CBCS SCHEME

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BCV403

Fourth Semester B.E./B.Tech Degree Supplementary Examination, June/July 2024

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 details of Jayakar committee and their recommendations.	10	L2	CO1
	b.	The speed of overtaking and overtaken vehicles are 70 and 40 kmph respectively on a two way traffic road. If the acceleration of overtaking vehicle is 0.99m/s^2. i) Calculate safe overtaking sight distance ii) Mention the minimum length of overtaking zone iii) Draw a neat sketch of overtaking zone and show the positions of sign posts.	10	L3	CO1
		OR			
Q.2	a.	List the types of road patterns. With usual notations draw any 4 road patterns.	10	L2	CO1
	b.	Calculate the length of transition curve and the shift using the following data : Design speed = 65 kmph Radius of circular curve = 220m Allowable rate of introduction of super elevation (pavement rotated about the centre line) = 1 in 150 Pavement width including extra widening = 7.5m.	10	L3	CO1
		Module – 2			
Q.3	a.	Explain the various applications of bituminous emulsion.	10	L2	CO2
	b.	Briefly explain the desirable properties of aggregates.	5	L2	CO2
	c.	Discuss the importance of highway drainage.	5	L2	CO2
		OR			
Q.4	a.	List and explain types of joints used in rigid pavement.	10	L2	CO2
	b.	The maximum quantity of water expected in one of the open longitudinal drain on clayey soil is 0.9m^3/s. Design the cross section and longitudinal slope of trapezoidal drain assuming the bottom width of trapezoidal section to be vertical : 1.5 horizontal. The allowable velocity of slow in the drain is 1.2m/s and Manning's roughness coefficient is 0.02.	10	L3	CO2
		Module – 3			
Q.5	a.	Explain the various road user characteristics.	10	L2	CO3
	b.	A vehicle of weight 2 tonnes skids through a distance equal to 40m before colliding with another parked vehicle of weight 1 tonne. After collision both the vehicles skids through a distance 12m before stopping. Compute the initial speed of the moving vehicle. Assume coefficient of friction as 0.5.	10	L3	CO3

		OR			
Q.6	**a.**	Explain the various vehicular characteristics.	**10**	**L2**	**CO3**
	b.	At a right angle intersection of two roads, road 1 has four lanes with a total width of 12m and road 2 has two lanes with a total width of 6.6 m. The volume of traffic approaching the intersection during design hour are 900 and 743 PCU/hour on the two approaches of Road 1 and 278 and 180 PCU/hour on two approaches of Road 2. Design the signal timings as per IRC guidelines.	**10**	**L3**	**CO3**
		Module – 4			
Q.7	**a.**	Explain : i) Coning of wheels ii) Tilting of roads.	**10**	**L2**	**CO4**
	b.	For 12.8m rail length of BG track, calculate the quantity of materials required per kilometer length of track. Assume sleeper density to be equal to M+4. Type of rail – 90R.	**10**	**L3**	**CO4**
		OR			
Q.8	**a.**	Briefly explain : i) Permanent way ii) Railway station and yards.	**10**	**L2**	**CO4**
	b.	If 8° curve track diverges from a main curve of 5° in an opposite direction in the layout of a BG yard, calculate the super elevation and the speed on the branch line, if the maximum speed permitted on the main line is 45 kmph.	**10**	**L3**	**CO4**
		Module – 5			
Q.9	**a.**	List and explain the aircraft characteristics affecting design and planning of airport.	**10**	**L2**	**CO5**
	b.	Explain the details of wind rose diagrams.	**10**	**L2**	**CO5**
		OR			
Q.10	**a.**	Explain the factors to be considered for selection of airport site.	**10**	**L2**	**CO5**
	b.	The length of runway under standard condition is 126.m. The airport site has an elevation of 270m. Its reference temperature is 32.90°C. If the runway is to be constructed with an effective gradient of 0.20 percent, determine the corrected runway length.	**10**	**L3**	**CO5**

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Q.1. a. Explain the details of Jayakar committee and their recomendations.

In order to report on the question of road developm
In India a committee is formed known as Jayakar committee.

Jayakar committee Recomendations:

i). The road development in the country should be considered as a national interest as this has become beyond the capacity of provisional govt. and Local bodies.

ii). An extra tax should be levied on petrol from the road users to develop a road development fund called "Central Road Fund".

iii). A semi Official technical body should be formed to pool technical known how from various parts of the country and to act as an advisory body on various aspects of roads.

iv). A research organisation should be instituted to carry out research and development work and to be available for constitution.

Implementations of Jayakar committee

a). Central Road Fund: 1929

b) Indian Road congress: 1934

c). Motor vehicle Act: 1939.

d). Central Road Research Institute: 1950

Q.1.b. The speed of overtaking overtaken vehicles are 70 and 40 kmph respectively on a two way traffic road. If the acceleration of overtaking vehicle is 0.99 m/sec²

i). OSD = $d_1 + d_2 + d_3$.

∴ ~~d1~~ V = 70 kmph = 19.44 m/sec V_b = 40 = 11.11 m/sec.

$a = 0.99\ m/sec^2$

$d_1 = V_b \times t = 11.1 \times 2 = 22.2\ m$

$d_2 = V_b \cdot T + 2S = 11.1 \times 7.47 + 2 \times 13.8 = 110.5\ m$

$S = (0.7V_b + 6) = (0.7 \times 11.1 + 6) = 13.8\ m$

$T = \sqrt{4S/a} = \sqrt{\frac{4 \times 13.8}{0.99}} = 7.47\ sec.$

$d_3 = VT = 19.4 \times 7.47 = 144.9\ m$

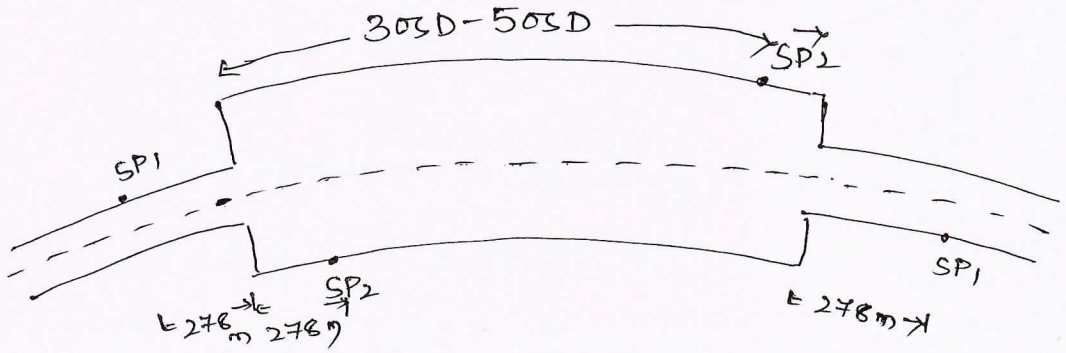
∴ OSD = $d_1 + d_2 + d_3$ = 22.2 + 110.5 + 144.9 m ≈ 277.6 = 278 m

ii). Minimum length of overtaking zone

$= 3(d_1 + d_2 + d_3) = 3 \times 278$

$= 834\ m$

iii). Neat sketch of overtaking zone



Q.2a. List the type of load patterns. With usual notations drawing 4 road patterns.

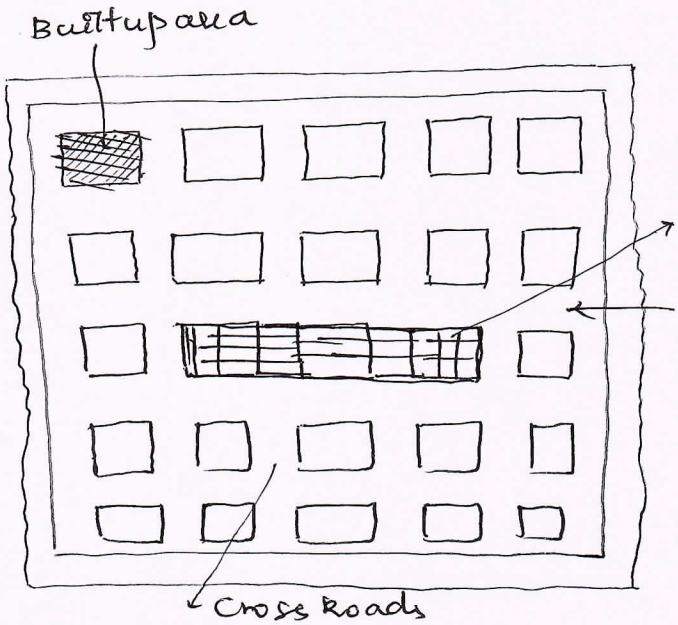
a). Rectangular Block Pattern

b). Radial star and block pattern

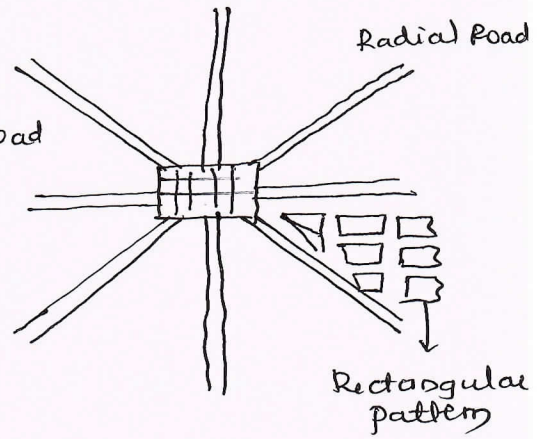
c). Radial star and Circular pattern

d). Radial star and Grid pattern.

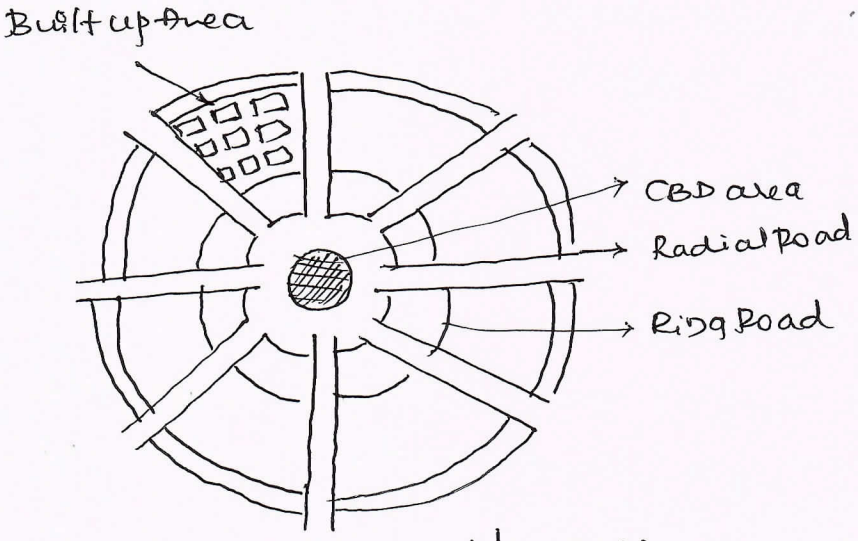
a).



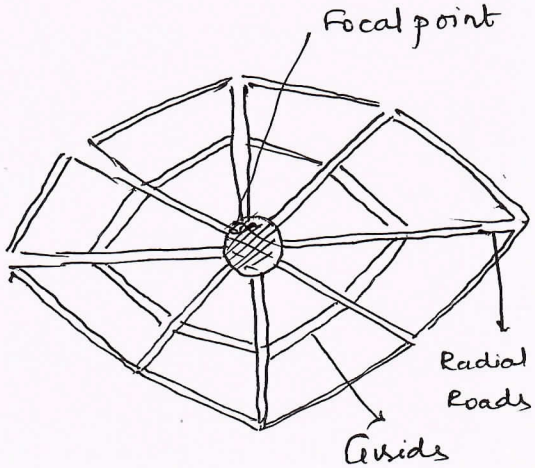
a). Rectangular Pattern (Block)



b). Radial star and Block pattern



c) Radial star & Circular Pattern



d). Radial star and Grid Pattern.

2b. Calculation of transition curve

Design speed = 65kmph, Radius of circular curve = 220m

Rate of super elevation = 1 in 150

Pavement width extra widening = 7.5m

a). Length of transition curve Ls as per allowable rate of centrifugal acceleration C

Allowable rate of change of centrifugal acceleration

$$C = \frac{80}{(75+v)} = \frac{80}{(75+65)} = 0.57 m/sec^3$$

The value 0.5 and 0.8 hence accepted

$$Ls = \frac{0.0215 v^3}{CR} = \frac{0.0215 \times 65^3}{0.57 \times 220} = 47.1 m$$

b). Length Ls by allowable rate of introduction of SE

$$e = \frac{V^2}{225R} = \frac{65^2}{225 \times 220} = 0.085$$

∴ As the value greater than 0.07, limit the value of e=0.07. Check for safety against transverse skidding

$$f = \frac{V^2}{127R} - e = \frac{65^2}{127 \times 220} - 0.07$$

$$= 0.15 - 0.07 = 0.08$$

As this value of f is less than the allowable value of 0.15. e=0.07 for design speed of 65kmph.

Total width of curve, B = 7.5m

Total raise of outer edge = $E/2 = eB/2 = \frac{0.07 \times 7.5}{2}$

$$= 0.26m$$

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

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

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

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

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.

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

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

v). 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.

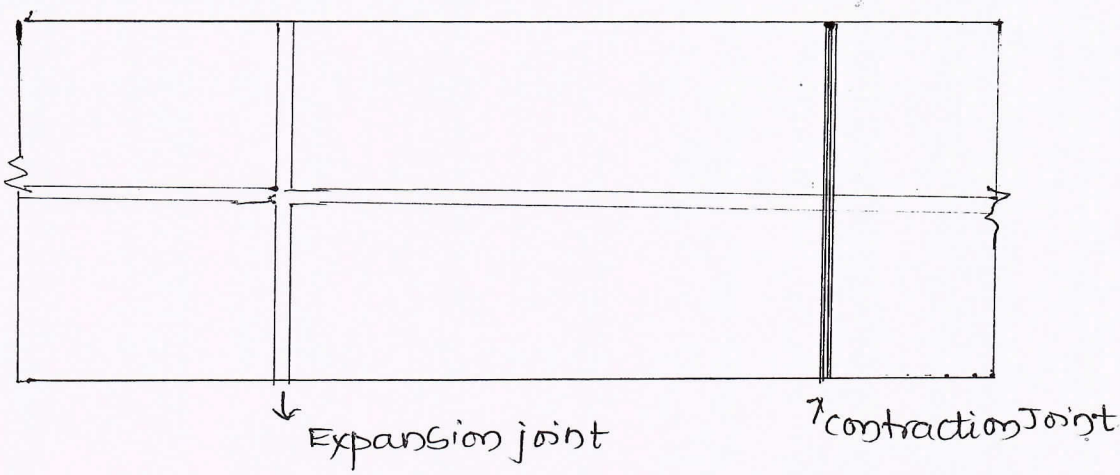
a). Expansion Joint
b). Contraction Joint
c). Warping Joint
d). Construction Joint

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.

c) Warping Joint: The warping joints are provided to reliere stresses included due to warping. These are known as binged joints. Longitudinal joints with tie bars fall in this class of joint.

a)



4b. b) Cross-Section

The allowable velocity of flow through the clay soil $v = 1.2$ m/sec.

Crossectional area of drain $A = Q/v = 0.9/1.2 = 0.75 m^2$

for trapazoidal section with bottom width 1.0m side slope 1.0 vertical to 1.5 horizontal, when depth of flow d meter, the top width would be $(1+3d)$ and the crossection area of drain $= (1+1+3d)\,d/2 = d + 3d^2/2$

$$d + 3d^2/2 = 0.75$$

$$1.5d^2 + d - 0.75 = 0$$

Solving the quadratic equation for d

$$d = \frac{-1 \pm \sqrt{1^2 - 4 \times 1.5(0.75)}}{2 \times 1.5} = 0.45m$$

∴ Allowing free board of 0.15m depth of side drain may be taken as $0.45 + 0.15 = 0.6m$

iv). 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.

Q5b. Let the original speed of the vehicle be v_1 m/sec, reduce to v_2 m/sec by applying brakes and skidding through $S_1 = 40$m, 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 $S_2 = 12$m, $f = 0.5$

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 at belly 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 road 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 road 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 = $\frac{17 \times 450}{278}$ = 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.

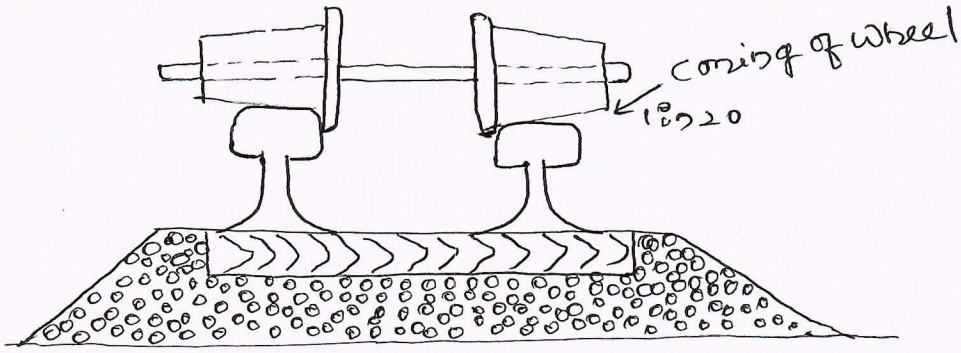
As signal cycle is multiple of 5 secs ∴ = 55 sec

The extra 2.5 sec per cycle may be appointed to the green time of road 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.

Q-7a. Explain the following

a). Coning of wheels:



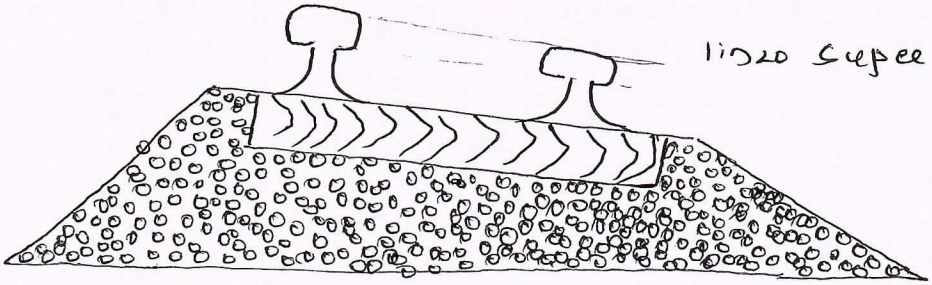
Coning of wheels is the outward sloping of the rim or flange of a wheel, usually at a ratio of 1:20. This slope helps keep train on track and allows wheels to cover different distances on curved tracks.

Benefits: a). Helps trains negotiate curve smoothly

b). Reduces friction between the wheels rim and the inner face of the wall.

b). Tilting of tracks:

Super Elevation is a common railway engineering practice where tracks are angled towards the inside of curves to help balance the centrifugal force that acts outward on trains, allowing them to safely travel at higher speeds without causing passenger discomfort or risking derailment.



1:20 Super Elevation.

Vehicle arrivals per lane cycle on Road 1

$450/55 = 8.2$ pcu

Minimum green time for clearing vehicles on Road

$= 6 + (8.2 - 1.0)\,2 = 20.4$ sec

Vehicle arrival per cycle on Road 2

$= 278/55 = 5.1$ PCU

Minimum green time for clearing vehicles on road 2

$= 6 + (5.1 - 1.0)\,2 = 14.2$ sec,

Lost time per cycle = amber + (inter green time lost for initial delay) for two phases $= (2+2+4) \times 2 = 16$ sec

Saturation flow for road 1 $= 525 \times 6 = 3150$ PCU/hr

Saturation of flow for road 2 $= 1850 + \frac{40 \times 3}{5} = 1874$ PCU/hr

$y_1 = 900/3150 = 0.286$ & $y_2 = \frac{278}{1874} = 0.148$

$y = 0.286 + 0.148 = 0.434$

Optimum cycle time $= C_0 = \frac{1.5L + 5}{1 - y}$

$= \frac{1.5 * 16 + 5}{1 - 0.434} = 51.2$ secs.

Road 1 Green = 29, Amber = 2, Red = (22+2) = 55sec

Road 2 Green = 18, Amber = 2, Red = (33+2) = 55sec

Q.7b. For 12.8m rail length of B.G track, calculate the quantity of materials required per kilometer length of track. Assume sleeper density to be equal to M+4. Type of rail - 90R.

i) No. of rails per km $= \frac{1000}{\text{Length of rail}} \times 2$

$= \frac{1000}{12.8} \times 2 = 156.2 = 157$ No's

ii) Weight of rails in tonnes per km

$= \text{No. of rails} \times \text{Length of rail} \times \frac{\text{wt. of rail}}{1000}$

$= \frac{157 \times 12.8 \times 44.7}{1000} = 89.82 \simeq 90$ tonnes.

iii) No. of Sleepers $= 1/2\ (\text{No of rails} \times (M+x))$

$= 157/2\ (12.8+4)$

$= 1319$ No's

iv) Fish plates = No. of fish plates 1km

$= 2 \times$ No. of rails

$= 2 \times 157$

$= 314$ No's.

v) Fish Bolts = No. of fish bolts

$= 4 \times$ No. of rails/km

$= 4 \times 157$

$= 628$ No's

vi) Bearing plates = $2 \times$ No. of sleepers

$= 2 \times 1319$

$= 2638$ No's

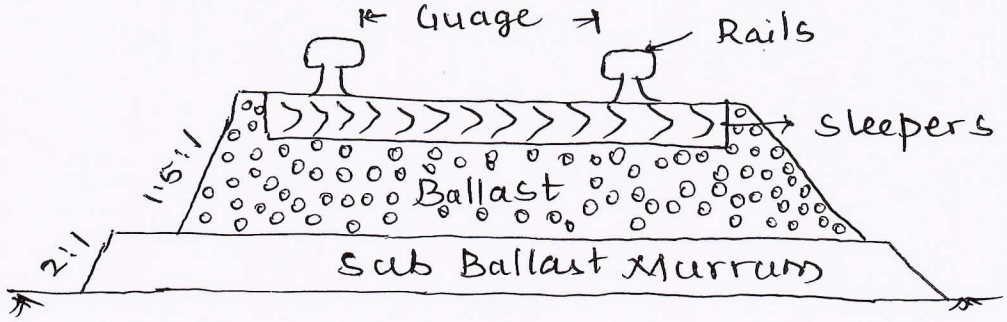
vii) No. of Dog Spikes = $4 \times$ No. of sleepers

$= 4 \times 1319$

$= 5276$ No's.

Q.8a. Briefly Explain

a). Permanent Way:



The combination of rails, fitted on sleepers and resting on ballast and subgrade is called the railway tracks 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 as 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.

8b. A 6 degree curve branches off from a 3 degree main curve in an opposite direction in the layout of a B.G yard. If the speed on the branch line is restricted to 35 kmph, determine the speed restriction on the main line. Assume permissible deficiency in cant as 76mm.

$\Rightarrow$ S.E for branch line $= 1.315 \frac{V^2}{R} = 1.315 \times \frac{35^2}{1719/6}$

$= 5.622$ cm

$\therefore$ Negative super elevation $= 5.622 - 7.60 = -1.978$ cm

$\therefore$ Maximum S.E that can be given on main line $= 1.978$ cm

$\therefore$ Theoretical S.E on main line $= 1.978 + 7.60 = 9.578$ cm

$\therefore$ Hence $9.578 = 1.315 \frac{V^2}{1719/3}$

$V = 65.64$ kmph, speed on main line

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 rates: 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.

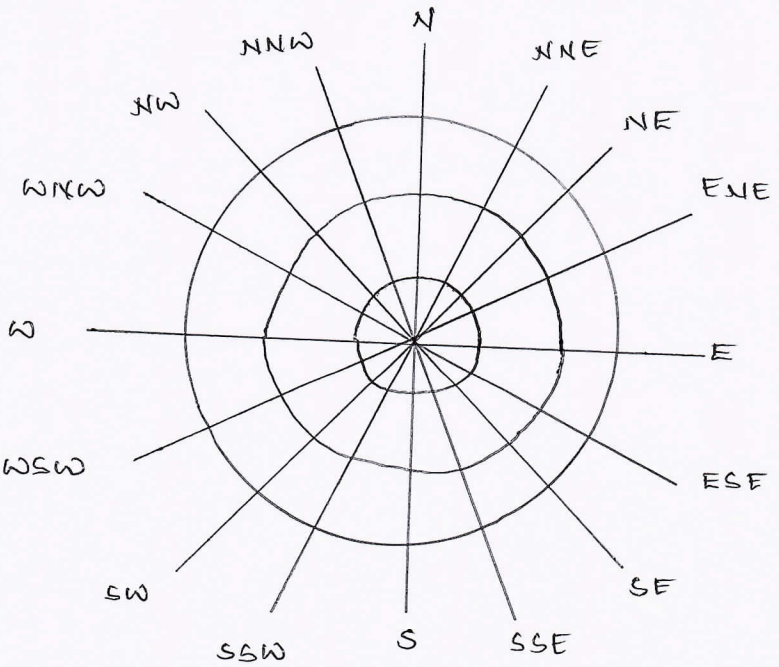
9b. Explain the details of wind rose diagram;

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° intervals



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

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, streams 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.

10b. Length of runway under standard condition is 1260
Elevation = 270m, reference tempreture = 32.90°C
Effective gradient = 0.20 percent

i). Correction for elevation = $\frac{7}{100} \times 1260 \times \frac{270}{300}$

$= \underline{79.38}$ m

Corrected length = 1260 + 79.38 = 1339.38m

ii). Correction for tempreture:

Determination for standard atmospheric tempreture

$= 15 - 0.00065 \times 270$

$= 14.82°C$.

Rise in tempreture - 32° - 14.82°C

$= 17.18°C$

Correction = $\frac{1339.38}{100} \times 17.18$

$= 230.10$ m

Corrected length = 1339.38 + 230.10 = 1569.48m

iii). Check for the total correction for elevation

$= \frac{1569.48 - 1260}{1260} \times 100$

$= 24.56\% < 35\%$ accepted.

iv). Check for gradient:

$= \frac{20}{100} \times 1569.48 \times 0.20 = 62.77$ m

∴ The total corrected runway length =

1569.48 + 62.77 = 1632m

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