HIGHWAY CROSS SECTION ELEMENTS

Pavement Surface depends on the pavement type. The pavement surface type is decided basedon the availability of materials and funds, volume and composition of traffic, sub grade, and climatic conditions. The important characteristics of the pavement are

1) Friction Considerations
2) Unevenness
3) Light Reflecting Characteristics
4) Drainage of Surface Water

1) Friction

The friction of skid resistance between vehicle tyre and pavement surface is one of thefactors determining the operating speed and the minimum distance requires for stopping of vehicles.

'Skid' occurs when the wheels slide without revolving or rotating or when the wheels partiallyrevolve i.e., when the path travelled along the road surface is more than the circumferential movements of the wheels due to their rotation When the brakes arc applied, the wheels are locked partially or fully, and if the vehicle moves forward, the longitudinal skidding takes placewhich may van, from 0 to 100%.

While a vehicle negotiates a horizontal curve, if the centrifugal force is greater than the counteracting forces (i.e. lateral friction and component of gravity due to super elevation) lateral skidding takes place. The lateral skid is considered dangerous as the vehicle goes out ofcontrol leading to an accident. The maximum lateral skid coefficient is generally equal to or slightly higher than the forward skid coefficient in braking tests.

'Slip' occurs when a wheel revolves more than the corresponding longitudinal movement alongthe roads. Slipping usually occurs in the driving wheel of a vehicle when the vehicle rapidly accelerates from stationary position or from slow speed on pavement surface which is either slippery and wet or when the road surface is loose with mud

Factors Affecting Friction or Skid Resistance

The maximum friction offered by pavement surface or the skid resistance depend* uponthe following factors:

Type of pavement surface namely, cement concrete, bituminous, WBM. earth surface etc.

- Macro-texture of the pavement surface or its relative roughness
- Condition of pavement namely
- Type and condition of tyre Speed of vehicle
- Extent of brake application or brake efficiency

- Load and tyre pressure
- Temperature of tyre and pavement

For the calculation purposes, the IRC has recommended the longitudinal friction co efficient values of 0.35 to 0.40 and lateral co efficient values of 0.15. for expressways and NH's with design speed of 120 and 100kmph it is 0.10 and 0.11

2) Pavement Unevenness

The longitudinal profile of the road pavement has to he even' in order to provide a good riding comfort to fast moving vehicles and to minimise the VOC. Presence of undulations on the pavement surface is called pavement unevenness which results in

- Increase in Discomfort and Fatigue to Road Users
- Increase in Fuel Consumption and Tyre Wear and Increase in VOC
- Reduction in Vehicle Operating Speed and Increase in Accident Rate

The pavement surface should therefore be maintained w i t h minimum possible unevenness or undulations so that the desired speed can be maintained m conformity w i t h other geometric standards Loose road surface increases the resistance to traction and causes increase in fuel consumption.

The unevenness of pavement surface is commonly measured by using a simple equipment called **'Bump Integrator' (BI),** in terms of **Unevenness Index** which is the cumulative measure of vertical undulations of the pavement surface recorded per unit length of the road. Internationally, the riding quality of a pavement surface is quantified in terms of 'roughness' and is expressed as International Roughness Index (IRI) in units of m/km. The relation betweenthe unevenness measured using bump integrator in mm/km and the International Roughness index in m/km is as follows

$$\mathbf{BI = 630\ (IRI)^{1.12}}$$

Undulations of newly laid pavement surface are sometimes measured using a straight edge andwedge scale, in terms of the depth and number of depressions or ruts along and across the pavement. It may be mentioned here that there are several advanced techniques and equipmentavailable now to evaluate the pavement surface condition.

3) Light Reflecting Characteristics

Night visibility depends upon the colour and light reflecting characteristics of the pavement surface. The glare caused by the reflection of head lights is considerably high on wetpavement surface than on the dry pavement.

- Light coloured or white pavement surface give good visibility at night particularly during rains: however white or light colour of pavement surface may produces glare and eye strain during bright sunlight.

- Black top pavement surface on the other hand provides very poor visibility at nights, especially when the surface is wet.

The cross section elements involved in highway geometric design,

- Kerbs
- Camber
- Shoulders
- Guard rails
- Side walks
- Right of way
- Service roads
- Drainage and Footpath

Cross Slope or Camber

Cross slope or camber is the slope provided to the road surface in the transverse direction to drain off the rain water from the road surface. Drainage and quick disposal of waterfrom the pavement surface by providing cross slope is considered important because of the following reasons:

1) To prevent the entry of surface water into the pavement layers and the subgrade soil through pavement.
2) To prevent the entry of water into the bituminous pavement layers, as continued contactwith water causes stripping of bitumen from the aggregates and results in deterioration of the pavement layer
3) To remove the rain water from the pavement surface as quickly as possible and to allowthe pavement to get dry soon after the rain.

The rate of camber or cross slope is usually designated by 1 in 'n' which means the transverseslope is in ratio 1 vertical to n horizontal.

The required camber of a pavement depends on

a) Type of pavement surface
b) The amount of rainfall

- It is desirable not to provide excessive camber or steep cross slope on road pavements. Only the minimum camber needed to drain off surface water may be adopted keeping in view the

type of pavement surface and the amount of rainfall in the locality. Too steep cross slope is notdesirable because of the following reasons:

- Transverse tilt of vehicles causes uncomfortable side thrust and a drag on the steering wheel of automobiles. Also, the thrust on the wheels along the pavement edges is morecausing unequal wear of the tyres as well as road surface
- Discomfort causing throw of vehicle when crossing the crown during overtaking operations.

- Problems of possible toppling over of highly laden bullock carts and trucks
- Formation of cross ruts due to rapid flow of water
- Tendency of most of the vehicles to travel along the centre line

Recommended values of camber

The values of camber recommended by the IRC for different types of road surfaces aregiven in the below table.

Recommended values of camber for different types of road surfaces

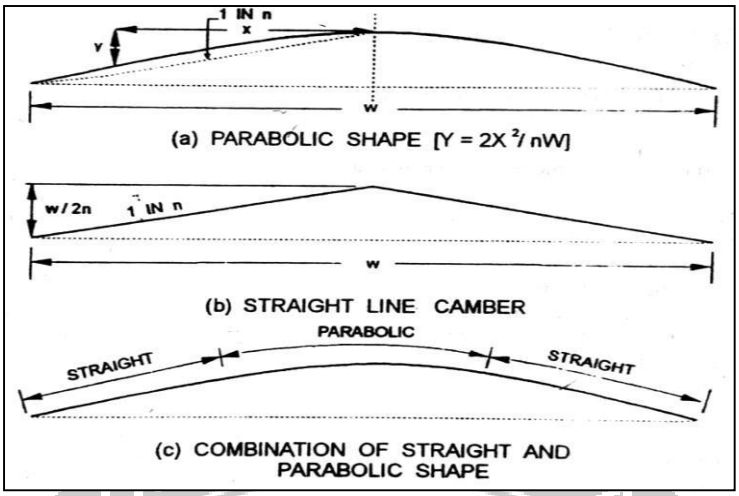
Sl. No.	Type of road surface	Range of camber in areas of	
		Heavy rainfall	Low rainfall
1.	Cement concrete and high type bituminous surface	1 in 50 or 2.0 %	1 in 60 or 1.7%
2.	Thin bituminous surface	1 in 40 or 2.5 %	1 in 50 or 2.0 %
3.	Water bound Macadam and gravel pavement	1 in 33 or 3.0 %	1 in 40 or 2.5%
4.	Earth road	1 in 25 or 4.0 %	1 in 33 or 3.0 %

The cross slope for shoulders should be 0.5% steeper than the cross slope of adjoining pavement, subject to a minimum of 3.0% and a maximum value of 5.0% for earth shoulders. The cross slope suggested for the carriageway, paved shoulders and edge strip of expresswayswith bituminous surface as well as cement concrete surface is 2.5 % in regions with annual rain fall exceeding 1000 mm and 2.0 % in places with less than 1000 mm rain fall.

SHAPE OF CROSS SLOPE

In the field, camber of the pavement cross section is provided with a suitable shape. Different shapes that are commonly adopted are

1) Parabolic
2) Straight Line
3) Straights with parabolic curve



Providing Camber in the field

In order to provide the desired amount and shape of camber, templates or camber boards are prepared with the chosen shape and specified cross slope and they can be used to check the lateral profile of finished pavements.

WIDTH OF PAVEMENT OR CARRIAGEWAY

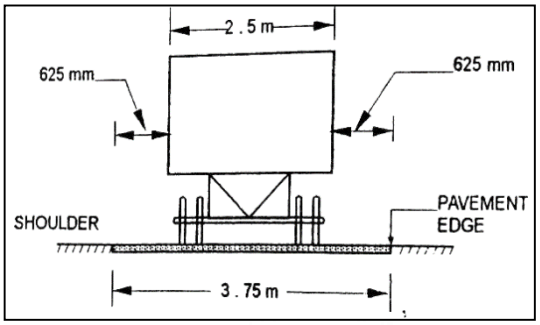
The width of pavement or carriageway depends on

1) Width of Traffic Lane
2) Number of Lanes.

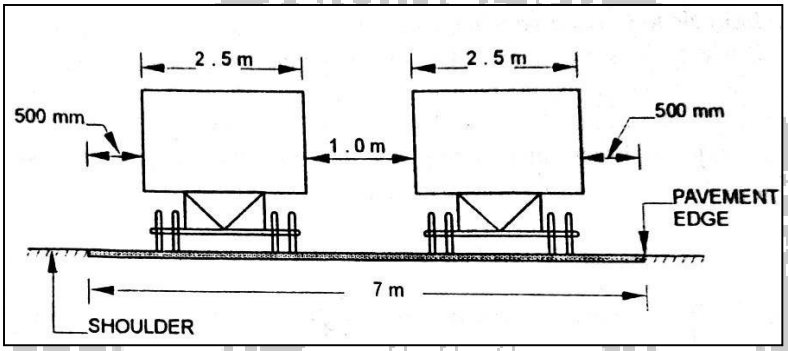
The portion of carriageway width that is intended for one line of traffic movement is called a traffic lane. As different classes of vehicles travel along the same roadway generally the lane width is decided based on a standard vehicle such as the passenger car. However, it isalso necessary to consider the maximum width of the largest vehicle class such as the heavy commercial vehicle (HCV) which is legally permitted to use the roadway in the country.

Width of carriageway recommended by IRC

Class of Road	Width of Carriageway, m
Single Lane Road	3.75
Two Lane Road, without raised kerbs	7.0
Two Lane Road, with raised kerbs	7.5
Intermediate Carriageway	5.5
Multi Lane Pavements	3.5 per lane



Single Lane Pavement



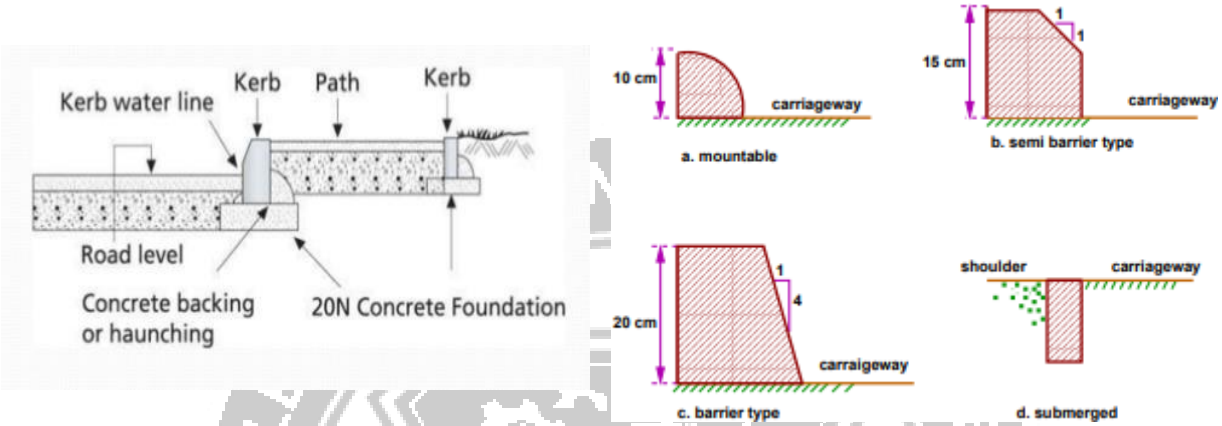
Two Lane Pavement

MEDIANS/TRAFFIC SEPARATORS

In highways with divided carriageway, a median is provided between two sets of traffic lanes intended to divide the traffic moving in opposite directions. The main functionof the median is to prevent head-on collision between vehicles moving in opposite directions on adjacent lanes. The median is also called or traffic separator. The traffic separators used may be in the form of pavement markings, physical dividers or area separators. Pavement marking is the simplest of all these, but this will not rule out head- on collision. The mechanical separator may be suitably designed keeping in view safety considerations.

KERBS

Kerb indicates the boundary between the pavement and median or foot path or islandor shoulder. It is desirable to provide kerbs on urban roads. Refer Fig. There are a variety ofkerb designs. Kerbs may be mainly divided based on their functions.



a) Low or Mountable Kerbs

These types of kerbs are provided such that they encourage the traffic to remain in the throughtraffic lanes and also allow the driver to enter the shoulder area with little difficulty.

b) Semi-Barrier Type Kerbs

When the pedestrian traffic is high, these kerbs are provided. Their height is 15 cm above the pavement edge.

c) Barrier Type Kerbs

They are designed to discourage vehicles from leaving the pavement. They are provided whenthere is considerable amount of pedestrian traffic. They are placed at a height of 20 cm above The Pavement Edge with A Steep Batter.

d) Submerged Kerbs

They are used in rural roads. The kerbs are provided at pavement edges between pavement edge and shoulder

ROAD MARGINS

The portion of the road beyond the carriageway and on the roadway can be generally calledroad margin. Various elements that form the road margins are given below.

Shoulders

Shoulders are provided on both sides of the pavement all along the road in the case ofundivided highway and are provided on the outer edge of the highway in divided carriage way

The important functions of shoulders are:

(a) Shoulders provide structural stability and support to the edges of the flexible pavements.

(b) The capacity of the carriageway and the operating speeds of vehicles increase if the shoulders are laid and maintained in good condition.

(c) Shoulders serve as emergency lanes for vehicle compelled to be taken out of the main carriageway or roadway. Shoulders should have sufficient load bearing capacity to support loaded truck even in wet weather

(d) Shoulders also act as service lanes for vehicles that are disabled. The width of shouldershould be adequate to accommodate stationary vehicle fairly away from the edge of adjacent lane.

Guard rails

Guard rails are provided at the edge of the shoulder when the road is constructed on afill so that vehicles are prevented from running off the embankment, especially when the height of the fill exceeds 3 m. Guard stones (painted with black and white strips) are installed

at suitable intervals along the outer edge of the formation at horizontal curves of roads runningon embankments along rural areas so as to provide better night visibility of the curves underhead lights of vehicles

Footpath or side-walk

In order to provide safe facility to pedestrians to walk along the roadway, foot paths orside-walks are provided in urban areas where the pedestrian traffic is noteworthy and the vehicular traffic is also heavy. By providing good foot path facility, the pedestrians can keepoff from the carriageway and they are segregated from the moving vehicular traffic. Thus, theoperating speeds of the vehicular traffic increases and there will be marked reduction in accidents involving pedestrians.

Drive ways

Drive ways connect the highway with commercial establishment like fuel-stations, service-stations etc. Drive ways should be properly designed and located, fairly away from anintersection. The radius of the drive way curve should be kept as large as possible, but the width of the drive way should be minimised to reduce the crossing distance for the pedestrians.

Cycle tracks

Cycle tracks are provided in urban areas where the volume of cycle traffic on the roadis very high. A minimum width of 2 m is provided for the cycle track and the width may be increased by 1.0 m for each additional cycle lane.

Parking lanes

Parking lanes are provided on urban roads to allow kerb parking. As far as possible only 'parallel parking' should be allowed as it is safer for moving vehicles. For parallel parking,the minimum lane width should be 3.0 m.

Bus bays

Bus bays may be provided by recessing the kerb to avoid conflict with moving traffic.
Bus bays should be located at least 75 m away from the intersections.

Lay-byes

Lay-byes are provided near public conveniences with guide maps to enable drivers to stop clear off the carriageway. Lay-byes should normally be of 3.0 width and at least 30 m length with 15 m end tapers on both sides.

Frontage roads

Frontage roads are provided to give access to properties along an important highway with controlled access to express way or freeway. The frontage roads may run parallel to the highway and are isolated by a separator, with approaches to the through facility only at selectedpoints, preferably with grade separation.

WIDTH OF FORMATION OR ROADWAY

Width of formation or roadway is the sum of widths of pavement or carriageway including separators, if any and the shoulders. Formation or roadway width is the top width ofthe highway embankment or the bottom width of highway cutting excluding the side drains.

RIGHT OF WAY AND LAND WIDTH

Right of way is the area of land acquired for the road, along its alignment. The width of the acquired land for right of way is known as 'land width' and it depends on the importanceof the road and possible future development. A minimum land width has been prescribed for each category of road. A desirable range of land width has also been suggested for each category of road. While acquiring land for a highway it is desirable to acquire more width of land as the cost of adjoining land invariably increases as soon as the new highway is constructed.