# Design Controls and Criteria

- Functional classification
- Projected traffic volumes and composition
- Design speed and design vehicle
- Topography
- Available Funding
- Driver performance factors
- Safety
- Politics
- Social and environmental impacts
- Right-of-Way (ROW)
- Costs

# Cross-section Elements



# Cross-section Elements

**Principal elements**

- Travel lane
- Shoulders

**Marginal elements**

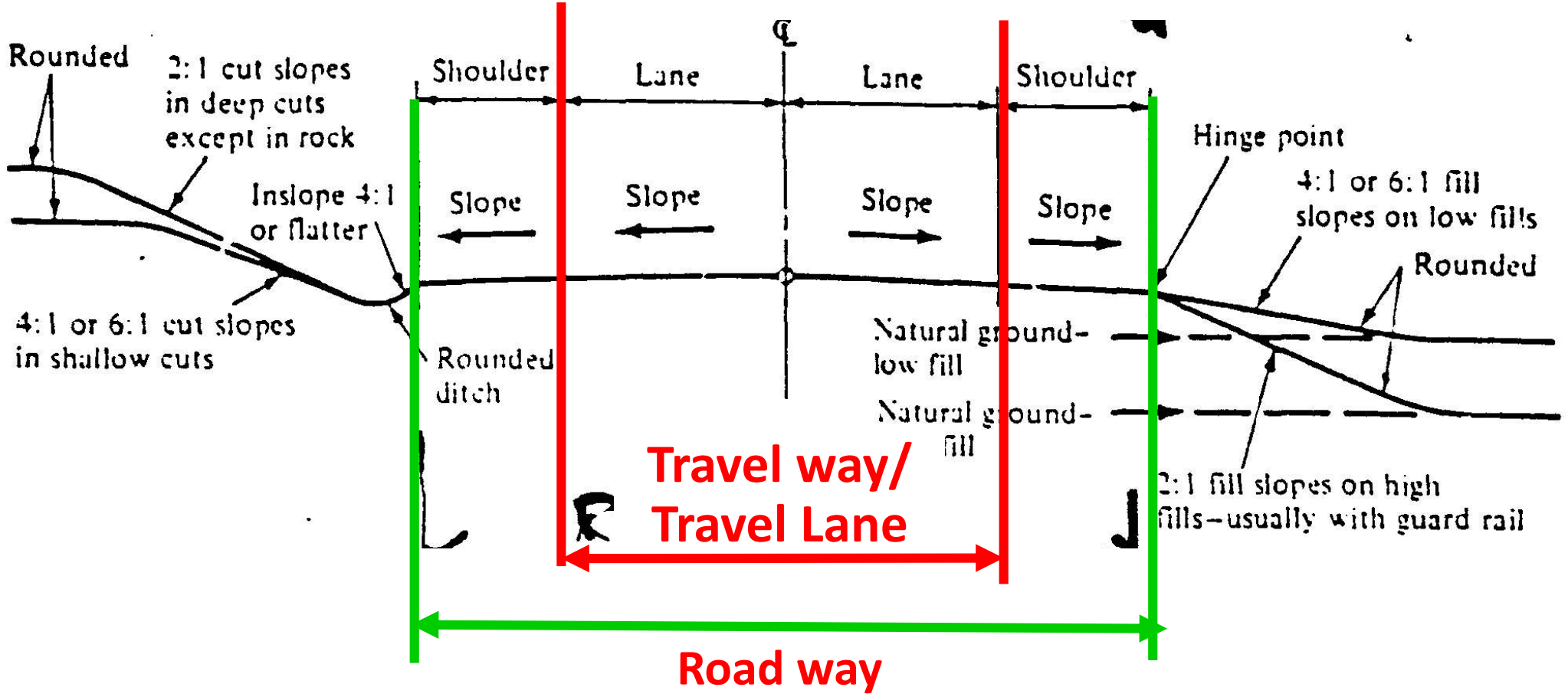
- Median and roadside barriers
- Curbs and gutters
- Guard rails
- Sidewalks
- Cross slopes
- Side slopes
- Right of way

**Additional Elements**

- Passing Lanes
- Turnouts
- Climbing Lane
- Frontage road/service road
- Bus layby
- Noise barrier
- Street light

- Show in a sketch the different cross sectional element of a tow lane two way highway
- List all cross sectional elements of a two lane two-way highway (principal element, marginal elements and additional elements)

# Road way and Travel way




**Roadway:** The portion of a highway, including shoulders, for vehicular use. A divided highway has two or more roadways.

**Traveled Way:** The portion of the roadway for the movement of vehicles, exclusive of shoulders.

# Cross-section Elements

## Lane Width

- ✓The width and number of lanes **should be adequate to accommodate the type and volume of traffic anticipated and the assumed designed speed of the veh**.
- ✓Roads may be of **two lane**, **three lane, multilane undivided, multilane**
- ✓**Four lane highway provide four times capacity of two lane highway**
- ✓Lane width affect **safety, comfort, speed and capacity**
- ✓Generally **10 to13 ft**. Most arterials have 12 ft travel lanes.
- ✓For two –lane, two-way Rural roads, 12 ft is recommended, 10-11 ft acceptable on low speed facilities
- ✓Under unusual and severe constraints, 9 ft acceptable for low-volume roads in rural & suburban areas

- ✓ **Auxiliary lanes at intersections and interchanges (like left turn lanes) should be as wide as poss but not less than 10 ft**, more for long, articulated veh.

# Geometric Design standards for Roads & Highway Department, Bangladesh

**Table 2.1 Road Cross-Section Standards**

| Design Type | Design year traffic volume PCU / peak hour (typical MV AADT) | Cross-section widths in metres | | | Indicative Road Classification |
|---|---|---|---|---|---|
| | | Crest width | Carriageway (no. of lanes) | Paved shoulders | |
| 1 | 4500 ≥ 8500 (19,000≥36,000) | 36.2 | 2 x 11 (6) | 1.8 | National |
| 2 | 2100 - 4500 (7,000 ≥ 19,000) | 21.6 | 2 x 7.3 (4) | 1.8 | |
| 3 | 1600 ≥ 2100 (5,000 ≥ 7,000) | 16.3 | 7.3 (2) | 1.5 | Regional |
| 4 | 800 ≥ 1600 (1,000 ≥ 5,000) | 12.1 | 6.2 (2) | 1.5 | |
| 5 | 400 ≥ 800 (500 ≥ 1,000) | 9.8 | 5.5 (2) | 1.2 | Feeder |
| 6 | <400 (<500) | 9.8 | 3.7 (1) | 1.2 | |

Notes
This is a summary table ≥ refer to Section 4 before using these standards

**Table 2.2 Typical Design Speeds**

| Design Type | Design Speed (km/h) | | |
|---|---|---|---|
| | Plain | Rolling | Hilly |
| 1 - 2 | 80 ≥100 | 80 | - |
| 3 | 80 | 65 | 50 |
| 4 | 65 | 50 | 40 |
| 5 - 6 | 50 | 40 | 30 |

Notes
Terrain: typical cross-slopes
Plain: 0 ≥ 10%
Rolling: 11 ≥ 25%
Hilly: >25%

**Table 2.4**
**Passenger Car Unit (PCU) Values**

| Vehicle Type | PCU Value |
|---|---|
| Truck | 3.0 |
| Bus | 3.0 |
| Minibus | 3.0 |
| Utility | 1.0 |
| Car | 1.0 |
| Baby taxi | 0.75 |
| Motorcycle | 0.75 |
| Bicycle | 0.5 |
| Cycle Rickshaw | 2.0 |
| Bullock Cart | 4.0 |

Source: p72, RMSS, Vol. V11A

**There are five basic carriageway widths within the six Design Type configurations:**

1. **3.7 m wide** - This is the standard single lane carriageway width, and is suitable for the more lightly-trafficked Feeder Roads. Vehicles travelling in opposing directions can pass each other by putting their outer wheels on the shoulder.

2. **5.5 m wide** - This is a minimum width two-lane carriageway. Large vehicles can pass each other at slow speed.

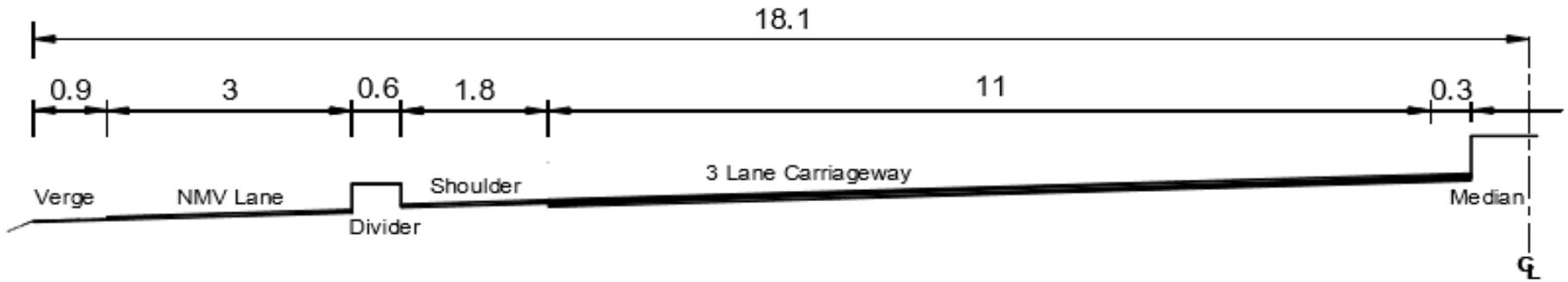
3. **6.2 m wide -** This is the lowest economic cost option for a very wide range of traffic volumes. It allows most vehicles to pass with sufficient clearance to avoid the need to slow down or move aside.

4. **7.3 m wide single** - This is a high standard two-lane single carriageway.

5. **7.3 m wide dual** - This is a high standard carriageway as one half of a dual 2-lane road.

6. **11 m wide dual** - This is a three-lane carriageway as one half of a dual 3-lane road.

## Figure 4.2 Design Type 1 Dual 3-lane 11m carriageway




| Width of sectional elements (m) | |
|---|---|
| Crest | 36.2 |
| Median | 1.0 |
| Carriageway | 11.0 |
| Shoulder (L) ð paved | 1.8 |
| Shoulder (R) ð paved | 0.3 |
| Divider | 0.6 |
| NMV lane | 3.0 |
| Verge | 0.9 |

Design Capacity
Maximum capacity: 8500 PCU/hr
(assumed NMV/MV ratio of 0.13)

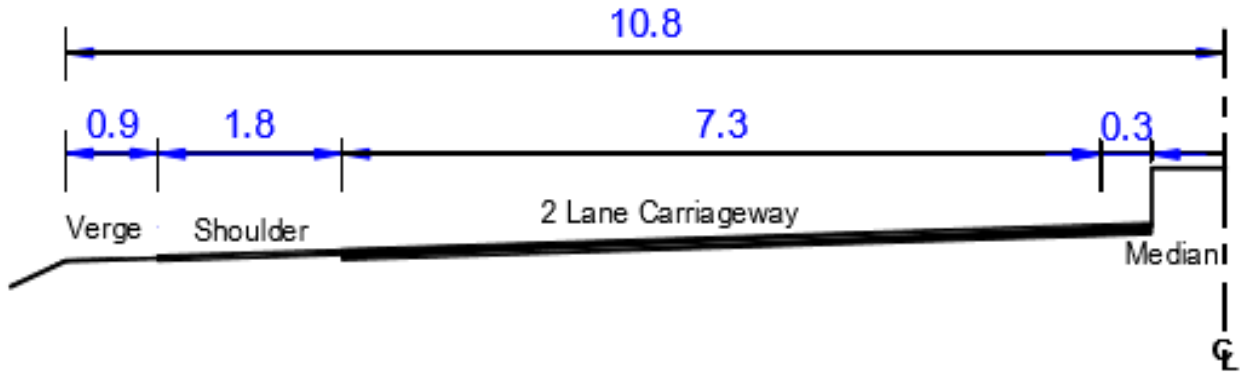
NMV provision

NMVs will use the separate NMV lane. Separation can be achieved in any of the three ways indicated in Figure 4.8. A standard width NMV lane is shown but this may need to be wider if NMV flows are high ð see Section 4.3. Exceptionally the NMV lane may be omitted where it is thought to be feasible to prohibit NMVs from using the road.

Median

See Figure 4.9 for alternative designs.

## Figure 4.3 Design Type 2 Dual 2 lane 7.3m carriageway




| Width of sectional elements (m) | |
|---|---|
| Crest | 21.6 |
| Median | 1.0 |
| Carriageway | 7.3 |
| Shoulder (L) ½ paved | 1.8 |
| Shoulder (R) ½ paved | 0.3 |
| Verge | 0.9 |

Design Capacity

Maximum capacity: 4500 PCU/hr
(assumes that NMVs are either prohibited or are less than 50 PCU/hr)

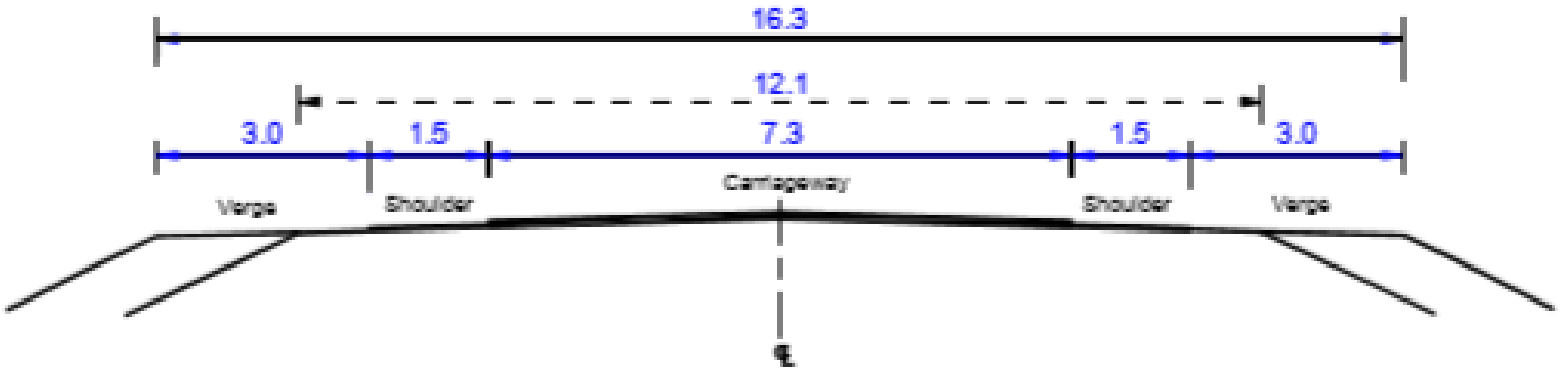
NMV provision

NMVs will use the shoulder. If the Design Year NMV PCU/hour exceeds 50 adopt the Type 2a cross-section which incorporates separate NMV lanes.

Median

See Figure 4.9 for alternative designs.

## Figure 4.4 Design Type 3 7.3m carriageway




| Width of sectional elements (m) | | Design Capacity |
|---|---|---|
| Crest | 16.3 | Maximum capacity: 2100 PCU/hr |
| Carriageway | 7.3 | (assumed NMV/MV ratio of 0.2) |
| Shoulder ½ paved | 1.5 | |
| Verge | 3.0 | |

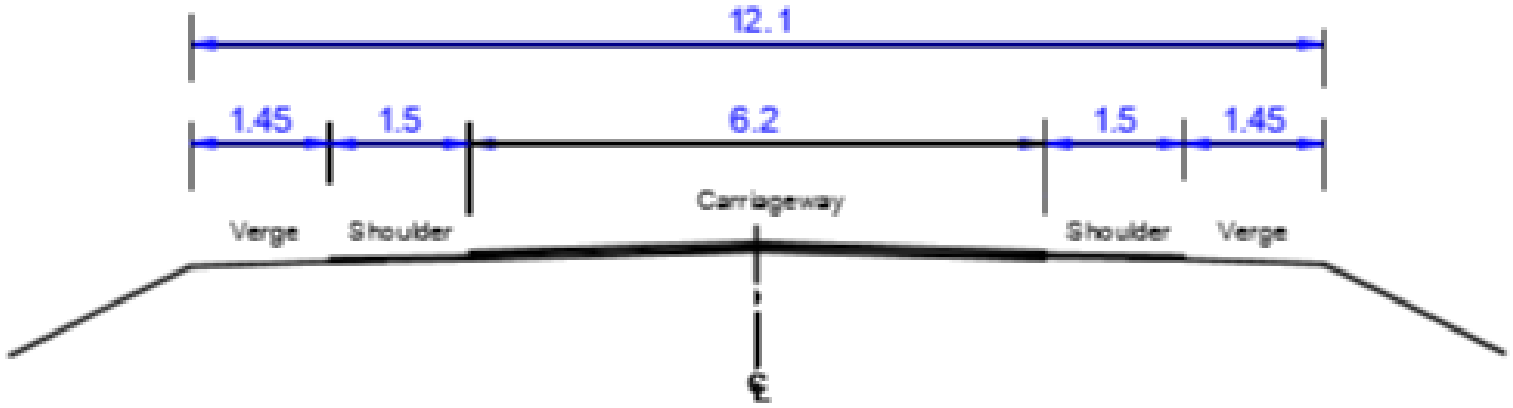
NMV provision

NMVs will use the paved shoulder. Consider providing separate NMV lanes (Type 3a cross-section) if the DY NMV PCU/hr exceeds 400 ÷ see Figure 4.8.

Crest width

The extra-wide embankment permits the future addition of NMV lanes. If it is unlikely that these will ever be needed the verge need only be 0.9m wide, making the crest width 12.1m.

## Figure 4.5 Design Type 4 6.2m carriageway




| Width of sectional elements (m) | | Design Capacity |
|---|---|---|
| Crest | 12.1 | Maximum capacity: 1600 PCU/hr |
| Carriageway | 6.2 | (assumed NMV/MV ratio of 0.14) |
| Shoulder ♀ paved | 1.5 | |
| Verge | 1.45 | |

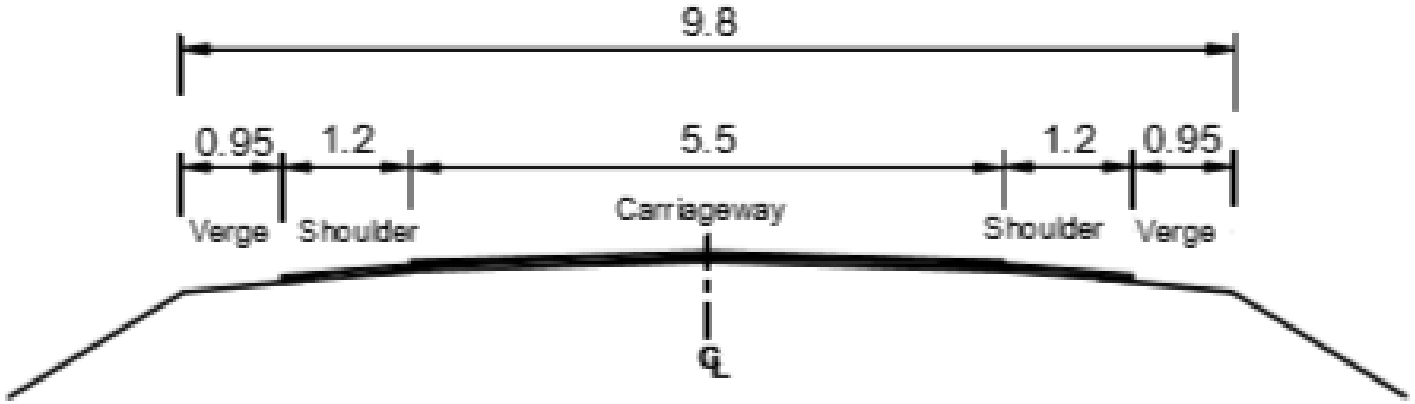
NMV provision

Where DY NMV PCU/hr exceeds 400 consider providing separate NMV lanes (Type 4a cross-section) ♀ see Figure 4.8.

Upgrading

The extra-wide embankment permits upgrading to Type 3 standard.

## Figure 4.6 Design Type 5 5.5m carriageway




| Width of sectional elements (m) | |
|---|---|
| Crest | 9.8 |
| Carriageway | 5.5 |
| Shoulder ½ paved | 1.2 |
| Verge | 0.95 |

Design Capacity

Maximum capacity: 800 PCU/hr

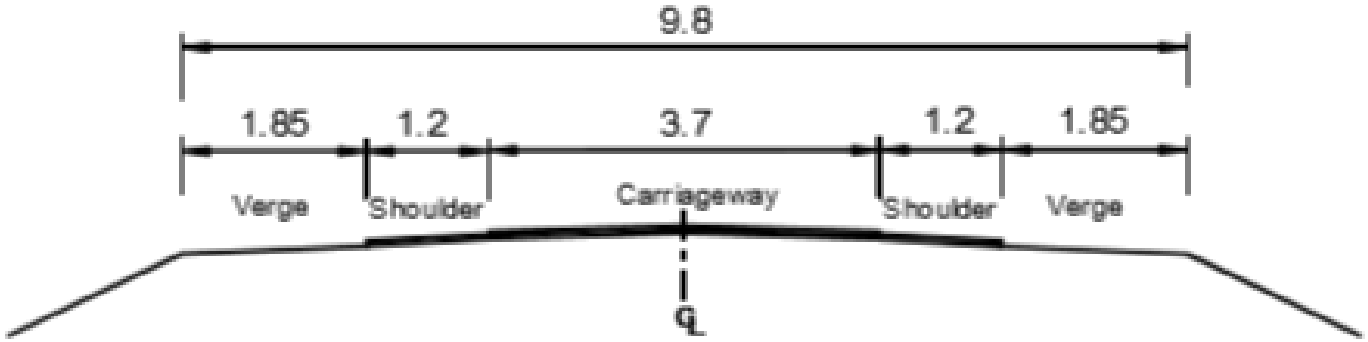
NMV provision

NMVs will use the carriageway and the shoulder, so it is essential that there is no difference in level between the two.

Upgrading

The extra-wide embankment permits upgrading to Type 4 standard.

## Figure 4.7 Design Type 6 3.7m single lane carriageway




| Width of sectional elements (m) | |
|---|---|
| Crest | 9.8 |
| Carriageway | 3.7 |
| Shoulder ± paved | 1.2 |
| Verge | 1.85 |

Design Capacity
Maximum capacity: 400 PCU/hr
(assumed NMV/MV ratio of 2.5)

NMV provision
NMVs will use the carriageway and the shoulder, so it is essential that there is no difference in level between the two.

Upgrading
The extra-wide embankment permits upgrading to Type 5 and Type 4 standards.

Capacity
The design capacity of 400 PCU/hr is only achievable with good, well-maintained shoulders and when most of the vehicles are NMVs.

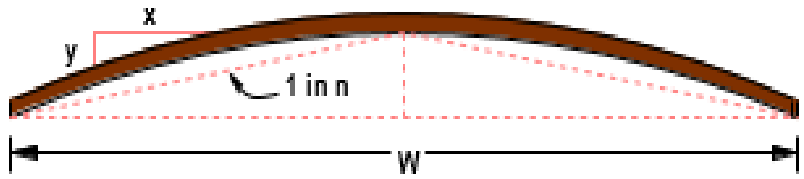
## How cross slopes are provided on roadway pavement?

## How to ensure surface drain off of rain water?

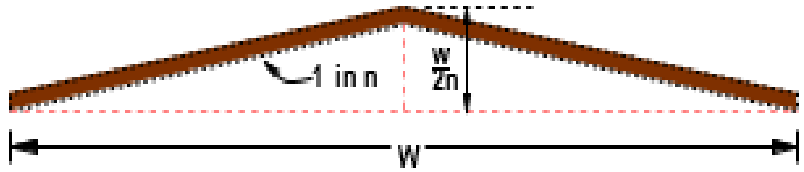
### Camber

- Camber is the cross slope provided to raise middle of the road surface in the transverse direction to drain off rain water from road surface.
- Too steep slope is undesirable for it will erode the surface.
- Camber is measured in *1 in n* or *n%* and the value depends on the type of pavement surface.

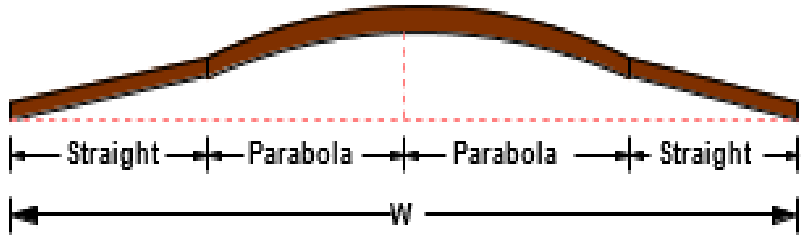
### Different types of camber




a. Parabolic camber, $y=2x^2/w$




b. Straight line camber




c. Combination of straight and parabolic camber

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

# How cross slopes are provided on roadway pavement?
# How to ensure surface drain off of rain water?

**Pavements** on straight sections of **two-lane and multilane highways without medians are sloped from the middle downward to both sides of the highway.** This **provide a cross slope** (crowned).

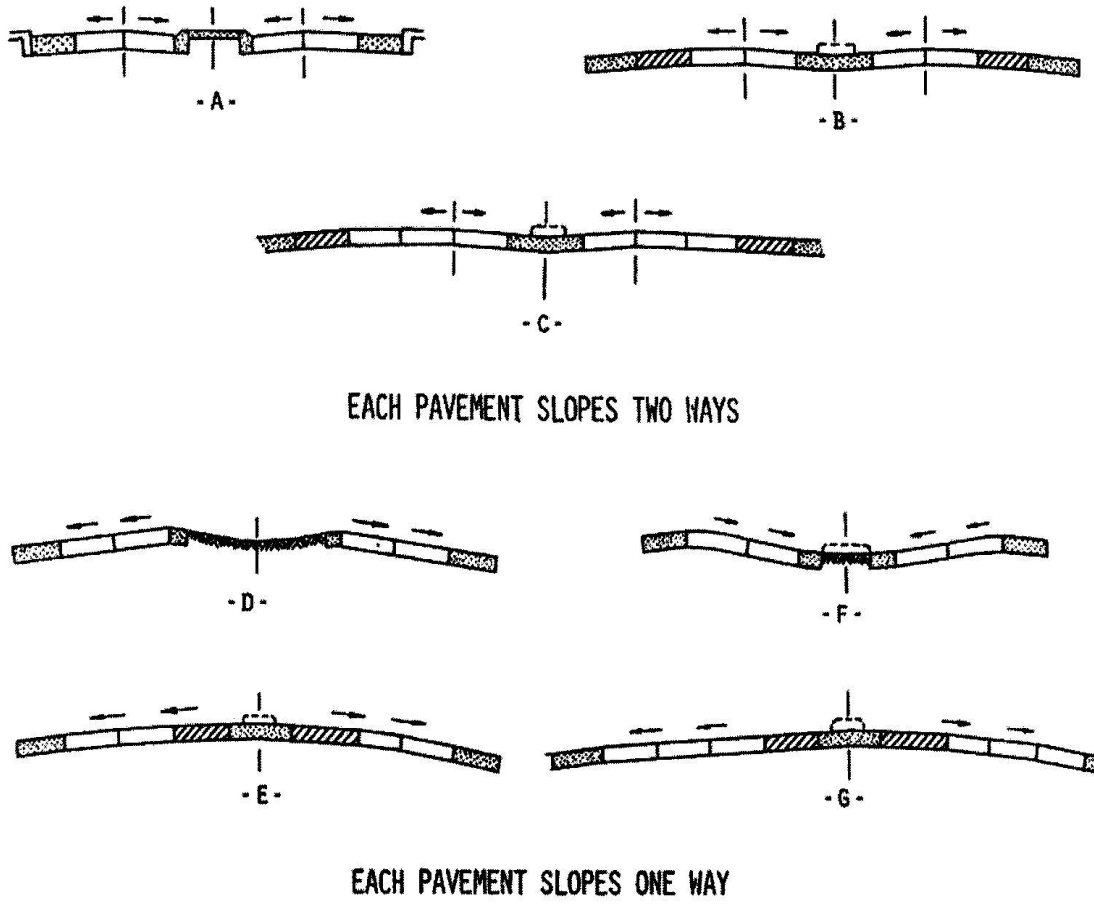
The **cross slopes on divided highways** are provided by either :

1. **Crowning the pavement in each direction** *(mainly used in areas with heavy rain and snow)*

   Advantage: quick drain of surface water from traveled roadway during heavy rain storm.

   Disadvantage: more drainage facilities are required such as inlets and underground drains.

2. **Sloping the entire pavement in one direction.**



# Shoulders

- **Portion of the rd way contiguous with the traveled way** on either side of the travel way
- May or may not be **surfaced, stabilized or paved**.
- Well designed and properly maintained shoulders are **nec on rural HY with appreciable amount of tfc, on FW and on some types of urban HW**
- It is essentials that shoulder be **flush with the edge of the traveled lane and sloped to facilitate drainage**






# Shoulders

## Shoulder width

- AASHTO: **10 -12 ft for highways having large number of trucks and high traffic volumes and high speeds**.
- Min width **4 ft w**hen **pedestrians and bicycles are permitted**
- Min **2 ft may be used on** difficult terrain and low tfc volume.

## Shoulder Slope

should be **slopped sufficiently to rapidly drain surface water** but not to the extent that veh use would be hazardous

- **Bitumen & concrete-surfaced: 2 to 6%, Gravel/crushed rock: 4 to 6%, Turf: 6 to 8%**

## Shoulder Contrast

**Color and texture** should be different from through tfc lanes. It clearly **defines at ni and inclement weather**, while discouraging the use of shoulder as through lanes

# Importance of Shoulders

1. Space for vehicles with problems to park
2. Space for drivers to stop and check maps, etc
3. Space for evasive maneuvers to avoid collisions
4. The sense of openness
5. Help providing required sight distance
6. Increased aesthetics
7. Improved capacity
8. Space for maintenance operations (snow & storage)
9. Lateral clearance for signs and guardrails
10. Discharge storm water away from the edge of pavement
11. Structural support for the pavement
12. Space for pedestrians and bicycles

# Shoulders













# Sidewalks

- Sidewalks are generally **provided when pedestrian traffic is high along main or high-speed roads in either rural or urban areas**.
- **Necessary on arterials with no shoulders even when pedestrian traffic is low**.
- Should be provided along **both sides of collector streets in urban areas** to provide pedestrian access to schools, parks, shopping centers, and transit stops.
- As a general practice, sidewalks should be constructed along any street or highway not provided with shoulders, even though pedestrian traffic may be light.
- Sidewalks should have all-weather surface to ensure their intended use.
- Sidewalk Min width of (4 ft) in residential areas, and (4 – 8 ft) in commercial areas.

# Side walks



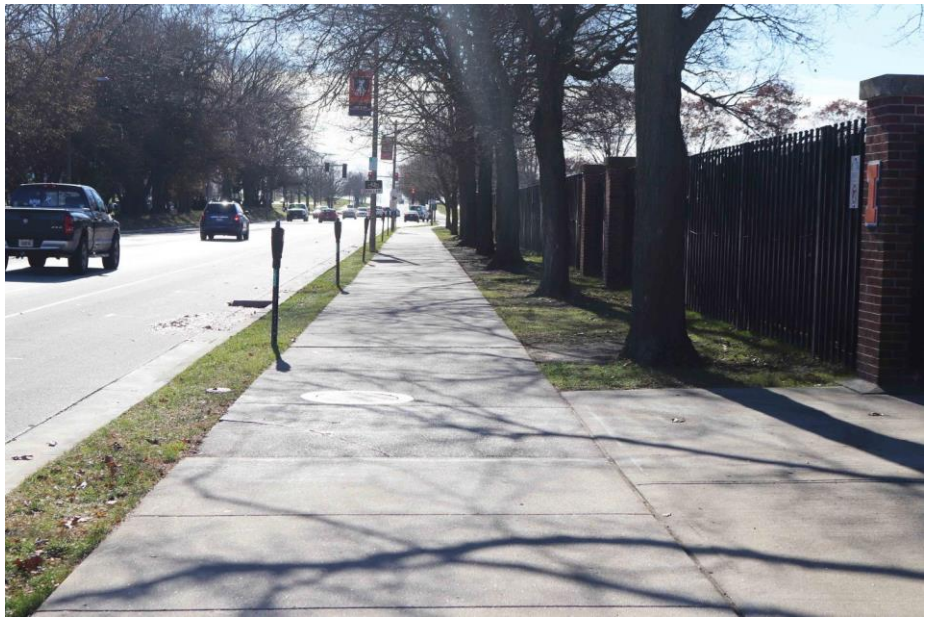




# Side walks









# Medians

**What is it?:** Is the section of a divided highway that separates the lanes in opposing directions.





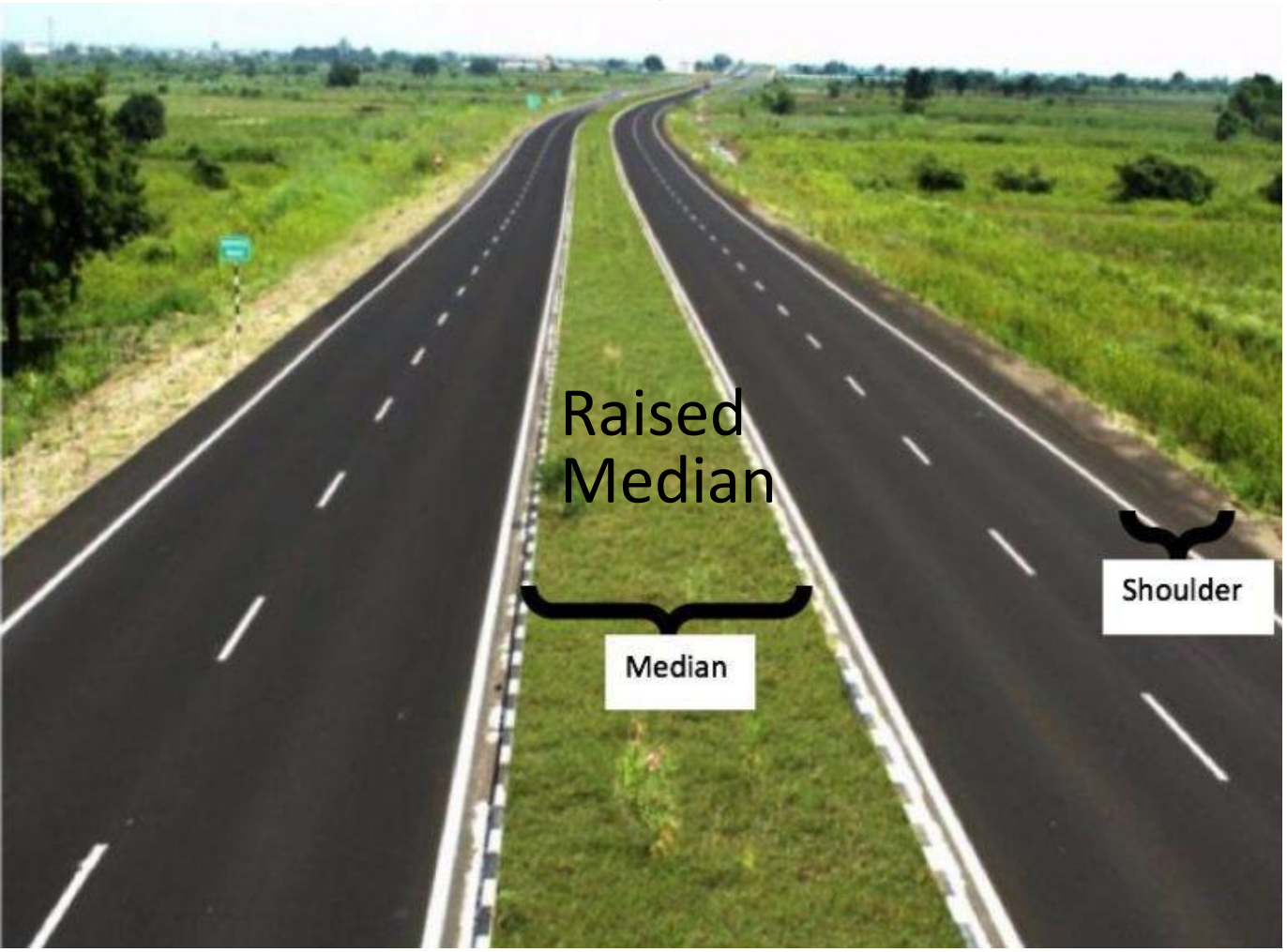
# Medians

**Median functions:**

- Provide recovery area for out-of-control vehicles.
- Separating opposing traffic.
- Providing stopping areas during emergencies.
- Providing storage areas for left-turning and U-turning vehicles.
- Providing refuge for pedestrians.
- Reducing the effect of headlight glare.
- Providing temporary lanes and cross-overs during maintenance operations.

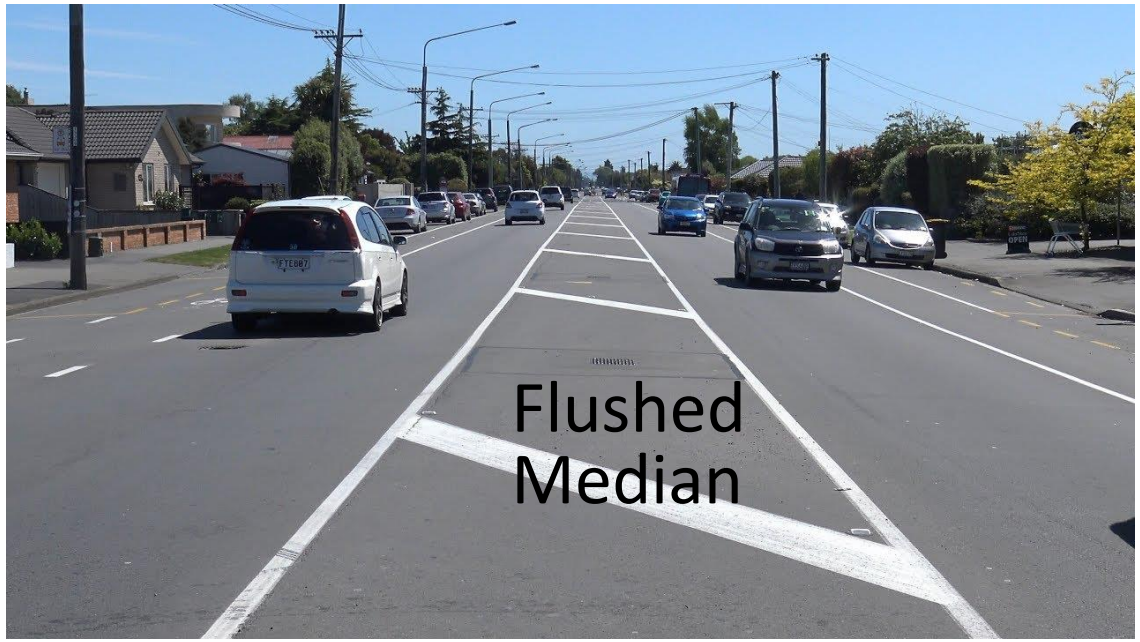
# Medians Types

1. Raised
2. Flush
3. Depressed









# Medians Types

**Raised Medians**

- used **in urban arterial streets** as they facilitate the control of left turning traffic at intersections by using part of the median width for left-turn only lanes.
- possible loss of control of the vehicle if the median is accidentally struck.
- Prevent headlight graring

**Flush Medians**

- Commonly used on urban arterials, also on free-ways but with a median barrier.
- Should be crowned to facilitate drainage of surface water.
- flush medians may be used as into two-way left-turn lanes
-

**Depressed medians**

- Used on freeways.
- More effective in draining surface water.

# Cross-section Elements

# Medians

**Medians  Width**

- Vary from (**4 - 80 ft) or more.**
- For **4-lane urban freeways** min of **10 ft**.

For **6-lane urban freeways** min of **22- 26** ft.

**Median Barriers**

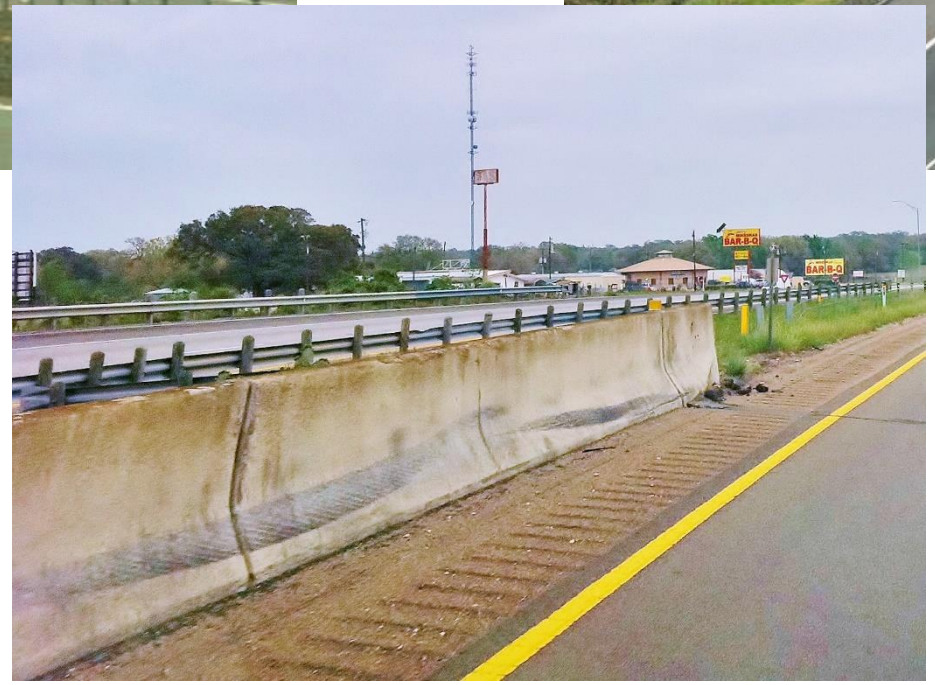
Median barriers are longitudinal system used to **prevent an errant vehicle from crossing** the portion of a divided highway separating the traveled ways for traffic in opposing directions.

Used to **shield pedestrians and property** from the traffic stream.

# Median and Median Barriers







# Drainage structures

1. Ditches
2. Curbs and Gutters
3. Parallel Drainage Structures

   Placed parallel to the flow of traffic.

   Commonly found under the driveway, median crossover, intersecting
   and other travelled ways generally at right angle to the main street c
4. Cross Drainage structures

   Designed to carry water underneath the road way embankment.

   Culvert, Bridges etc



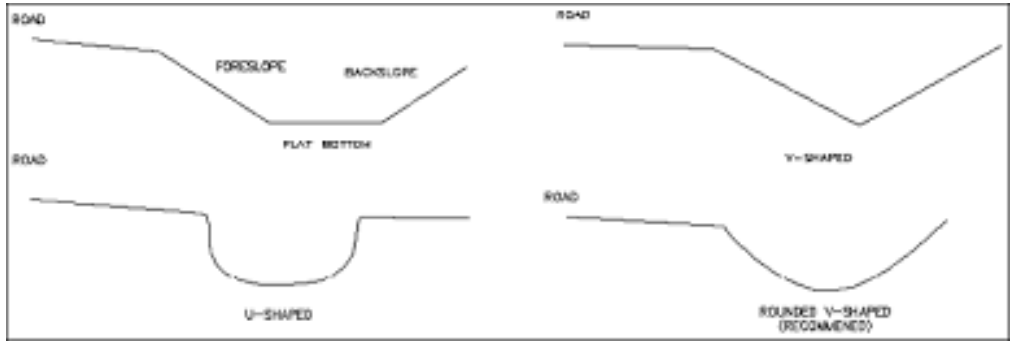


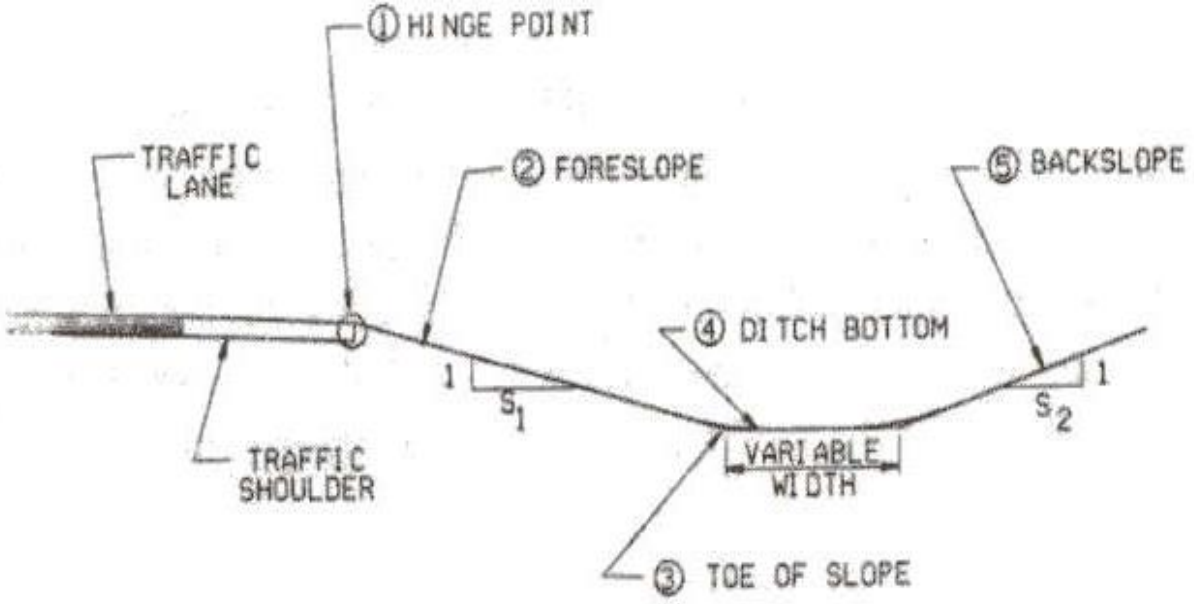




# Drainage Structures-Ditches

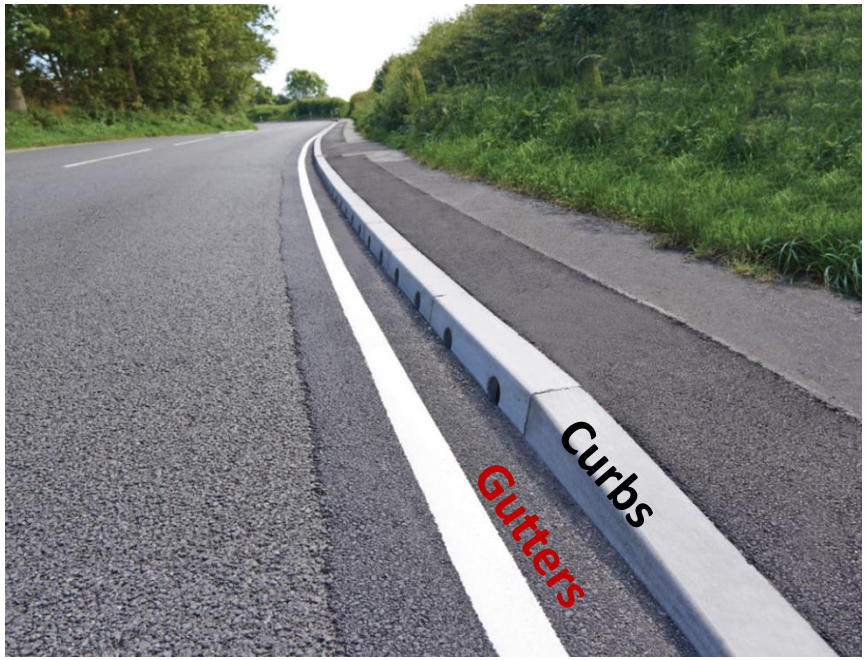
- The side slope of ditches should be as flat as poss consistent with drainage requirement.
- Preferable the bottom of the ditch should be wide and rounded so as to be traversable by out of con veh.
- Deep narrow ditches need to be shielded by roadside barriers.

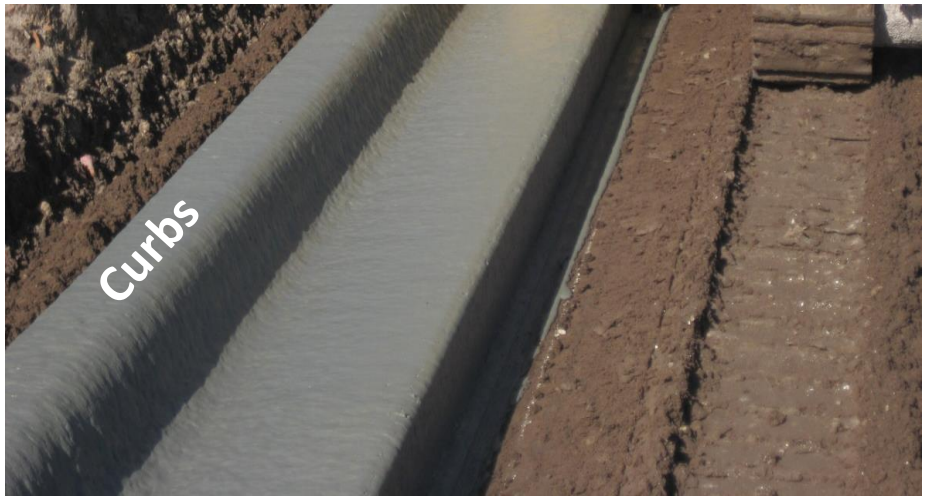





# Drainage Structure- Curbs and Gutters







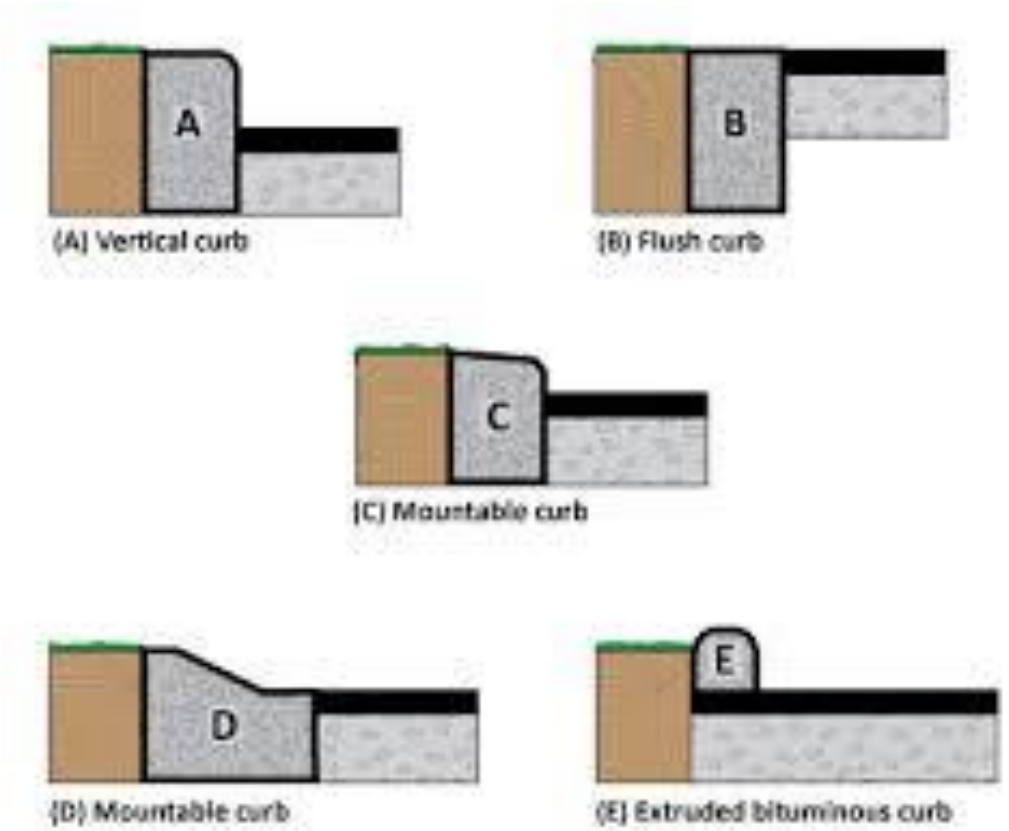





# Curbs/Kerbs

Raised structures made of either Portland cement concrete or bituminous concrete that are used mainly on urban highways to :

- Delineate pavement edges and pedestrian walkways.
- indicate the boundary between the carriage way and the shoulder or islands or footpathsControl drainage.
- Improve aesthetics.

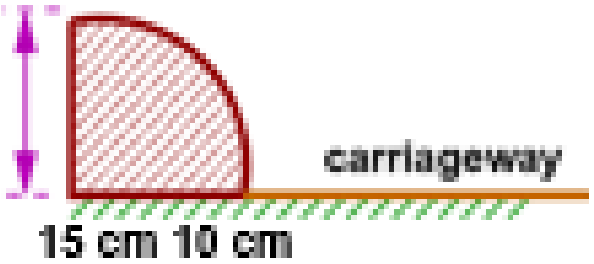


# Curbs/Kerbs

**Low or mountable kerbs:**

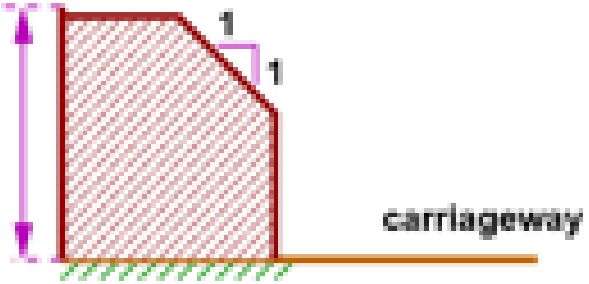
**<u>encourage the traffic to remain in the through traffic lanes and also llow the driver to enter the shoulder area with little difficulty</u>**.

usually **<u>provided at medians and channelization schemes and also helps in longitudinal drainage</u>**.




**Semi-barrier type kerbs:**

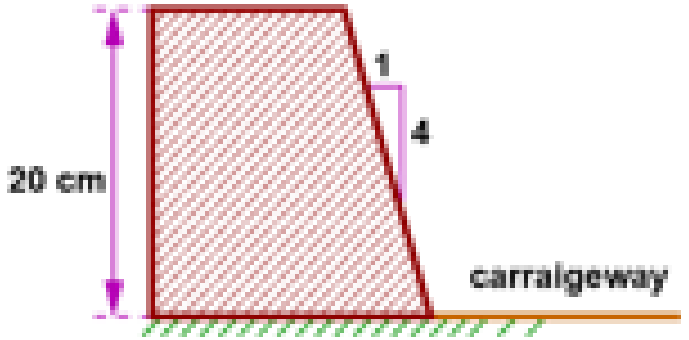
This type of kerb prevents encroachment of parking vehicles, but at acute emergency it is possible to drive over this kerb with some difficulty.



# Curbs/Kerbs

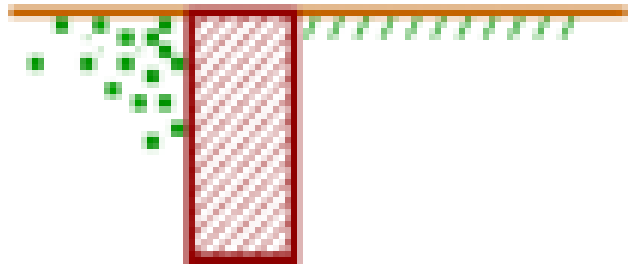
**Barrier type kerbs:**

**<u>designed to discourage vehicles from leaving the pavement</u>**
They are provided **<u>when there is considerable amount of pedestrian traffic</u>**.




**Submerged kerbs:**

They are used in **<u>rural roads</u>**. The kerbs are provided at pavement edges between the pavement edge and shoulders. They **<u>provide lateral confinement and stability to the pavement.</u>**



# Gutters

- A **street gutter** is a depression running parallel to a road designed to collect rainwater flowing along the street and divert it into a storm drain. Also known as drainage ditches.
- A gutter alleviates water buildup on a street, allowing pedestrians to pass safely and smoothly
- Can be designed as V-type sections or as broad, flat, rounded sections







# Longitudinal barriers

Purpose: to prevent veh from leaving the roadway and crushing into the roadside obstacle, overturning and crossing into the path of veh travelling in opposite direction.

Roadside Barriers like guard rail

Medians

Bridge Railing

# Guard rails

Guard rails are longitudinal barriers whose main function is to prevent vehicles from leaving the roadbed.

Placed on:

- The outside of sharp curves (where there is sudden change in alignment)
- Where greater reduction of speed is nec
- Sections with high fills (embankments > 8 ft)
- Shoulder slopes > 4:1
- Loc with steep banks, deep roadside ditches and other ROW limitations.

Shoulder width to be increased by 2 ft where guard rails are to be used.

# Guard Rails



















# Right of Way (ROW)

Is the total land area acquired for the construction of the highway.

Its width should be enough to:

- Accommodate all elements of the highway cross section.
- Any planned widening of the highway.
- Any public utility facilities that will be installed along the highway.

In some cases the side slopes may be located outside the ROW on easement areas.

The min. width of ROW for freeway depend on the number of lanes and the existence of frontage roads.

for two-lane urban collectors: (40 – 60 ft)

for  two-lane arterials: (min of 84 ft)

for undivided 4-lane arterials: (64 – 108 ft)

for divided arterials: (120 – 300 ft)

# Marginal Cross sectional Elements

## Footpath, Bike way

- 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.







# Marginal Cross sectional Elements

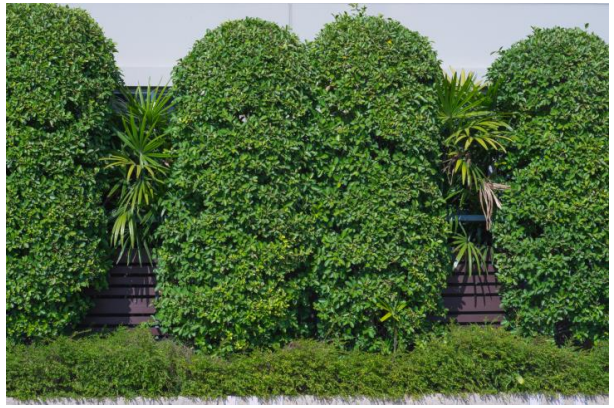
**Noise Barrier**

Motor vehicles generate traffic noise.  Designers should design noise barrier or sound walls to minimize the radiation of noise into noise-sensitive areas along the highway.
Noise reduction designs: depressed highways, sound barriers, natural barriers (trees)





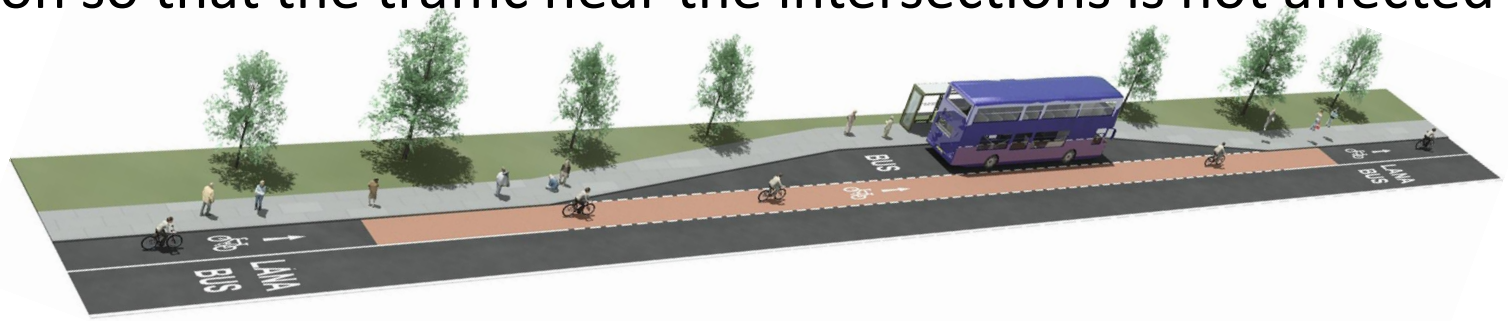





# Marginal Cross sectional Elements

## 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.









# Marginal Cross sectional Elements

## Service roads/Frontage Road

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.






# Marginal Cross sectional Elements

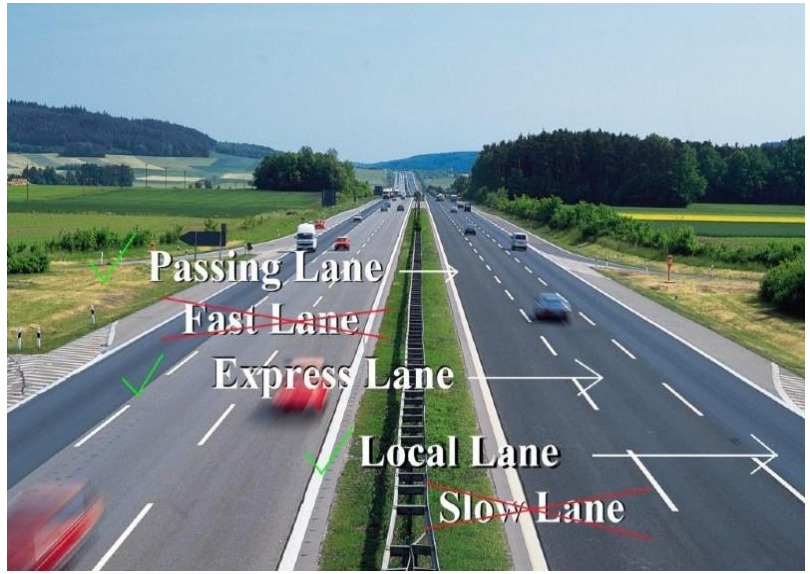
## Passing Lane

- **A lane added to improve overall traffic operations**, should be long enough, over 0.3 mi. The optimal length is 0.5 to 2 miles
- Provide systematically at regular interval (otherwise inform the drivers well in advance to reduce their frustration)
- A minimum sight distance of 1000 ft is recommended.
- Provide signs to inform drivers.









# Marginal Cross sectional Elements

**Turnout**

- **It is a widened, unobstructed area that allows slow-moving vehicles to pull out of the through lane to give passing opportunities to following vehicles.**
- Minimum = 200 ft, Maximum = 600 ft to avoid for use as a passing lane. It include the entry and exit taper lengths ranging from 50 to 100 ft.
- Available sight distance – at minimum 1000 ft.
- Proper signing and pavement marking essential not to misguide the drives

# Marginal Cross sectional Elements

## Climbing Lane

A highway section with a climbing lane is not considered a three-lane highway, but a two-lane highway with an added lane.

**For low-volume two-lane highways, climbing lanes may not be justified economically. In such cases, vehicle turnouts should be used**

Generally climbing lanes should not be considered unless the volume exceeds the service volume of LOS D.

If not warranted now, but may be in the future, then preserve right-of-ways for such additions.

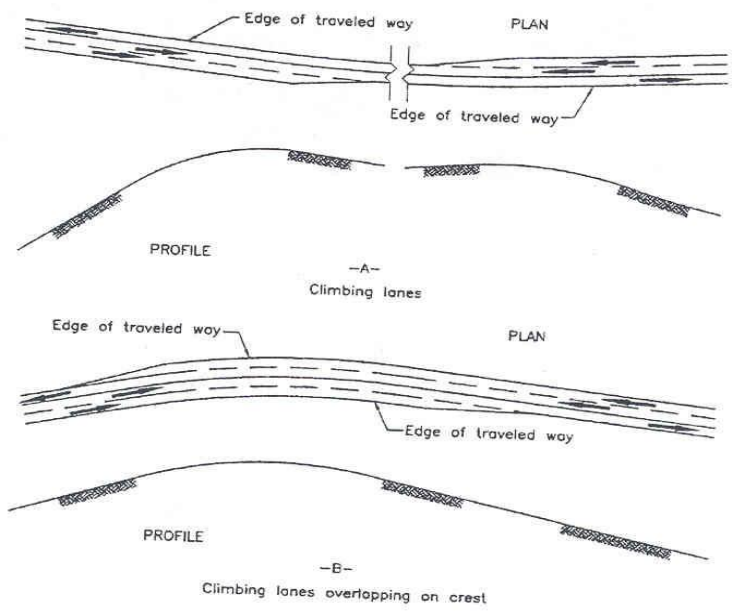



Exhibit 3-61. Climbing Lanes on Two-Lane Highways

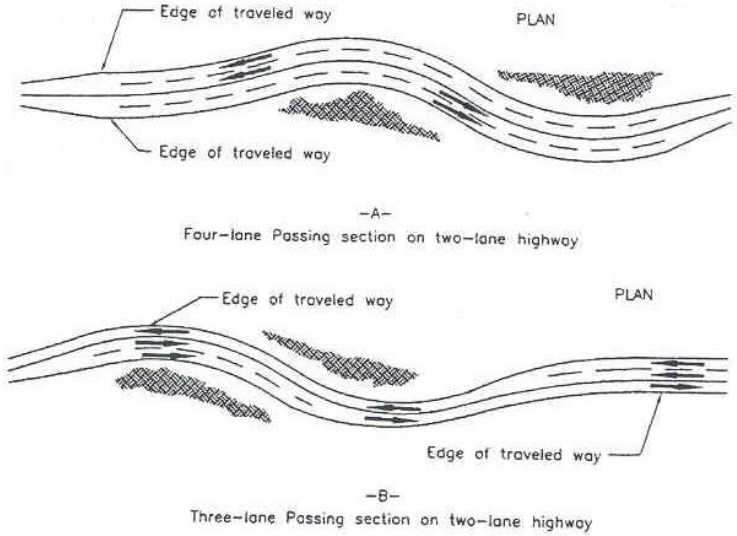



Exhibit 3-63. Passing Lanes Section on Two-Lane Roads

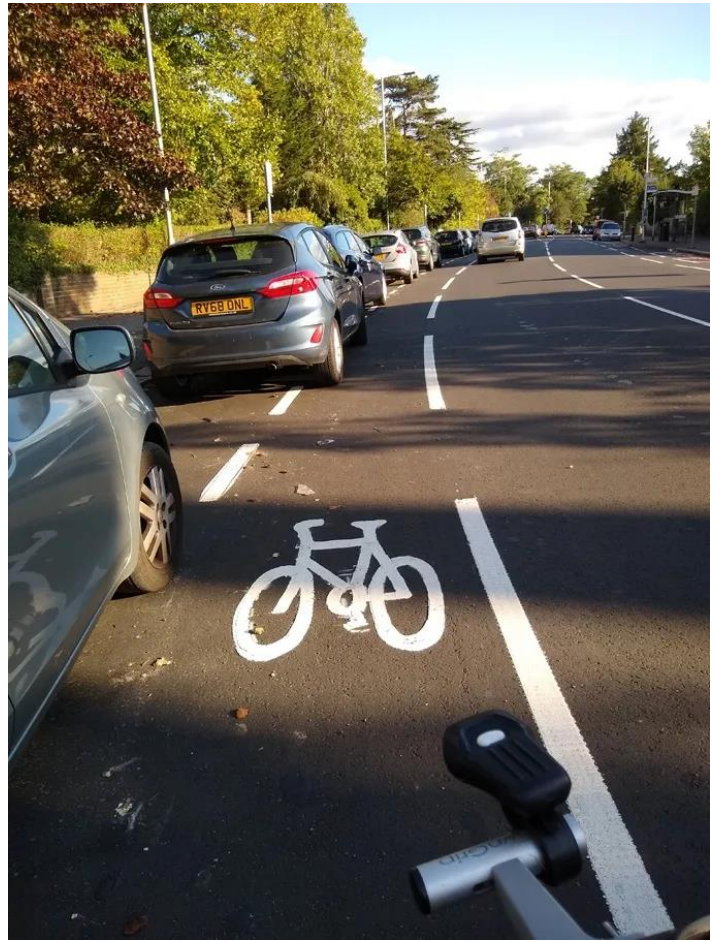
# Marginal Cross sectional Elements

## 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.





# Types of Parking Facilities

**On-street / curb parking**

- along curb
- Seriously impede tfc flow and contribute to conflicts/ crashes
- short stay
- convenient
- preferable parallel
- charged or free

**Off-street parking**

- away from curb
- long stay
- may be inconvenient as walking is reqd
- preferably angle
- Types: back street, surface car parks/parking lots, multi storied (self or auto), basement parks

# Method of Parking

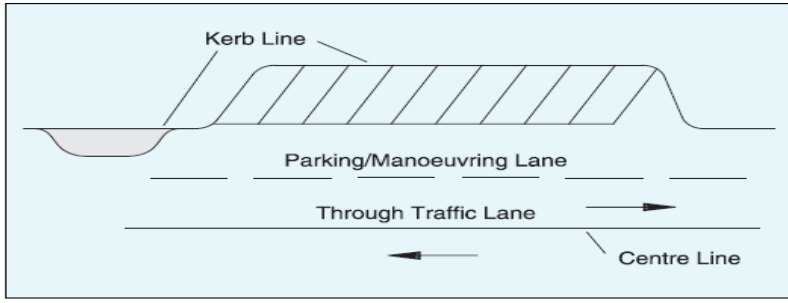
## Parallel parking

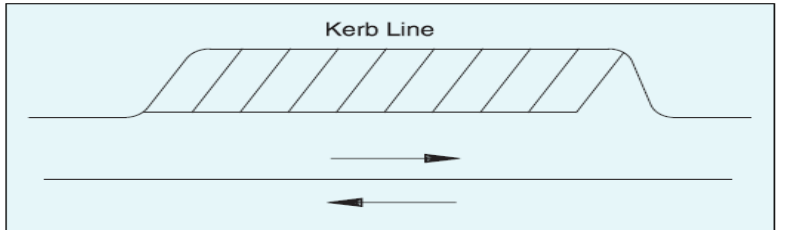
- Space reqr for parking and unparking maneuvers is least
- Reqr least rdway width but max curb length
- Maneuver is very difficult
- Off side door opening difficult
- Gen recommended for road with narrow width or with high vol of through tfc



## Angle Parking

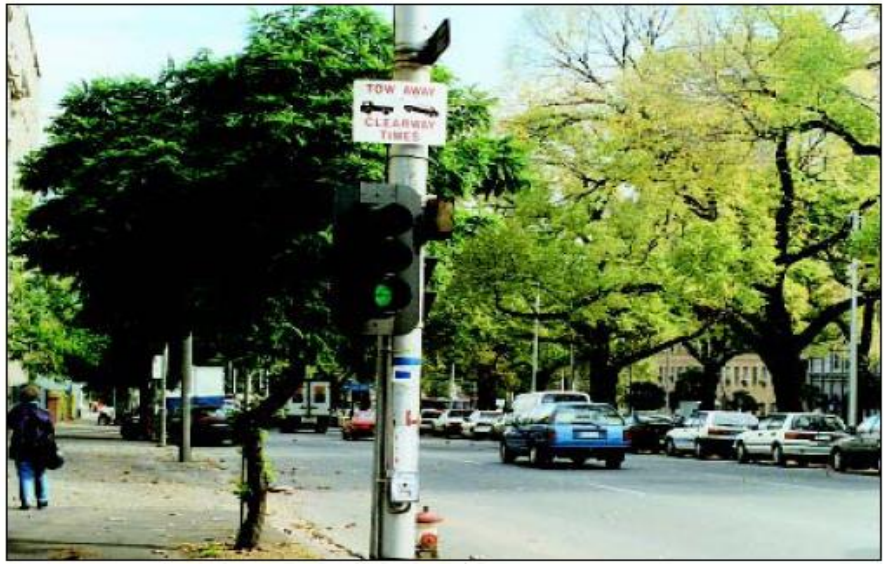
- Space reqr for parking and unparking man increases with angle
- Reqr more rdway width but less curb length
- Maneuver is more convenient or easier
- Usually recommended for off street parking or for exceptionally wider rd or rd with low vol of through tfc



# On Street Parking








# Street Lighting

## Arrangement/Layout

- Single side
- Both sides: staggered or opposite
- Central : one arm or two arms

## Recommended arrangement

✓ One side when pavement width <= 30 ft

✓ Both sides staggered for pavement 30 ft > width <= 60 ft

✓ Both sides opposite for pavement width > 60 ft







# Street Lighting

**Key Loc where Adequate Street Lighting is Necessary**

- Where there are high proportion of ped, cyclist or other poorly lit rd users incl animals
- Intersection where both veh and ped flow is high
- Sharp bend, summit curves, tunnels, ped x-ing areas, br sites, level x-ing, other bottlenecks
- Hazardous obj like road humps, channelizing islands etc.