*) Classification of Roads

1) Urban Roads = A road within a City (or) town

a) Express ways (or) Motor way.

Central portion of a road for high speed vehicles

→ Parking, loading & unloading of goods are not permitted

→ Pedestrain Crossing are also not allowed

b) Arterial Streets:

A Continuous Major roads in a city having high traffic (eg: Bandar road, Eluru road in Vijayawada)

c) Collector Streets:

Collecting & distributing the traffic to and from local streets.

→ These are located in residential, industrial & Commercial area

→ No restrictions for parking & loading

2) Non-Urban Roads = A road outside the City (or) town

a) National Highways.

→ These are Major & important roads of a Country

→ Connecting important places (like State capitals, airports..etc)

→ organised by CPWD (Central Government)

b) State Highways

→ Connecting district headquarters & neighbouring states

→ Organised by PWD (State Government)

c) Major district roads & d) Village Roads

*) Organisations:

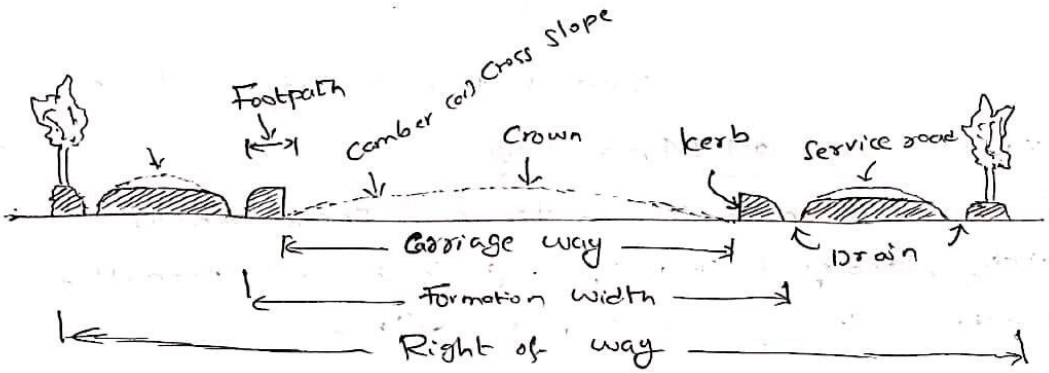
1. First major/longest road = Kolkata – Lahore
2. IRTDA = Mumbai (Head office), Under Jayakar Committee
3. CRO in 1934
4. IRC in 1943, New Delhi (Head office)

* Highway Planning in India

1. Nagpur Road Plan (or) First 20-year Road plan (1943-63)
   → Recommended "Star & Grid" formulae
   → Road length achieved by 1961
2. Bombay Plan (or) Second 20-year Road plan (1961-81)
   → 5 different formulas for diff roads

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*1) Components of a City Road



1. Right of way

The area of land acquired for construction & future development of a road.

2. Formation width

Bottom width of high way cutting excluding side drains.

i.e Formation width = Carriage way + Shoulders

3. Carriage way (or) pavement.

portion on road surface used for vehicular traffic

For Single lane road = 3.75m

Single lane Bridge road = 4.25m

4. Shoulders

b/w outer edge of Carriage way – inner edge of side drains

→ Footpaths are the portions in shoulders

→ prevent edges of the road from wear & tear

→ Minimum Shoulder width = 2.5m (IRC)

5) Crown

Highest point on the road surface

6. Kerbs:

Rised portion/boundary b/w carriage way & Shoulder

→ Also provided b/w pavement & Seperators/dividers.

7. Side Slopes

= 1:1.5



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Camber: (or) Cross Slope (or) Cross fall

The slope of line joining Crown & edge of the road surface.

→ To drain off the water from road surface (main object)

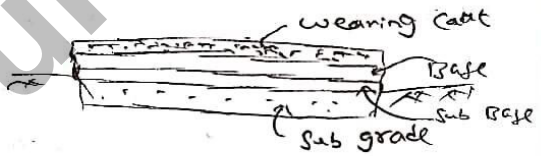
Sloped Camber =  Two St. Slopy joining center (For CC pavements)

Barrel Camber =  Continuous curve either parabolic/Elliptical

IRC Recommendations

Type of Road Surface (Permeability factor)	Range of Camber	
	Heavy rainfall	Light rainfall
1. CC & high bitumen	1 in 50 (2%)	1 in 60 (1.7%)
2. Thin bitumen	1 in 40 (2.5%)	1 in 50 (2%)
3. WBM & Gravel pavement	1 in 33 (3%)	1 in 40 (2.5%)
4. Earth Surface	1 in 25 (4%)	1 in 33 (3%)

Components of Road Surface



1) Sub Grade

The ground on which foundation of a road rests.

→ It is provided by digging up the Sub-soil

→ The Strength & durability of ~~Soil~~ road depends upon its Sub-grade

→ Entire load ultimately transfered to Sub-grade

2) Sub-Base:

Additional layer b/w Sub-grade & Base

→ provided when Bearing capacity of soil is poor & high traffic

3) Base (or) Soiling (or) Foundation of Road:

It recieves impact of traffic through wearing course

→ Base Course ⩾ 30 cm and ⩽ 10cm (for flexible)

→ Rigid (in case of Rigid pavement) & Broken Stone (in case of flexible pavement)

4) Wearing Course

The Superstructure of the road

→ Wearing Course ⩾ 10cm

→ It should be impervious, friction, abrasion & resistance to impact of wheels.

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Super Elevation

Super Elevation (or) Cant or Banking

When a vehicle negotiate a curves path, it is subjected to a centrifugal force. to resist this outer edge of curve raised above the inner edge.

(or)

Inward tilt given to the total length of curve

→ In the absence of super elevation pot holes are put across the outer edge of the road curve.

→ Super elevation ≠ Camber

→ Greater super elevation inconvenience to slow moving traffic.

→ Max super elevation = 1 in 15.

Forces acting on vehicle while moving in curve

1. Centrifugal force $\left(P = \frac{Wv^2}{gR}\right)$
2. weight of vehicle (W), 3. Frictional force

Equation:

$$\frac{P}{W} = \frac{\tan\theta + f}{1 - f\tan\theta}$$

$$\Rightarrow \frac{P}{W} \simeq \tan\theta + f = e + f$$

$$\therefore e + f = \frac{v^2}{gR}$$

where
$e = \tan\theta$ = Super elevation
f = Lateral frictional Coefficient = 0.15
v = Speed of vehicle (m/s)
R = Radius of curve (m)

$\left[\because e = \tan\theta = \frac{\text{Rise}}{\text{Width of pavement}}\right]$

(or)

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

($\because V$ = in kmph)

Equilibrium Super elevation (∵ Neglect friction, i.e $f = 0$)

$$\therefore \boxed{e = \frac{V^2}{127R}}$$

Maximum Super elevation (IRC)

According to IRC Super elevation balance centrifugal force corresponding to maximum of 75% (i.e $\frac{3}{4}$th) of the design speed. $\Rightarrow e = \frac{(0.75v)^2}{127R}$

$$\therefore \boxed{e = \frac{V^2}{225R}}$$

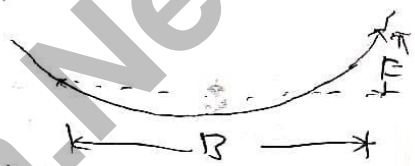
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Gradients

Gradient of the road depends upon
→ Rainfall of the locality
→ Nature of traffic
→ Nature of ground.

1. Minimum gradient
→ For the purpose of easy drain off rain water
Minimum gradient for Flexible pavement (1 in 250)
Rigid pavement (1 in 300)

2. Maximum or Limiting gradient
Max / steepst gradient allowed on road, when
→ To avoid deep excavations
→ To avoid long detours



3. Average gradient

$$= \frac{\text{Rise/fall b/w any two points in the alignment}}{\text{Horizontal distance b/w two points}} = \frac{E}{B}$$

4. Exceptional gradient:
The gradient < Minimum gradient &
> Maximum gradient

→ Neccessary to avoid deep cuttings
→ Max length of Exception gradient ≯ 60m per one km.

5. Ruling gradient
The engineer designed gradient after all factors considered

IRC Recommendations

Nature of Terrain	Ruling gradient	Limiting gradient	Exceptional gradient
1. plains	1 in 30	1 in 20	1 in 15
2. Hills	1 in 20	1 in 17	1 in 14
3. Steep terrain	1 in 17	1 in 14	1 in 12.5

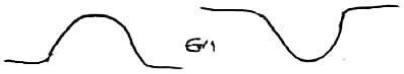
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Curves

1. Horizontal Curve or Transition Curve



Change in direction

2. Vertical Curve  or

Change in gradient

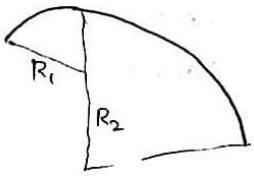
1) Simple Curve 

Single arc Connecting two St'ling

2. Reverse Curve 

Two simple curve opposite in direction joint at Common tangent point

3. Compound Curve.



Two (or) more simple curve same direction (with dif Radius) joining at common tangent point.

1. Transition Curve:

Radius gradually changes from infinite value to finite value (or) vise versa for giving easy change of direction is called a Transition curve (or) Spiral (or) easement curve.

$$\text{Length of Transition Curve } (L) = \frac{V^3}{48CR}$$

$$\text{Rate of change of acceleration}(C) = \frac{80}{70+V} \in [0.5, 0.8]$$

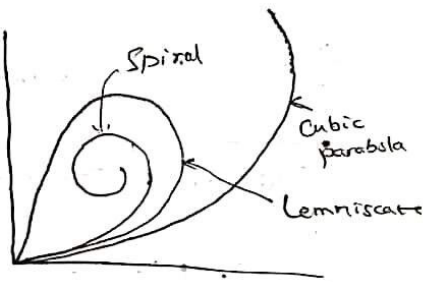
(m^3/s^3)

a) True Spiral (or) Clothoid

It is an Ideal Shape of Transition Curve

b) Cubic Spiral

Transition curve recommended by IRC is "Cubic Spiral"



Polar deflection angle (α) = $\frac{1}{3}$rd of Deviation angle of the curve(ϕ)

c) Cubic parabola (or) Froude's transition/easement curve

d) Bernoulli's lemniscate curve

Most used in modern road construction & when deflection angle b/w tangents is large

$$\text{Polar equation } (r) = \sqrt{2R^2 L \sin 2\alpha}$$

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2. Vertical Curves

Due to Change in grade in the vertical alignment of highway

a) Summit (or) Crest curves

Convexity upwards

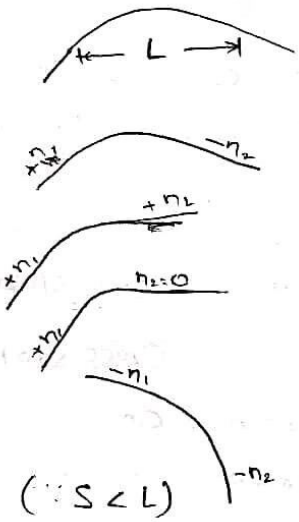
Required to introduce at

→ +ve grade meets -ve grad

→ +ve meets middle +ve

→ +ve meets level stretch

→ -ve meets steepu -ve



Safe OSD $(L) = \frac{GS^2}{9.6}$ $(\because S < L)$

$= 2S - \frac{9.6}{G}$ $(S > L)$ $(\because S$ = Sight Distance)

Safe SSD $(L) = \frac{GS^2}{4}$ $(S < L$

$= 2S - \frac{4}{G}$ $(S > L)$

b) Valley (or) Sag Curve

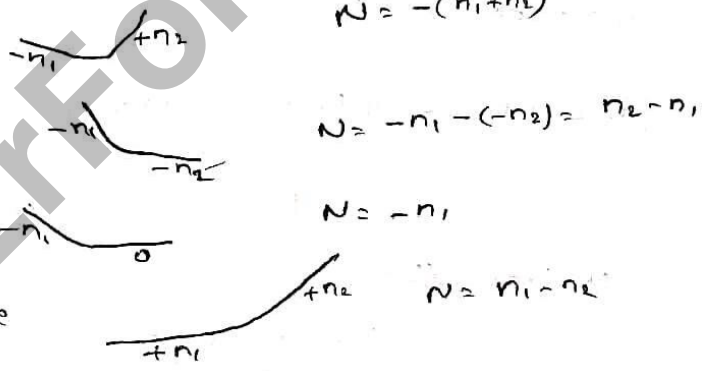
Required to introduce @

→ -ve gr meets +ve

→ -ve meets middle -ve

→ -ve meets level

→ +ve meets steeper +ve



According to IRC

Based on Comfort conditions

Length of vally curve (L) = 2 x length of transition curve (L_s)

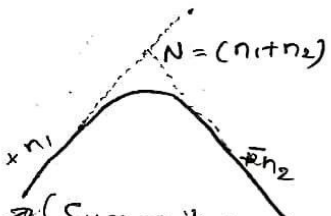
SSD = head light beam distance

Head light = 0.75 m (from Road Surface)

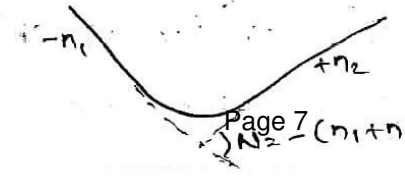
3. Deviation angle [i.e $N = n_1 - n_2$]

Deviation angle maximum when

a) Ascending gradient meets descending gradient → (Summit curve)



b) Descending gradient meets ascending gradient



vally curve

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Hill Roads

1. Fixing alignment of Hill Road

Reconnaissance → Trace cut → Detailed Survey
(Paper work) (Prepare inspection road = 1-1.2m) (Field survey)

2. Terms used in Hill Roads

a) level terrain Cross-slope < 10%.

b) Rolling terrain Cross-slope 10 - 25%.

c) Mountainy terrain Cross-slope 25 - 60%.

d) Steep terrain Cross-slope > 60%.

e) Salient curve Convex shape (⌒)

f) Re-entrant curve Concave shape (⌣)

g) Floating gradient

The gradient at which no tractive effort is required to main tain constant speed (i.e slightly -ve gradient)

Gradient > Floating gradient (need to increase speed to maintain constant speed)

Gradient < Floating gradient (Need tractive effort (Brake) to maintain consb speed)

3. Classification of Hill Roads (Boarder roads organisation)

a) National Highways

b) Class 9 (6m wide for 3-tonne vehicle)

c) Class 5 (4.9m " " 1-tonne ")

d) Class 3 (2.45 - 3.65m " for Jeeps)

4. Standards of Hill Roads

a) Carriage way ≯ 3.75m or ≃ 3m (for Jeeps)

b) Camber = Steep camber (Generally)
= Flatter camber (when longitudinal slope > 1 in 20)

c) Sight Distance = SSD

d) Curve radius ≯ 30m

e) Super elevation ≯ 10% (1 in 10)
≯ 7% (1 in 15) Snow-bound section

f) Gradient ≯ $\frac{75}{R}$ %

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5. Construction of Hill Roads

a) Retaining Walls

Top width = 60 cm

Bottom width = 0.4H (H < 6m)

= 0.4H + 30cm (H > 6m)

Batter = 1 in 12 (wall outside)

b) Brest walls

Thickness of wall = 60 cm (Throughout)

c) Parapet walls (Valley side)

Thickness of wall = 60 cm (Throughout)

Height = 75 cm (From berm level)

Group Index Method

G.I of a soil is a number which reflects the characteristic of the soil.

G.I = 0 to 20

GI ∝ Sub-Base thickness.

California Bearing Ratio (CBR) method

C.B.R of a soil is a percent which gives an idea about quality of material. compared to Excellent material (100%)

CBR apparatus consist of

Mould = 150 mm dia

Cylindrical Plugen = 50 mm dia

Penetrate @ 1.25 mm/minute

Values recorded @ 2.5 mm & 5.0 mm.

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Concrete Pavements

1. Thickness of the Slab:

$$t = \sqrt{\frac{3W}{\sigma}} \quad \text{(Older's theory)}$$

$$= \sqrt{\frac{2.4WC}{\sigma}} \quad \text{(Sheet's formula)}$$

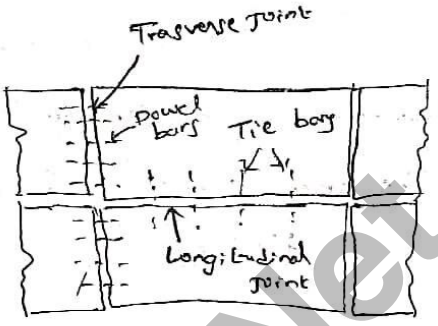
Where

W = Wheel load

σ = Unit stress in Tension

C = Coefficient of Subgrade Support

2. Joints in Concrete Pavement



a) Longitudinal Joints:

→ Butt joint is simplest longitudinal joint recommended by IRC

→ Tie bars are used to hold the adjacent slab together.

Length of Tie bar ≥ 2 × length req to develop bond strength

$$L_t = \frac{2a\sigma_s}{2.46p}$$

($\because$ a, p = Area & perimeter of bar, σ_s = allowable work by steel)

b) Transverse Joints

a) Expansion Joints. (induced by Temperature Stresses)

These are connected by Dowel bars Spaced 300 mm c/c

b) Contraction joints (induced by moisture change)

Max Spacing of Contraction joints = 4.5 m (Unreinforced cc)

c) Warping or Hinged Joints = 14 m (Reinforced cc)

Longitudinal joints with tie bars fall in this class of joint.

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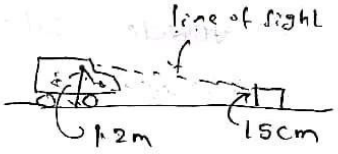
Sight Distance

1. Sight Distance (SD)

The distance, measured along the centre line of a road, over which a driver can see the opposite object on the road.

Line of sight for a driver = 1.2 m

object can see = 15 cm



2. Stopping Sight distance (SSD)

Stopping or absolute minimum or Non passing or non-overtaking Distance.

The minimum sight distance required by the driver to stop vehicle after an object on the way becomes visible.

Minimum SSD = Reaction distance + Breaking distance

*) PIEV Theory:

Totoal reaction time of driver is split in to four parts.

(i) perception (eye & ear – brain)

(ii) Intellection (Understanding & comparision . . etc)

(iii) Emotion (fear, anger)

(iv) Volition (Time required to final decision/action)

Total Time reaction = 0.5 sec (for simple situation)

$$SSD(S) = 0.28Vt + \frac{0.01V^2}{\eta}$$

$$= \frac{5}{18}Vt + \frac{V^2}{254\eta}$$

$$= vt + \frac{v^2}{2g\eta}$$

3. Intermediate Sight Distance (ISD)

Is provided to give limited overtaking opertunitiy to fast moving vehicles (when OSD not provided)

$$\boxed{ISD = 2 \times SSD}$$

Recommended by IRC

Design Speed (kmph)	20	25	30	40	50	60	65	80	100
SSD (m)	20	25	30	45	60	80	90	120	180

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4. Overtaking Sight Distance (OSD)

Minimum OSD (or) Safe passing sight distance

The minimum distance required for overtaking another vehicle safely & without interfering the speed of an opposite vehicle travelling @ design speed.

$$OSD = d_1 \text{ (reaction distance)} + d_2 \text{ (Actual overtaking distance)} + d_3 \text{ (opposite vehicle travelling during } d_2)$$

(or)

$$OSD = d_1 + d_2 \text{ (one way traffic)}$$
$$= d_1 + d_2 + d_2 \text{ (Two way traffic)}$$

→ If you provide overtaking zone with sign post

Minimum length of overtaking zone = $3 \times OSD$

*) According to IRC

Time Req for opposite vehicle (T) to travel (d_3)

$= \frac{2}{3} \times$ Overtaking manoeuvre (T+t) to travel (d_1+d_2)

The overtaking manoeuvre takes about (T+t)

= 9 to 14 sec (Corresponding to 40 kmph – 100 kmph)

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Traffic Characteristics

1. Traffic Volume : = Traffic density x Traffic speed.

a) Annual average daily traffic (AADT or ADT)
Average number of vehicle per day passing on a section of road during a particular year.

b) Design Hourly volume (DHV)
used for design purpose
DHV = Higher volume of (volume during most of hours in an year)

2. Traffic type.

a) Current traffic
= Existing traffic + diverted traffic

b) Increase in traffic
= Normal traffic growth (increase in vehicle year to year)
+ Generated traffic (construction of new facilities)
+ Developed traffic (improvements in adjacent)

3. Traffic Capacity :

a) Basic Capacity
Max. No. of PCU's moving in one hour without gaps.

b) Possible Capacity
Max. No. of PCU's moving in one hour with some speed having No restrictions & No obstructions

c) Practical Capacity.
Max. No. of PCU's moving in one hour with design speed having general restriction & obstruction.

∴ Basic capacity > possible capacity > practical capacity

d) Theoritical Capacity
No. of vehicle passing any point in one hour per lane

∴ Theoritical Capacity (C) = $\frac{1000V}{S}$ (PCU's/hour)

where V = Design Speed of vehicle (kmph)
S = Centre-centre spacing of moving vehicle
= Reaction distance + Average length of vehicle.

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4. Passenger Car Unit (PCU)

In a mixed flow traffic (like cars, buses, rickshaw, carts ... etc) Consider passenger car as the stard vehicle unit (1.0) to Convert other vehicle units (by size & speed). And this unit is called "passenger car unit".

Traffic capacity in PCU/hour (or)

PCU/lane/hour

Traffic density in PCU/km

Tentative PCU values Suggested by IRC

Vehicle class	PCU
Passenger car, Auto, Agriculture tractor	1.0
Bike, cycle	0.5
Rickshaw	1.5
Bus, truck, lorry, tractor with trailer	3.0
1 horse vehicle.	4.0
Small bullock cart & hand cart	6.0
Large bullock cart	8.0

* Practical Capacity

PCU/day (Both direction)

→ Single lane (3.75m) + earth shoulders — 1000

→ Single lane (3.75m) + 1.0m hard shoulder — 2500

→ Two lane (7m) + earth shoulder — 10,000

5. Speed of Vehicles.

Running Speed = Distance covered by running time

Spot Speed = Speed of vehicle at a particular point/spot

→ Spot Speed Measured by (i) Enoscope (mirror box supported by Tripoid)

Simple & cheap, Not much accurate

(ii) Radar Speed meter

Easily but accurate

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6. Vehicle characteristic effects.

a) Overall length of vehicle
   Effect on turning radii of curve & OSD

b) Overall width of vehicle
   Effect on width of pavement, bridges, other drainage structures

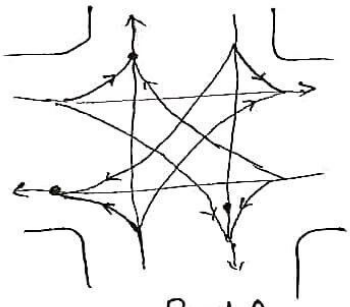
c) Overall height of vehicle
   Effect on underpassage & tunnels

d) Weight of vehicle
   Effect on Thickness of the pavement.

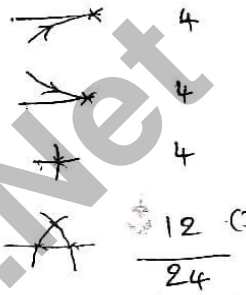
7. Conflicts

No. of intersections while crossings.

No. of Conflicts



Conflicts



No. of lanes	Both roads Two-way	Both roads one-way
2	24	6
3	24	11
4	44	18

Parking of vehicles is usually preferred at 75° to the aisles.

8. Traffic Signals

a) Signs

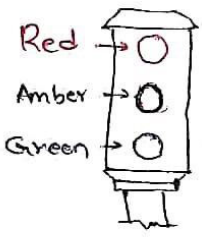
→ Generally installed at a height of 2.75 m – 2.8 m
→ Reverse side of sign plate painted Gray Color
→ STOP signal by  octagonal shape

a) Regulatory (or) Mandatory Signs
   Voilation of this may cause punishment
   ("Give way, Restriction end Signs" are also fall in this category)

b) Warning Signs
   Voilation of this may cause accident

c) Informatory Signs
   Used to guid the road users. These are Rectangle in Shape

b) Signals



Flexible progressive System is the most efficient traffic Signal System.

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