CBCS SCHEME

USN | | | | | | | | | | BCV403

Fourth Semester B.E./B.Tech. Degree Examination, June/July 2025
Transportation Engineering

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. M : Marks , L: Bloom's level , C: Course outcomes.

		Module – 1	M	L	C
Q.1	a.	Explain the role of transportation in social and economic development of country.	10	L2	CO1
	b.	Enumerate the steps for practical design of super elevation considering mixed traffic as per IRC guidelines.	10	L2	CO1
		OR			
Q.2	a.	Explain the factor affecting geometric design of highways.	10	L2	CO1
	b.	Calculate the safe stopping sight distance for design speed of 50 Kmph for i) Two way traffic on two lane road ii) Two way traffic on a single lane road Assume f = 0.37 and reaction time t = 2.5 Sec.	10	L3	CO1
		Module – 2			
Q.3	a.	Explain the desirable properties of road aggregates. List the various tests to access these properties.	10	L2	CO2
	b.	Explain the factors controlling design of flexible highway pavement.	10	L2	CO2
		OR			
Q.4	a.	With neat sketches, explain the following types of joints in CC pavement. i) Expansion Joint ii) Contraction Joint	10	L2	CO2
	b.	With neat sketches, explain the different methods of providing subsurface drainage system.	10	L2	CO2
		Module – 3			
Q.5	a.	What are the various road user characteristics? Explain any two characteristics.	10	L2	CO3
	b.	What are the different traffic engineering studies carried out for collecting traffic data? Explain any two methods.	10	L2	CO3

OR

Q.6	a.	What are the various methods of conducting speed and delay survey? Explain the floating car method of survey.	10	L2	CO3
	b.	Spot speed studies are carried out at a certain stretch of a highway with mixed flow and the consolidated data collected are given below :	10	L3	CO3

Speed rang Kmph	No. of vehicles observed	Speed range Kmph	No. of vehicles observed.
0 to 10	12	50 to 60	255
10 to 20	18	60 to 70	119
20 to 30	68	70 to 80	43
30 to 40	89	80 to 90	33
40 to 50	204	90 to 100	9

Determine

i) Upper and lower speed limits for regulations.

ii) Design speed for checking the geometric design elements of the highway.

Module – 4

Q.7	a.	What do you understand by a permanent way? Mention the requirement of an ideal permanent way.	10	L2	CO4
	b.	What are the functions and requirements of rails?	10	L2	CO4

OR

Q.8	a.	What are the functions and requirements of sleepers?	10	L2	CO4
	b.	What are the functions and requirements of ballast?	10	L2	CO4

Module – 5

Q.9	a.	What are the various factors considered in the selection of suitable site for airport?	10	L2	CO5
	b.	An airport is planned at an elevation of 380 m above MSL. The monthly mean of maximum and average daily temperature for the hottest month at the site are 40°C and 28°C respectively. The effective gradient is 0.18 percent. Determine the length of runway required at the proposed site if the basic runway length is 1900 m.	10	L3	CO5

OR

Q.10	a.	List and explain aircraft characteristics which affect planning and design of airport.	10	L2	CO5
	b.	What is wind rose diagram? Explain any one method of orientation of runway with wind rose diagram.	10	L2	CO5

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Q.1a. Explain the role of transportation in Socio economic development of nation.

a. Sectionalism and transportation: Improved transportation has important implication in reducing sectionalism with in the country & also outside the country. Under developed colonies and tribes are improving their living condition since the distances have apperently reduced.

b. Concentration of population in urban areas: The improved transportation network brings prosperity to the urban population. The prosperity and employment opportunities in urban areas attract the population from other areas resulting in economic enhancement for the activities. Adequate mass transportation facilities are needed to cater the internal movements.

c. Aspects of safety, Law and order: Transportation facilities are essential for rushing aids to areas affected by an emergency. To maintain law and order at home, it is required to have an efficient system of transportation network.

Q.16. Enumerate the steps for practicle design of super elevation considering mixed traffic conditions as per IRC guidelines.

Step 1). The super elevation for 75% of design speed is calculated neglecting friction

$$e = \frac{(0.75v)^2}{gR}$$

$$e = \frac{v^2}{225R}$$

Step 2). If the calculated value of e is less than 7% or 0.07 the value so obtained is provided If the value e as per equation exceeds 0.07 the provide the maximum super elevation equal to 0.07

Step 3). Check the co-efficient of friction developed for the maximum value of e = 0.07

$$F = \left(\frac{v^2}{gR} - 0.07\right)$$

Step 4). As an alternate step the allowable speed (v a m/sec, v a kmph) at the curve is calculated by considering the design co-efficient of lateral friction and the maximum super elevation

$$e + f = 0.07 + 0.15$$

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

Q. 2a. Factors affecting geometry design of highways.

a). Design speed.
b). Topography
c). Traffic factors
d). Design hourly volume & capacity
e). Environmental & other factors

a). Design speed: The most important factor controlling the geometry design elements of highways The design speed is decided in to account the overall requirements of highways.

b). Topography: The topography or the terrain condition influences the geometry design of highway significantly

c). Traffic factors: The factors associated with traffic that affect geometry design of road are the vehicular characteristics and human characteristics of road user.

d). Design hourly volume & capacity: The traffic flow or volume keeps fluctuating with time from a low value during off peak hours.

e). Environmental other factors: The environmental factors such as aesthetic, landscaping, air pollution noise pollution and other local condition should be given due consideration in design on road geometrics.

Q-2b. Calculate the safe stopping sight distance for design speed of 50 kmph for

a). Two way traffic on two lane road.

Stopping distance = Lag distance + braking distance

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

$v = 50$ kmph $= v = \frac{50}{3.6} = 13.9$ m/sec.

$t = 2.5$ sec $\quad f = 0.37$.

a). SSD 2 way 2 lane road

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

$$= \frac{13.9 \times 2.5 + (13.9)^2}{2 \times 9.81 \times 0.37}$$

$$= 34.8 + 26.60$$

$$= 61.4 \text{ m}.$$

b). SSD 2 way 1 lane road

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

$$= 61.4 \text{ m} \times 2$$

$$= 122.80 \text{ m}.$$

Three types of emulsions are prepared

a). Rapid setting (RS) - Surface dressing work

b). Medium setting (MS) - Premixing of coarse aggregate

c). Slow setting (SS) - Fine aggregate mixes.

Q.3b. Desirable properties of aggregate ✓

a). Strength: Strong to withstand the stresses due to traffic wheel load.

b). Hardness: Hard enough to resist the wear due to abrassive action of traffic.

c). Toughness: Aggregates should be strong enough against the sudden application of load.

d). Durability: Aggregate should be durable and resist disintegration due to the action of weather.

e). Shape of aggregate: Flaky aggregates are weak they cannot take much load.

3c. Importance of highway drainage

a). Excess moisture in soil subgrade causes considerable lowering of it's stability. The pavement is likely to fail due to subgrade failure.

b). Increase in moisture cause reduction in strength of many pavement materials like stablized soil and water bound macadam.

c). In some clayey soil variation in moisture content causes considerable variation in volume of subgrade

Rate of introduction of super elevation 1 in N = 1 in 150

$$Ls = EN/2 = 0.26 \times 150 = 39m$$

c). Minimum value of Ls as per IRC

$$= \frac{2.7v^2}{R} = \frac{2.7 \times 65^2}{220} = 51.9m$$

∴ Adopt the highest value of three 51.9 or 52m as the design length of transition curve

$$\text{Shift } S = \frac{Ls^2}{24R} = \frac{52^2}{24 \times 220} = 0.51m$$

Q.3a. Various application of bituminous emulsion

A bitumen emulsion is liquid product in which a substantial amount of bitumen is suspended in finely divided condition in an aqueous medium and stablized by means of one or more suitable materials.

Application :

a). When emulsion is applied on the road, it breaks down and the binder starts binding the aggregates through the full binding power develops slowly.

b). Emulsions are used in bituminous road constructions especially maintenance and patch repair works.

c). Emulsions can be used in wet weather even when it is raining.

d). Emulsion bave been used in soil stablization, particularly for the stablization of sand in desert area.

Step 5:- $F_2 = 0.133$, b/a

$$\frac{E_s}{E_p} = \frac{1}{80}$$

from graph, $b/a = 2.8$, $b = 2.8 \times 14.75$ (a)

$b = 42$ cms

∴ Thickness of pavement = $b = 42$ cms.

Q.No3a. List the design factors considered in the design of flexible pavement? Explain any 3. (08M)

a. Wheel load.
b. Axle configuration.
c. Tire contact pressure
d. Vehicle speed.
e. Repitation of Loads.
f. Subgrade type.
g. Temprature effect on pavement design.
i. Precipitation.

a. Wheel Load :→ Wheel load on pavement is an important factor to be determine the pavement thickness to be adopted. By providing adequate thickness the load coming from wheels doesn't affect the subgrade soil. The wheel load is acts at particular point on pavement & cause deformati

If the vehicle contains dual wheel on one side of axle, then convert it into equivalent single wheel load. Dual wheeled axle vehicle control the contact pressure with in limit.

b. Axle configuation :-

Axles are important part of vehicles which enables the wheels to rotate while moving, By providing multiple axle, vehicles can carry more load, so the axle load also influence the design of pavement.

c. Vehicle Speed :

If the vehicle is moving at creep speed then also damage occurs to the pavement. If the vehicle speed is gradually increased then it will cause smaller strains in the pavement.

Q.No 3b. Design a highway pavement (OBM) for a wheel load of 4100 kg with a tyre pressure of 5kg/cm² by Mc.Leod method. The plate bearing test carried on a subgrade soil using 30cm ϕ plate yeilded a pressure of 2.5 kg/cm² aflee 10 repitation of load as 0.5cm defletion.

b). One of the most important causes of pavement failures by the formation of waves and corrugations in flexible pavements is due to poor drainage.

c). The prime cause of failure in rigid pavement by mud pumping is due to the presence of water in fine subgrade.

Q.4a. List and explain types of joints used in rigid pavement.

a). Expansion Joint
b). Contraction Joint
c). Warping Joint
d). Construction Joint

a). Expansion Joint: These joints are provided to allow for expansion of the slab due rise in slab tempreture above the construction of the cement concrete. Expansion joints also permit the contraction joints slab.

b). Contraction Joint: Joints are provided to permit the contraction slab. These joints are spaced closer than expansion joint. Load transfer at the joint is provided through the physical interlocking by the aggregates projecting out at the joint faces.

(ii). Slope

The Longitudinal slope may be found using Mannings formula

$$V = 1/n \cdot R^{2/3} \cdot S^{1/2}$$

Assume roughness co-efficient n for clay = 0.02

velocity of flow v = 1.2 m/sec

∴ Area of trapezoidal section is $0.75\ m^2$

and the wetted perimeter is $\sqrt{0.45^2+(1.5\times0.45)^2}\times2+1.0$

$= 2.62m$

Hydraulic radius R = area/perimeter = 0.75/2.62

$= 0.286$

$$S^{1/2} = Vn/R^{2/3} = \frac{1.2\times0.02}{(0.286)^{2/3}} = 0.0553$$

Slope S = 0.0031 or 1 in 322.5

∴ Provide Longitudinal slope of 1 in 320.

Q.5a. Various load user characteristics:

The various factors which effect road user characteristics may broadly classified in to

Physical, Mental, Psychological and Environmental factors

Physical Characteristics:

Vision and Hearing

Vision: Plays important role of all these. These includes the acuity of vision, peripheral vision and eye moment glare vision, glare recovery and depth judgement.

Hearing: It is more important for pedestrains and cyclist.

Mental characteristics:

knowledge, skill, intelligence experience and literacy can affect the road user characteristics. knowledge of vehicle characteristics, traffic behaviour driving patience rules of roads and psychology of road user will be quite useful for safe traffic operation.

Psychological factors: These affect reaction to traffic situation of road user to a great extent.

Environmetal factors: Traffic stream characteristics, facilities to the traffic, atmospheric condition and the locality.

Q 5b. Let the original speed of the vehicle be v_1 m/sec, reduce to v_2 m/sec by applying brakes and skidding through $S_1 = 40m$, just after the collision, let both vehicles A and B start moving together with speed v_3 m/sec and finally stop $v_4 = 0$ after skidding through distance $S_2 = 12m$, $f = 0.5$

a). After collision:

$$\frac{(W_a + W_b)}{2g}(v_3^2 - v_4^2) = (W_a + W_b) f \cdot S_2$$

$$\therefore \frac{v_3^2}{2g} = 0.5 \times 12$$

$$v_3 = \sqrt{2 \times 9.8 \times 0.5 \times 12} = \sqrt{117.6} \text{ m/sec}.$$

b). At collision:

Momentum before impact = momentum after impact.

$$\frac{W_a V_2}{g} = \frac{(W_a + W_b) V_3}{g}$$

$$\frac{W_a + W_b}{W_a} = \frac{2+1}{2} = 3/2$$

$$V_2 = \frac{(W_a + W_b)}{W_a} V_3 = \frac{3}{2}\sqrt{117.6} \text{ m/sec.}$$

c). Before collision:

Loss of kinetic energy = Work done against braking force

$$\frac{W_a}{2g}(V_1^2 - V_2^2) = W_a \times f \times S_1$$

$$V_1^2 = 2gfS_1 + V_2^2 = 2 \times 9.8 \times 0.5 \times 40 + \frac{9}{4} \times 117.6$$

$$= 656.6$$

$$V_1 = 25.6 \text{ m/sec}$$

Original speed $V_1 = 3.6 \times 25.6 = 92.2$ kmph.

Q.6a. Various vehicular characteristics:

The various vehicular characteristics affecting the road design may be classified as static and dynamic characteristics of the vehicle.

a). Static characteristics:

The vehicles characteristics affecting the road design are dimension, weight and maximum turning angle. The height of the vehicle affects the clearance of the overhead structures. The height of driver affects the visibility distance and height of the head light affects the head light sight distance curves.

b). Dynamic characteristics:

The vehicles affecting road design are speed, acceleration and braking characteristics and some aspects of vehicle body design.

The speed and acceleration depends upon power of engine and the resistances to be overcome and are important in all the geometric design elements.

4. Vehicle dimension: The dimensions to be mainly considered are the overall width, height and length of different vehicles, particularly of the largest ones. The width of the vehicle affects the width of traffic lanes.

Q. 6b. Design traffic on load 1 = higher of the two approach volume per lane = 900/2 = 450 pcu/hr.

Design traffic on road 2 = 278 pcu/hr

a) Pedestrain green time for Road 1 = $\frac{12}{1.2}$ + 7.0 = 17 sec

Pedestrain green time for load 2 = $\frac{6.6}{1.2}$ + 7.0 = 12.5 sec

Green time for vehicles on Road 2, G_2 = 17.0 sec

b) Green time for Road 1 = $17 \times \frac{450}{278}$ = 27.5 sec.

c) Adding 2.0 secs. each towards clearence amber & 2.0 secs. intergreen period for each phase

total cycle required time = (2+17+2)+(2+27.5+2)
= 52.2 sec.

As signal cycle is multiple of 5 secs ∴ = 55 sec

The extra 2.5 sec per cycle may be appointed to the green time of load 1 & 2 as 1.5 and 1.0 sec

∴ G_1 = 27.5+1.5 = 29 sec G_2 = 17.0+1.0 = 18.0 sec.

6a. What are the various methods of conducting speed and delay survey? Explain the floating car method of survey.

a). Floating car method.
b). Average speed method.
c). License plate method.
d). Tag on car method.
e). Moving observer method.
f). House hold survey.
g). Video recording method.
h). GPS tracking method.

Explanation on floating car method:

The floating car method is commonly used technique in traffic engineering to measure average travel speed, journey time, traffic flow & delay on road section. In this method a test vehicle is driven along the traffic stream so that it floats with traffic.

a). Select road section to be studied.
b). Drive a test vehicle along the section in the direction of traffic flow
c). The driver maintains speed such that the vehicle floats with the traffic stream
d). An observer records
   i). Time taken to travel
   ii). Number of vehicles overtaken
   iii). Number of vehicles overtaking the test vehicle
e). Survey is repeated several times in both direction.

96b. Spot speed studies.

Speed range	x Midspeed	f	f%	Cumulative f%
1	2	3	4	5
0-10	5	12	1.41	1.41
10-20	15	18	2.12	3.53
20-30	25	68	8.0	11.53
30-40	35	89	10.47	22.0
40-50	45	204	24.0	46.0
50-60	55	255	33.0	76.0
60-70	65	119	14.0	90.0
70-80	75	43	5.06	95.06
80-90	85	33	3.88	98.46
90-100	95	9	1.06	100.0
			100.0	

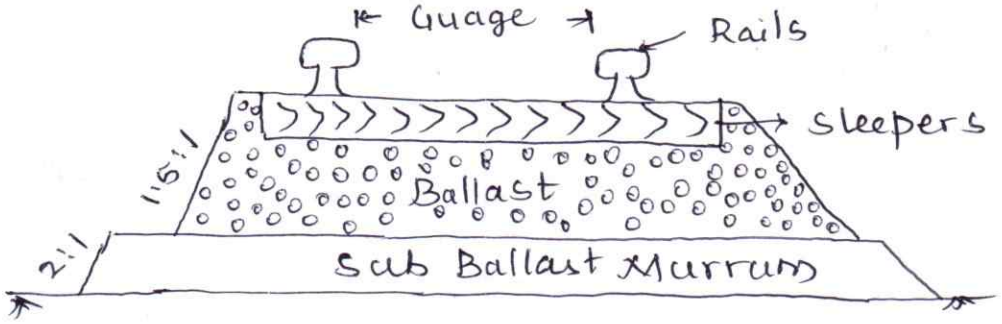
a). Upper speed limit for regulation
= 85th percentile speed
= 60 kmph

b). Lower speed limit for regulation
= 15th percentile speed
= 30 kmph

c). Speed to check design elements
= 98th percentile speed
= 84 kmph

Q.8a. Briefly Explain

a). Permanent Way:



The combination of rails, fitted on sleepers and resting on ballast and subgrade is called the railway track or permanent way.

Across curves, ballast is raised at one end and rails are raised at the same end to counteract the centrifugal force.

b). Railway station and Yards:

Railway station: Any place on a railway line where traffic is booked and dealt with and where an authority to proceed is given to the trains. In some situations, only one of these functions carried out and accordingly they are classified as flag stations and block stations.

Yards: A yard is a defined as system of tracks laid within definite limits for various purpose such as storing of vehicles, making up trains, dispatch of vehicles.

7b. What are functions and requirements of rails.

a). Functions of rails

i). Rail provide hard, smooth surface for movement of coaches

ii). It bears stress against the lateral loads

iii). The rail should give minimum wear to avoid replacement.

iv). It transmits load to sleeper and ballast to subgrade.

Requirements:

a). Should be of proper composition of steels & should be manufactured by duplex process.

b). Rails should be capable of withstanding lateral forces.

c). The head must be sufficiently deep against the wear of rail.

d). Foot should be wide so that it must be stable against overturning.

e). The tensile strength of the rail should not be less than 72 kg/m².

f). Relative distribution of material of rail in head, web & foot must be balanced.

6a. Functions and requirements of sleepers

functions:

a). To hold the rails to correct guages.

b). To hold the rails in proper level at 1 in 20 tilt in straight track.

c). To act as elastic medium in between the ballast and rails

d). To hold the fixtures & fastenings to the chairs & lateral to rails.

e). It adds lateral & longitudinal strength to the track.

Requirements of sleepers:

a). Should be economical, less initial cost & maintenace

b). Rigid & capacity should be max to carry load of uniform weight.

c). Weight should be moderate to ease of handling

d). Sleeper should be capable of resisting creep, buckling and kinks.

e). Placed with a proper spacing in the alignment for easy removal & replacement of ballast.

f). It should be designed such process it should not damaged during packing.

8b. What are the functions & requirement of ballast.

Functions:

a). It transfer the load from sleeper to subgrade

b). It holds sleepers in position & prevents lateral & longitudinal movement.

c). It provides uniform guages.

d). It provides good drainage to protect top surface of formation.

Requirements:

a). It should be able to withstand hand packing with out disintegration.

b). It should not make track dusty or muddy under dynamic wheel loads

c). It should allow for easy drainage.

d). It should offer resistance to abrasion & wear.

e). It should be available in near by quarries.

10a. Factors to be Considered for selection of an airport

a). Regional plan: The site selected for an airport should fit well into the regional plan.

b). Airport use: The selection of airport site mainly depends upon type of airport like international or national airport.

c). Proximity to the other airports: Proper distance should be maintained between two airports, so that proper take off & landing should take place.

d). Ground accessibility: The distance from origin place should not be more than 30 min. of travel through bus or car to the airport site.

e). Topography: Nature of land profile like ground contours, trees, stream etc. Hill top is considered.

f). Obstructions: Obstructions are minimised in an airport site to avoid the accidents. Just to gain or loose the speed. An extra area is provided on either side of runway known as approach area.

g) Visibility: Site should be free from fog and smoke, future growth of industries.

h). Wind: Wind pattern is studied as direction, duration and intensity for about 5 years.

i). Grading, drainage and soil characteristics:

Study of run off, drainage is done, water table pattern is also studied. Soil characteristics like gravels, sand of decomposed granites are used.

Q.9a. Aircraft characteristics affecting design of planning an airport.

a). Aircraft size and dimension

b). Weight of an aircraft.

c). Performance characteristics

d). Noise characteristics

e). Jet Blast

f). Fuel requirement

g). Aircraft category

a). Aircraft size:

Wingspan: Affects taxiway and runway separation

Length: Influences apron layout, taxiway radii.

Height: Affects hanger design.

b). Weight of an aircraft: Maximum take off weight determines pavement strength

Landing gear configuration: Affects runway wear and load distribution.

c). Performance characteristics:

Take off and landing distance; Impacts runway length

Climb and decent rate: Influences obstacle clearance

Approach speed: Affects runway occupancy time

d). Noise characteristics: Influences

Runway orientation and land use planning around airports. Environment impact assesments.

e). Jet Blast: Affects taxiway & runway spacing, design blast fences.

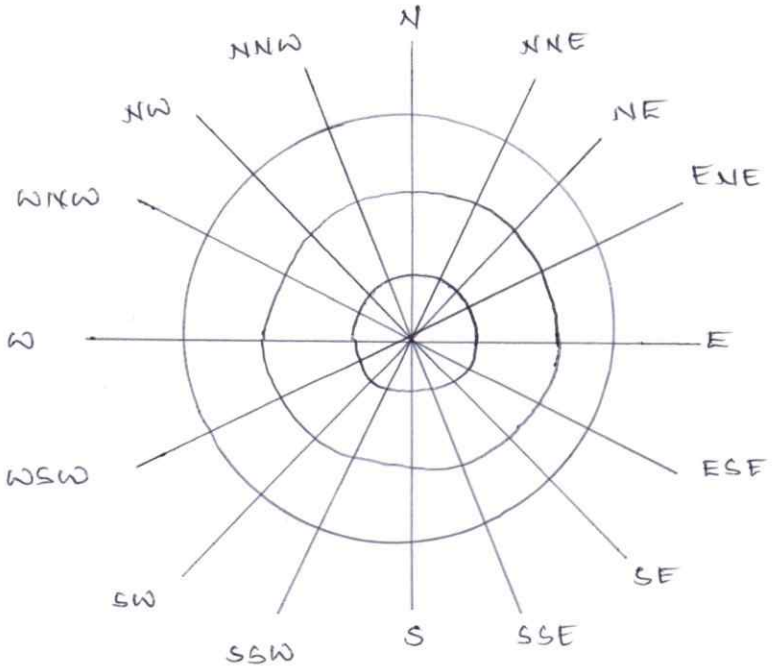
9b. Explain the details of wind rose diagram;

A wind rose diagram is a graphical tool used in airport planning and to represent the frequency and direction of winds at a specific location.

Purpose of wind rose diagram:

a). The optimal orientation of runway
b). The most common wind direction
c). The percentage of time wind blows in each direction
d). Crosswind and headwind components for safe aircraft operation.

e). Centre point represents calm winds (no significant wind direction)
f). Radial line represents wind directions
g). Length of radial line indicates frequency or percentage of total time wind comes from that direction.
h). Divided into 16 sectors representing 22.5° interval



Radial line indicates → Direction
Circles indicates → Duration & blocks indicates – Frequency.