NEPAL ENGINEERING COUNCIL LICENSURE EXAMINATION

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MSC. IN TRANSPORTATION ENGINEERING
PULCHOWK CAMPUS

TRANSPORTATION ENGINEERING SYLLABUS OF NEC LICENSE EXAM

9. Transportation **(ACiE09)**

9.1 Highway planning and survey: Modes of transport, history of road development in Nepal; classification of roads; road survey; highway alignment and controlling factors; evaluating alternate alignments; Road Standards of Nepal. (ACiE0901)

9.2 Geometric design of highway: basic design control and criteria; elements of highway cross-section; highway curves; super elevation; average and ruling gradients; stopping sight distance; design considerations for horizontal and vertical alignments, extra widening, and set back distance; design of road drainage structures; design considerations for hill roads. (ACiE0902)

9.3 Highway materials: types of aggregates and tests on their gradation, strength, durability; binding materials and their tests; design of asphalt mixes; evaluation of subgrade soil. (ACiE0903)

9.4 Traffic engineering and safety: impact of human and vehicular characteristics on traffic planning; traffic operations and regulations; traffic control devices; traffic studies (volume, speed, O&D, traffic capacity, traffic flow characteristics, parking, accident, flow); road intersections (types, configurations, design); traffic lights; factors influencing night visibility, road safety measures. (ACiE0904)

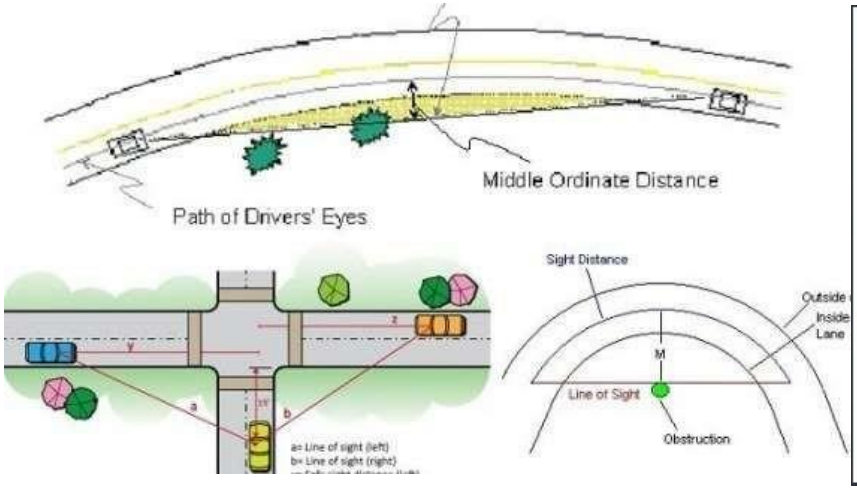
9.5 Road pavement: different types of pavement; design methods for flexible and rigid pavements (DOR Guidelines); loads and other factors controlling pavement design; stress due to load, temperature. (ACiE0905)

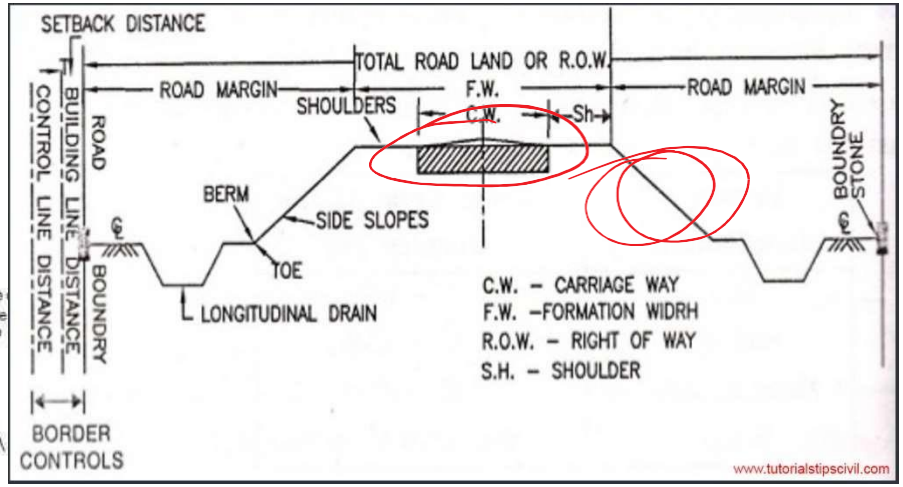
9.6 Road construction & maintenance: activities, techniques, tools, equipment and plants used in road construction; preparation of road subgrade; field compaction control and soil stabilization; construction of asphalt concrete layers; construction procedure for penetration macadam, bituminous bound macadam and plain cement concrete pavements; road maintenance, repair and rehabilitation. (ACiE0906)

GEOMETRIC DESIGN DEFINITION

Geometric Design of highway

- Deals with the dimension and layout of visible features of the highway
- Emphasizes driver and vehicle requirement for safety, comfort, efficiency etc.





GEOMETRIC DESIGN

- Cross sectional Elements
  - Camber, Super elevation, traffic lane, carriageway, shoulder, side slope, ROW, etc.
- Sight Distance Characteristics
  - SSD, OSD, etc
- Horizontal and Vertical Alignments
  - Radius of curve, Curve length, transition curve, grade, etc.
- Road Intersections

BASIC DESIGN CONTROL CRITERIA

1. Design Speed(most important criteria of geometric design)
   - decided based on the importance of the road (road class) and the type of terrain.
   - Directly affects sight distance, horizontal curve and length of vertical curve
   - NRS 2070 has recommended following values of design speed under different topographic conditions

Road Class	Plain (0-10%)	Rolling (10-25%)	Mountainous (25-60%)	Steep (>60%)
I	120	100	80	60
II	100	80	60	40
III	80	60	40	30
IV	60	40	30	20

2. DESIGN VEHICLE

- Dimensions, weight of the axle and operating characteristics of vehicle influences the design aspects such as road width, radii of curves clearances, etc.
- The maximum dimensions of vehicles considered for design of roads in Nepal are as follows: (imp)

  - Maximum Width: 2.50 m
  - Maximum Height: 4.75 m
  - Maximum Length: 18.00 m
  - Maximum single axle load: 100 KN

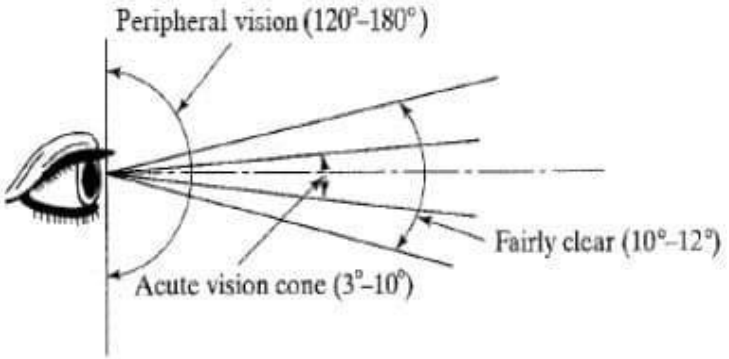
3. TOPOGRAPHY

- GD standards are different for different terrain to keep the time and cost of construction under control
- Terrain is classified according to the percent slope of the country across road alignment

Terrain Classification as per NRS 2070

S.No.	Terrain Type	Percent Cross Slope	Degree
1	Plain	0-10	0^o – 5.7^o
2	Rolling	> 10-25	> 5.7^o – 14^o
3	Mountainous	>25-60	> 14^o – 31^o
4	Steep	>60	> 31^o

4. TRAFFIC FACTORS



- Vehicular characteristics
  - Speed
  - Vehicle dimension
  - Axle weight
- Human characteristics (Driver and Pedestrian)
  - Physical -> Vision, hearing, strength, etc
  - Mental -> skill, intelligence, experience, knowledge and literacy
  - Psychological -> anger, fear, superstition, impatience, anxiety, etc.
  - Environmental -> Atmospheric conditions, traffic facilities, the traffic stream characteristics

5. DESIGN HOURLY VOLUME AND CAPACITY

- **Generally 30th highest hourly traffic volume is used for design purpose(VVI information)**
  - **» 30th highest hourly traffic volume -> hourly volume that exceeded only 29 times in a year and all other hourly volume of the year will be less than this value**
- **Traffic capacity needed to estimate the no. of lanes required**
  - **» Traffic capacity-> maximum traffic density a road can accommodate at a given speed without delay**

6. ROAD USER BEHAVIOR

- Also plays an important role in determining the different parameters of road design
- Cannot be quantified but their effect cannot be ignored

7. ENVIRONMENTAL AND OTHER FACTORS

landscaping, air pollution, noise pollution, aesthetic conditions, etc should be given due consideration in GD of roads

TRAFFIC VOLUME

– No. of vehicle that pass a given point on the roadway in a specified period of time

Daily Volume – E.g. 15 minute volume

- Average Annual Daily Traffic(AADT)
  - average 24-hour traffic volume at a given location over a full 365-day year
- Average Annual Weekday Traffic(AAWT)
  - average 24-hour traffic volume occurring on weekdays over a full year
  - Exclude traffic volume of Saturday and Sunday (i.e. weekly holiday)
- Average Daily Traffic(ADT)
  - average 24-hour traffic volume at a given location for some period of time less than a year
- Average Weekday Traffic(AWT)
  - average 24-hour traffic volume occurring on weekdays for some period of time less than one year

As per 2070, the maximum height of the vehicles for design of roads in Nepal is

a. 2.50 m

b. 3.75 m

c. 4.75 m

d. 5.50 m

The width of formation is calculated by adding?

a) Sum of the width of pavements
b) Width of pavement+ separators
c) Width of pavement + separators + shoulders
d) Width of pavement + separator + shoulders + side drains

What is the minimum clearance for most facilities?

a) 18 ft
b) b) 15 ft
c) c) 10 ft
d) d) 11 ft

Design hourly volume is the volume which is exceeded _____ times in a year

- 30 times
- 29 times
- 28 times
- 27 times

The maximum length of the vehicle taken for design of road is

a. 2.5m
b. 4.75 m
c. 12.5 m
d. 18m

The type of the terrain with percentage cross slope 25-60 [14°-31°] falls under

a. Plain terrain
b. Rolling terrain
c. Steep terrain
d. Mountainous terrain

S.No.	Terrain Type	Percent Cross Slope	Degree
1	Plain	0-10	0^o – 5.7^o
2	Rolling	> 10-25	> 5.7^o – 14^o
3	Mountainous	>25-60	> 14^o – 31^o
4	Steep	>60	> 31^o

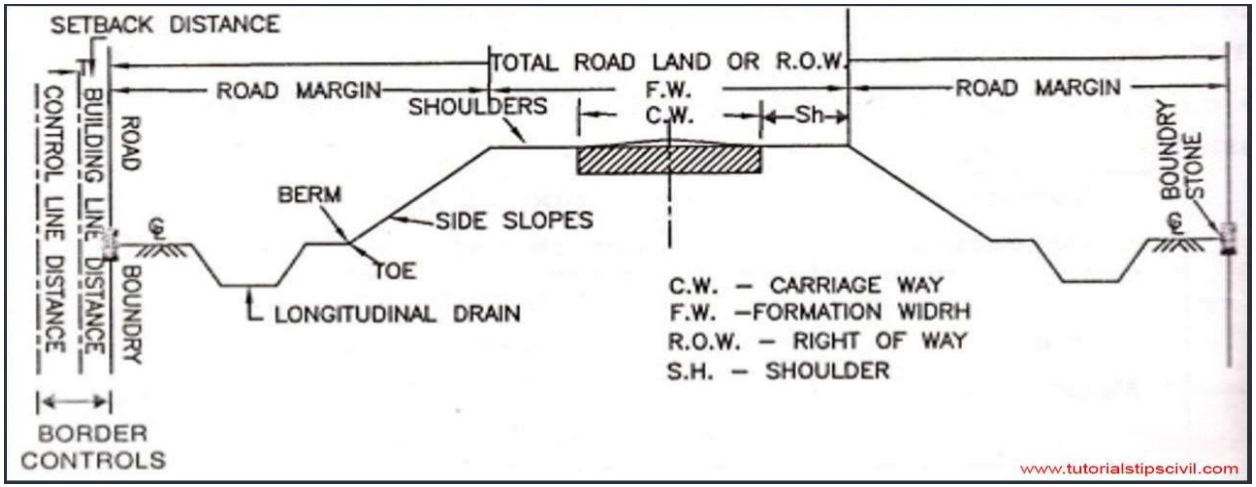
As per NRS, the minimum shoulder width provided for class IV road in each side of carriageway is

a. 2.0m
b. 1.5m
c. 1.0m
d. 0.75 m

Lane width of the intermediate lane according to NRS 2070 is

a.5 m
b.5.5 m
c.3.75m
d. 3.5m

ELEMENTS OF HIGHWAY CROSS SECTION



- Carriage way or Pavement width (imp)
  - Strip of road considered for movement of vehicular traffic
    - Single Lane -> 3.75m
    - Double lane -> 7m
    - Intermediate lane -> 5.5m
    - Multiple lane -> n*3.5m, where n-> no. of lane

SHOULDER

- Strip provided along the road edge

☐ 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.

☐ 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.

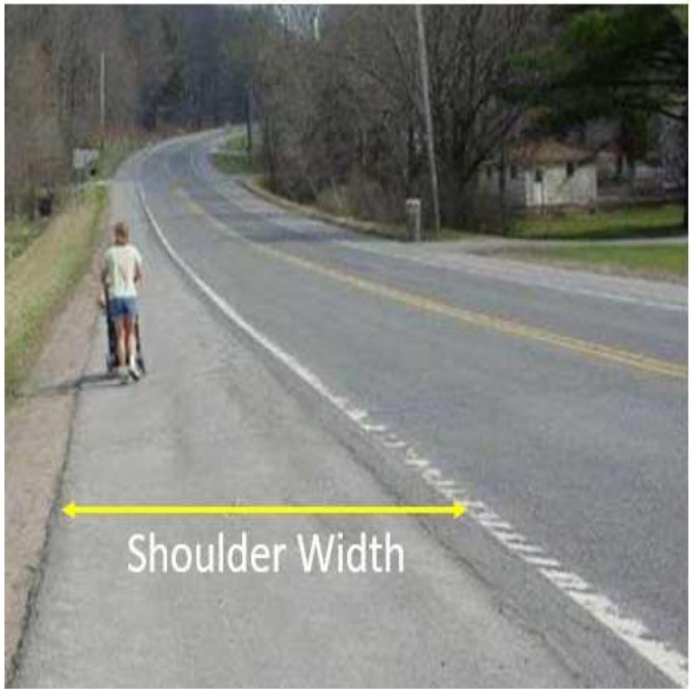
☐ The colour should be different from that of the pavement to be distinct.

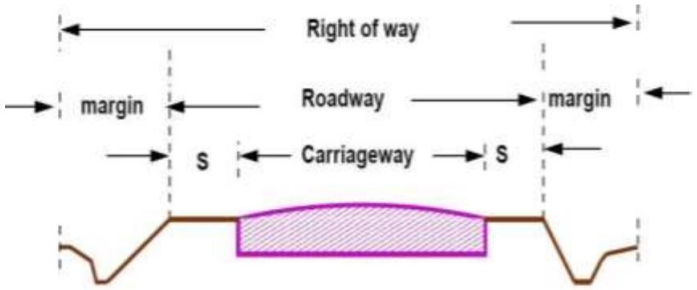
The width of shoulders on either side of the carriageway shall be at least 0.75m.

Width of Shoulders, m

Road Class	Class I	Class II	Class III	Class IV
Minimum shoulder width, m	3.75	2.5	2.0	1.5


shoulder

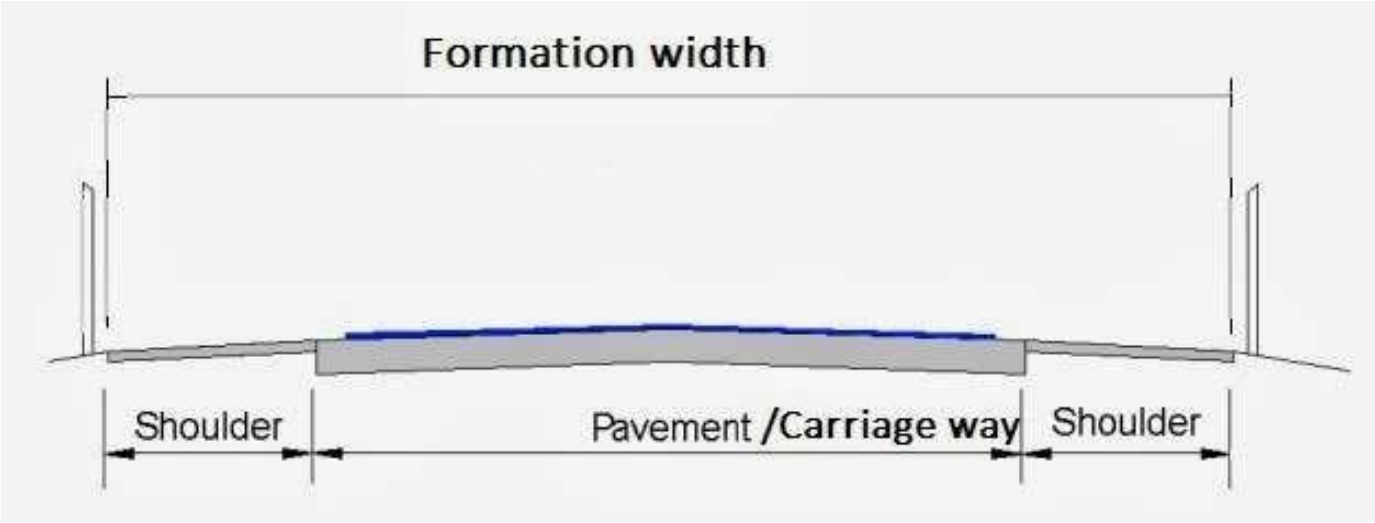

Shoulder Width


Right of way
margin
Roadway
margin
S
Carriageway
S

S- shoulder

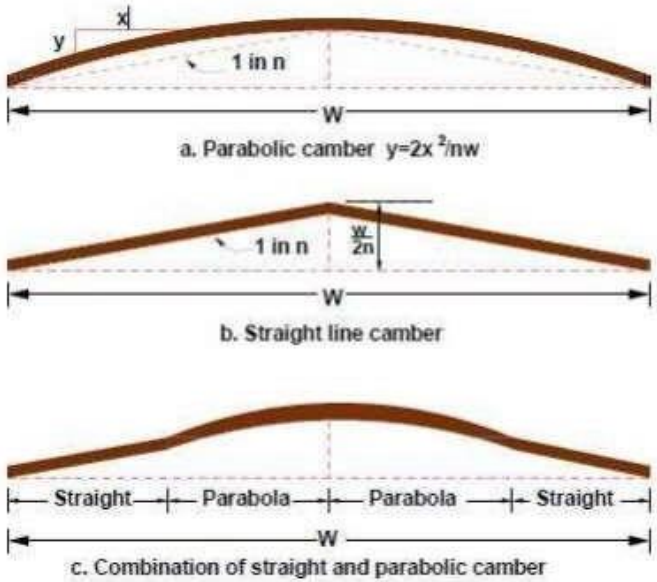
FORMATION OR ROADWAY WIDTH

– of widths of carriageways, medians and shoulders



- **Camber**

– cross slope provided to raise middle of the road surface in the transverse direction to drain of rain water from road surface.



Camber, % as per NRS 2070

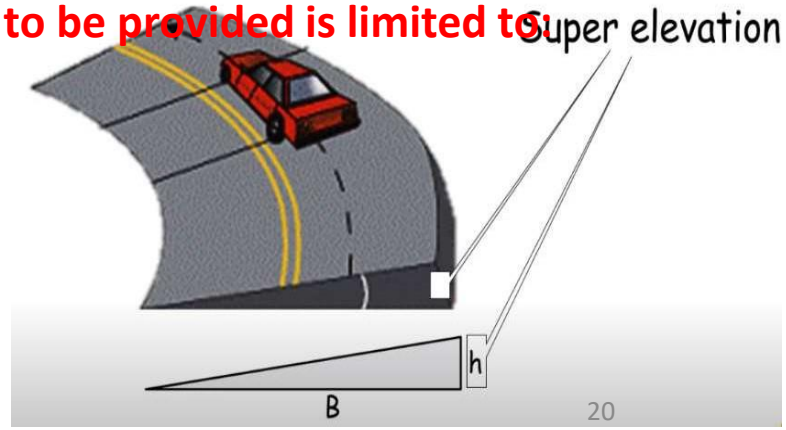
Pavement type	Cement Concrete	Bituminous	Gravel	Earthen
Camber, %	1.5 to 2.0	2.5	4.0	5.0

- **Super elevation**
  - The outer edge of the road is slightly raised than inner edge of the road which is called superelevation
  - Why?
    - to counteract the effect of centrifugal force and reduce the tendency of vehicle to overturn and to skid laterally outwards

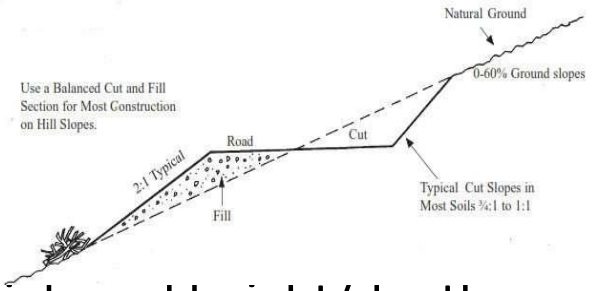
$$e = \frac{V^2}{127R} - f$$

As per NRS 2070 Maximum super elevation to be provided is limited to: (IMP)

- In plain and rolling terrain 7%
- In snow bound areas 7%
- In hilly areas not bound by snows 10%



- Drainage
  - should be absolutely impermeable to prevent seepage of water into the pavement layers.
  - Different types:
    - Rectangular
    - Trapezoidal
    - U shape
    - V shape



- Side slope of fill and cut
  - depend on the type of fill/cut materials and height/depth of filling/cutting.
  - Recommended side slopes for embankments and cutting as per NRS 2070 are given below

Embankment Side Slopes

Height, m	Side Slope(vertical:horizontal)
<1.5	1:4
1.5-3.0	1:3
3.0-4.5	1:2.5
4.5-12.0	1:2
>12.0	Design specially

Cuttings side slopes

Soil type	Side Slope(vertical:horizontal)
Ordinary Soil	1:2 to 1:1
Disintegrated rock or conglomerate	1:$^1/_2$ to 1: $^1/_4$
Soft rock, shale	1: $^1/_4$ to 1: $^1/_8$
Medium Rock	1: $^1/_{12}$ to 1: $^1/_{16}$
Hard Rock	Almost vertical

- Lay bys
  - paved area at the side of a highway designated for drivers to stop in, for emergency parking.
  - Tapered gradually towards the carriageway

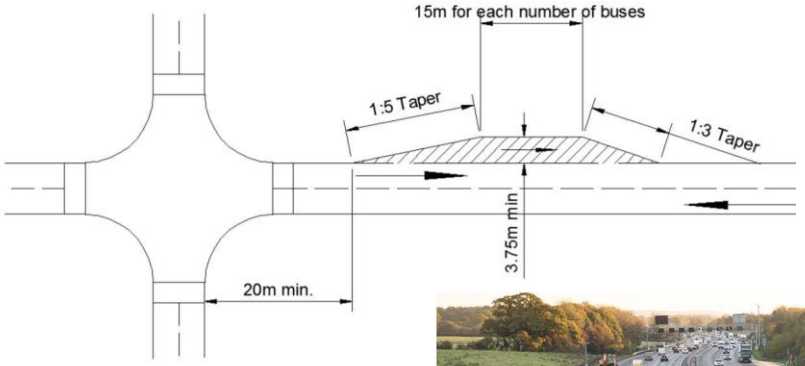
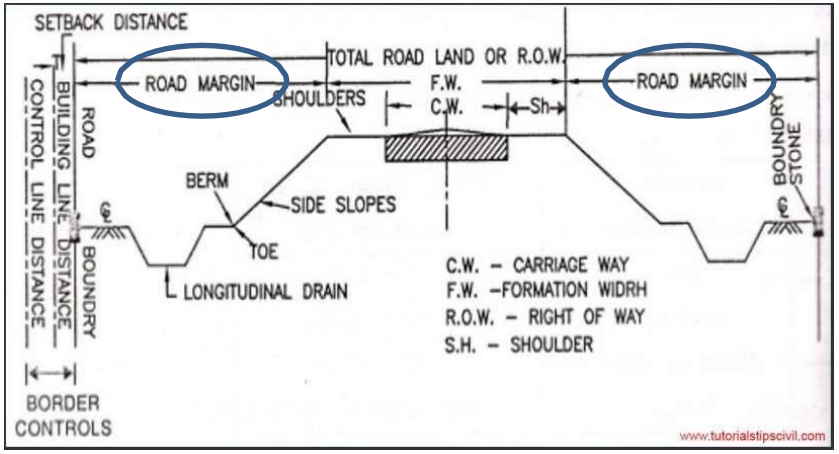
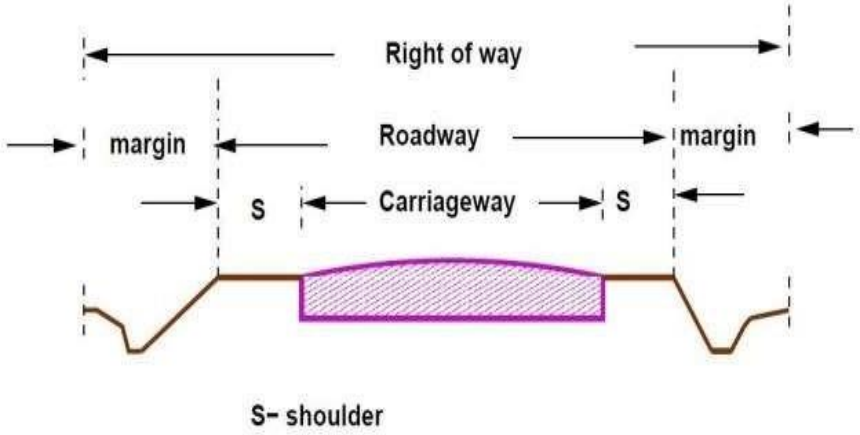


Figure 13-3 :Bus Lay Bys Plan

- Road Margin
  - Portion of the road beyond the edge of the roadway up to the road boundary
  - **Include** foot-paths, drain, side slopes and guide rails



- Right of way (ROW)
  - width of land acquired for the road, along its alignment.
  - right of way width is governed by:
    - Width of formation: depends on the highway category
    - Side slopes of embankment or cutting: depends on the height of the slope, soil type etc.
    - Drainage system and their size: depends on rainfall, topography etc.
    - Sight distance considerations : On curves etc
    - Reserve land for future widening: like widening of the road



A typical Right of way (ROW)

Right of way as per NRS 2070(IMP)

Road Type	Total Right of Way,m
Highways	50
Feeder Roads	30
District Roads	20

Element of cross section for urban road

- Kerbs
  - Provided between carriage way and shoulder
  - Function:
    - Facilate and control drainage
    - Strengthen and protect the pavement edge

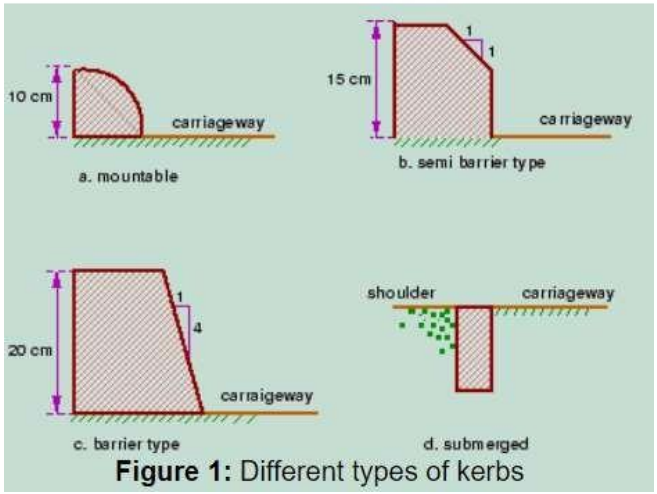


Figure 1: Different types of kerbs

- **Sidewalk / Footpath**
  - Provided for the movement of pedestrian traffic
  - Raised about 15 – 30 cm high from carriage way(IMP)
  - Min. width = 1.5m (IMP)

- **Medians**
  - –Central raised strip within the roadways to separate traffic flowing

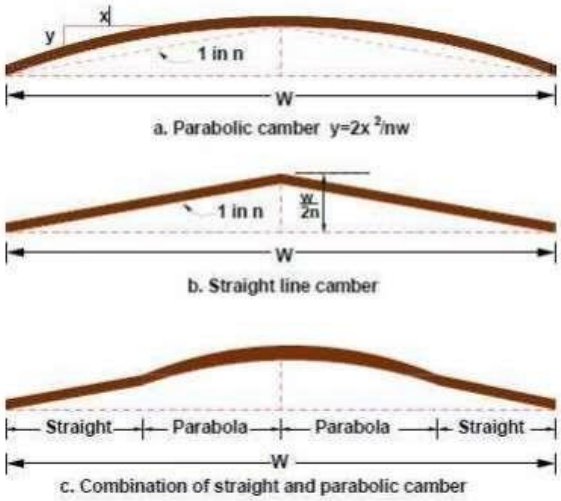
in one direction from opposite direction.

  - –For roads with 4 or more lanes, it is recommended to provide medians or traffic separators.
  - **–Function:**
    - **Minimize head light glare**
    - **Cutoff head on collision**

Camber

Type:

- Straight line camber
- Parabolic camber
- Composite camber



Note

- Shoulder having the same surface as the carriageway should have same cross slope
- 0.5 to 1% steeper than that of carriageway is provided for unpaved shoulder

The most raised portion of the pavement is called _____

a) Super elevation
b) Camber
c) Crown
d) Kerb

As per NRS, the total right of way provided in feeder road is

a. 50m
b. 30m
c. 20m
d. 6m

The changes in gradient and vertical curve are covered under which type of alignment?

a) Horizontal alignment
b) Vertical alignment
c) Geometric design
d) Highway specifications

The economical option during the construction of a road around a hill is _____

a)Cut the hill
b) Provide a tunnel
c) Provide a road around the hill
d) Look for other alternative approaches

If the camber is x%, then cross slope is _____
a) 100X
b) 200/X
c) X/100
d) 100+X

The camber is not provided in which of the following shape?
a) Straight
b) Parabolic
c) Combination of straight and parabolic
d) Circular

The equation of parabolic camber is given by _____
a) $Y=x/a$
b) $Y=x^2/a$
c) $Y=x^3/a$
d) $Y=ax^2$

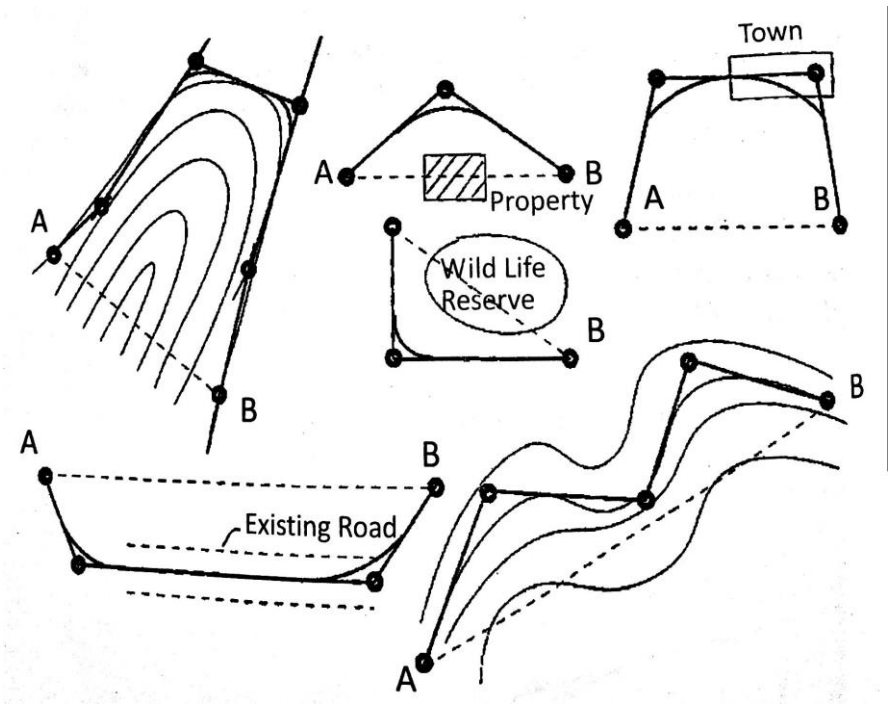
The minimum width of carriage way in urban roads is _____
a) 2.5m
b) 3.0m
c) 3.5m
d) 3.75m

- **HORIZONTAL CURVES**
  - Provided between two straight alignments of highways in order to change the direction.
  - enhances comfort to the passengers by avoiding the sudden change in direction
  - reduces mental strain by travelling monotonously along the straight route

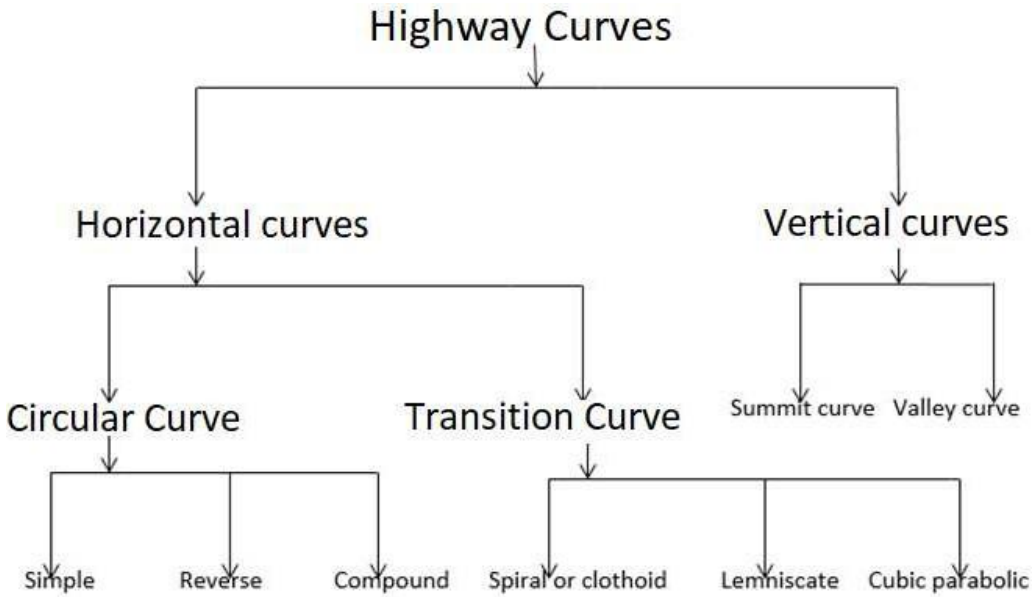
HORIZONTAL CURVES

Necessity of curve arises due to the following reasons:

- Topography of the terrain
- Restrictions imposed by property
- Providing access to certain locality
- Minimizing earthwork quantity
- Preservation of existing amenities
- Maintaining consistency with the topographical features of the terrain



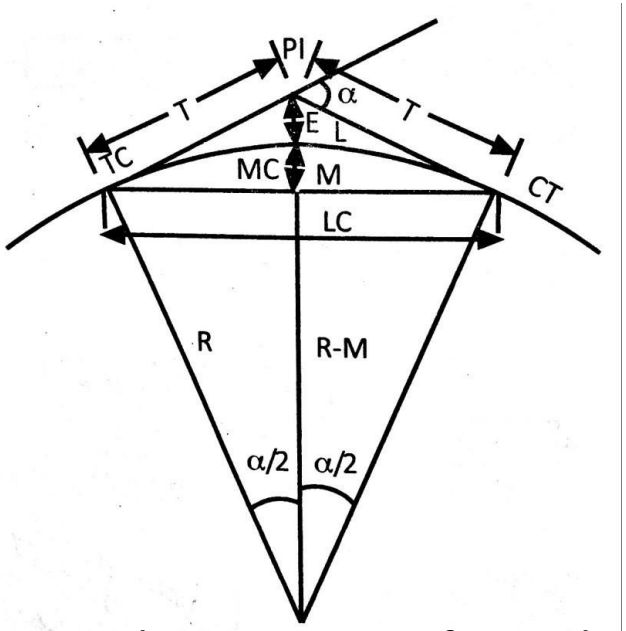
TYPES OF CURVES



Simple circular curves: consists of a single arc connecting two straight lines.
Reverse circular curves: consists of two or more arcs of one or different circles turning in two opposite directions that join at the common tangent point.
Compound circular curves: consists of series of simple circular curves of one or different radius that turns in the same direction and meet at the common tangent point.

ELEMENTS OF CIRCULAR CURVE

- PI = Point of intersection, Apex point
- TC = Tangent to curve, Beginning of curve
- CT = Curve to tangent, End of curve
- MC = Middle point of curve
- α = Angle of deviation
- R = radius of curve
- T = Tangent length, Distance between PI to tangent point
- E = Apex distance, Distance from PI to MC
- L = Length of curve
- M = Chord to curve length
- Lc = Long chord length



From simple geometry of a circle, following derivations can be made

$T = R \tan \alpha/2$

$E = R (\sec \alpha/2 - 1) = R [1 / \cos (\alpha/2) - 1]$

$M = R (1 - \cos \alpha/2)$

$L = \pi R \alpha/180$

$Lc = 2R \sin \alpha/2$