CLASS TEST

Sl.NO. : 01 JP_CE_01082023

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CIVIL ENGINEERING

HIGHWAY ENGINEERING

Duration : 1:00 hr. **Maximum Marks : 50**

Read the following instructions carefully

1. This question paper contains **30** objective questions. **Q.1-10** carry one mark each and **Q.11-30** carry two marks each.
2. Answer all the questions.
3. Questions must be answered on Objective Response Sheet (**ORS**) by darkening the appropriate bubble (marked **A**, **B**, **C**, **D**) using HB pencil against the question number. Each question has only one correct answer. In case you wish to change an answer, erase the old answer completely using a good soft eraser.
4. There will be **NEGATIVE** marking. For each wrong answer **1/3rd** of the full marks of the question will be deducted. More than one answer marked against a question will be deemed as an incorrect response and will be negatively marked.
5. Write your name & Roll No. at the specified locations on the right half of the **ORS**.
6. No charts or tables will be provided in the examination hall.
7. Choose the **Closest** numerical answer among the choices given.
8. If a candidate gives more than one answer, it will be treated as a **wrong answer** even if one of the given answers happens to be correct and there will be same penalty as above to that questions.
9. If a question is left blank, i.e., no answer is given by the candidate, there will be **no penalty** for that question.

DO NOT OPEN THIS TEST BOOKLET UNTIL YOU ARE ASKED TO DO SO

Q.No. 1 to Q.No. 10 carry 1 mark each

Q.1 The maximum permissible width of a vehicle and desirable side clearance for single lane carriageway as per IRC is
(a) 2.44 m and 0.53 m
(b) 3.75 m and 0.65 m
(c) 2.44 m and 0.65 m
(d) 2.75 m and 0.65 m

Q.2 The amount of mechanical energy imparted on the aggregates during the aggregate impact test is of the order of
(a) 6750 kg-cm
(b) 7980 kg-cm
(c) 11400 kg-cm
(d) 5320 kg-cm

Q.3 The design speed on a highway is 100 kmph and the radius of circular curve is 180 m in plain topography. Which one of the following is the minimum length of transition curve as per empirical formula of IRC?
(a) 120 m
(b) 135 m
(c) 150 m
(d) 165 m

Q.4 An ascending gradient of 1 in 75 meets a descending gradient of 1 in 50. The length of summit curve required to provide overtaking sight distance of 400 m will be
(a) 480 m
(b) 555 m
(c) 675 m
(d) 725 m

Q.5 The important factor considered in the design of summit curves on highway is
(a) impact factor
(b) superelevation
(c) sight distance
(d) comfort to passenger

Q.6 The safety within a roundabout and the efficiency of a roundabout can be increased, respectively by
(a) decreasing the entry radius and decreasing the exit radius
(b) decreasing the entry radius and increasing the exit radius
(c) increasing the entry radius and increasing the exit radius
(d) increasing the entry radius and decreasing the exit radius

Q.7 Which of the following statements are correct regarding pavements?
1. Flexible pavements are more affected by temperature variation than rigid pavements.
2. Rigid pavements are more suitable than flexible pavements for stage construction.

Select the correct answer using the codes given below:
(a) 1 only
(b) 2 only
(c) Both 1 and 2
(d) Neither 1 nor 2

Q.8 Match **List-I** with **List-II** and select the correct answer using the code given below the lists:

List-I
A. Penetration test
B. Marshall test
C. Ring and ball test
D. Bankelman beam test

List-II
1. Design of bituminous concrete mix
2. Overlay design
3. Gradation of asphalt cement
4. Determination of softening point

Codes:

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

Q.9 A transition curve is provided on a circular curve on a highway to provide
1. gradual introduction of superelevation.
2. comfort and safety of passengers.
3. minimum stopping sight distance.
4. gradual introduction of centrifugal force.

Select the correct answer using the codes given below:
(a) 1, 2 and 3
(b) 1, 3 and 4
(c) 2, 3 and 4
(d) 1, 2 and 4

Q.10 The type of signalling system in which it is possible to vary the length of cycle, cycle division and the time schedule at each signal point is called
(a) Simple progressive system
(b) Alternate system
(c) Simultaneous system
(d) Flexible progressive system

Q. No. 11 to Q. No. 30 carry 2 marks each

Q.11 The design speed for a two-lane road is 75 kmph. When a design vehicle with a wheelbase of 6.6 m is negotiating a horizontal curve on that road, the off-tracking is measured as 0.1 m. The required widening of carriageway of the two-lane road on the curve is approximately
(a) 0.73 m
(b) 0.80 m
(c) 0.63 m
(d) 0.68 m

Q.12 The normal flows on two approach roads at an intersection are 600 PCU/hr and 300 PCU/hr. The corresponding saturation flow is 1500 PCU/hr on each road. The total lost time per signal cycle is 16s. The optimum cycle time by Webster's method is
(a) 68 sec
(b) 73 sec
(c) 60 sec
(d) 80 sec

Q.13 What will be the ruling radius of a horizontal curve on a National Highway for a design vehicle speed of 80 kmph, assuming allowable super elevation to be 7% and lateral friction as 0.13?
(a) 360 m
(b) 336 m
(c) 312 m
(d) 252 m

Q.14 The rate of equilibrium superelevation on a road is
1. Inversely proportional to the square of vehicle velocity.
2. Directly proportional to the square of the radius of the horizontal curve.
3. Inversely proportional to the radius of the horizontal curve.

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

Q.15 A 5.0% gradient is provided on a hill road. But on a curve of radius 60 m, this gradient has to be reduced. The reduction in gradient as per IRC is __________ %.
(a) 1.25
(b) 3.75
(c) 4
(d) 1

Q.16 There are four different alternatives of road plans for a minor district. The details are presented in the form of table below:
Assuming utility units of 1, 2, 4, 8 for the four population ranges and utility units of 1.0 and 5 per 1000 tonnes of agricultural and industrial products served respectively.

Alternative	Road length (km)	Number of towns and villages served with population range				Productivity in two thousand tonne	
		<2000	2001-5000	5001-10000	>10000	Agriculture	Industrial
P	500	100	70	50	20	50	20
Q	600	200	120	30	10	60	25
R	800	100	90	80	80	30	15
S	900	150	130	100	10	50	12

Which of the following alternative is considered the best and whet is its utility per road length?
(a) *R*, 1.625
(b) *P*, 1.5
(c) *R*, 1.813
(d) *P*, 1.8

Q.17 A horizontal curve of radius 350 m is provided on a high speed road for allowing a vehicle to travel at 180 kmph. The superelevation provided is 1 in N. The value of N is ____. (Take f = 0.15)
(a) 1.62 (b) 1.43
(c) 1.92 (d) 1.73

Q.18 A vehicle is traversing a descending gradient with a velocity of 60 kmph. Suddenly driver observes an obstacle and applies brakes having efficiency 80% and stops after covering a total distance of 230 m. The magnitude of descending gradient is __________%.
[Assume longitudinal friction on road is 0.40 and reaction time as 2.5 sec.]
(a) 14.5 (b) 24.5
(c) 34.5 (d) 20.5

Q.19 For a two-way traffic road, the following are the particulars:
Speed of overtaking vehicle = 65 kmph
Speed differential between the vehicles = 12 kmph
Acceleration of overtaking vehicles = 2.86 kmph/sec
Perception time of driver of overtaking vehicle = 2 sec
Length of overtaking vehicle = 6 m
Required overtaking sight distance for the road will be _____.
(a) 362.48 m (b) 165.16 m
(c) 392.48 m (d) 402.48 m

Q.20 A concrete slab of width 4.2 m and 18 cm thickness is reinforced with steel of 10 mm dia bars spaced at 260 mm. If the unit weight of concrete is 2400 kg/m^3 and allowable tensile stress in steel is 1400 kg/cm^2 then what is the spacing between contraction joints? (f = 1.5)
(a) 13 m (b) 6 m
(c) 8 m (d) 15 m

Q.21 The radius of relative stiffness for a 25 cm thick slab with $E = 3 \times 10^5$ kg/cm^2 and Poisson's ratio = 0.15, resting on a subgrade having modulus of sub-grade reaction of 6 kg/cm^3 is
(a) 90.34 cm (b) 93.55 cm
(c) 97.43 (d) None of these

Q.22 The following data pertains to the number of commercial vehicles per day for the design of a flexible pavement for a national highway as per IRC : 37-1984 :

Type of commercial vehicle	Number of vehicles per day consideration for number of lanes	Vehicle damage factor
Two axle trucks	1800	4
Tandem axle trucks	300	7

Assuming a traffic growth factor of 8% per annum for both the type of vehicles and lane distribution factor as one, the cumulative number of standard axle load repetitions (in millions) for a design life of 12 years is
(a) 14.55 (b) 49.87
(c) 64.42 (d) 20.97

Q.23 Due to seasonal variation of temperature in the summer season, nature of stress developed in a cement concrete pavement when friction is considered and when friction is neglected is __________ and ________ respectively.
(a) Compressive, Tensile (b) Compressive, No stress
(c) Tensile, compressive (d) No stress, tensile

Q.24 Total thickness of bituminous course of flexible pavement by CBR method depends upon the CBR value of ___________

(a) Base course
(b) Surface course
(c) Subgrade
(d) Bituminous pavement

Q.25 A vehicle of weight 40 kN negotiating a horizontal curve of radius 250 m is subjected to the friction force of 5 kN. The distance between the wheels of the axle is 0.8 m and height of CG of vehicle from road surface is 0.6 m. Determine the maximum speed of vehicle permitted so that overturning and sliding can be prevented.

(a) 63.04 kmph
(b) 17.51 kmph
(c) 40.54 kmph
(d) 145.93 kmph

Q.26 Subsidence is a pavement deficiency which is caused by

(a) removal of larger surface aggregates leaving craters.
(b) abrupt lowering of the road surface due to poor drainage.
(c) progressive disintegration of bituminous premix carpet surfacing by loss of aggregate.
(d) a general lowering of the road surface.

Q.27 In the context of design of rotary, consider the following pair of statements:

I. Practical capacity of rotary is directly related to the length of weaving section.
II. Practical capacity of rotary is directly related to weaving ratio.

Which of the following combinations is correct?

(a) I-True, II-False
(b) I-True, II-True
(c) I-False, II-False
(d) I-False, II-True

Q.28 The test performed on the aggregate shows the following results:

1. Mass of oven-dry aggregate in air = 1000g.
2. Mass of saturated surface-dry aggregate in air = 1010g.
3. Mass of saturated surface-dry aggregate under water = 610g.

Based on the above results, the correct option is:

(a) bulk specific gravity of aggregate = 2.5 and water absorption = 2.5%.
(b) bulk specific gravity of aggregate = 2.5 and water absorption = 1%.
(c) bulk specific gravity of aggregate = 2.5% and water absorption = 1.
(d) bulk specific gravity of aggregate = 1.1% and water absorption = 2.5.

Q.29 The vehicle arrival rate at a section of road is 280 veh/hr. The probability for the arrival of 10 vehicles within 2 minutes time interval is ____________.

(a) 0.132
(b) 0.112
(c) 0.142
(d) 0.122

Q.30 For the data given below, the value of annual average daily traffic (AADT) is ________.

Time	8:00 - 9:00	9:00 - 10:00	10:00 - 11:00	11:00 - 12:00
Volume	500	350	200	150
Hourly expansion factor (HEF)	14.5	17.6	15.3	18.1

Assume : Daily expansion factor as 5.7
Monthly expansion factor as 1.35

(a) 4796.25
(b) 3905.52
(c) 3207.64
(d) 5272.45

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HIGHWAY ENGINEERING

CIVIL ENGINEERING

Date of Test : 01/08/2023

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (c)

As per IRC, the maximum permissible width of vehicle is 2.44 m and the desirable side clearance for single lane carriageway is 0.65 m. This require minimum lane width of 3.75 m for a single lane road.

2. (b)

A metal hammer of weight 13.5-14.0 kg having a free fall from a height 38 cm is dropped 15 times in aggregate impact test.

So energy imparted = 14 × 38 × 15 = 7980 kg-cm

3. (c)

As per IRC, minimum length of transition curve in plain or rolling terrain

$$L_s = \frac{2.7V^2}{R} = \frac{2.7\times100^2}{180} = 150 \text{ m}$$

4. (b)

Deviation angle, $N = \frac{1}{75}+\frac{1}{50} = 0.0333$

Assuming, $L > S$

$$L = \frac{NS^2}{9.6} = \frac{0.0333\times400^2}{9.6}$$

$= 555.56 > S\ (= 400 \text{ m})$ (OK)

5. (c)

Summit curve: Summit curves are vertical curves with convexity upward. The design of a summit curve is governed by consideration of sight distance.

7. (b)

Rigid pavements are more affected by temperature variation than flexible pavements.

9. (d)

Objectives of providing transition curve are:

(i) To introduce gradually the centrifugal force between the tangent points and beginning of circular curve, avoiding sudden jerk on the vehicle.
(ii) To enable the driver turn the steering gradually for comfort and safety.
(iii) It introduces superelevation and extra widening on curve gradually.
(iv) To improve aesthetic appearance of road.

10. (d)

Flexible progressive system: In the system it is possible to automatically vary cycle length, cycle division and the time schedule at each intersection with the help of a computer.

Note:

Simultaneous system: All signals along the given road show some indications at same time.

Alternate system: Alternate signals show opposite indication along the route at same time. It is more satisfactory then simultaneous system.

Simple progressive system: A time schedule is made to permit as nearly as possible a continuous operation of group of vehicles along the main road at a reasonable speed.

11. (a)

Off-tracking, $$\frac{l^2}{2R} = 0.1 \text{ m}$$

$\Rightarrow$ $$R = \frac{(6.6)^2}{2\times 0.1} = 217.8 \text{ m}$$

Extra-widening, $$E_W = \frac{nl^2}{2R} + \frac{V}{9.5\sqrt{R}}$$

$$= 2\times 0.1 + \frac{75}{9.5\sqrt{217.8}}$$

$$= 0.2 + 0.53 = 0.73 \text{ m}$$

12. (b)

Sum of critical flow ratio, $Y = y_a + y_b$

$$= \frac{600}{1500} + \frac{300}{1500} = 0.6$$

Optimum cycle time, $$C_0 = \frac{1.5L+5}{1-Y} = \frac{1.5\times 16+5}{1-0.6}$$

$$= 72.5 \text{ sec} \simeq 73 \text{ sec (say)}$$

13. (d)

$$R_{\text{ruling}} = \frac{V^2}{127(e+f)} = \frac{80^2}{127(0.07+0.13)}$$

$$= 251.97 \simeq 252 \text{ m}$$

14. (c)

Equilibrium superlevation:

$$f = 0$$

The superelevation required to balance the vehicle over a curve only with superelevation without considering friction.

$$e + f = \frac{v^2}{gR}$$

$$e_{eq} = \frac{v^2}{gR}$$

15. (d)

Grade compensation (in %) = $\frac{30+R}{R} \not> \frac{75}{R} = \frac{30+60}{60} \not> \frac{75}{60}$ = 1.5 $\not>$ 1.25

Compensated gradient = 5 – 1.25

= 3.75% < 4%

Adopt compensated gradient = 4%

Hence reduction in gradient = 1%

16. (c)

Road	Length (km)	Total utility served by the road	Utility per unit length	Priority
P	500	100 × 1 + 70 × 2 + 50 × 4 + 20 × 8 + 50 × 2 + 20 × 10 = 900	$\frac{900}{500}$ = 1.8	II
Q	600	200 × 1 + 120 × 2 + 30 × 4 + 10 × 8 + 60 × 2 + 25 × 10 = 1010	$\frac{1010}{600}$ = 1.683	IV
R	800	100 × 1 + 90 × 2 + 80 × 4 + 80 × 8 + 30 × 2 + 15 × 10 = 1450	$\frac{1450}{800}$ = 1.813	I
S	900	150 × 1 + 130 × 2 + 100 × 4 + 10 × 8 + 50 × 2 + 12 × 10 = 1110	$\frac{1110}{900}$ = 1.23	IV

17. (c)

For a particular vehicle on a high speed track.

$$\frac{e+f}{1-ef} = \frac{V^2}{127R}$$

$$\Rightarrow \quad \frac{e+0.15}{1-e\times 0.15} = \frac{180^2}{127\times 350}$$

$$\Rightarrow \quad e + 0.15 = 0.7289 - 0.109\,e$$

$$\Rightarrow \quad 1.109e = 0.5789$$

$$\Rightarrow \quad e = 0.522 = \frac{1}{1.916}$$

$$\therefore \quad N = 1.916 \simeq 1.92$$

18. (b)

As we know,

Stopping sight distance, $$\text{SSD} = 0.278Vt + \frac{V^2}{254(n_b \times f - 0.01n)}$$

Where, n_b is the braking efficiency and n is descending gradient (in %).

$$\Rightarrow \quad 230 = 0.278\times 60\times 2.5 + \frac{60^2}{254(0.8\times 0.4 - 0.01n)}$$

$$\Rightarrow \quad n = 24.5\%$$

19. (a)

Velocity of slow moving vehicle, $V_B = 65 - 12 = 53$ kmph

Space headway, $S = 0.2\ V_B + l$ where l is length of vehicle

$= 0.2 \times 53 + 6$

$= 16.6$ m

$$T = \sqrt{\frac{4S}{a}} = \sqrt{\frac{4 \times 16.6 \times 18}{2.86 \times 5}} = 9.14 \text{ sec}$$

$\therefore$ $d_1 = 0.278\ V_B t_R$

$\Rightarrow$ $d_1 = 0.278 \times 53 \times 2 = 29.47$ m

$$d_2 = 0.278 V_B T + \frac{1}{2} a T^2$$

$$\Rightarrow \quad d_2 = 0.278 \times 53 \times 9.14 + \frac{1}{2} \times 2.86 \times \frac{5}{18} \times 9.14^2$$

$\Rightarrow$ $d_2 = 134.67 + 33.18 = 167.85$ m

$d_3 = 0.278\ V_C T$

$\Rightarrow$ $d_3 = 0.278 \times 65 \times 9.14 = 165.16$ m

So, overtaking sight distance, OSD $= d_1 + d_2 + d_3 = 362.48$ m

20. (a)

Spacing between contraction joints

$$= \frac{2\sigma_s A_s}{bh\gamma_c f}$$

$$\text{Total area of steel} = \frac{\pi}{4} \times 10^2 \times \frac{4200}{260} = 1268.72 \text{ mm}^2 = 12.69 \text{ cm}^2$$

$$\text{Spacing} = \frac{2 \times 1400 \times 12.69}{420 \times 18 \times 2400 \times 10^{-6} \times 1.5} = 1305.56 \text{ cm} = 13.06 \text{ m} \simeq 13 \text{ m (say)}$$

21. (a)

Given, $h = 25$ cm, $E = 3 \times 10^5$ kg/cm^2, $\mu = 0.15$, $k = 6$ kg/cm^3

$$L = \left[\frac{Eh^3}{12k\left(1-\mu^2\right)}\right]^{1/4} = \left[\frac{3 \times 10^5 \times 25^3}{12 \times 6\left\{1-(0.15)^2\right\}}\right]^{1/4}$$

$\Rightarrow$ $L = 90.34$ cm

22. (c)

$$N_{S_1} = \frac{365 A_1\left[(1+r)^n - 1\right]}{r} \times F = \frac{365 \times 1800\left[\left(1+\frac{8}{100}\right)^{12} - 1\right]}{\frac{8}{100} \times 10^6} \times 4$$

$= 49.87$ msa

$$N_{S_2} = \frac{365A_2\left[(1+r)^n - 1\right]}{r} \times F_2$$

$$= \frac{365 \times 300\left[(1+0.08)^{12} - 1\right]}{0.08 \times 10^6} \times 7$$

$$= 14.55$$

$$\therefore \quad N_s = N_{S_1} + N_{S_2}$$

$$= 49.87 + 14.55$$

$$= 64.42 \text{ msa}$$

23. (b)

When friction is neglected, no stresses will be developed in the cement concrete pavement.

24. (c)

$$T_p = \sqrt{\frac{1.75P}{CBR\%} - \frac{P}{\pi p}}$$

Here T_p denotes thickness of pavement above the test layer whose CBR value is taken.

25. (a)

Condition for the prevention of overturning and sliding is

$$\frac{V^2}{gR} < \min\begin{cases} \dfrac{b}{2h} \\ f \end{cases}$$

$$\frac{b}{2h} = \frac{0.8}{2 \times 0.6} = 0.67$$

$$f = \frac{F}{N} = \frac{5}{40} = 0.125$$

So, $$\frac{V^2}{gR} = 0.125$$

$\Rightarrow$ $$V^2 = 0.125 \times 250 \times 9.81$$

$\Rightarrow$ $$V^2 = 306.5625$$

$\Rightarrow$ $$V = 17.51 \text{ m/s}$$

$\Rightarrow$ $$V = 63.04 \text{ kmph}$$

27. (a)

Practical capacity of a rotary is given by

$$Q_p = \frac{280\,w\left(1 + \dfrac{e}{w}\right)\left(1 - \dfrac{p_{\max}}{3}\right)}{1 + \dfrac{w}{L}}$$

Statement-I: True

As with increase in length of weaving section, practical capacity increases.

Statement-II: False

As with increase in weaving ratio, numerator decreases and practical capacity of rotary ultimately decreases.

28. (b)

$$\text{Bulk specific gravity} = \frac{1000}{1010-610} = 2.5$$

$$\text{Water absorption} = \frac{1010-1000}{1000} \times 100 = 1\%$$

29. (d)

$$\lambda = 280 \text{ veh/hr}$$

Probability for 10 vehicles arriving within 2 minutes time interval

$$P(n,\ t) = \frac{(\lambda t)^n e^{-\lambda t}}{n!}$$

$$P\left(10, \frac{2}{60}\right) = \frac{\left(280 \times \frac{2}{60}\right)^{10} e^{-280\times\frac{2}{60}}}{10!}$$

$$= \frac{5.016 \times 10^9 \times 8.84 \times 10^{-5}}{10!}$$

$$= 0.122$$

30. (d)

Time	Volume	HEF	Volume × HEF
8:00 - 9:00	500	14.5	7250
9:00 - 10:00	350	17.6	6160
10:00 - 11:00	200	15.3	3060
11:00 - 12:00	150	18.1	2715
			Σx = 19185

$$\text{Average daily traffic} = \frac{\Sigma x}{4} = \frac{19185}{4} = 4796.25$$

$$\text{Weekly average daily traffic} = \frac{4796.25 \times DEF}{7} = \frac{4796.25 \times 5.7}{7} = 3905.52$$

Annual average daily traffic, AADT = 3905.52 × 1.35 = 5272.45

■■■■