RAMA UNIVERSITY

www.ramauniversity.ac.in

TRANSPORTATION ENGINEERING – I

DEPARTMENT OF CIVIL ENGINEERING

FACULTY OF ENGINEERING & TECHNOLOGY

TRANSPORTATION ENGINEERING – I (Highway Engineering) UNIT-2 LECTURE -1

Topics to be covered:

- Geometric Design
- Cross sectional Elements
- Camber
- Width of Carriage way
- Kerb
- Road Margins
- Width of Formation
- Right of Way (ROW)
- Shoulder

PREPARED BY:

SHASHIKANT SRIVASTAVA

ASSISTANT PROFESSOR DEPARTMENT

OF CIVIL ENGINEERING

FACULTY OF ENGINEERING & TECHNOLOGY

RAMA UNIVERSITY UTTAR PRADESH, KANPUR (INDIA)

INTRODUCTION TO GEOMETRIC DESIGN:

- The geometric design of roadways manages the measurements and design of obvious highlights of the highway.
- The accentuation of the geometric plan is to address the necessity of the driver and the vehicle, for example, security, comfort, effectiveness, and so forth.
- The highlights typically considered are the cross sectional components, sight distance consideration, horizontal curves, angles, and convergence.
- The structure of these highlights is to an extraordinary expand impacted by driver conduct and brain science, vehicle attributes, traffic qualities, for example, speed and volume.
- Appropriate geometric plan will help in the decrease of mishaps and their seriousness. In this way, the target of geometric plan is to give ideal proficiency in rush hour gridlock activity and most extreme wellbeing at sensible expense.

- The arranging is impossible stage shrewd for this situation like that of an road, however must be done well progress of time.

The main components of geometric design are:

- ✓ Factors affecting the geometric design,
- ✓ Highway alignment,
- ✓ Road classification,
- ✓ Pavement surface characteristics,
- ✓ Cross-section elements including cross slope,
- ✓ Various widths of roads and features in the road margins.
- ✓ Sight distance elements including cross slope, various widths and features in the road margins.
- ✓ Horizontal alignment which includes features like super elevation, transition curve, extra widening and set back distance.
- ✓ Vertical alignment and its components like gradient, sight distance and design of length of curves.

CROSS SECTIONAL ELEMENTS :

OVERVIEW : The features of the cross-section of the pavement influences the life of the pavement as well as the riding comfort and safety. Pavement surface characteristics affect both of these. Camber, Kerbs, and geometry of various cross-sectional elements are important aspects to be considered in this regard.

PAVEMENT SURFACE CHARACTERISTICS : For safe and comfortable driving four aspects of the pavement surface are important; the friction between the wheels and the pavement surface, smoothness of the road surface, the light reflection characteristics of the top of pavement surface, and drainage to water.

FRICTION : Friction between the wheel and the pavement surface is a crucial factor in the design of horizontal curves and thus the safe operating speed. It also affects the acceleration and deceleration ability of vehicles. Lack of adequate friction can cause skidding or slipping of vehicles. Skidding happens when the path traveled along the road surface is more than the circumferenti l movement of the wheels due to friction. Slip occurs when the wheel revolves more than the corresponding longitudinal movement along the road. 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.
- Impact on Pavement (Gradual or Sudden application of Brakes)

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.

Continued…… PAVEMENT SURFACE CHARACTERISTICS :

UNEVENNESS : It is consistently attractive to have an even surface, however it is only here and there conceivable to have such a one. Regardless of whether a street is built with excellent pavers, it is conceivable to develop unevenness because of road disappointments. Unevenness influence the vehicle working cost, speed, riding speed, security, fuel utilization and wear and tear of tires. Unevenness index is a proportion of Unevenness, which is the combined proportion of vertical undulations of the pavement surface recorded per unit flat length of the street. An Unevenness index esteem under 1500 mm/km is considered as acceptable, a worth under 2500 mm/km is palatable up to speed of 100 kmph and quantities more prominent than 3200 mm/km is considered as uncomfortable in any event, for 55 kmph. CRRI has invented a device to measure the unevenness of the pavement namely, **"Bump Indicator" or "Bump Integrator".**

LIGHT REFLECTION CHARACTERISTICS :

- It is necessary that the road surface should be visible at night and reflection of light is the factor that answers it.
- White roads have good visibility at night, but caused glare during daytime.
- Black roads has no glare during day, but has poor visibility at night.
- Concrete roads has better visibility and less glare.

➢The light reflection characteristics are important to identify the markings along the road, so a black pavement with white marking is always preferred over all other possible combinations.

➢Sometimes, the glaring devices or lights or markings are also provided on the pavement in order to identify the markings along the pavement.

DRAINAGE : The pavement surface should be absolutely impermeable to prevent seepage of water into the pavement layers. Further, both the geometry and texture of pavement surface should help in draining out the water from the surface in less time.

CAMBER :

Camber or cant is the cross slope provided to raise middle of the road surface in the transverse direction to drain off rain water from road surface. Pavements on straight sections of two-lane and multi lane roadways without medians are sloped from the middle downward to both sides of the roadway. This provides a cross slope, whose road cross section can be either curved or plane or a combination of the two.The objectives of providing camber are:

a) Surface protection especially for gravel and bituminous roads

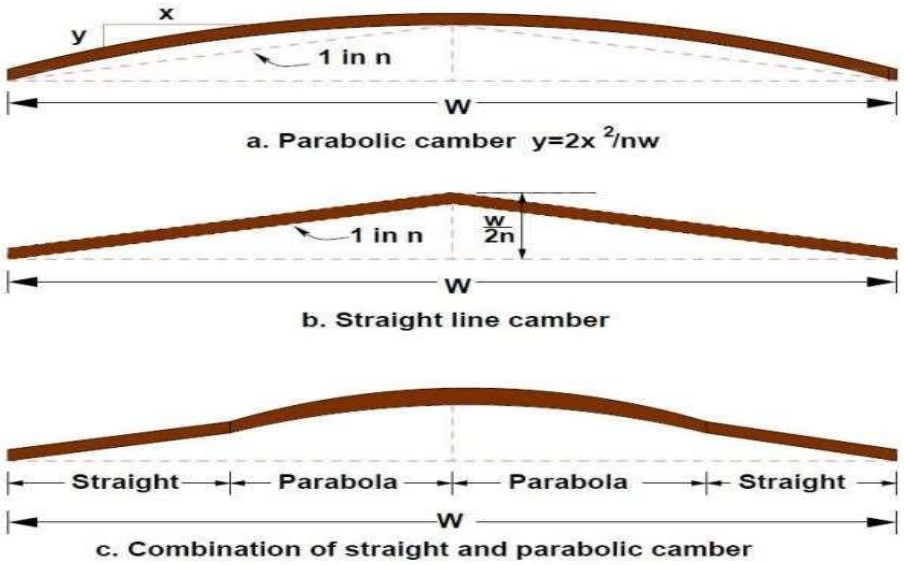
b) Sub-grade protection by proper drainage

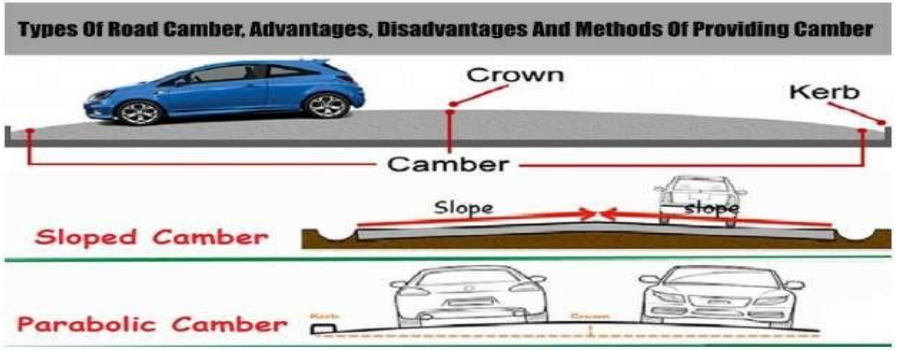
c)Quick drying of pavement which in turn increases safety.

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

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.

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





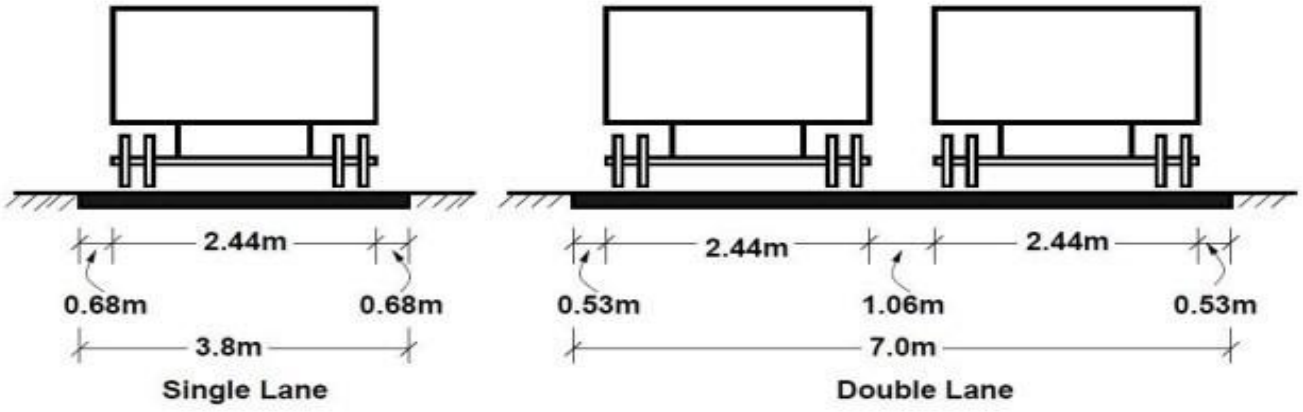
IRC VALUES FOR CAMBER

Surface Type	Heavy Rain	Light Rain
Highway Bituminous surface / Cement Concrete road	1 in 50 (2.0%)	1 in 60 (1.7%)
Thin bituminous surface road.	1 in 40 (2.5%)	1 in 50 (2.0%)
W.B.M, Gravel road surface	1 in 33 (3.0%)	1 in 40 (2.5%)
Earthen Road	1 in 25 (4.0%)	1 in 33 (3.0%)

WIDTH OF CARRIAGE WAY :

Width of the carriage way or the width of the pavement depends on the width of the traffic lane and number of lanes. Width of a traffic lane depends on the width of the vehicle and the clearance. Side clearance improves operating speed and safety. The maximum permissible width of a vehicle is 2.44 m and the desirable side clearance for single lane traffic is 0.68 m. This require minimum of lane width of 3.75 m for a single lane road. However, the side clearance required is about 0.53 m, on both side and 1.06 m in the centre. Therefore, a two lane road require minimum of 3.5 meter for each lane.

IRC SPECIFICATION FOR CARRIAGE WAY WIDTH (m)	
SINGLE LANE	3.75
TWO LANE, NO KERBS	7.0
TWO LANE, RAISED KERBS	7.5
INTERMEDIATE CARRIAGE	5.5
MULTI-LANE	3.5 m/lane



Lane width for single and two lane roads

KERB :

Kerbs indicate the boundary between the carriage way and the shoulder or islands or footpaths.

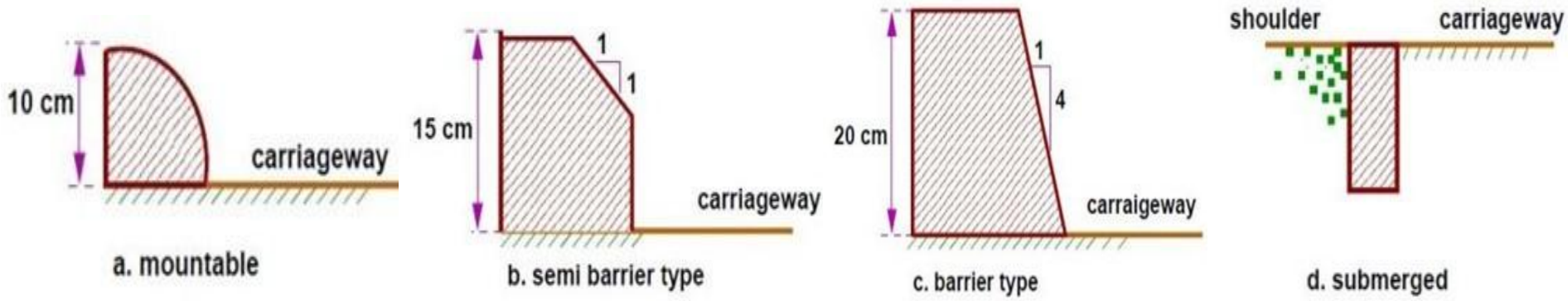
TYPES OF KERBS:

LOW OR MOUNTABLE KERBS : These types of kerbs are provided such that they encourage the traffic to remain in the through traffic lanes and also allow the driver to enter the shoulder area with little difficulty. The height of this kerb is about 10 cm above the pavement edge with a slope which allows the vehicle to climb easily. This is usually provided at medians and channelization schemes and also helps in longitudinal drainage.

SEMI-BARRIER TYPE KERBS : When the pedestrian traffic is high, these kerbs are provided. Their height is 15 cm above the pavement edge. This type of kerb prevents encroachment of parking vehicles, but at acute emergency it is possible to drive over this kerb with some difficulty.

BARRIER TYPE KERBS : They are designed to discourage vehicles from leaving the pavement. They are provided when there is considerable amount of pedestrian traffic. They are placed at a height of 20 cm above the pavement edge with a steep batter.

SUBMERGED KERBS : They are used in rural roads. The kerbs are provided at pavement edges between the pavement edge and shoulders. They provide lateral confinement and stability to the pavement.



ROAD MARGINS :

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

SHOULDERS : Shoulders are provided along the road edge and is intended for accommodation of stopped vehicles, serve as an emergency lane for vehicles and provide lateral support for base and surface courses. The shoulder should be strong enough to bear the weight of a fully loaded truck even in wet conditions. The shoulder width should be adequate for giving working space around a stopped vehicle. It is desirable to have a width of 4.6 m for the shoulders. A minimum width of 2.5 m is recommended for 2-lane rural highways in India.

PARKING LANES : Parking lanes are provided in urban lanes for side parking. Parallel parking is preferred because it is safe for the vehicles moving on the road. The parking lane should have a minimum of 3.0 m width in the case of parallel parking.

BUS-BAYS : Bus bays are provided by recessing the kerbs for bus stops. They are provided so that they do not obstruct the movement of vehicles in the carriage way. They should be at least 75 meters away from the intersection so that the traffic near the intersections is not affected by the bus-bay.

Shoulders

Parking Lanes

Bus-Bays

Continues…… ROAD MARGINS :

SERVICE ROADS : Service roads or frontage roads give access to access controlled highways like freeways and expressways. They run parallel to the highway and will be usually isolated by a separator and access to the highway will be provided only at selected points. These roads are provided to avoid congestion in the expressways and also the speed of the traffic in those lanes is not reduced.

CYCLE TRACK : Cycle tracks are provided in urban areas when the volume of cycle traffic is high Minimum width of 2 meter is required, which may be increased by 1 meter for every additional track.

FOOTPATH : Footpaths are exclusive right of way to pedestrians, especially in urban areas. They are provided for the safety of the pedestrians when both the pedestrian traffic and vehicular traffic is high. Minimum width is 1.5 meter and may be increased based on the traffic. The footpath should be either as smooth as the pavement or more smoother than that to induce the pedestrian to use the footpath.

GUARD RAILS : They are provided at the edge of the shoulder usually when the road is on an embankment. They serve to prevent the vehicles from running off the embankment, especially when the height of the fill exceeds 3 m. Various designs of guard rails are there. Guard stones painted in alternate black and white are usually used. They also give better visibility of curves at night under headlights of vehicles.

Service Road

Cycle-Track

Foot-Path

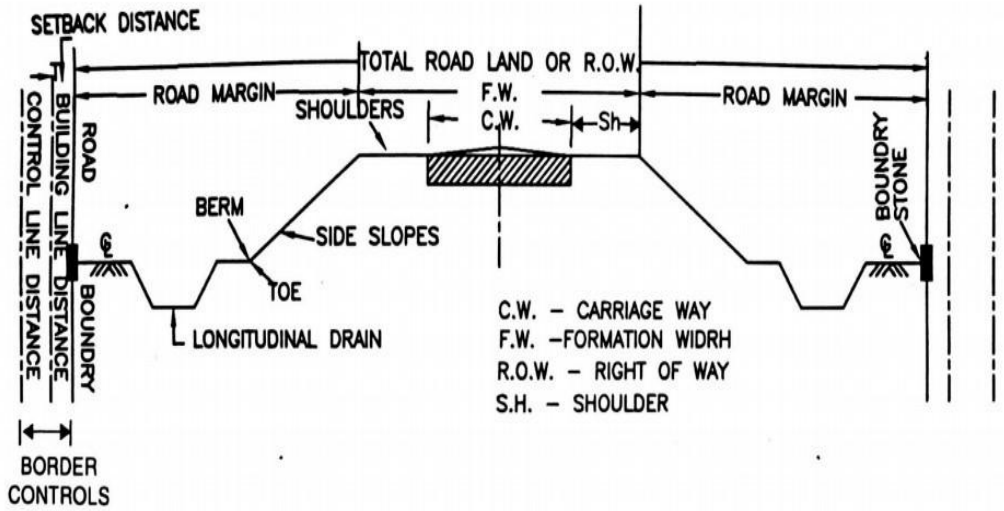
Guard - Rail

WIDTH OF FORMATION :

Width of formation or roadway width is the sum of the widths of pavements or carriage way including separators and shoulders. This does not include the extra land in formation/cutting. The values suggested by IRC are given in Table below:

WIDTH OF FORMATION FOR VARIOUS CLASSED OF ROADS		
Road Classification	**Roadway width in m**	
	Plain and Rolling Terrain	**Mountainous and Steep Terrain**
NH/SH	12	6.25-8.8
MDR	9	4.75
ODR	7.5-9.0	4.75
VR	7.5	4.0

CROSS-SECTION OF ROADS



Sr. No.	Road classification	Width of Formation in m	
		Plain&Rolling Terrain	Mountainous Terrain
1	NH & SH		
	(a) Single Lane	12.0	6.25
	(b)Two Lanes	12.0	8.80
2	MDR		
	(a) Single Lane	9.0	4.75
	(b)Two Lanes	9.0	-
3	ODR		
	(a) Single Lane	7.5	4.75
	(b)Two Lanes	9.0	-
4	VR-Single Lane	7.5	4.0

RIGHT OF WAY (ROW) :

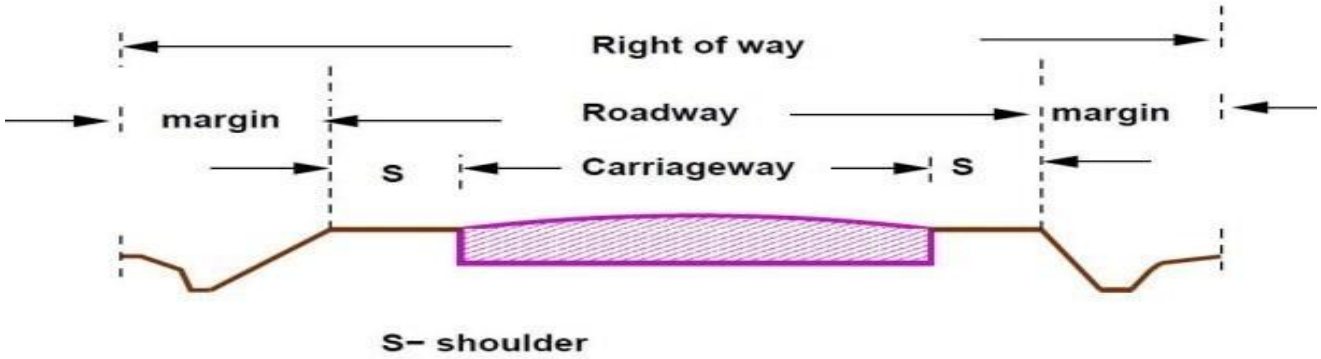
Right of way (ROW) or land width is the width of land acquired for the road, along its alignment. It should be adequate to accommodate all the cross-sectional elements of the highway and may reasonably provide for future development. To prevent ribbon development along highways, control lines and building 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.

✓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.)



A TYPICAL VIEW OF RIGHT OF WAY (ROW)

NORMAL RIGHT OF WAY FOR OPEN AREAS		
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

OTHER IMPORTANT TERMS RELATED TO ROADS :

SIDE SLOPE : The slope of earthwork in filling or in cutting is called Side Slope. It imparts stability to the earthwork. For filling purpose its value suggested by IRC is 1Vertical to 2 Horizontal. For Cutting purpose its values ranges are given in the table below :

TYPE OF SOIL	SOIL SLOPE SUGGESTED
Ordinary Soil	1:1 to 1:1/2
Broken Rock	1:1/2 to 1:1/4
Soft Rock	1:1/4 to 1:1/8
Hard Rock	Approximately Perpendicular

BERM : The distance between the road toe and the inner edge of the borrow pit is called Berm. It prevents the erosion of embankment soil.

BOUNDARY STONE : To indicate the boundary of land acquired for road, stones are driven into the ground at about 30 meters distance on either side from the centre line of the road. These stones are known as Boundary Stones.

SIDE DRAINS : For the drainage of rainwater, drains are provided on either side of the road. These drains are called Side Drains in general. Normally, Side Drains are required for the road in cutting. For roads in embankment, Side Drain is not necessary.

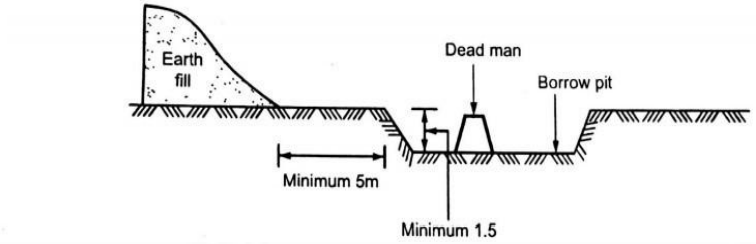
BUILDING LINE : The distance from the centre line of road on either side, within which construction of Buildings is not permitted, is called Building Line.

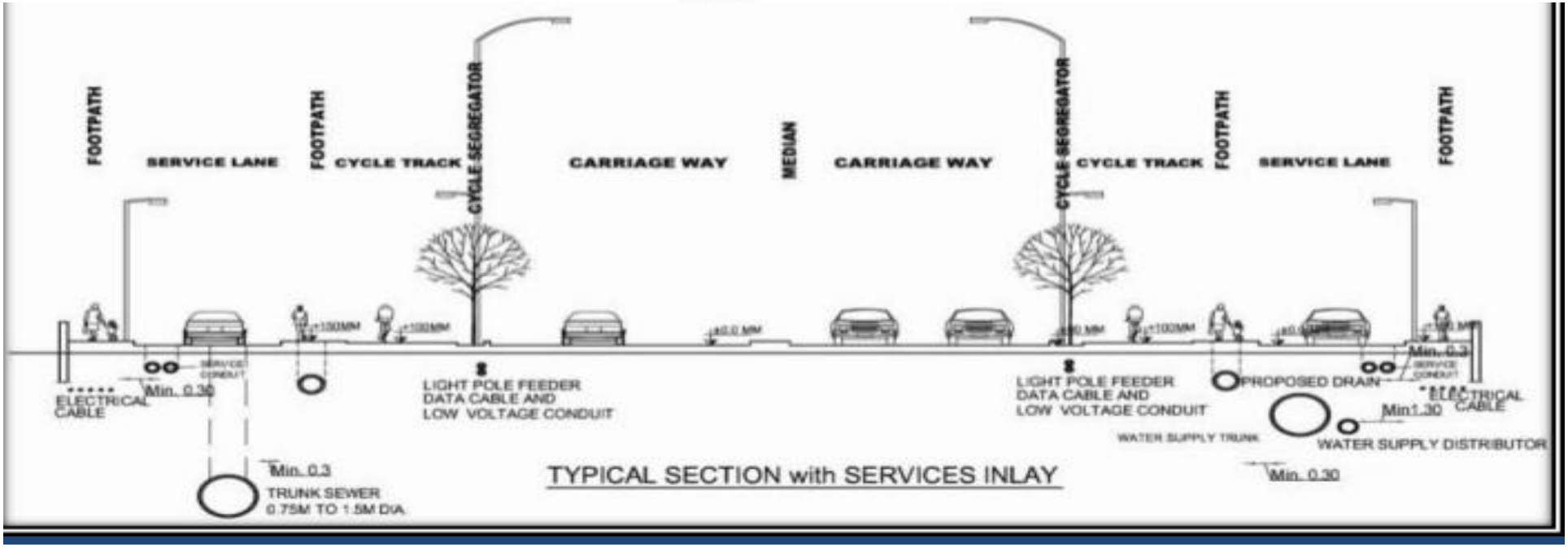
CONTROL LINE : At the locations like bank, Hospital, Factory, Theatre, etc. on the road, where more people gather, disturbance to the traffic will be greater in amount, so control line restricts the entry of those premises on the road.

OTHER IMPORTANT TERMS RELATED TO ROADS : Continued……

SPOIL BANK : The banks constructed from surplus excavated earth on side of road cutting parallel to its alignment, are known as Spoil Banks. The soil from Spoil Bank can be used for the repair of shoulders.

BORROW PITS : The pits dug along the road alignment for using excavated earth in the construction of embankment, are known as Borrow Pits. The small portion of earth left undug in a Barrow Pit to measure depth of excavation is known as Deadman.





SHOULDER :

➢The portion of the road way between the outer edges of the pavement and edges of the top surface of embankment or inner edges of the side drains in cutting are known as 'shoulder'.

- Shoulder are provided along the road edge to serve as an emergency lane.

➢A shoulder, is an emergency stopping lane by the verge of a road or motorway, on the right in countries which drive on the right, or on the left side in India, Pakistan, Japan, the UK, Australia, and other left-side driving countries.

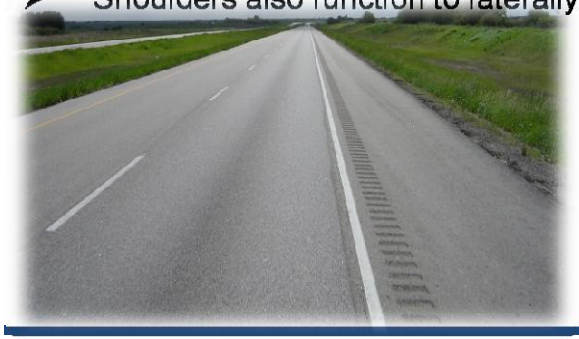
➢Many freeways have shoulders on both sides of each directional carriageway, in the median as well as at the outer edges of the road, for additional safety.

- Shoulders are not intended for use by through traffic, although there are exceptions.
- The shoulder is usually slightly narrower than a full traffic lane.

➢In some cases, particularl on older rura roadways, shoulders that initiall existed were hardened with grave rather than bein paved with asphalt or concrete.

➢In the cross section of roads it is that portion of the roadway between the outer edge of the outer traffic lane and the inside edge of the ditch, gutter, curb or slope.

- Shoulders are provided for the safe operation and to allow the development of full traffic capacity.
- Shoulder also provides a place for vehicle to park in emergency e.g. for changing tires.
- Shoulders also function to laterally support the pavement structure.



SHOULDER : Continues……..

PURPOSE OF A SHOULDER :

The purpose of building a shoulder is that in the event of an emergency or breakdown, a motorist can pull into the shoulder to get out of the flow of traffic and obtain a greater degree of safety.

Emergency vehicles such as ambulances, fire trucks and police cars may use the shoulder to bypass traffic congestion.

Active traffic management, used on busy multi-lane roads, may allow 'hard shoulder running' by general traffic at reduced speeds during periods of high traffic volumes.

In some places a "bus bypass shoulder" may be provided which allows bus services to pass stationary traffic.

Paved shoulders provide additional space should a motorist need to take evasive action (such as avoiding a wrong-way driver) or need to recover control of their vehicle before a run-off-road collision occurs.

In some rural areas without sidewalks, pedestrians and cyclists may be allowed to walk or ride on the shoulders.

On curbed roadways, shoulders move the gutter away from the travel lanes which reduces the risk of hydroplaning, and reduces splash and spray of storm water onto pedestrians using any adjacent sidewalk.

Paved shoulders move water away from the roadway before it can infiltrate into the road's sub base, increasing the life expectancy of the road surface.

Shoulders help provide extra structural support of the roadway.

When semi-truck drivers need sleep and there are no available parking spaces at truck stops and rest areas, either because there are no such facilities nearby or because all semi-truck parking spaces are filled to capacity, drivers may pull over to the highway shoulder and sleep in their truck cabin.

In some countries, parking in the shoulder isn't prohibited by the law, and mushroom and berry pickers commonly use them on roads going through a forest.

"Thank you"

Have Any Query ?

Ask us @ shashikant.fet@ramauniversity.ac.in or shashikantchitransh3@gmail.com