X/D/TZ

Reg. No:

Final Assessment Test – April 2026

Course: BCLE305L - *Transportation Engineering*

Class NBR(s): 1302 | Slot: B1+TB1

Time: Three Hours | Max. Marks: 100

- **KEEPING MOBILE PHONE/ANY ELECTRONIC GADGETS, EVEN IN 'OFF' POSITION IS TREATED AS EXAM MALPRACTICE**
- **DON'T WRITE ANYTHING ON THE QUESTION PAPER**

General Instruction : Necessary formulae and guidelines from IRC are provided in Appendix

COs	CO Statements
CO1	Identify the most suitable highway alignment through engineering surveys.
CO2	Design the geometric elements and understand various traffic elements on a highway.
CO3	Study the traffic conditions on a road and identify basic solutions for traffic problems.
CO4	Perform tests and identify whether a given highway pavement material is suitable for construction
CO5	Design a highway pavement using IRC method.

BL – Blooms Taxonomy Level (1 – Remember, 2 – Understand, 3 – Apply, 4 – Analyse, 5 – Evaluate, 6 – Create)

PART – A (8 X 5 = 40 Marks)

Answer ALL Questions

1. In a city such as Vellore, some roads carry large volumes of traffic at higher speeds, while others mainly provide access to homes and local streets. **CO1 BL2**

   Describe the functional classification of urban roads and write the role of each category.

2. An existing road between two towns passes through several villages and experiences congestion and delays. A proposal has been made to construct an alternative highway between the towns. There are two alignment options. **CO1 BL2**

   Briefly discuss the procedure followed to evaluate whether the new highway is economically feasible and which alignment to be chosen. Note: Limit your answer to about 60 words.

3. Water stagnation on highway leads to pavement damage. Briefly describe the three design features that collectively provide good drainage of water so that water does not damage highways. Use appropriate schematic diagram(s). **CO2 BL2**

4. Traffic volume count at a road section in peak hour resulted in the following data. Passenger car equivalency of each vehicle class are given. Calculate total volume in PCUs by 15-min interval and calculate the peak hour factor. **CO3 BL3**

Table 1 Traffic volume count data

		Passenger Car Equlvalency			
		0.4	1.2	1	5
Time period	Vehicle class	Motorized Two-wheelers	Autorickshaws	Cars/vans	Buses
9am-9:15am		150	57	171	85
9:15am-9:30am		210	61	234	105
9:30am-9:45am		182	62	190	90
9:45am-10:00am		136	58	182	110

5. Briefly describe the special features to be provided at the following locations to support movement of persons with disabilities. CO2 BL2

- Parking areas
- Walking areas and crossings.

6. Compare impact value test and abrasion test which test the *suitability* of aggregates for highway construction. Follow the format given below: *CO4* *BL3*

Aspect	Impact value test	Abrasion test
Property of aggregate tested		
Nature of loading being simulated		
Output value		
Passing criteria		

7. Draw the cross-section of a typical rigid pavement and write what each layer contains. Write the function of each layer. CO5 BL1

8. Large amounts of mobility data are now available from mobile phones, GPS devices, and CCTV cameras. CO3 BL2

Describe any four transportation engineering applications of such data and briefly explain how the data would be used in each application.

Format:

Application	How the data is used
....	....

PART – B (6 X 10 = 60 Marks)
Answer ALL Questions

9. Calculate intermediate sight distance for a highway with design speed 70 km/h. CO2 BL3

On this road, a raising section of 1 in 40 slope meets a falling section of 1 in 50 slope. Determine the vertical curve length at the joining of these sections such that at least intermediate sight distance is available for overtaking. Show your calculations.

10.a) A two-lane MDR is being designed for 65 km/h speed. CO2 BL3

At a turning point shown in Figure 1, centreline is at E=22 m distance from Point of Intersection (O). Δ=52 deg.

Calculate the minimum horizontal curve radius allowed for safe turning at this speed. Calculate the radius of curve and design superelevation for this curve. Find maximum safe speed on this curve.

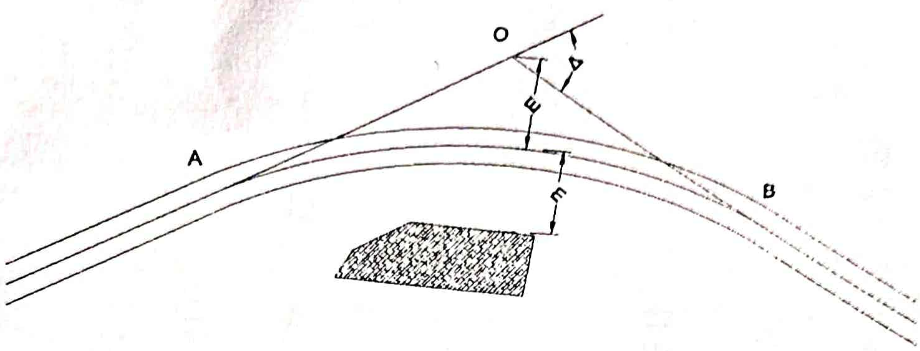


Figure 1 Horizontal curve

OR

10.b) Write the significance of set-back distance at a horizontal curve on a two-lane state highway as shown in Figure 1. For providing safe stopping sight distance (S) on this curve with radius R, derive an expression for the minimum value of set-back distance, m, when length of curve L > S. CO2 BL3

Assuming SSD=110 m, Δ=60 deg., and radius=120 m, calculate the set-back distance required.

11. A two-lane highway currently (in 2026) carries an Annual Average Daily Traffic (AADT) of 13,900 vehicles. This contains 35% cars, 15% Motorcycles (PCE=0.3), 15% autorickshaws (PCE= 1.2), 20% heavy vehicles (PCE=5) and 15% buses (PCE=4.5). CO2 BL3

The highway is planned for capacity addition to meet traffic demand in the design year 2040. The traffic is expected to grow at a compound annual growth rate (CAGR) of 4.5%.

For design purposes, use peak hourly share K=0.095 and Directional distribution factor D=0.55. The capacity of a single lane is estimated as 1950 PCU/hour.

Determine the number of lanes to be provided in the design year 2040 to ensure at least LOS C. Clearly justify your answer with calculations of Directional Design Hour Volume (DDHV) and Maximum Service Volume.

V/C ratio thresholds for different LOS from IndoHCM are: LOS A: 0.2, LOS B: 0.30, LOS C: 0.50, LOS D: 0.70 and LOS E: 1.0.

12. A highway (4-lane divided) connects with a town through a 2-lane road as shown in Figure 2. The highway authority found that conflicts were happening as vehicles from/to the town road interact with high-speed highway traffic. Draw and explain the necessary improvements needed at this intersection to mitigate this problem. CO3

Note: Show and explain Physical improvements (ex: channelization);

Show and explain Signs and pavement markings

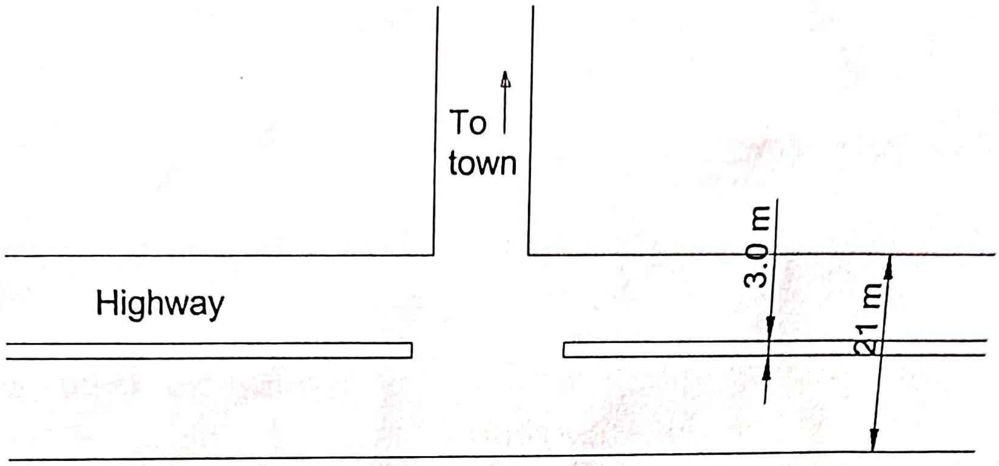


Figure 2 T- intersection at a highway connecting with a road to town

13. Bitumen is to be used for construction of a flexible pavement in a region experiencing high daytime temperatures and moderate rainfall. *CO4* *BL3*

a) List four important properties of bitumen for this condition. For each, write: **[6]**
- The property's relevance to the given climate
- Name of the test to verify the suitability of bitumen for highway pavement
- What this test measures

b) Two bitumen samples gave the following results: **[4]**

Property	Sample 1	Sample 2
Penetration (0.1mm)	80	40
Softening point	Low	High

Which sample is more suitable for the situation given above? Justify based on expected pavement performance.

14.a) Answer the following;	CO5	BL3

(i) Calculate the cumulative number of standard-axle-loads that would be applied on a two-lane highway pavement's design lane in a total design period of 15 years. **[6]**

AADT in the year of opening: 8000 veh/day

Annual traffic growth: 5% CAGR

%share of commercial vehicles: 2-axle 4 tyre (Type A): 6%, 2-axle 6-tyre (Type B): 5%;

Vehicle damage factor (VDF): Type A: 1.90, Type B: 2.65.

(ii) Using the following pavement performance equations from IRC 37-2018 equations, describe how the number of cumulative standard-axle-loads is used conceptually in design of flexible pavements. **[4]**

$$N_R = 4.1656 \times 10^{-8}[1/\epsilon^{v}]^{4.5337}$$

$$N_f = 1.6064 \times C \times 10^{-4}[1/\epsilon_t]^{3.89}[1/M_{Rm}]^{0.854}$$

OR

14.b) Describe the role of vehicle damage factor (VDF) in design of highway pavement.	CO5	BL3

An axle load survey measured weights of both tandem axles of the five axle trucks ()

Estimate the VDF for 5-axle trucks using the following information.

The survey obtained the axle load spectrum for tandem axles as shown in Table 2. Estimate the "total number of standard axles" and "axle equivalency factor" for tandem axle. If axle equivalency factor for front axles is 0.6, estimate the vehicle damage factor for 5-axle trucks.

Table 2

Weight in tonnes	No. of TandemAxles
0 to <3	1
3 to <6	3
6 to <9	9
9 to <12	19
12 to <15	25
15 to <18	23
18 to <21	18
21 to <24	8
24 to <27	3
27 to <30	1

Appendix

Formulae:

Geometric design:

Circular curve formulae: Δ = deflection angle; E=external distance=$R(\sec(\Delta/2)-1)$,

M=middle ordinate=$R(1-\cos\Delta/2)$;

Length of curve: $L=R\Delta\Pi/180$; $T=R\tan(\Delta/2)$

Horizontal curve at equilibrium: $e+f_s= v^2/gR$,

$SSD=vt_R+v^2/2g(f\pm G)$,

Transition curve:

$L_s= 0.0215V^3/CR$, $C=80/(75+V)$

$Ls= (W+W_e)/2 * e* N$

$F=P(1+r)^n$ $P=[(1+r)^n-1]/[r(1+r)^n]$

Vertical curve length:

Summit curve: L>S: $L=\frac{NS^2}{(\sqrt{2H}+\sqrt{2h})^2}$, if L<S: $L=2S-\frac{(\sqrt{2H}+\sqrt{2h})^2}{N}$

Valley curve: L>S: $L=\frac{NS^2}{(2h_1+2S\tan\alpha)}$, if L<S: $L=2S-\frac{(2h_1+2S\tan\alpha)}{N}$

Highest or lowest point on curve: $x=[n1/(n1+n2)*L]$

Ordinates from tangent line along vertical curve (y) at x is $y= N/2L *x^2$

Traffic Engineering:

Greenshield's model: $v=v_f-v_f(k/k_j)$ or $k=k_j-k_j(v/v_f)$

Pavement Engineering:

Cumulative number of standard axles: $N_{Des}=\frac{365\times[(1+r)^n-1]}{r}\times A\times D\times F$

Equivalent repetitions of standard axle loads = (Axle load in kN/standard axle load in kN)^4

Tables from IRC 73-2023

Table 3.2 Design speeds for NH/SH/MDR/ODR/VR

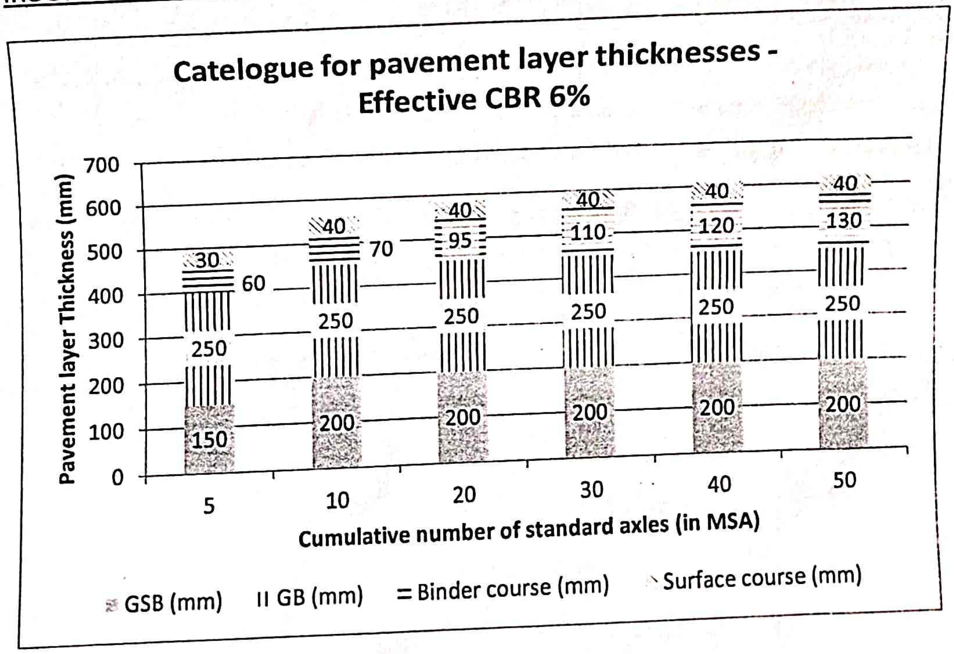
S.No.	Nature of Terrain	Percent cross slope of the country	Design speed (km/h) (4/6/8-lane NH/SH)		Design speed (2-lane NH/SH)		Design speed (km/h) (MDR)		Design speed (km/h) (ODR/VR)	
			Ruling	Minimum	Ruling	Minimum	Ruling	Minimum	Ruling	Minimum
1	Plain	0-10	100	80	100	80	80	65	50	40
2	Rolling	10-25	100	80	100	80	65	50	50	40
3	Mountainous	25-60	60	40	50	40	40	30	30	20
4	Steep	>60	60	40	40	30	30	20	30	20

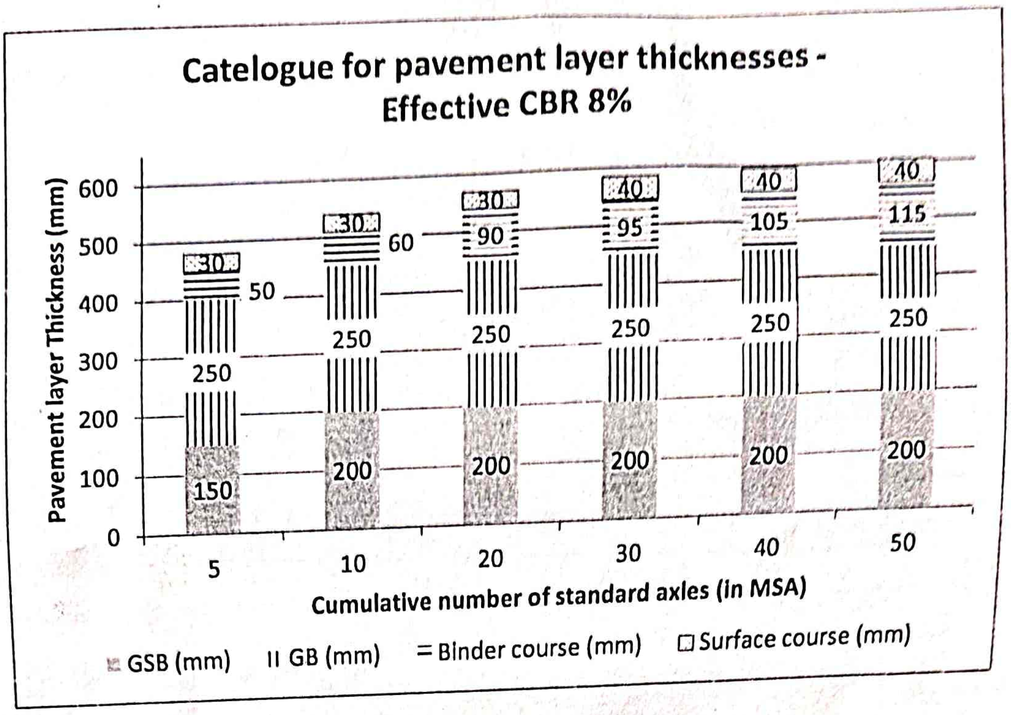
Table 7.5 Minimum Length of the Vertical Curve

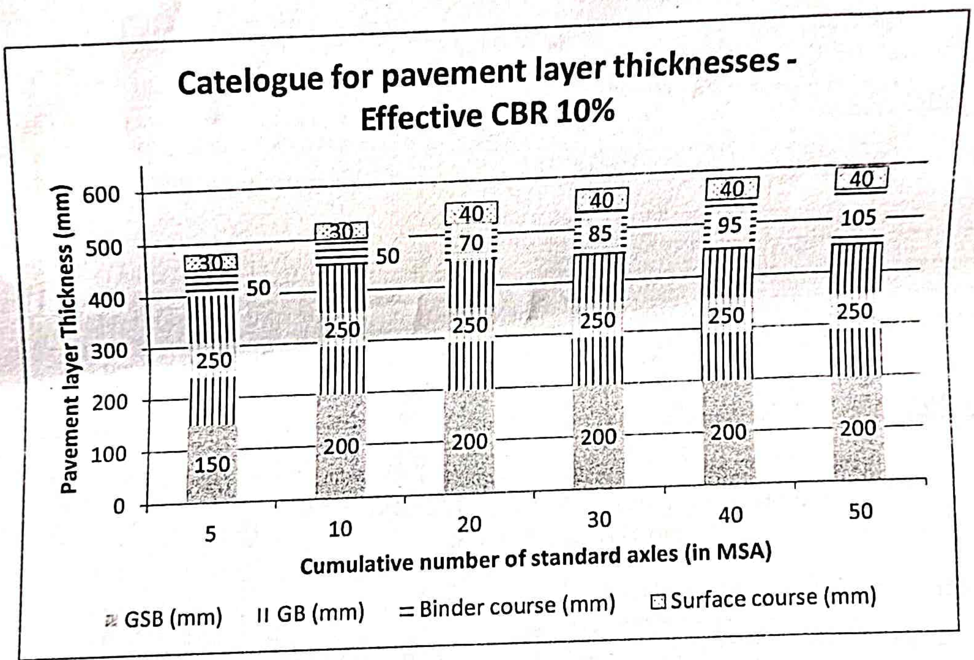
Design Speed (km/h)	Maximum Grade Change (percent) up to which Vertical Curve is not required	Minimum Length of a Vertical Curve (metre)
Up to 35	1.5	15
40	1.2	20
50	1.0	30
60	0.8	40
80	0.6	50 / 70*
100	0.5	60 / 85*
120	0.5	100*

Note: Minimum length of vertical curves shown in asterisk (*) are applicable for expressways.

IRC 37-2018 Flexible Pavement Design Catalogues




Catelogue for pavement layer thicknesses - Effective CBR 8%
Pavement layer Thickness (mm)
600
500
400
300
200
100
0
30
50
250
150
30
60
250
200
30
90
250
200
40
95
250
200
40
105
250
200
40
115
250
200
5
10
20
30
40
50
Cumulative number of standard axles (in MSA)
GSB (mm)
GB (mm)
Binder course (mm)
Surface course (mm)


Catelogue for pavement layer thicknesses - Effective CBR 10%
Pavement layer Thickness (mm)
600
500
400
300
200
100
0
30
50
250
150
30
50
250
200
40
70
250
200
40
85
250
200
40
95
250
200
40
105
250
200
5
10
20
30
40
50
Cumulative number of standard axles (in MSA)
GSB (mm)
GB (mm)
Binder course (mm)
Surface course (mm)

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