



Class – VII Semester / IV Year

Subject – Transportation Engineering

Unit –2 Highway Geometric Design

Presented by – Jitesh Kumar Jain (Assistant Professor)

**Department of Civil Engineering,
Jaipur Engineering College and Research Centre
Jaipur**

VISION

- To become a role model in the field of Civil Engineering for the sustainable development of the society

MISSION

- 1) To provide outcome base education.
- 2) To create a learning environment conducive for achieving academic excellence.
- 3) To prepare civil engineers for the society with high ethical values.

PROGRAMME OUTCOMES (PO)

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

COURSE OUTCOMES

Name of Subject – TRANSPORTATION ENGINEERING

Semester- VII

Code – 7CE4-01

CO1:-Introduction,modes,development,classification,planning & alignment of highway in India.

CO2:-Design of highway & desirable properties, testing of material as per IRC code.

CO 3:-Method of highway construction, Equipment & design of flexible & rigid pavements as per IRC.

CO4:-Introduction of Railway,Waterways,Airways,Engineering

Importance of geometric design

•The geometric design of a highway deals with the dimensions and layout of visible features of the highway such as alignment, sight distance and intersection.

1.The main objective of highway design is to provide optimum efficiency in traffic operation with maximum safety at reasonable cost.

2.Geometric design of highways deals with following elements :

- Cross section elements
- Sight distance considerations
- Horizontal alignment details
- Vertical alignment details
- Intersection elements

Design Controls and criteria

- Design speed
- Topography
- Traffic factors
- Design hourly volume and capacity
- Environmental and other factors

Design speed

- In India different speed standards have been assigned for different class of road
- Design speed may be modified depending upon the terrain conditions.

Topography

- Classified based on the general slope of the country.
 - Plane terrain- $<10\%$
 - Rolling terrain- $10-25\%$
 - Mountainous terrain- $25-60\%$
 - Steep terrain- $>60\%$

Traffic factor

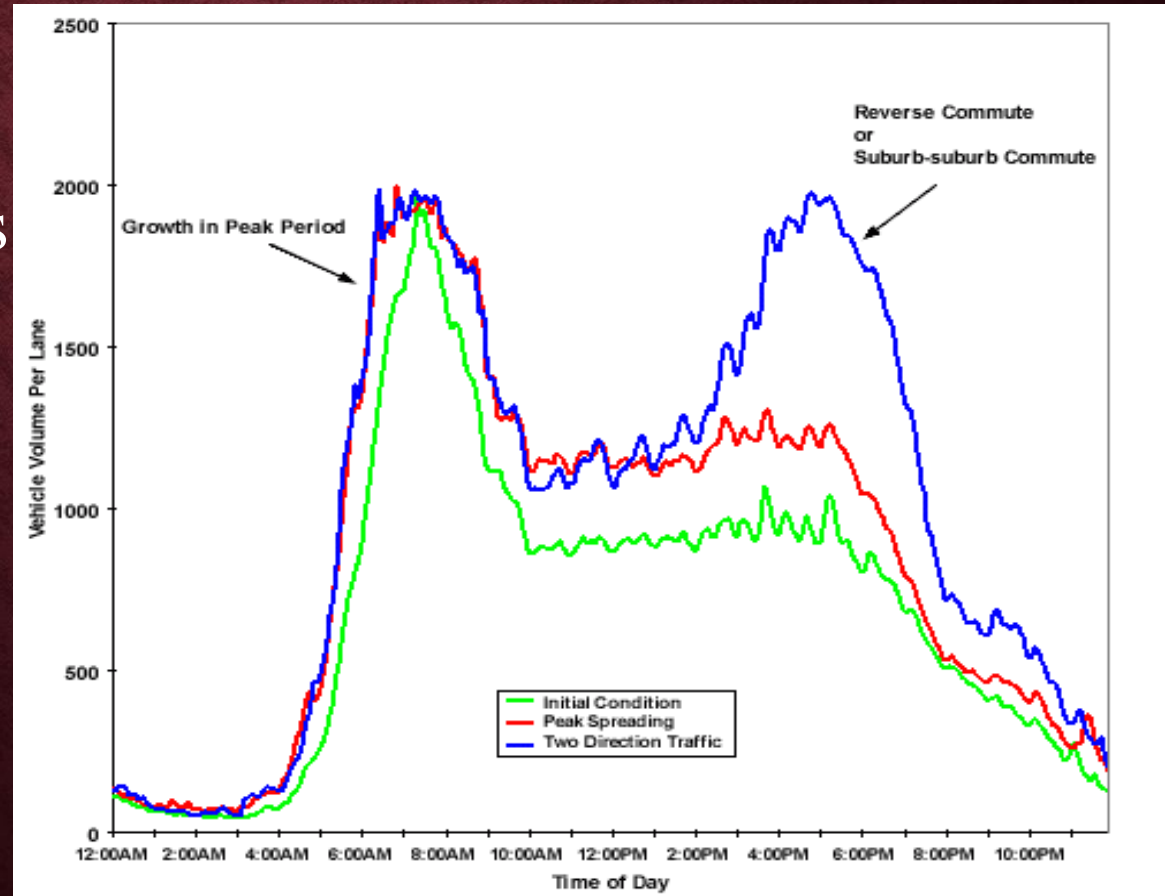
- Vehicular characteristics and human characteristics of road users.
- Different vehicle classes have different speed and acceleration characteristics, different dimensions and weight .
- Human factor includes the physical, mental and psychological characteristics of driver and pedestrian.

Design hourly volume and capacity

- Traffic flow fluctuating with time
- Low value during off-peak hours to the highest value during the peak hour.
- It is uneconomical to design the roadway for peak traffic flow.

Environmental factors

- Aesthetics
- Landscaping
- Air pollution
- Noise pollution



Pavement surface characteristics

Pavement surface depends on the type of pavement which is decided based on the,

- Availability of material
- Volume and composition of traffic
- Soil subgrade
- Climatic condition
- Construction facility
- Cost consideration

The important surface characteristics are:

- Friction
- Pavement unevenness
- Light reflecting characteristics
- Drainage of surface water

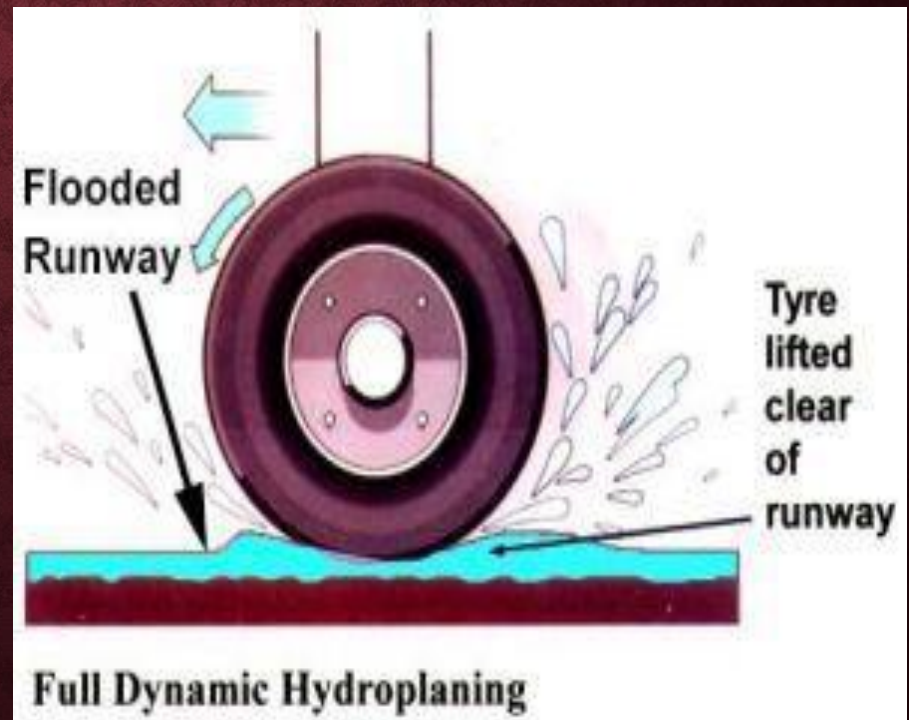
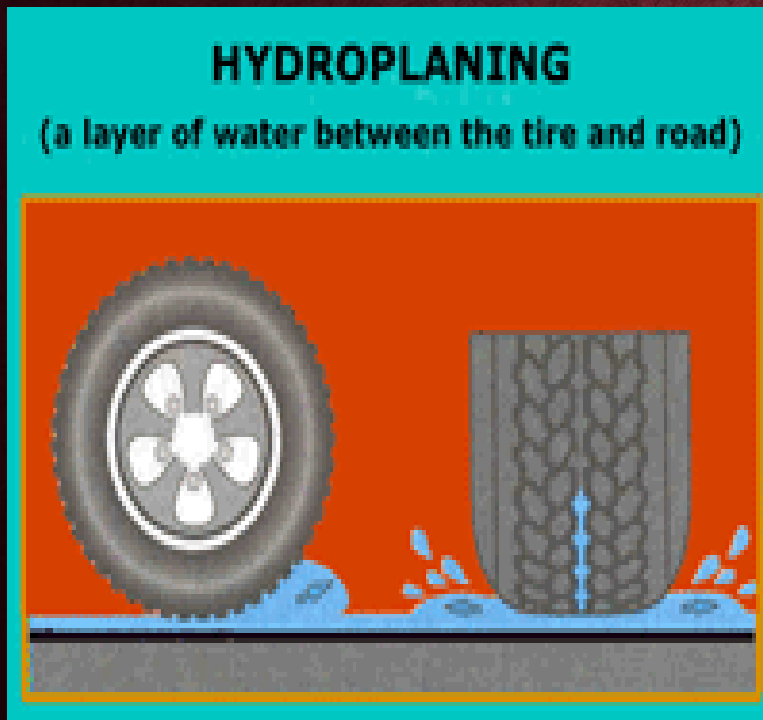
Friction

- Skidding: when the path travelled along the road surface is more than the circumferential movement of the wheels due to their rotation.
- Slipping: when a wheel revolves more than the corresponding longitudinal movement along the road.

Factors affecting the friction or skid resistance

- Types of pavement surface
- Roughness of pavement
- Condition of the pavement: wet or dry
- Type and condition of tyre
- Speed of the vehicle
- Brake efficiency
- Load and tyre pressure
- Temperature of tyre and pavement

- Smooth and worn out tyres offer higher friction factor on dry pavement but new tyre with good tread gives higher friction factor on wet pavement
- IRC recommended the longitudinal co-efficient of friction varies 0.35 to 0.4 and lateral co-efficient of friction of 0.15



Pavement unevenness

- Higher operating speed are possible on even surface than uneven surface.

- It affects,

- Vehicle operation cost

- Comfort and safety

- Fuel consumption

- Wear and tear of tyres and other moving parts

- It is commonly measure by an equipment call “Bump Integrator”

- Bump integrator is the cumulative measure of vertical undulations of the pavement surface recorded per unit horizontal length.

- 250 cm/km for a speed of 100kmph and more than 350 cm/km considered very unsatisfactory even at speed of 50 kmph.

➤ Unevenness of pavement surface may be caused by

- Inadequate compaction of the fill, subgrade and pavement layers.
- Un-scientific construction practices including the use of boulder stones and bricks as soiling course over loose subgrade soil.
- Use of inferior pavement material.
- Improper surface and subsurface drainage.
- Improper construction machinery.
- Poor maintenance



Light reflecting characteristics

- Night visibility very much depends upon the light reflecting characteristics of the pavement surface
- The glare caused by the reflection of head light is high on wet pavement surface than on dry pavement particularly in case of black top pavement or flexible pavement.
- Light colored or white pavement or rigid pavement surface give good visibility at night particularly during the rain, and produces glare or eye strain during bright sunlight.

Highway cross section elements

- Carriageway
- Shoulder
- Roadway width
- Right of way
- Building line
- Control line
- Median
- Camber/ cross slope
- Crown
- Side slope
- Kerb
- Guard rail
- Side drain
- Other facilities

Carriageway:

- It is the travel way which is used for movement of vehicle, it takes the vehicular loading .
- It may be cement concrete road or bituminous pavement.
- Width of carriageway is determined on the basis of the width of the vehicle and the minimum side clearance for safety.
- As per IRC specification, the maximum width of vehicle is 2.44m, minimum clearance of 0.68 in case of single lane and 1.02m in case of double lane.

WIDTH OF CARRIAGEWAY

SL. NO.	Class of road	Width of carriageway in 'm'
1	Single lane	3.75
2	Two lane without raised kerbs	7.0
3	Two lane with raised kerbs	7.5
4	Intermediate lane	5.5
5	Multilane pavement	3.5/lane

WIDTH OF ROADWAY OF VARIOUS CLASSES OF ROADS

SL. No.	Road classification	Roadway width	
		Plane and rolling terrain	Mountainous and steep terrain
1	NH & SH		
	a) Single lane b) two lane	12 12	6.25 6.25
2	MDR		
	a) Single lane b) two lane	9 9	4.75 4.75
3	ODR		
	a) Single lane b) two lane	7.5 9	4.75 4.75
4	Village roads-single lane	7.5	4

Two lane two-way road

carriageway



Shoulder:

- It is provided along the road edge to serve as an emergency lane for vehicle.
- It act as a service lane for vehicles that have broken down.
- The minimum shoulder width of 4.6 m so that a truck stationed at the side of the shoulder would have a clearance of 1.85m from the pavement edge.
- IRC recommended the minimum shoulder width is 2.5 m
- It should have sufficient load bearing capacity even in wet weather.
- The surface of the should be rougher than the traffic lanes so that vehicles are discouraged to use the shoulder as a regular traffic.
- The colour should be different from that of the pavement so as to be distinct.



shoulder



Cycle track



Footpath



}



unTreated
shoulder

Treated
shoulder

Width of the roadway or formation width:

- It is the sum of the width of the carriageway or pavement including separators if any and the shoulders.

Right of way:

- It is the total area of land acquired for the road along its alignment.

- It depends on the importance of the road and possible future development.

- It is desirable to acquire more width of land as the cost of adjoining land invariably increases very much , soon after the new highway is constructed.

Building lane:

- In order to reserve sufficient space for future development of roads, it is desirable to control the building activities on either side of the road boundary, beyond the land width acquired for the land.

Control lines:

- In addition to “building line”, it is desirable to control the nature of building up to further “setback distance”.

Traffic separators or median:

- The main function is to prevent head on collision between the vehicle moving in opposite direction.
- Channelize traffic into streams at intersection.
- Segregate slow traffic and to protect pedestrians.
- IRC recommends a minimum desirable width of 5 m and may be reduce to 3 m where land is restricted.
- The minimum width of median in urban area is 1.2m.

4-lane divided carriage way or dual carriage way

Median/
separator



Cross slope or camber:

- It is the slope provided to the road surface in the transverse direction to drain off the rain water from the road surface.
- To prevent the entry of surface water into the subgradesoil through pavement.
- To prevent the entry of water into the bituminous pavement layer.
- To remove the rain water from the pavement surface as quick as possible and to allow the pavement to get dry soon after the rain.
- It is expressed as a percentage or 1 V:Nh.
- It depends on the pavement surface and amount of rainfall.

Shape of the cross slope:

- Parabolic shape(fast moving vehicle)
- Straight line
- Combination of parabolic and straight line

Recommended values of camber for different types of road surface

Sl no.	Type of road surface	Range of camber in areas of rain fall range	
		heavy	light
1	Cement concrete and high type bituminous pavement	1 in 50(2%)	1 in 60(1.7%)
2	Thin bituminous surface	1 in 40(2.5%)	1 in 50(2%)
3	Water bound macadam(WBM) and gravel pavement	1 in 33(3%)	1 in 40(2.5%)
4	Earth	1 in 25(4%)	1 in 33(3%)

Too steep slope is not desirable because of the following reasons

- Uncomfortable side thrust and unequal wear of the tyres as well as road surface.
- Problem of toppling over highly laden bullock cart and truck.
- Tendency of most of vehicle travel along the centre line.

Kerb:

- It indicates the boundary between the pavement and shoulder.
- It is desirable to provide kerbs in urban areas.
- It is of three types

1-Low or mountable kerb:

- It allow the driver to enter the shoulder area with little difficulty.
- The height of the this type of shoulder kerb is about 10 cm above the pavement edge with slope to help the vehicle climb the kerbeasily.

2-Semi-barrier kerb:

- It is provided on the periphery of a roadway where the pedestrian traffic is high.
- Height of about 15 cm above the pavement edge with a batter of 1:1 on the top 7.5 cm.
- It prevents parking the vehicle but during emergency it is possible to drive over this kerb with some difficulty.

3-Barrier type kerb:

- It is provided in built-up area adjacent to the foot paths with considerable pedestrian traffic.
- The height of the kerb is about 20 cm above the pavement edge with a steep batter of 1V:0.25H.



kerb



Guard rail

- It is provided at the edge of the shoulder when the road is constructed on a fill exceeds 3 m.
- It is also provided on horizontal curve so as to provide a better night visibility of the curves under the head light of the vehicle.



Guard rail

Road margins

Parking lane:

- These 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 vehicle.
- It should have sufficient width say 3m

Lay bay:

- These are provided near the public conveniences with guide map to enable driver to stop clear off the carriageway.
- It has 3m width, 30m length with 15m end tapers on both sides.

Bus bays:

- These may be provided by recessing the kerb to avoid conflict with moving traffic.
- It is located at least 75m away from the intersection

Frontage road:

- These are provided to give access to properties along an important highway with control access to express way or free way
- It may run parallel to the highway and are isolated by separator.

Driveway:

- It connect the highway with commercial establishment like fuel stations, service stations etc...
- It should be located away from the intersection.

Cycle track:

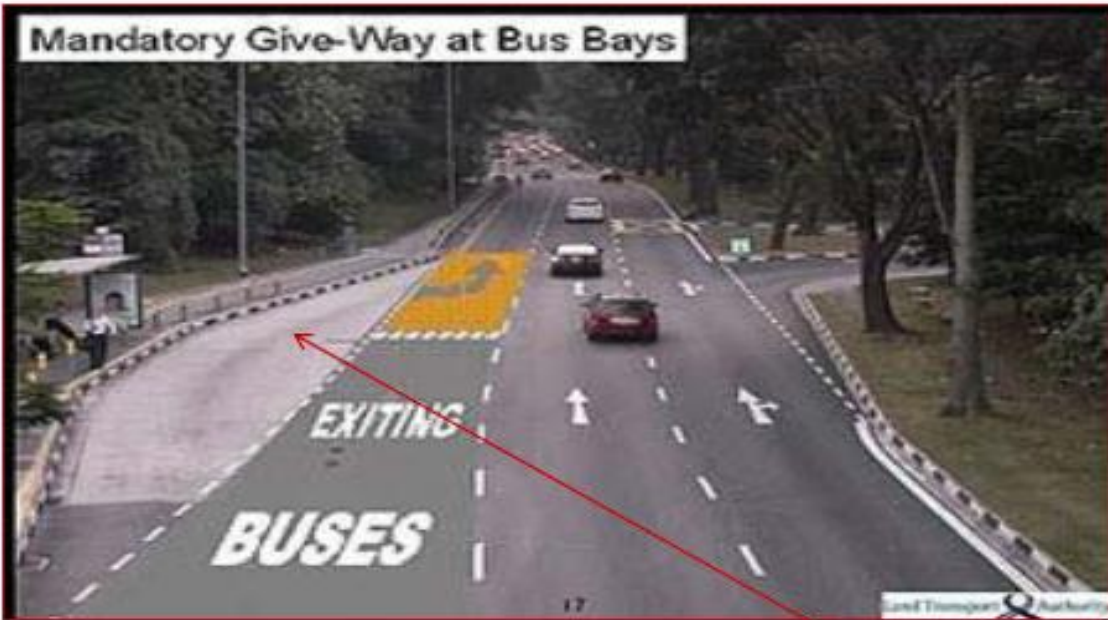
- It provided in urban areas when the volume of cycle traffic on the road is very high.
- A minimum width of 2m is provided for cycle track.

Footpath:

- These are provided in urban areas when the vehicular as well as pedestrian traffic are heavy.
- To protect the pedestrian and decrease accident.
- Minimum width of 1.5m is provided.



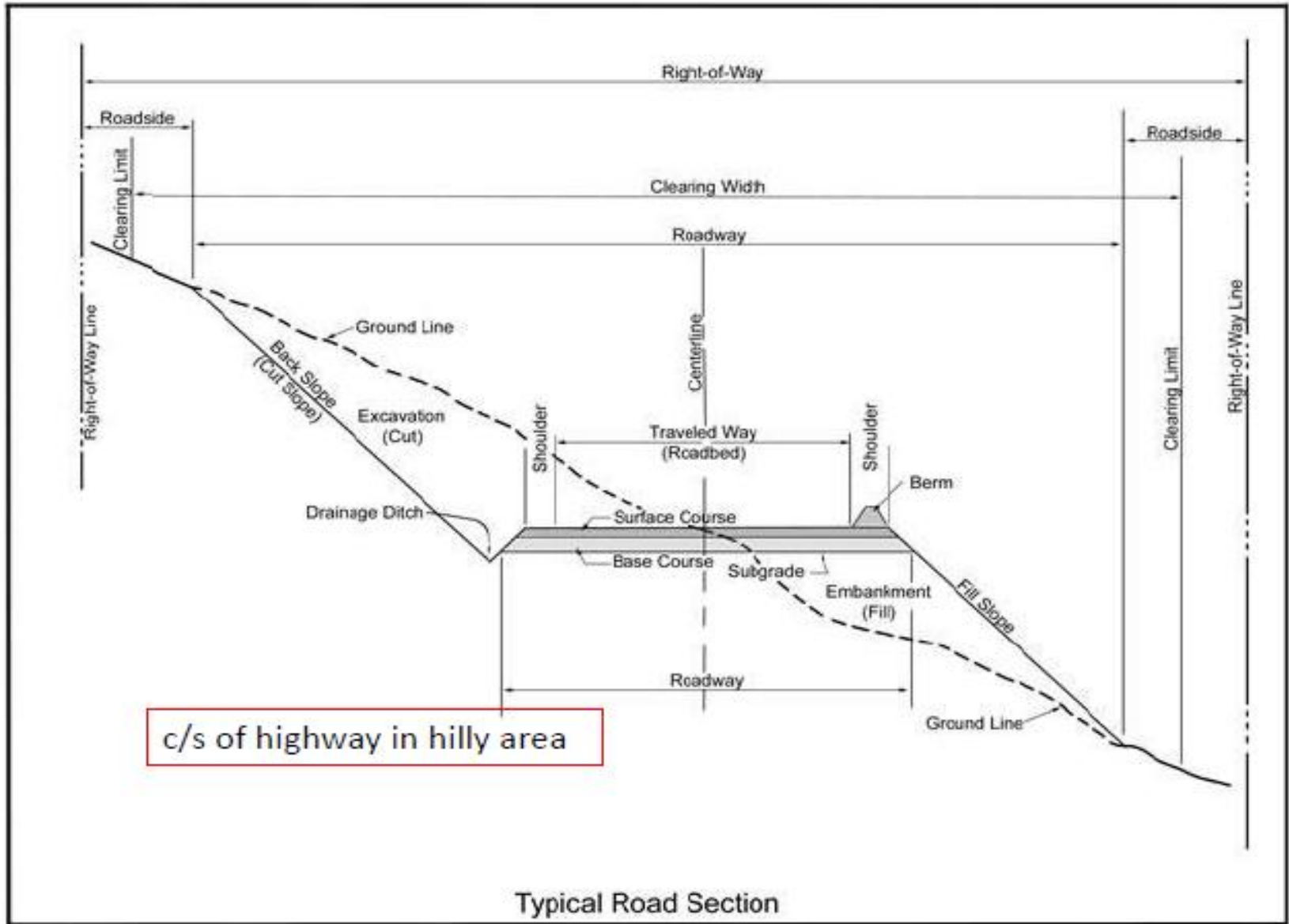
Mandatory Give-Way at Bus Bays

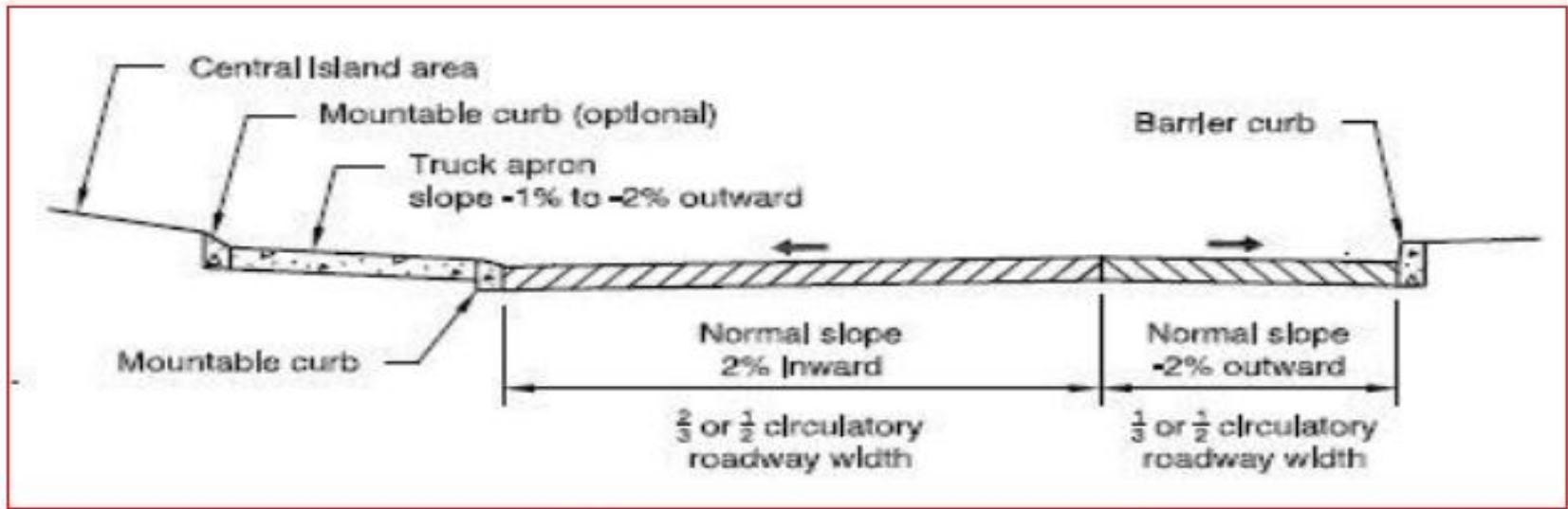


Bus bays

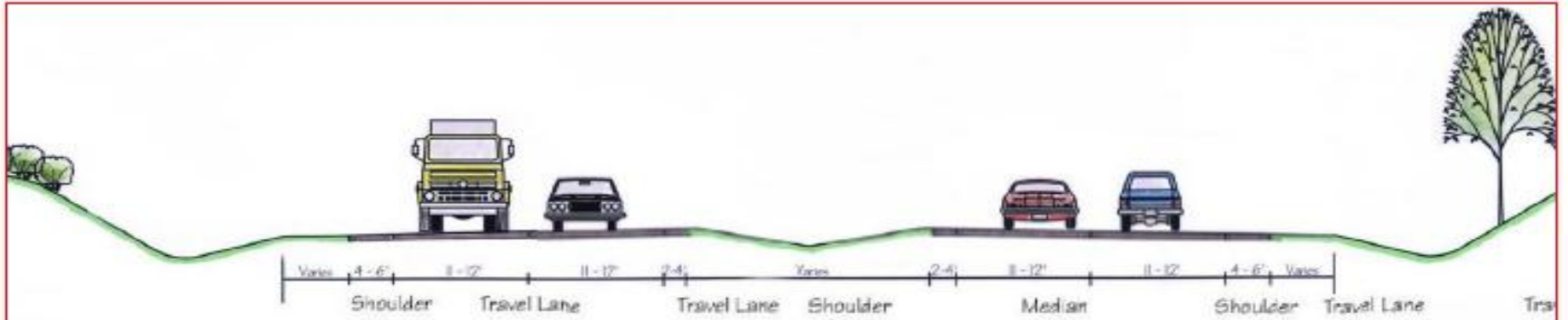


Frontage
road



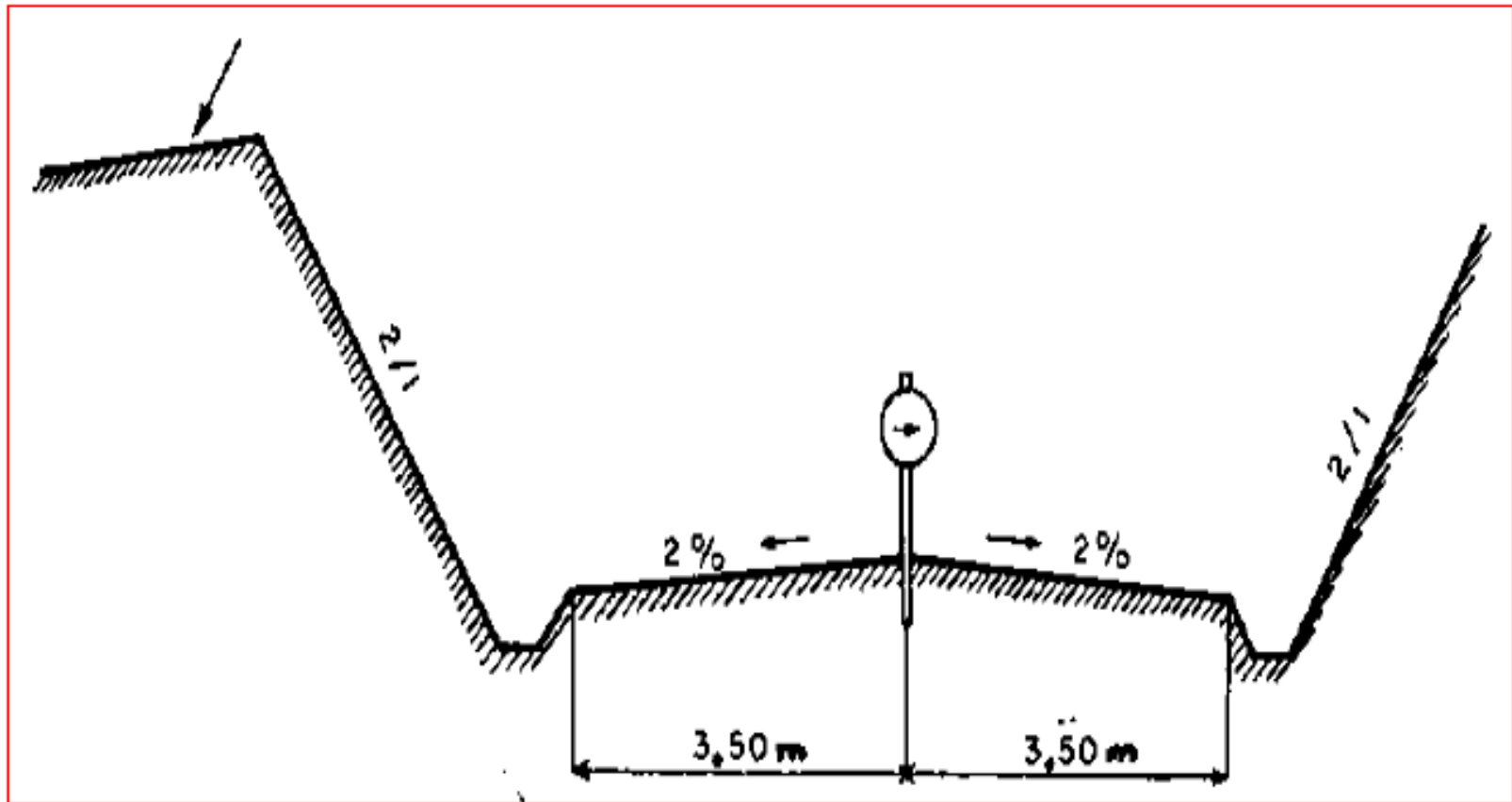


c/s of road in built-up area



Four Lane Divided Roadway





c/s of road in cutting



Guard rails



Bibliography

- Khanna, S. K., & Justo, C. E. G. “*Highway engineering*”. *NemChand & Bros.*
- IRC Codes.*

Thank
you

