SSC-JE 2025

Staff Selection Commission

Junior Engineer Examination

Civil Engineering

Transportation Engineering

Well Illustrated **Theory** *with*

Solved Examples and **Practice Questions**

MADE EASY PUBLICATIONS

Transportation Engineering

Contents

Chapter 1

Highway Development and Planning

1.1 Introduction

1. **Roads:** Any hardened surface which can carry the load of moving vehicle is called road.
2. **Pavement:** Road made by number of layers is called pavement.
3. **Highway:** It is a special type of road which is designed for high speed of vehicle.
    - In order to maintain high speed highways are generally constructed over an embankment.
    - Roads over embankment has following advantages.
        (i) Lateral entry of vehicle/animal/public can be avoided.
        (ii) Safe from drainage point of view.

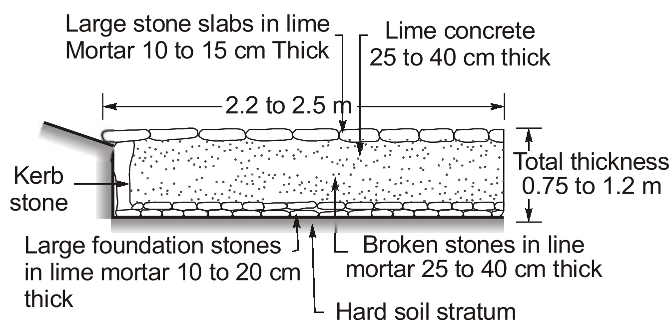
1.2 Development of Roads

Roman Roads

During this period of Roman civilization many roads were built of stone blocks of considerable thickness.

Main features of roman roads are:

(*i*) they were built straight regardless of gradient.
(*ii*) total thickness of the construction was as high as 0.75 m to 1.2 m.
(*iii*) they were built after the soft soil was removed and a hard stratum was reached.
(*iv*) the wearing course consisted of dressed large stone blocks set in lime mortar.



Typical cross section of Roman Road

Treseguet Construction:

Pierre treseguet developed an improved method of construction in France during 1764 AD.

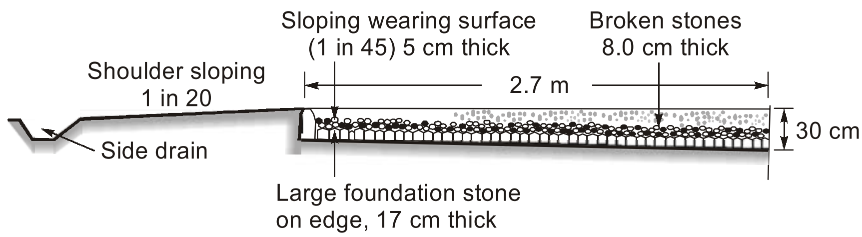
Main feature of the Treseguet construction are:

(i) Thickness of the road was order of 30 cm.

(ii) Consideration was given to subgrade moisture condition and drainage of surface water

(iii) The top wearing course was made up of smaller slope having a cross slope of 1 in 45 to the surface to provide surface drainage.

(iv) Shoulder sloping was also provided of the order of 1 in 20 to drain the surface water to the side drain.



Typical cross-section of Tresaguet's construction

Telford Construction:

His work started in early 19th century in England.

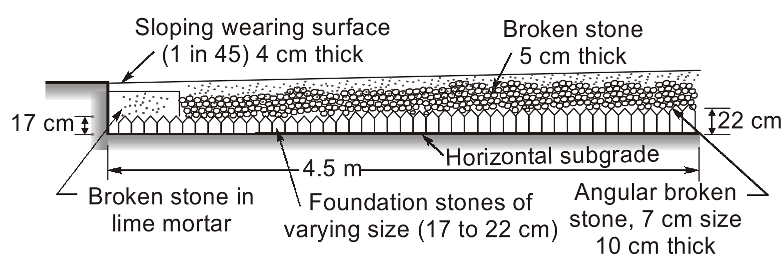
Main feature of the Telford construction:

(i) He proposed a level subgrade of width 9 m.

(ii) Thickness of foundation stone varied from 17 cm at edges to 22 cm at the centre.

(iii) A binding layer of wearing course 4 cm thick was provided with cross-slope of 1 in 45.

(iv) The central of about 5.5 m width was covered with two layers of angular broken stones to compacted thickness of 10 cm and 5 cm.



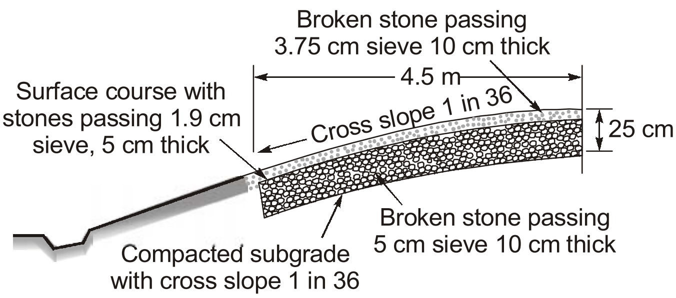
Typical cross-section of Telford's construction

Metcalf Construction:

Metcalf believed that a good road should have good foundations, be well drained and have a smooth convex (rounded) surface to allow rainwater to drain quickly into ditches at the side of the road.

Macadam construction:

- John macadam (1756 - 1836) put forward and entirely new method of road construction as compared to all the previous methods.
- Macadam was the first person who suggested that heavy foundation stones are not at all required to be placed at the bottom layer. He provided stones of size less than 5 mm to a uniform thickness of 10 cm.
- The importance to subgrade drainage and compaction was given so the subgrade was compacted and prepared with cross slope of 1 in 36. The size of broken stone for the top layers was decided on the basis of stability under animal drawn vehicles.
- The pavement surface was also given the cross slope of 1 in 36.
- Total thickness was kept uniform from edge to centre to a minimum of 25 cm.



Typical cross-section of Macadam's construction

1.3 Difference between Telford and Macadam Construction

The Macadam and Telford methods of construction differ considerably though both the methods were put forward in the early 19th century:

Macadam Method:

- The subgrade was given a cross slope of 1 in 36 to felicitate subgrade drainage.
- The bottom layer of pavement or the sub-base course consisted of broken stones of less than 5 cm size to uniform thickness equal to 10 cm only.
- Base and surface courses consisted of broken stones of smaller sizes to compacted thickness of 10 and 5 cm respectively and the top surface was given a cross slope of 1 in 36.
- The total thickness of pavement construction was kept uniform from edge to centre to a minimum value of only 25 cm.

Telford Method:

- The subgrade was kept horizontal and hence subgrade drainage was not proper.
- Heavy foundation stones of varying size, about 17 cm towards the centre were hand packed and prepared to serve as sub base course.
- Two layers of broken stones were compacted over the foundation stones before laying the wearing course, 4 cm thick with a cross slope of 1 in 45.
- The total thickness of construction varied from about 35 cm at the edge to about 41 cm at the centre.

1.4 Water bound Macadam (WBM):

In this method the broken stones of the base course and surface course are bounded by the stone dust in the presence of moisture.

1.5 Modern Road Developed In India

After the first world war, motor vehicles using the roads increased and demanded a better road network. So, British government passed a resolution in 1927, in response to which Jayekar Committee was consulted in 1927.

Recommendations of Jayekar Committee

(i) Road development should be considered as national interest.
Result: Participation of fund for road development.

(ii) An extra tax should be charged on petrol and diesel for road development and maintenance.
Result: Central road fund established in '1929'.

(iii) A technical body should be established for design and specification.
Result: IRC in 1934.

(iv) A research and development organization should be established for a new roads in India.
Result: CRRI- Central Road Research Institute Established in 1950.

(v) Jayakar Committee gives more stress for long term planning.
Result: Various 20 years plan.

First 20 years Road Plan (Nagpur Road Plan): (1943 - 1963)

Features: This plan was a major attempt in planning for road development in a scientific manner. The total road length of 5,32,700 km with a density of 16 km of road length per 100 km^2 area would be available by 1963. All the roads were classified into five categories.

(i) National Highway (NH)
(ii) State Highway (SH)
(iii) Major District Roads (MDR)
(iv) Other District Roads (ODR)
(v) Village Roads (VR)

They recommended the construction of star and grid pattern of roads throughout the country. They recommended development allowance of 15%. Nagpur plan give formula for road length of different classes, considering the geographical, agricultural and population conditions.

(i) Length of national highway and state highway and major district roads (in miles):

$$= \frac{A}{5} + \frac{B}{20} + N + 5T + D - R$$

where,
B = Non-agricultural area in (sq. miles)
N = Number of towns and villages having a population of 2000 - 5000
T = Number of towns and villages having a population of over 5000.
D = An allowance for agricultural and industrial development.
R = Railway mileage in the area under consideration.

(ii) Length of other district and village roads (in miles):

$$= \frac{V}{5} + \frac{Q}{2} + R + 2S + D$$

where, Q = Number of villages with population 501-1000.
R = Number of villages with population 1001-2000.
S = Number of villages with population 2001-5000.
D = An allowance for agricultural and industrial development during the next 20 years.

Second 20 years Road Plan (Bombay Road Plan): (1961 - 1981)

Features:

(i) At the end of plan, the target road length was 32 km per 100 sq. km area.
(ii) Maximum distance of any place in a developed or agricultural area would be 6.4 km from a metalled road and 2.4 km from any category of roads.
(iii) 1600 km expressways have been considered in this plan within proposed target of national highway.
(iv) Every town with a population above 2000 in plans and above 1000 in semihilly areas and above 500 in hilly areas should be connected by metalled road.
(v) A development allowance of 5% is provided for future developments.
(vi) Traffic engineering cells should be established in each state.

Third 20 years Road Plan (Lucknow Road Plan): (1981 - 2001)

Features:

(i) In this plan roads are classified into primary, secondary and territory road system.

(ii) All village with over 500 population should be connected by all weather roads.

(iii) The overall road density was targeted as 82 km per 100 sq. km area.

(iv) The NH network should be expanded to form square grids of 100 km sides so that no part of the country is more than 50 km away from a NH.

(v) 2000 km expressway have been considered in this plan along major traffic corridors to provide fast travels.

Primary Road: (EH + NH) → (Express highway + National highway)

Secondary Road: (SH + MDR) → (State highway + Major District Road)

Tertiary Road: (ODR + VR) → (Other district road + Village road)

Note: Total length of national highway is approximately about 90000 km which is just 2% of total road length. Which carries 40% of total traffic.

Road lengths as per 3rd 20 year road plan:

(i) $$\text{Total length of road (km)} = \max \begin{cases} 4.74 \times (\text{No. of towns + village}) \\ \text{or} \\ \text{Road density} \times \text{Area} \end{cases}$$

(ii) $$\text{Length of NH (km)} = \frac{\text{Area (km}^2)}{50}$$

(iii) $$\text{Length of SH(km)} = \max \begin{cases} \dfrac{\text{Area (km}^2)}{25} \\ \text{or} \\ 62.5 \times \text{No. of town} - \text{NH length} \end{cases}$$

(iv) $$\text{Length of MDR(km)} = \max \begin{cases} \dfrac{\text{Area (km}^2)}{12.5} \\ \text{or} \\ 90 \times \text{No. of town} \end{cases}$$

Example 1.1 Area of Maharashtra is 308,000 km^2 number of towns is 216 and number of villages 41833. Find out the length of all the roads according to 3rd 20 years road plan.

Solution:

Given: Area = 308 000 km^2

$$\text{Number of towns} = 216$$
$$\text{Number of villages} = 41833$$

$$\text{Total length of road} = \max \begin{cases} 4.74 \times (216 + 41833) = 199312.26 \text{ km} \\ \text{or} \\ \dfrac{82}{100} \times 308000 = 252560 \text{ km} \end{cases}$$

$$= 252560 \text{ km}$$

$$\text{Length of NH (km)} = \frac{\text{Area (km}^2)}{50} = \frac{30800}{50} = 6160 \text{ km}$$

$$\text{Length of SH(km)} = \max\begin{cases}\dfrac{\text{Area (km}^2)}{25} = \dfrac{308000}{25} = 12320 \text{ km} \\ \quad \text{or} \\ 62.5 \times 216 - 6160 = 7340 \text{ km}\end{cases}$$

$$= 12320 \text{ km}$$

$$\text{Length of MDR(km)} = \max\begin{cases}\dfrac{\text{Area (km}^2)}{12.5} = \dfrac{308000}{12.5} = 24640 \text{ km} \\ \quad \text{or} \\ 90 \times 216 = 19400 \text{ km}\end{cases}$$

$$= 24640 \text{ km}$$

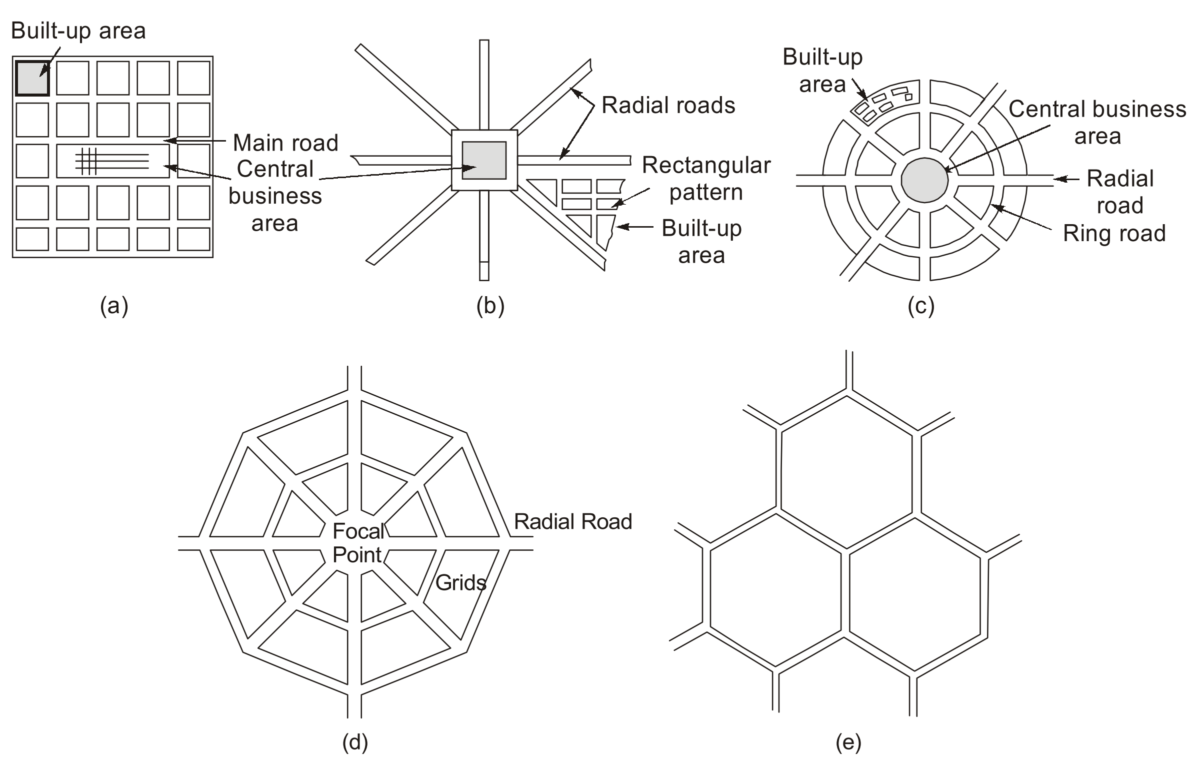
Primary Road: (NH + EH) $\rightarrow$ 6160 + 0 = 6160 km

Secondary Road: (SH + MDR) $\rightarrow$ 12320 + 24640 = 36960 km

Rural Road: (Total length) – (Primary + secondary) = 252560 – (6160 + 36960) = 209440 km

1.6 Road Patterns

The various road patterns may be classified as follows:



(a) Rectangular or Block pattern (b) Radial or Star and Block pattern
(c) Radial or Star and Circular pattern (d) Radial or star and Grid pattern and (e) Hexagonal pattern

- The rectangular pattern has been adopted in the city roads of Chandigarh. Radial and circular pattern is the road network of Cannaught place in New Delhi.

1.7 Engineering Survey for Highway Locations

Before highway alignment is finalized engineering survey are to be carried out in following stages.

(i) **Map study:** Different alignment are drawn on map (contour, topographical and cadastral), crossing minimum number of obstruction and passing maximum utilization area.

(ii) **Reconnaissance:** It is done by visiting at sites locations for detailing of features which are not available on map.

(iii) **Preliminary survey:** Chain survey, traverse survey, levelling work and other various survey are done along with → soil investigation, traffic study, and drainage study.

- Survey alignment is finalized in the preliminary survey.

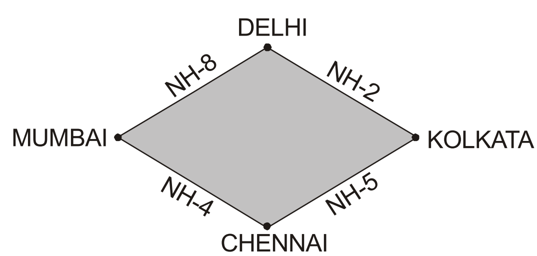
(iv) **Detailed survey:** Planning, designing, material estimation, cost estimation are done along finalized alignment and a DPR is prepared.

1.8 National Highway Development Program (NHDP)

It consists the following program:

Before highway alignment is finalized engineering survey are to be carried out in following stages.

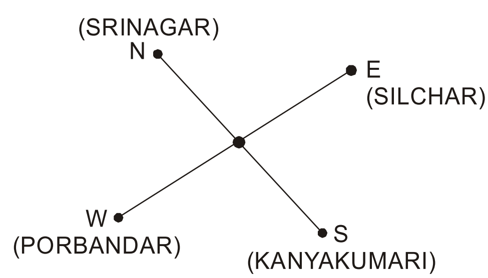
(i) Golden quadrilateral: (Delhi -Mumbai-Chennai-Kolkata)



Golden quadrilateral

Total length of highway in golden quadrilateral is approximately 4500 km.

(ii) North-South and East-West corridor: Srinagar to Kanyakumari and slichar to Porbander



Total length of highway in N-S and E-W corridor is approximately 7250 km.

1.9 Concept of Saturation System and Maximum Utility System

This system is used to find optimum road length. It depends upon length of road, population and production.

Rules to provide utility value:

(i) Provide utility value of 0.5 to lowest population range and increase it as multiple of 2 for next population range.

(ii) Provide utility factor of 1 to production.

Example 1.2 Four new roads P, Q, R and S are planned in a district. The data for these roads are given below:

Road Lines	Length (km)	Number of towns and villages served with population ranges				Total production in 1000 tonnes
		1001 - 2000	2001 - 5000	5001 - 10000	> 100000	
P	300	160	80	30	6	200
Q	400	200	90	60	8	270
R	500	240	110	70	1	315
S	500	248	112	73	1	355

Based on the principle of maximum utility, find out the order of priority for these four roads.

Solution:

$$\text{Utility per unit length for } P = \frac{160\times0.5+80\times1+30\times2+6\times4+200\times1}{300} = 1.48$$

$$\text{For } Q = \frac{200\times0.5+90\times1+60\times2+8\times4+200\times1}{400} = 1.53$$

$$\text{For } R = \frac{240\times0.5+110\times1+70\times2+1\times4+315\times1}{500} = 1.37$$

$$\text{For } S = \frac{248\times0.5+112\times1+73\times2+1\times4+355\times1}{500} = 1.482$$

Priority order: $Q > S > P > R$

■■■■

STUDENT'S ASSIGNMENTS

Q.1 The star and grid pattern of road network was adopted in
(a) Nagpur road plan
(b) Lucknow road plan
(c) Bombay road plan
(d) Delhi road plan

Q.2 The construction of 'expressway' was planned for first time in _______.
(a) Jayakar Committee
(b) Bombay plan
(c) Nagpur road plan
(d) Lucknow plan

Q.3 Consider:
1. Creation of central road fund.
2. National Highway Act
3. Formation of Indian Road Congress
4. Creation of Highway Research Board

The correct chronological order of these events is ________
(a) 4, 3, 2, 1 (b) 2, 1, 3, 4
(c) 1, 3, 2, 4 (d) 2, 3, 1, 4

Q.4 The saturation system of development of optimum road length is based on
(a) Population only
(b) Population and agricultural productivity
(c) Agricultural and industrial productivity
(d) Population and productivity of both agricultural and industrial sectors.

Q.5 The new roads P, Q and R are planned in a district. The data for these roads are given below in the table. Based on the principle of maximum utility the order of priority for these three roads should be______

Road	Length (km)	Number of villages with		Population
		< 2000	2000 - 5000	> 5000
P	20	8	6	1
Q	28	19	8	4
R	12	7	5	2

(a) P, Q, R (b) Q, R, P
(c) R, P, Q (d) R, Q, P

Q.6 According to the recommendations of Nagpur conference the width formation of an ideal national highway in hard rock cutting is_____.
(a) 8.9 m (b) 7.9 m
(c) 6.9 m (d) 6.5 m

[SSC-JE: 2017]

Q.7 The length of national highway as per 3rd 20 years (Lucknow) road plan is given by
(a) Area of the country/75
(b) Area of the country/50
(c) Area of the country/40
(d) Area of the country/25

Q.8 The road foundation for modern highway construction was developed by
(a) Treseguet
(b) Telford
(c) Macadam
(d) Macadam and Telford Simultaneously

ANSWER KEY / STUDENT'S ASSIGNMENTS

1. (a) **2.** (b) **3.** (c) **4.** (d) **5.** (d)
6. (b) **7.** (b) **8.** (d)

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5. (d)

Utility per unit length

$$\text{For P} = \frac{8\times0.5+6\times1+1\times2}{20} = \frac{12}{20} = 0.6$$

$$\text{For Q} = \frac{19\times0.5+8\times1+4\times2}{28} = \frac{25.5}{28} = 0.91$$

$$\text{For R} = \frac{7\times0.5+5\times1+2\times2}{12} = 1.04$$

∴ Priority order, $R > Q > P$

■■■■

CHAPTER 2

Geometric Design of Highway

2.1 Introduction

This unit contents the principle of road layouts. A highway has many visible dimensions and the design of visible dimensions is known as Geometric Design. These visible dimensions are:

(i) Cross sectional elements
(ii) Sight distance considerations
(iii) Horizontal alignment
(iv) Vertical alignment

2.2 Factors Controlling Geometric Design

There are certain basic design controls and criteria which govern the geometric features of a highway.

(i) Topography
(ii) Design speed
(iii) Road user characteristics
(iv) Vehicle characteristics
(v) Traffic (its volume, directional distribution and composition including the future estimates)
(vi) Traffic capacity
(vii) Environmental considerations
(viii) Economy in construction, maintenance and operation of vehicles

Topography

The topography of the land, through which the road passes, also known as the terrain, controls the geometric design.

Terrain classification				
S.No.	1.	2.	3.	4.
Type of Terrain	Plain	Rolling	Mountain	Steep
Cross-slope of country(in %)	0 - 10	10 - 25	25 - 60	> 60

Design Speed

Most important factors for controlling the geometric design elements of highway.

- Factors considered in India for deciding design speeds are:
  (i) Importance of road (ii) Terrain or topography

For rural highway two types of design speeds

(i) Ruling design speed: The speed that should generally be considered as guiding extension for correlating the various design factures.

(ii) **Minimum design speed:** The speed that should be adopted in sections where site conditions or economics do not permit a design based on the ruling design speed.

Design speeds in kmph as per IRC (Ruling and minimum)

Ruling and minimum				
Type of road	**Plain**	**Rolling**	**Hilly**	**Steep**
NH & SH	100 - 80	80 - 65	50 - 40	40 - 30
MDR	80 - 65	65 - 50	40 - 30	30 - 20
ODR	65 - 50	50 - 40	30 - 25	25 - 20
VR	50 - 40	40 - 35	25 - 20	25 - 20

2.3 Highway Cross-section Elements

These are the features of the cross-section of the pavement that affects the life of pavement, riding comfort and safety.

- Following are the cross-sectional elements of the pavement:
  - (i) Right of way
  - (ii) Width of formation
  - (iii) Road margins
  - (iv) Medians
  - (v) Kerbs
  - (vi) Width of pavement or carriageway
  - (vii) Camber or cross slope
  - (viii) Pavement characteristics

Pavement Characteristics

(a) **Friction:** Friction between wheel and pavement surface is a crucial factors in the design of horizontal curves and thus the safe operating speed. Further it also affects the acceleration and deceleration ability of vehicles.

(i) Longitudinal friction: Due to frictional force developed in horizontal direction.

- This friction supports movement of vehicles.
- As per IRC, f_{longi} = 0.35 – 0.4

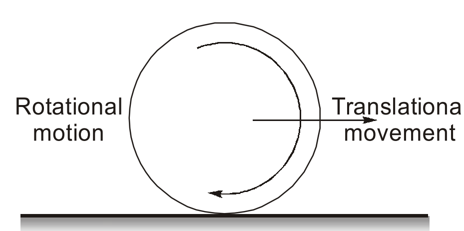
NOTE

- Higher the speed of vehicle, lower the coefficient of longitudinal friction due to less area of contact.
- On dry pavement old tyre generates more coefficient of friction than a new tyre due to large area of contact. However on wet pavement condition is reversed because water acts as a lubricating agent.

(ii) Lateral friction: Frictional force developed in transverse direction to vehicle movement. This friction comes in picture only when there is a curve on road. As per IRC $f_{lateral}$ = 0.15.

(b) Skid and slip:

- Skid: During brake, (Rotational motion < Translations motion)
- Slip: During acceleration (Rotational motion > Translations motion)



Skid and Slip

(c) Pavement Uneveness:

- Measured by unevenness index which is the cumulative vertical undulations of the pavement surface per unit horizontal length of road (cm/km).

- It should be low.
- For good pavement: (150 cm/km)
- (250 cm/km) is satisfactory for design speed of 100 kmph.

NOTE: It is measured by using roughometer and bump integrator (developed by CRRI).

$BI = 630\ [IRI]^{1.12}$

IRI - (International : BI-Bump integrator roughness index)

(i) As per IRC, if bump integrator is more than 320 cm/km then road is considered as uncomfortable. In this case reconstruction of road required.

Camber

It is the cross slope provided to road by elevating the centre line in order to allow the flow of water from surface to drainage system.

Functions: To drain off the rain water from road surface.

- Better surface drainage is important from considerations of:
  (i) Prevention of entry of surface water into sub-grade soil through pavement.
  (ii) To make the surface dry soon after the rain so that skid resistance does not reduce.
  (iii) Designation:
  As 1 in n
  or (1V = nH) or as percentage(%)
  Ex: Camber = 4% = $\frac{4}{100}\left(\frac{1}{25}\right)$ or 1 in 25 or 1 V : 25 H or (0.04) or 1/25
- Factors:
  (i) Type of pavement surface
  (ii) Amount of rainfall

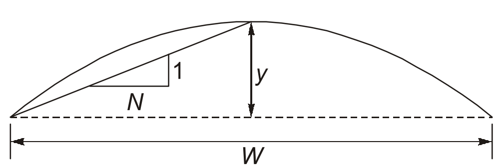
As per IRC

Amount of rainfall		
Surface type	**Heavy rainfall**	**Light rainfall**
High type bituminous surfacing or cement concrete	2%	1.7%
Thin bituminous surfacing	2.5%	2%
Water bound macadam	3%	2.5%
Earth	4%	3%

Types of Camber based on shape

(i) **Parabolic Camber:**

Equation $y = \frac{2x^2}{NW}$

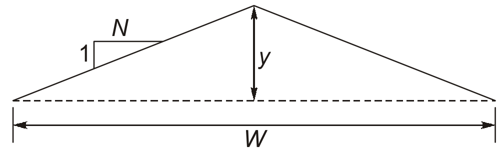


Parabolic Camber

Merits: Profile will be flat at the middle and steeper towards the edges. It is preferred for fast moving vehicles as then have to frequently cross the crown line during overtaking operation.

Demerits: Since steeper at edges slow moving vehicles have a tendency to overturn inside and hence try to occupy the central portion of the roadway, resulting in reduction of traffic capacities.

(ii) **Straight line camber:** Generally in cement concrete pavements, the wheels does not have contact at centre when straight camber is provided or when vehicle is on a curved slope

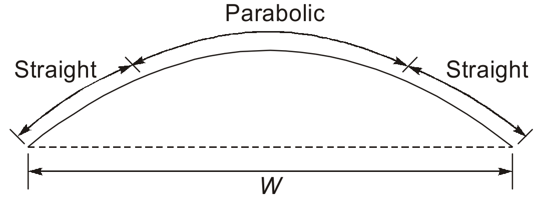


Straight line camber

Merits: Uniform cross slope on either side of centre, comfortable for slow moving vehicles.

Demerits: Discomfort for fast moving vehicles which have a tendency to overtake slow moving vehicles by crossing the centre line, which is a sharp point, resulting in jerk. Further the road is likely to get damaged at the centre, since stress intensity is high because of sharp point of negligible area.

(iii) **Combination of straight and parabolic:** This is particularly useful to increase the area of contact of the wheel and thus decrease the contact straight pressure in case of animal drawn vehicles with steel types occupying different lateral positions of the pavement



Combination of straight and parabolic

- It has the positive points of both parabolic and straight cambers. i.e. comfortable for both slow and fast moving vehicles and less damage to the road.

NOTE

Relation between longitudinal gradient and camber: For better drainage and smooth flow of traffic, the camber(C) of the road should be approximately equal to half of longitudinal gradient (G) i.e. $G = 2C$.

- Superior the road flatter the camber
- The cross slope for shoulder should be 0.5% steeper than the cross slope of adjoints pavements, subject to an minimum of 3%.

Example 2.1 In a district load where the rainfall is heavy major district of WBM pavement, 3.8 m wide and a state highway of bituminous concrete pavement 7.0 m wide are to be constructed, what should be the height of crown with respect to the edges in these two cases.

Solution:

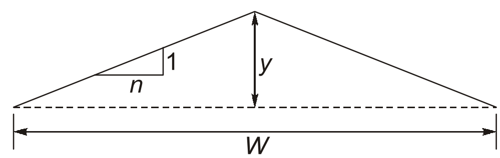
For WBM road,

As the rainfall is heavy, Camber = 3% (1 in 33)

∴ Rise of camber with respect to edges $= \frac{W}{2n} = \frac{3.8}{2 \times 33} = 0.058$ m

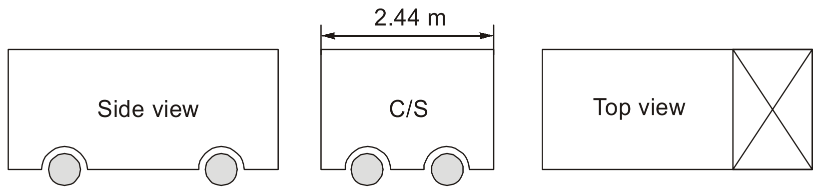
(For Bituminous concrete road): provide a cross slope of 2% (1 in 50)

∴ Rise of crown with respect to edges $= \frac{W}{2n} = \frac{7}{2 \times 50} = 0.07$ m



Width of Pavement or Carriage Way

The maximum width of vehicle as per IRC is 2.44 m.



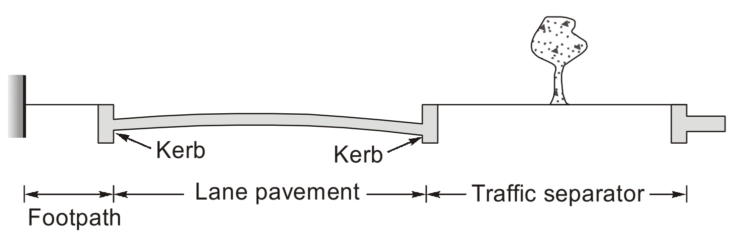
Pavement and Carriage way

S.No.	Classification	Width of carriageway
1.	Single lane	3.75 m for all roads
2.	Two lanes without raised kerb	7.0 m
3.	Two lanes with raised kerb	7.5 m
4.	Intermediate carriageway	5.5 m
5.	Multilane pavements	3.5 m per lane

Note: The width of pavement is increased on horizontal curves, to take care of off tracking and psychological effects called extra widening.

Traffic Separators or Medians/Kerb

Kerbs: Kerb is boundary between pavement and footpath. It provides lateral support to the pavement.



Kerbs

Medians: It separates road traffic moving in opposite direction so that chances of head on collision can be reduced. It also reduce the glaring effect due to head light of vehicle coming from opposite direction in night.

As per IRC: Minimum width of divider/medians required for highway is 5 m. When space is restricted than provide 3 m.

- On long bridges width of medians reduced upto 1.2 to 1.5 m

Road Margins

- Shoulders: Extra width provided adjacent to outer edge of pavement for emergency purpose (breakdown of vehicle/ambulance) called shoulder.
- The surface of shoulder should be rougher than the traffic lanes so that vehicles are discouraged to used the shoulder as a regular traffic lane.

As per IRC

(i) Minimum width of shoulder should be 2.5 m in one direction.

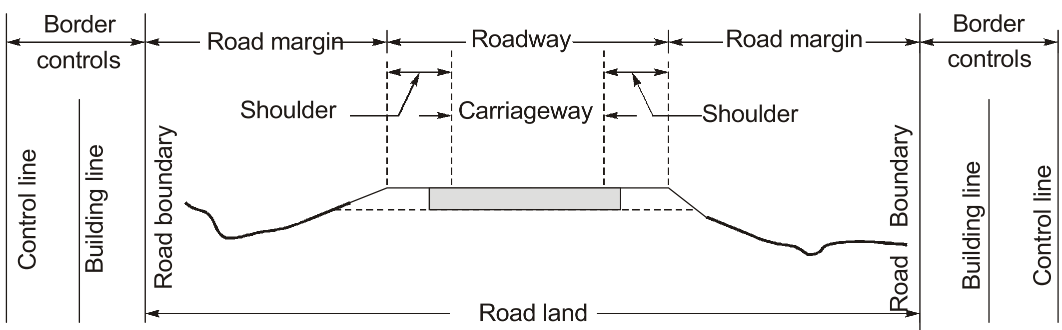
(ii) Camber of shoulder should be 0.5% steeper than camber of road.

(iii) Minimum camber for shoulder should be 3%.

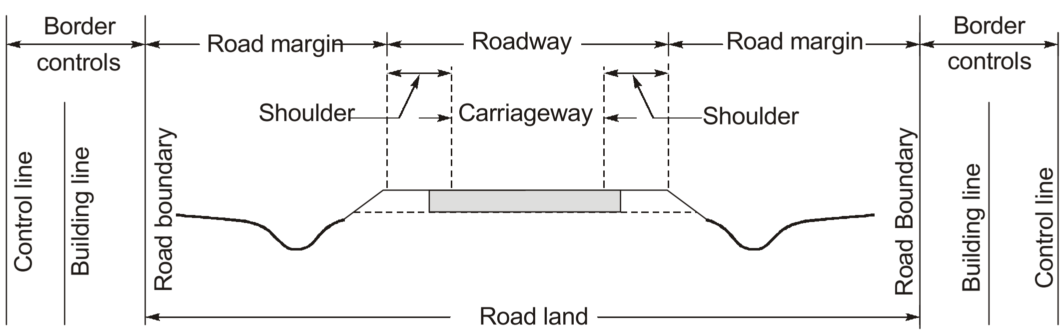
(iv) For superelevated section

Camber of road = Camber of shoulder

- Frontage roads: Are provided to give access to properties along an important highway with controlled access as expressway or freeway.
- Driveways: Connects the highway with commercial establishments like fuel stations, service stations etc.
- Guard rails: When embankment height is more than 3 m.



(a) In embankment



(b) In cutting

Cross section details

Width of roadway or formation

Formation width = Carriageway width (including separators) + Shoulders

- It is the top width of highway embankment (or) bottom width of highway cutting excluding side drains.

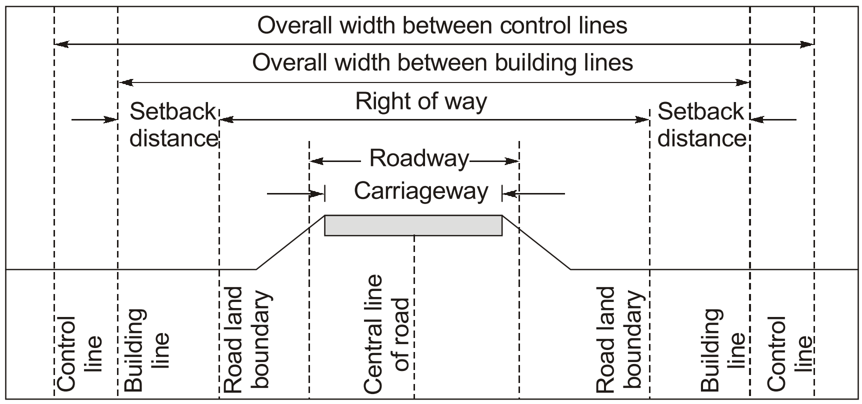
Right of Way

Area of land required for the road, along its alignment. The width of this acquired land is known as land width.

Right of way = Formation width + Road margins

- Building activities are to be disallowed upto building line with sufficient setback from road boundary. In addition to this it is desirable to exercise control on the nature of building upto control lines.

- Normal land width required for NH and SH is 45 m.
- Maximum land width required for NH and SH is 60 m.
- Corresponding distance between building lines is 80 m and between control lines is 150 m.



Road margins

2.4 Sight Distances

Geometric design of highway is done in such a way that from every point on highway the length of view available is sufficient so that the vehicle could be stopped in that visible distance 'or' operations like overtaking could be safely performed.

Various types of sight distances:

(i) SSD (Stopping sight distance): Also known as non-passing sight distance. It is provided for safety stopping the vehicle.

(ii) OSD (Overtaking sight distance): Also known as passing sight distance, provided for safe overtaking operation.

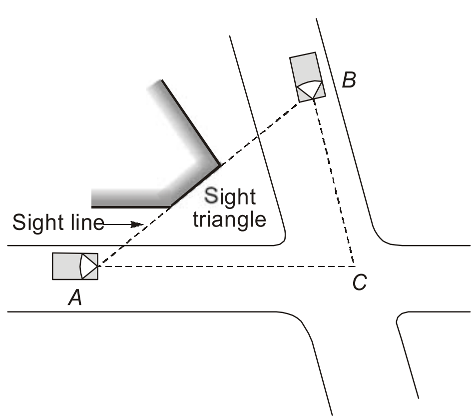
(ii) ISD (Intermediate sight distance): When OSD can't be provided, we provide ISD, so as to give some degree of overtaking opportunity

$$ISD = 2 \times SSD$$

(iv) Head light sight distance (HSSD): Distance visible to the driver at night under head light illumination.

Minimum value of HSSD $\simeq$ SSD

(v) Safe sight distance to enter into an intersection.



Sight distance at intersection

Stopping sight distance (SSD):

- It is also known as absolute minimum sight distance.
- It is the minimum sight distance that should be available at all spots on highway such that vehicles travelling at design speed could be safely stopped within that distance.

SSD depends upon

(i) Speed of vehicle

(ii) Reaction time of the driver (t_R)

- Reaction time of driver is the time taken from the instant the object is visible to the driver to the instant when the brakes are applied.
- The total reaction time may be split up into four components based on PIEV theory.

P. Perception time (Time lost in perceiving any object)

I. Intellection time (Time Lost in understanding the situation)

E - Emotion time (Time Lost due to anger or fear)

V - volition time (Time Lost in final action)

$\therefore \quad t_R = P + I + E + V$

As per IRC	t_R
SSD	2.5
OSD/ISD	2
Minimum space headway	2.7

(iii) Braking efficiency: IRC assumes a brakes efficiency of 50%. It has already being included in the longitudinal friction coefficient.

(iv) Friction coefficient, f = (0.35 – 0.4) As per IRC

Speed (km/h)	Longitudinal coefficient of friction (f)
20 - 30	0.40
40	0.38
50	0.37
60	0.36
65	0.36
80	0.35
100	0.35

(v) Longitudinal gradient of road.

- Up gradient will leads to lower value of SSD.
- Down gradient will leads to higher value of SSD.

Calculation of SSD:

Case-1: When the vehicle is moving on level ground, i.e. no longitudinal gradient.

Assumptions: Height of obstruction = 0.15 m height of driver's eye = 1.2 m above carriageway.