Internal Assessment Test 1 – Sept. 2017

Solution

HIGHWAY GEOMETRIC DESIGN					Sub Code:	10CV755	Branch:	CIVIL
21/ 09 / 2017	Duration:	90 mins	Max Marks:	50	Sem / Sec:	VII (A & B)		

1 (a) Enumerate the concept of PCU in geometric design of highways. List out the factors governing PCU. Give some typical values as recommended by IRC for rural conditions.

Passenger Car Unit (PCU):

Different classes of vehicles such as cars, vans, buses, trucks, auto rickshaw, motor cycles, pedal cycles etc. are found to use the common roadway facilities without segregation. The flow of traffic with unrestricted mixing of different vehicle classes forms the _Mixed Traffic Flow'. In a mixed traffic condition, the traffic flow characteristics are very much complex when compared to homogeneous traffic consisting of passenger cars only. It is very difficult to estimate the traffic volume and capacity of roadway facilities under mixed traffic flow. Hence the different vehicle classes are converted to one common standard vehicle unit. It is common practice to consider the passenger car as the standard vehicle unit to convert the other vehicle classes and this unit is called Passenger Car Unit (or) PCU. Thus in a mixed traffic flow, traffic volume and capacity are generally expressed as pcu / hr (or) pcu / lane/ hr and traffic density as pcu / km length of lane.

Factors affecting PCU Values:

 Vehicles characteristics such as dimensions, power, speed, acceleration and braking characteristics.

 Transverse and longitudinal gaps (or) clearances between moving vehicles which depends upon speed, driver characteristics.

 Traffic stream characteristics such as composition of different vehicle classes, mean speed and speed distribution of mixed traffic stream, volume to capacity ratio etc.

 Roadway characteristics such as road geometrics includes gradient, curve etc., rural or urban road, presence of intersections and the types of intersections.

 Regulation and control of traffic such as speed limit, one-way traffic, presence of different traffic control devices etc. Environmental and climatic conditions.

PCU values suggested by IRC:

S. No	Vehicle Type	PCU
1.	Passenger Car, Pick up van or auto rickshaw	1
2.	Motor Cycle or scooter or cycle	0.5
3.	Agricultural tractor, Light Commercial Vehicle	1.5
4.	Truck or Bus	3
5.	Tractor-trailer , Agricultural Tractor- trailer	4.5
6.	Cycle- Rickshaw	2
7.	Hand Cart	3
8.	Horse Drawn Vehicle	4
9.	Bullock Cart Smaller bullock cart	6-8 6

2 (a). What is a design vehicle? Explain with a neat sketch. Indicate the IRC and AASHTO specifications with respect to dimensions and axle loads.

Design Vehicle

A 'Design vehicle' is a selected motor vehicle, the weight, dimensions and operating characteristics of which are used to establish highway design controls to accommodate vehicles of a designated type. The dimensions and operating characteristics of a vehicle influence the geometric design aspects such as radii, width of pavements, clearances, parking geometrics etc. the weight of axles and the weight of vehicles affect the structural design of the pavement and structures, as also the operating characteristics of vehicles on grades. Hence the standardization of the dimensions have been done to formulate the geometric design standards.

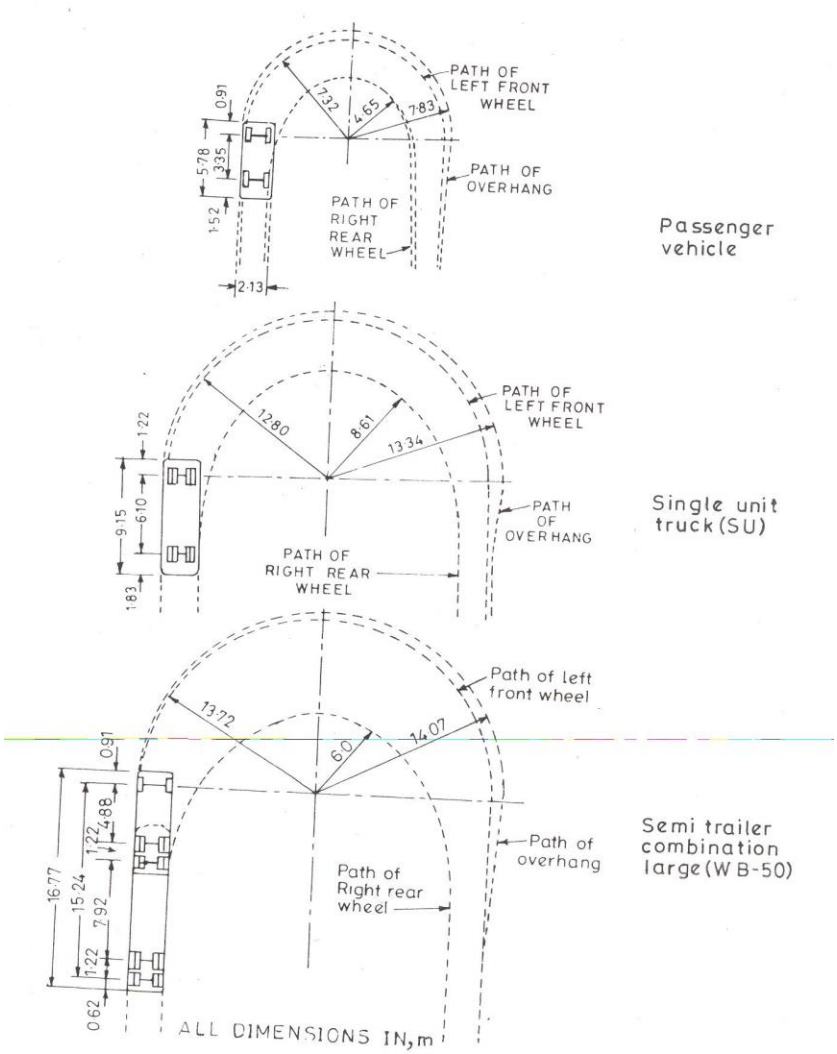


Table 6.5. Standards of dimensions for design vehicles by various authorities (in metres)

Authority / Country	*Maximum Width*	*Maximum Height*	*Maximum length*				
			Passenger car	*Single unit Truck*	*Semi Trailer*	*Truck Trailer*	*Single unit Bus*
AASHTO (USA)	2.59	4.12	5.8	9.14	16.8	8.91	
U.K.	2.5	4.57 (bus)	5.5	11.0	18.0	13.0	
IRC (1983)	2.5	3.8—4.2 (Truck) 4.75 (Double Decker Bus)	—	11.0	16.0	18.0	12.0

The turning radii for the various AASHTO design vehicles are given in Table 6.6.

Table 6.6. Turning radii of AASHTO design vehicle (in metres)

Design Vehicle Type	*Passenger Car (P)*	*Single Unit Truck (SU)*	*Semitrailer (large) (WB—50)*	*Semitrailerfull Trailer (WB—60)*
Minimum Turning Radius (m)	7.32	12.8	13.72	13.75
Minimum Inside Radius (m)	4.65	8.61	6.00	6.85

The turning radii for some of the vehicles in common use are given in Fig. 6.2.

6.3.4.4. Axle loads and weights of vehicles. The maximum axle loads of vehicles as per standards in some of the countries are given in Table 6.7.

Table 6.7. Maximum axle loads in different countries (tonnes)

	Single Axle	*Tandem Axle*
AASHTO (USA)	9.0	14.5
U.K.	10.0	—
IRC	10.2	18.0

The maximum weight of vehicles depends upon the number, configuration and spacing of axles.

(b) Explain the significance of design speed in the geometric design of a road. List the suggested design speed values for Rural Highways and Urban streets.

Design Speed

The design speed, is the single most important factor in the design of horizontal alignment. The design speed also depends on the type of the road. For e.g, the design speed expected from a National highway will be much higher than a village road, and hence the curve geometry will vary significantly.

The design speed also depends on the type of terrain. A plain terrain can afford to have any geometry, but for the same standard in a hilly terrain requires substantial cutting and filling implying exorbitant costs as well as safety concern due to unstable slopes. Therefore, the design speed is normally reduced for terrains with steep slopes.

Indian Road Congress (IRC) has classified the terrains into four categories, namely plain, rolling, mountainous, and steep based on the cross slope as given in table 1.

Based on the type of road and type of terrain the design speed varies.

TABLE 2. DESIGN SPEEDS

S. No.	Road classification	Design speed, km/h							
		Plain terrain		Rolling terrain		Mountainous terrain		Steep terrain	
		Ruling design speed	Minimum design speed	Ruling design speed	Minimum design speed	Ruling design speed	Minimum design speed	Ruling design speed	Minimum design speed
1.	National and State Highways	100	80	80	65	50	40	40	30
2.	Major District Roads	80	65	65	50	40	30	30	20
3.	Other District Roads	65	50	50	40	30	25	25	20
4.	Village Roads	50	40	40	35	25	20	25	20

3 (a) What is camber? What are the objectives of providing camber? Discuss the factors governing camber. Explain different shapes of camber with the help of neat sketches.

Camber:
Camber or cant is the cross slope provided to raise middle of the road surface in the transverse direction to drain of rain water from road surface.

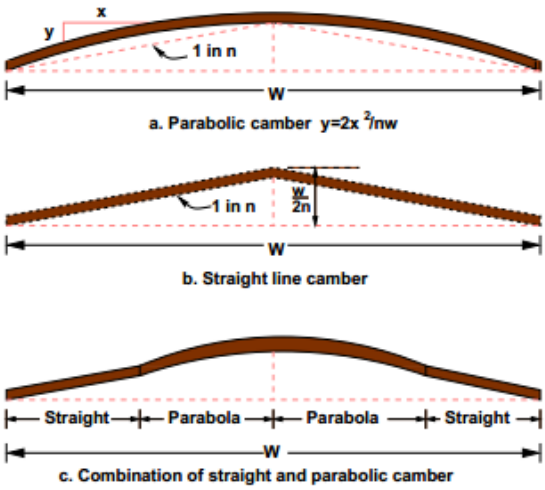
The objectives of providing camber are:
- Surface protection especially for gravel and bituminous roads
- Sub-grade protection by proper drainage
- Quick drying of pavement which in turn increases safety

Too steep slope is undesirable for it will erode the surface.

Factors affecting camber:

Camber is measured in 1 in n or n% (Eg. 1 in 50 or 2%) and the value depends on the type of pavement surface and the amount of rainfall

The common types of camber are parabolic, straight, or combination of them.



(b) Mention the various cross-sectional elements to be designed for a pavement. What is right of way? State the factors influencing right of way.

Cross-sectional elements:

- Camber
- Width of the pavement
- Shoulders
- Width of formation
- Right of way

Right Of way:

Right of way

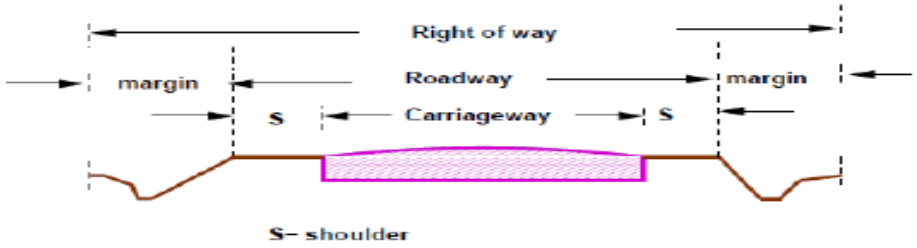
Right of way (ROW) or land width is the width of land acquired for the road, along its alignment. It should be adequate to accommodate all the cross-sectional elements of the highway and may reasonably provide for future development. To prevent ribbon development along highways, control lines and building lines may be provided. Control line is a line which represents the nearest limits of future uncontrolled building activity in relation to a road. Building line represents a line on either side of the road; between which and the road no building activity is permitted at all.

The right of way width is governed by:

- Width of formation: It depends on the category of the highway and width of roadway and road margins.
- Height of embankment or depth of cutting: It is governed by the topography and the vertical alignment.
- Side slopes of embankment or cutting: It depends on the height of the slope, soil type etc.
- Drainage system and their size which depends on rainfall, topography etc.
- Sight distance considerations: On curves etc. there is restriction to the visibility on the inner side of the curve due to the presence of some obstructions like building structures etc.
- Reserve land for future widening: Some land has to be acquired in advance anticipating future developments like widening of the road.

Road classification	Roadway width in m	
	Plain and rolling terrain	Mountainous and steep terrain
Open areas		
NH/SH	45	24
MDR	25	18
ODR	15	15
VR	12	9
Built-up areas		
NH/SH	30	20
MDR	20	15
ODR	15	12
VR	10	9

The importance of reserved land is emphasized by the following. Extra width of land is available for the construction of roadside facilities. Land acquisition is not possible later, because the land may be occupied for various other purposes (buildings, business etc.) The normal ROW requirements for built up and open areas as specified by IRC is given in table above. A typical cross section of a ROW is given in figure below.



S– shoulder

4 (a) Explain the various factors affecting skid resistance with necessary sketches. List the different methods of measuring skid resistance.

Factors affecting Skid resistance

Various factors that affect friction are:

- Type of the pavement (like bituminous, concrete, or gravel),
- Condition of the pavement (dry or wet, hot or cold, etc),
- Condition of the tyre (new or old), and
- Speed and load of the vehicle.

The frictional force that develops between the wheel and the pavement is the load acting multiplied by a factor called the coefficient of friction and denoted as f. The choice of the value of f is a very complicated issue since it depends on many variables. IRC suggests the coefficient of longitudinal friction as 0.35-0.4 depending on the speed and coefficient of lateral friction as 0.15. The former is useful in sight distance calculation and the latter in horizontal curve design.

Methods of Measuring Skid resistance

1. Stopping of test vehicle
2. Braking of trailers towed by vehicles
3. Braking of vehicles with a test wheel
4. Measuring sideway force that develops when a wheel placed at an inclination side-slips
5. Portable laboratory instrument

(b) Give the IRC recommendations for different values of camber. Determine the height of crown with respect to edges of road in the following cases: i) WBM road 3.8 m wide in low rainfall area. ii) WBM road 7.0 m wide in heavy rainfall area. iii) Bituminous road 7.5 m in heavy rainfall area

The values suggested by IRC for various categories of pavement is given in Table below.

Table 12:1: IRC Values for camber

Surface type	Heavy rain	Light rain
Concrete/Bituminous	2 %	1.7 %
Gravel/WBM	3 %	2.5 %
Earthen	4 %	3.0 %

- For WBM road 3.8m wide

Value of camber : 2.5% (1 in 40 for low rainfall)

Rise of crown w.r to edges

(3.8 / 2) * (1 /40) = 0.0475 m

- For WBM road 7.0m wide

Value of camber : 3% (1 in 33 for heavy rainfall)

Rise of crown w.r to edges

(7.0 / 2) * (1 /33) = 0.106 m

- For Bituminous Road 7.5m wide

Value of camber : 2% (1 in 50 for heavy rainfall)

Rise of crown w.r to edges

(7.5 / 2) * (1 /50) = 0.075 m