reading.

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UNIT-I

TRANSPORTATION ENGINEERING

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CHAPTER 1

HIGHWAY DEVELOPEMENT AND PLANNING

OBJECTIVE QUESTIONS

1. Reconnaissance is best done with the help of
(a) Aerial photographic survey
(b) Cadastral survey
(c) Topographical survey
(d) None of these

2. Which one of the following is the chronological sequence in regard to road construction/design development?
(a) Telford, Tresaguet, CBR, Macadam
(b) Tresaguet, Telford, Macadam, CBR
(c) Macadam, CBR, Tresaguet, Telford
(d) Tresaguet, Macadam, Telford, CBR

3. The Indian Road Congress came into existence in
(a) 1927 (b) 1934
(c) 1943 (d) 1947

4. The roads connecting one village with another town is designated as
(a) National Highway
(b) State Highway
(c) District Roads
(d) Village Roads

5. The Nagpur road plan formula is prepared assuming which road pattern?
(a) Circular pattern
(b) Block pattern
(c) Star and block pattern
(d) Star and grid pattern

[PEB-SUB ER. - 2017]

6. Which of the following is unmetalled road?
(a) Earthern road
(b) Cement concrete road
(c) Bituminous road
(d) WBM road

[PEB-SUB ER. - 2017]

7. The headquarter of Indian Road Congress (IRC) is located at
(a) Kolkata (b) Bangalore
(c) Mumbai (d) New Delhi

[KPSC - JE]

8. The overall road density in the country should be increased to 82 km per 100 sq. km. area by the year 2001 according to
(a) First twenty year road plan
(b) Second twenty year road plan
(c) Third twenty year road plan
(d) Fourth twenty year road plan

9. Arterial road come under category of which road
(a) Secondary rural (b) Rural
(c) Urban (d) Primary rural

10. The primary road system classification comprises of
(a) Expressways and National Highways
(b) State Highways and Major District Roads
(c) Other District Roads and Village Roads
(d) Major District Roads and Other District Roads

11. The first 20-year road development plan for India was called as

(a) Bombay Road Plan

(b) Nagpur Road Plan

(c) Lucknow Road Plan

(d) Delhi Road Plan

12. Alternate routes for a highway project are suggested by the study of

(a) Political map

(b) Traffic map

(c) Topographic map

(d) Road map

[TSPSC-AE - 2015]

13. A committee was appointed by the Government with M.R. Jayaker as chairman in

(a) 1920 (b) 1925

(c) 1926 (d) 1927

[TSPSC-AE - 2015]

14. Give the full form of IRC

(a) Indian Road Concrete

(b) Indian Road Congress

(c) Indian Rail Congress

(d) India Road Congress

[Haryana JE - 2018]

15. Give the full form of CRRI.

(a) Central Road Research Institute

(b) Central Research Road Institute

(c) Central Railway Research Institute

(d) Central Research Railway Institute

[Haryana JE - 2018]

16. What are particularly provided in the case of urban roads?

(a) Footpaths

(b) Express way

(c) Carriage way

(d) Highway

[Haryana JE - 2018]

17. The target of achieving an overall density of road length in third twenty year Road Development Plan (1981-2001) was

(a) 32 km/100 km^2

(b) 45.7 km/100 km^2

(c) 82 km/100 km^2

(d) 100 km^2/100 km^2

[U.K. Combined AE Paper II - 2012]

18. Based on location and function, Nagpur Road plan has classified the roads in India in

(a) 2 categories (b) 4 categories

(c) 5 categories (d) 6 categories

[U.K. Combined AE paper II - 2012]

19. Which of the following statements is/are correct with respect to Lucknow Road Plan?

1. Expressways of total length 2000 km should be developed for fast travel
2. Total length of National Highways in the country should be 66000 km
3. Total length of State Highways in the country should be 145000 km

(a) Only 1 (b) 1 & 3

(c) 2 & 3 (d) 1, 2 & 3

[UPSSSC JE - 2016]

20. Which road pattern was assumed to prepare the formula of Nagpur Road Plan?

(a) Rectangular or block patern

(b) Star and grid pattern

(c) Star and block pattern

(d) Star and circular pattern

[UPSSSC JE - 2016]

21. What is the road within a city or town is called as?

(a) Urban road (b) Town road

(c) Country road (d) Rural road

[M. P. Sub Eng. - 2016]

22. Which among the following organizations was set up in 1930?

(a) Central road organization

(b) State road organization

(c) Town road organization

(d) Urban road organization

[M. P. Sub Eng. - 2016]

23. According to Indian Roads Congress, the _____ of a road vehicle is 2.44 m.

(a) Maximum width

(b) Maximum length and minimum width

(c) Minimum width and maximum length

(d) Minimum length and maximum width

[M.P. Sub Eng. - 2016]

24. The _____ board was established in 1960.

(a) Border Road Development

(b) Central Road Development

(c) State Road Development

(d) Defence Road Development

[M.P. Sub Eng. - 2016]

25. Factors controlling alignment:

(a) Short

(b) Easy

(c) Geometric design

(d) None of the other options

[Chhattisgarh Professional Exam. Board - 2016]

26. For the preparation of highways

(a) Longitudinal sections are required

(b) Cross-sections are required

(c) (a) and (b) are required

(d) None of the above

[SSC JE - 2007]

27. Alignment of road is finally decoded on the basis of

(a) Selection of route

(b) Field survey

(c) Trace cut

(d) None of these

[DSSSB JE - 2015]

28. In conducting the detailed survey for a strip covering on either side of the chosen center line, what should be the width in case of straight stretches and in case of sharp curves?

(a) 15m ; 30 m (b) 15 ; 40 m

(c) 10 m ; 40 m (d) 15 m ; 60 m

[M.P. Sub Eng. - 2016]

29. The sequence of survey in a road project is

(a) Topographic, reconnaissance,preliminary and detailed

(b) Reconnaissance, topographic, preliminary and detailed

(c) Preliminary, reconnaissance, topographic and detailed

(d) Topographic, preliminary, reconnaissance and detailed

[UPRVUNL AE - 2015]

30. The sequence of four stages of survey in a highway alignment is

(a) Reconnaissance, map study, preliminary survey and detailed survey

(b) Map study, preliminary survey, reconnaissance and detailed survey

(c) Map study, reconnaissance, preliminary survey and detailed survey

(d) Preliminary survey, map study, reconnaissance and detailed survey

[HPSSSB JE - 2016]

❑❑❑

ANSWERS SHEET

1. *Ans. (a)*
2. *Ans. (b)*
3. *Ans. (b)*
4. *Ans. (d)*
5. *Ans. (d)*
6. *Ans. (a)*
7. *Ans. (d)*
8. *Ans. (c)*
9. *Ans. (c)*
10. *Ans. (a)*
11. *Ans. (b)*
12. *Ans. (c)*
13. *Ans. (d)*
14. *Ans. (b)*
15. *Ans. (a)*
16. *Ans. (a)*
17. *Ans. (c)*
18. *Ans. (c)*
19. *Ans. (d)*
20. *Ans. (b)*
21. *Ans. (a)*
22. *Ans. (a)*
23. *Ans. (a)*
24. *Ans. (a)*
25. *Ans. (c)*
26. *Ans. (c)*
27. *Ans. (b)*
28. *Ans. (a)*
29. *Ans. (a)*
30. *Ans. (c)*

❑❑❑

CHAPTER 2

GEOMETRIC DESIGN

OBJECTIVE QUESTIONS

1. Geometric design of highway include

(a) Cross-section elements

(b) Horizontal and vertical curves

(c) Sight distances

(d) All of these

2. The meaning of roadway width 'b' shoulder width 'S' and carriage way width 'w' should be taken as

(a) $b = w + S$ (b) $b = w - S$

(c) $b = w + 2S$ (d) $b = w - 2S$

3. For good roads with high design speed cumulative undulations should be

(a) $\leq$ 150 cm/km (b) $\geq$ 150 cm/km

(c) $\leq$ 100 cm/km (d) $\geq$ 100 cm/km

4. When longitudinal movement is less than rotational movement of a tyre, the condition is

(a) Skid (b) Slip

(c) Out skid (d) All of these

5. The steepest gradient in ordinary condition should not exceed

(a) Ruling gradient

(b) Maximum gradient

(c) Exceptional gradient

(d) Floating gradient

6. Height of low or mountable kerb is

(a) 10 cm (b) 20 cm

(c) 15 cm (d) 36 cm

7. The horizontal gap in vehicles on double lane road is

(a) 0.65 m (b) 1 m

(c) 0.56 m (d) 2 m

8. The maximum design gradient for vertical profile of a road is

(a) ruling gradient

(b) limiting gradient

(c) exceptional gradient

(d) minimum gradient

9. Design of horizontal curves on highways, is based on

(a) Design speed of vehicles

(b) Permissible friction on the road surface

(c) Permissible centrifugal ratio

(d) All of the above

10. Setting out of lemniscate transition curves, is done with

(a) Perpendicular offsets

(b) Radial offsets

(c) Deflection angles

(d) Polar deflection angles

11. Brake reaction time depends on

(a) Skill of driver

(b) Environmental conditions

(c) Both of these

(d) None of these

12. In PIEV theory, V stands for

(a) Vehicle (b) Violation

(c) Velocity (d) Volition

13. For water bound macadam roads in localities of heavy rainfall, the recommended value of camber is

(a) 1 in 30 (b) 1 in 33

(c) 1 in 48 (d) 1 in 60

14. Compared to a level surface, on a descending gradient the stopping sight distance is

(a) less (b) more

(c) same (d) Any of the above

15. The stopping sight distance depends upon

(a) total reaction time of driver

(b) speed of vehicle

(c) efficiency of brakes

(d) all of the above

16. For ISD, minimum height of object should be

(a) 0.15 m (b) 1.5 m

(c) 0.12 m (d) 1.2 m

17. Reaction time of a driver

(a) increases with increase in speed

(b) decreases with increase in speed

(c) is same for all speeds

(d) none of the above

18. The absolute minimum radius of curve for safe operation for a speed of 110 kmph is

(a) 110 m (b) 220 m

(c) 430 m (d) 577 m

19. Which of the following shape is preferred in a valley curve?

(a) Simple parabola (b) Cubic parabola

(c) Spiral (d) Lemniscate

20. Select the correct statement.

(a) Psychological extra widening depends on the number of traffic lanes.

(b) Mechanical extra widening depends on the speed of vehicle.

(c) Psychological extra widening depends on the length of wheel base.

(d) Psychological extra widening depends on the speed of vehicle.

21. Design speed of arterial road should be

(a) 80 kmph (b) 60 kmph

(c) 50 kmph (d) 0 kmph

22. The camber for hill roads in case of thin bituminous surfacing is adopted as

(a) 2% (b) 2.5%

(c) 3% (d) 4%

23. The minimum design speed for hairpin bends in hill roads is taken as

(a) 20 Kmph (b) 30 Kmph

(c) 40 Kmph (d) 50 Kmph

24. While designing the superelevation of a highway, its maximum value is fixed considering the need to

(a) Avoid toppling of slow moving vehicles in mixed traffic flow

(b) Avoid transverse skidding

(c) Provide drainage

(d) Counteract centrifugal force due to 75% of design speed.

25. A vehicle was stopped in two seconds by fully jamming the brakes. The skid marks measured 9.8 metres. The average skid resistance coefficient will be

(a) 0.7 (b) 0.5

(c) 0.4 (d) 0.25

26. As per IRC, the camber on cement concrete roads should be

(a) 1 in 50 to 60 (b) 1 in 45 to 60

(c) 1 in 20 to 24 (d) 1 in 12 to 16

[Punjab JE. - 2014]

27. The ideal form of curve for the summit curve is

(a) Spiral (b) Parabola

(c) Circular (d) None of the above

[Punjab JE. - 2014]

28. If a National Highway in plain terrain has a ruling design speed of 100 km per hour with super elevation (e) = 0.075 and friction coefficient = 0.145 then the ruling minimum radius of such horizontal curve is close to :

(a) 430 m (b) 360 m

(c) 250 m (d) 170 m

[RPSC VPITI - 2016]

29. For a vehicle with a speed of v m/s on a road surface with the coefficient of friction f and acceleration due to gravity g, braking distance is given by :

(a) v^2/gf (b) $v^2/2gf$

(c) $2v^2/gf$ (d) $v^2/4gf$

[RPSC - VPITI - 2016]

30. As per IRC recommendations the rulling gradient for plain terrain is : –

(a) 1 in 15 (b) 1 in 20

(c) 1 in 40 (d) 1 in 30

[RPSC VPITI - 2016]

31. The shoulder provided along the road edge should be

(a) Rougher than the traffic lanes

(b) Smoother than the traffic lanes

(c) Of same colour as that of the pavement

(d) Of very low load bearing capacity

[RPSC, RPSC ACF - 2011]

32. Width of carriage way for a single lane is recommended to be

(a) 7.5 m (b) 7.0 m

(c) 3.75 m (d) 5.5 m

[RPSC, Coal India - 2017]

33. Design speed of NH & SH on rolling terrain

(a) 100 kmph (b) 80 kmph

(c) 60 kmph (d) 65 kmph

34. The alignment of highways are generally taken along–

(a) Along the contour line

(b) Across the contour line

(c) Along the valley line

(d) Along the ridge line

[RPSC]

35. What is the crown height with respect to the edges to be provided in case of state highway of concrete pavement of width 7.0 m and very high rainfall?

(a) 0.07 (b) 0.035

(c) 0.11 (d) 0.06

[PEB SUB ER. - 2017]

36. A two-lane road with the design speed of 80 kmph has a horizontal curve of radius 500 m. What is the rate of super elevation for mixed traffic?

(a) 0.07 (b) 0.02

(c) 0.057 (d) 0.12

[PEB SUB ER. - 2017]

37. The length of the road ahead of the vehicle which is visible to the driver is called as ___ .

(a) Sight distance (b) Safe distance

(c) Clear distance (d) Invisible distance

[PEB SUB ER. - 2017]

38. The distance between the midpoint of the long chord to the midpoint of curve is known as ___.

(a) Cub chord (b) Normal chord

(c) Mid ordinate (d) Long chord

[PEB SUB ER. - 2017]

39. The value of maximum gradient for hill roads is

(a) 1 in 5 (b) 1 in 10

(c) 1 in 15 (d) 1 in 20

40. In case of multi lane road, overtaking is generally permitted from

(a) Left side only (b) Right side only

(c) Both sides (d) None of the above

[PEB SUB ER. - 2017]

41. The widening of a road at curve is not required when its radius will be

(a) Less than 300 m

(b) Less than 460 m

(c) More than 300 m

(d) More than 260 m

42. When the coefficient of friction is neglected, the maximum rate of super elevation is given by

(a) $\frac{V^2}{127R}$ (b) $\frac{V^2}{227R}$

(c) $\frac{V^2}{225R}$ (d) $\frac{V^2}{125R}$

43. For a comfortable travel on highways, the centrifugal ratio should not exceed ___.

(a) 0.1 (b) 0.2

(c) 0.25 (d) 0.15

[PEB SUB ER. - 2017]

44. If the radial acceleration of transition curve is 30 cm/sec^2, radius is 200 m and the velocity is 14 m/sec. The length of the transition curve is ___.

(a) 46.0 m (b) 46.5 m

(c) 45.0 m (d) 44.5 m

[PEB-SUB ER. - 2017]

45. The minimum length of overtaking zone should be :

(a) One and half times safe overtaking distance

(b) Three times the safe overtaking distance

(c) Twice the safe overtaking distance

(d) Four times the safe overtaking distance

[PEB-SUB ER. - 2017]

46. What is the ruling minimum radius of horizontal curve of a National Highway in plain terrain with ruling design speed of 100 kmph?

(a) 160 (b) 200

(c) 360 (d) 400

[PEB-SUB ER. - 2017]

47. What is the width of carriageway to be adopted for two-lane road with raised kerbs?

(a) 8.0 m (b) 7.5 m

(c) 7.0 m (d) 5.5 m

[PEB-SUB ER. - 2017]

48. Length of transition curve as per IRC for hilly terrain is given by

(a) 2.7 v^2/R (b) 1.7 v^2/R

(c) v^2/R (d) v/R

49. Kerbs are necessary in road pavements because

(a) They provide strength to the sides of road pavements and avoid lateral displacement of carriageway due to traffic loads

(b) In terms of road safety, they serve as a separation line between footway and carriageway and aid car drivers in driving safely

(c) They act as a vertical barrier to guide the surface runoff collected in road pavements to the gullies

(d) All of the above

[GESCOM - AE]

50. 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 25 meets a falling gradient of 1 in 50 to form a valley curve
3. The length of valley curve is determined on the basis of head light sight distance.

Which one of the statements given above is/are correct?

(a) 1 and 2 (b) 1 and 3

(c) 2 and 3 (d) 1, 2 and 3

[KPSC - AE]

ANSWERS SHEET

1. ***Ans. (d)***

2. ***Ans. (c)***

3. ***Ans. (a)***

4. ***Ans. (b)***

5. ***Ans. (a)***

6. ***Ans. (a)***

7. ***Ans. (b)***

8. ***Ans. (a)***

9. ***Ans. (d)***

10. ***Ans. (d)***

11. ***Ans. (c)***

12. ***Ans. (d)***

13. ***Ans. (b)***

14. ***Ans. (b)***

15. ***Ans. (d)***

16. ***Ans. (d)***

17. ***Ans. (b)***

18. ***Ans. (c)***

$$R_{min} = \frac{V^2}{127(e_{max} + f_{max})}$$

$$= \frac{110^2}{127 \times (0.07 + 0.15)}$$

$$= 433.33\text{m}$$

19. ***Ans. (b)***

20. ***Ans. (d)***

21. ***Ans. (a)***

22. ***Ans. (b)***

23. ***Ans. (a)***

24. ***Ans. (a)***

25. ***Ans. (b)***

$$s = \frac{1}{2}at^2$$

Since, $a = g \times f$

$$9.8 = \frac{1}{2} \times 9.81 \times f \times 2^2$$

$$f = 0.5$$

26. ***Ans. (a)***

27. ***Ans. (c)***

28. ***Ans. (b)***

$$e = 0.075$$

$$f = 0.145$$

$$\text{Ruling minimum radius} = \frac{v^2}{127(e_{max} + f_{max})}$$

$$= \frac{(100)^2}{127(0.075 + 0.145)}$$

$$= 357.90 \text{ m}$$

29. ***Ans. (b)***

30. ***Ans. (d)***

31. ***Ans. (a)***

32. ***Ans. (c)***

33. ***Ans. (b)***

34. ***Ans. (a)***

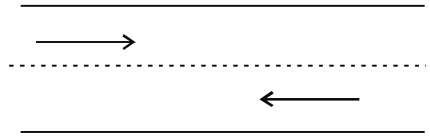
35. ***Ans. (a)***

$$y = \frac{w}{2n}$$

$$= \frac{7}{2 \times 50} = 0.07$$

Camber for heavy rainfall = 2%

36. ***Ans. (c)***



Speed = 80 km/h

R = 500 m

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

$$= 0.057$$

37. ***Ans. (a)***

38. ***Ans. (c)***

39. ***Ans. (c)***

40. ***Ans. (c)***

41. ***Ans. (c)***

42. ***Ans. (c)***

43. ***Ans. (c)***

For highway $= \frac{1}{4}$

For railway $= \frac{1}{8}$

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

44. ***Ans. (a)***

Acceleration = 30 cm/sec^2

R = 200 m

V = 14 m/sec

$$L_s = \frac{V^3}{CR}$$

$$= \frac{14^3}{0.30 \times 200} = 45.73 \text{ m}$$

45. ***Ans. (b)***

46. ***Ans. (c)***

$e = 0.07 \Rightarrow$ Plain terrain

$$\text{Ruling mini radius} = \frac{V^2}{127(e_{max} + f_{max})}$$

$$= \frac{(100)^2}{127(0.07 + 0.15)}$$

$$= 357.90 \text{ m}$$

47. ***Ans. (b)***

48. ***Ans. (c)***

49. ***Ans. (d)***

50. ***Ans. (c)***

51. ***Ans. (a)***

V = 50 kmph

t = 2.3 sec

f = 0.38

$$SSD = 0.278 \times 50 \times 2.3 + \frac{(50)^2}{254.27 \times 0.38}$$

$$= 31.97 + 25.87 \Rightarrow 57.84 \text{ m}$$

SSD = 57.84 m

52. ***Ans. (c)***

53. ***Ans. (d)***

54. ***Ans. (c)***

55. ***Ans. (b)***

56. ***Ans. (a)***

57. ***Ans. (b)***

58. ***Ans. (d)***

59. ***Ans. (b)***

60. ***Ans. (d)***

61. ***Ans. (a)***

62. ***Ans. (d)***

63. ***Ans. (b)***

64. ***Ans. (b)***

$$L_D = 0.278 \times V \times t$$

$$= 0.278 \times 40 \times 2$$

$$= 22.24 \text{ m}$$

65. ***Ans. (b)***

66. ***Ans. (b)***

67. ***Ans. (b)***

68. ***Ans. (a)***

69. ***Ans. (a)***

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

$$= \frac{30 + 60}{60}$$

$$= 1.5\%$$

70. ***Ans. (d)***

$$\text{Rise} = \frac{W}{2n} = \frac{10}{2 \times 50}$$

$$= 0.1 \text{ m}$$

71. ***Ans. (c)***

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

$$= \frac{(75)^2}{225 \times 1000}$$

$$= \frac{25}{1000} = 1 \text{ in } 40$$

72. ***Ans. (b)***

73. ***Ans. (c)***

74. ***Ans. (c)***

75. ***Ans. (a)***

76. ***Ans. (b)***

77. ***Ans. (a)***

78. ***Ans. (c)***

79. ***Ans. (b)***

80. ***Ans. (c)***

81. ***Ans. (a)***

82. ***Ans. (d)***

83. ***Ans. (d)***

84. ***Ans. (a)***

85. ***Ans. (a)***

86. ***Ans. (d)***

87. ***Ans. (b)***

88. ***Ans. (d)***

89. ***Ans. (d)***

90. ***Ans. (c)***

91. ***Ans. (a)***

92. ***Ans. (a)***

93. ***Ans. (a)***

94. ***Ans. (b)***

$$SSD = 0.278 \, Vt + \frac{V^2}{254f}$$

$$= 0.278 \times 72 \times 2.5 + \frac{72^2}{254 \times 0.4}$$

$$SSD = 101.08\text{m}$$

For two-way single lane road, $SSD_{provided}$

$$= 2 \times SSD_{theoritical}$$

$$SSD_{provided} = 2 \times 101.08$$

$$= 202.17 \text{ m} \simeq 200 \text{ m}$$

95. ***Ans. (d)***

96. ***Ans. (c)***

97. ***Ans. (a)***

98. ***Ans. (b)***

99. ***Ans. (c)***

$$e = \frac{V^2}{225R} = \frac{75^2}{225 \times 600}$$

$$= 0.041$$

100. ***Ans. (d)***

101. ***Ans. (d)***

102. ***Ans. (b)***

$$W_e = W_M + W_P$$

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

$$W_e = \frac{4 \times 6^2}{2 \times 400} + \frac{50}{9.5\sqrt{400}}$$

$$W_e = 0.18 + 0.263$$

$$W_e = 0.44 \text{ m}$$

103. ***Ans. (b)***

Grade compensation

$$= \text{minimum of } \left\{\frac{30+R}{R} \text{or} \frac{75}{R}\right\}$$