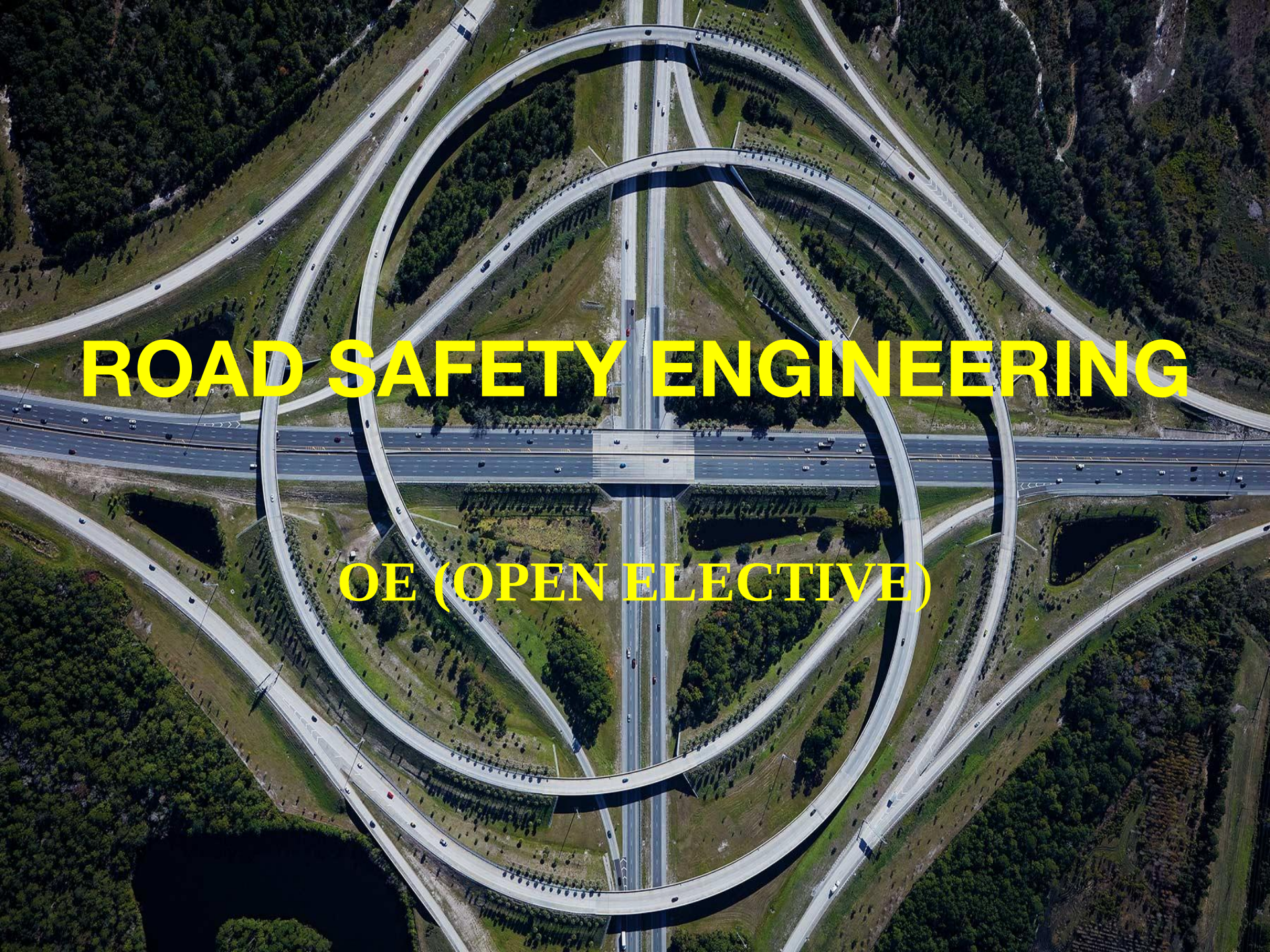


# ROAD SAFETY ENGINEERING

## OE (OPEN ELECTIVE)

# UNIT-1

- **Introduction**: Road Safety scenario in India and World, Road Accident Characteristics.
- **Traffic Safety Analysis**: Fundamentals of Traffic Engineering - Basic Characteristics of Motor-Vehicle Traffic, Highway Capacity, Applications of Traffic Control Devices, Design of Parking Facilities;
- **Statistical Methods** in Traffic Safety Analysis – Regression Methods, Poisson Distribution, Chi-Squared Distribution, Statistical Comparisons.

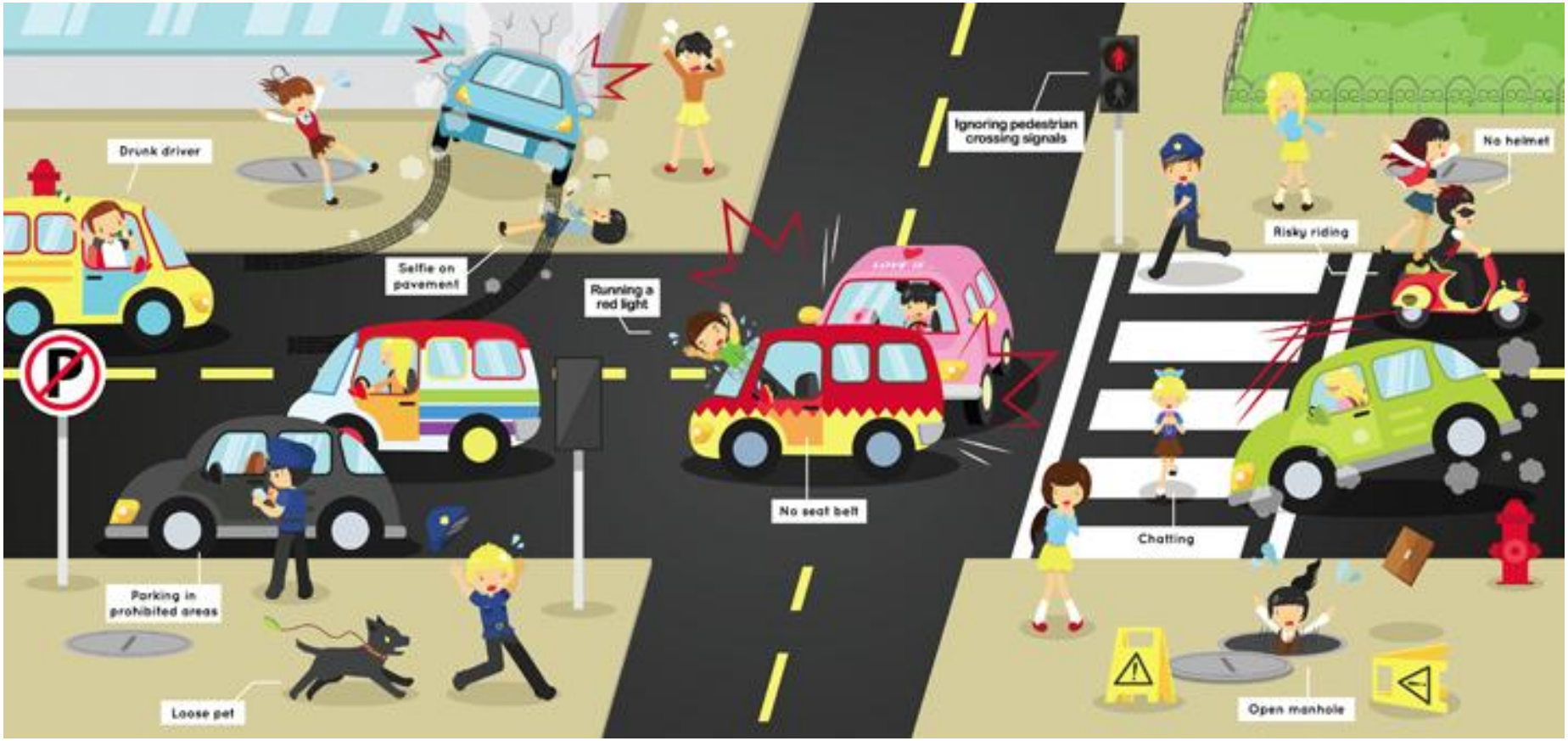
Road traffic safety refers to the methods and measures used to prevent road users from being killed or seriously injured.

Typical road users include pedestrians, cyclists, motorists, vehicle passengers, horse riders, and passengers of on-road public transport.

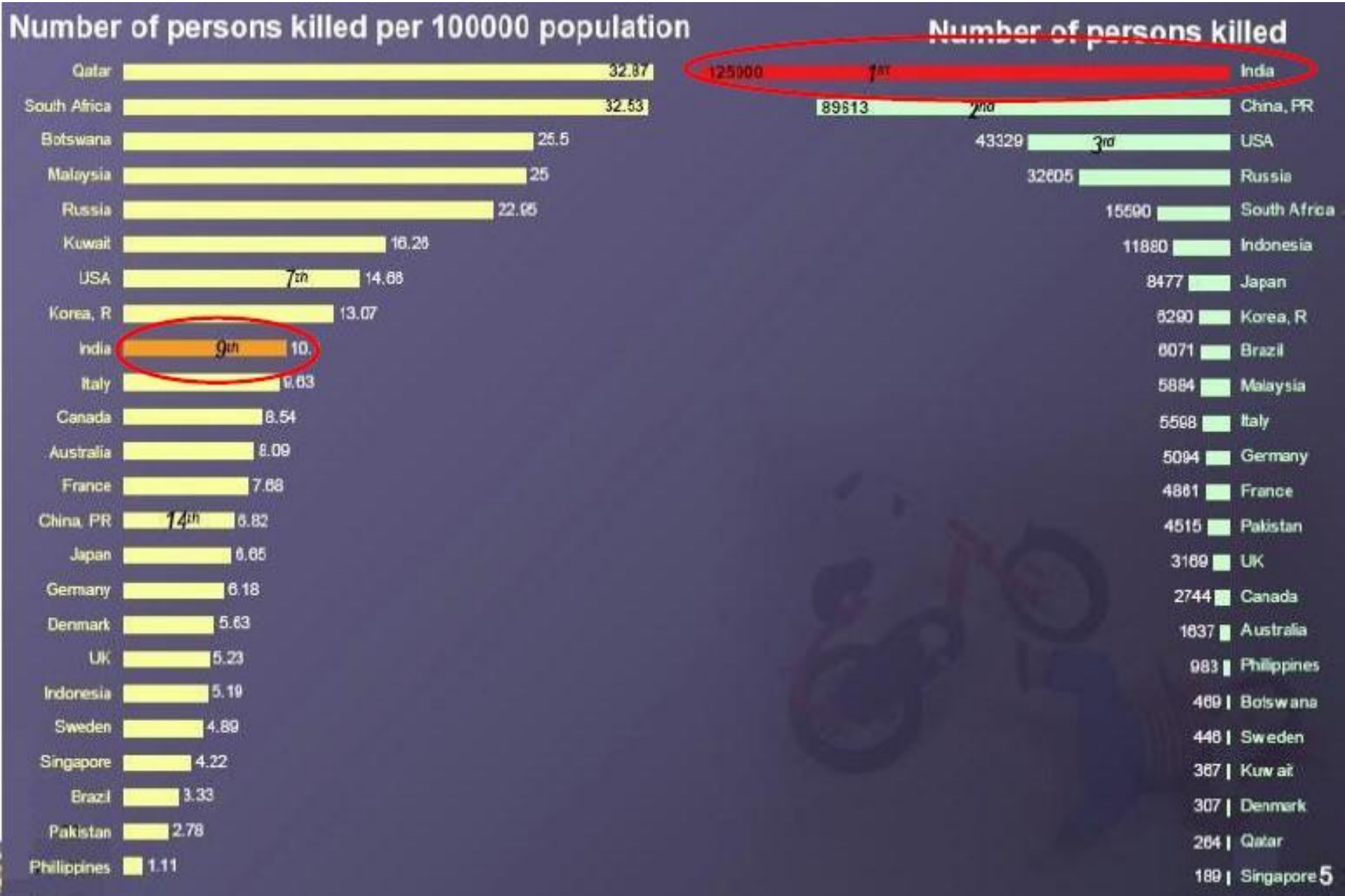
Road ecosystem:

- Human,
- Vehicle and
- Infrastructure

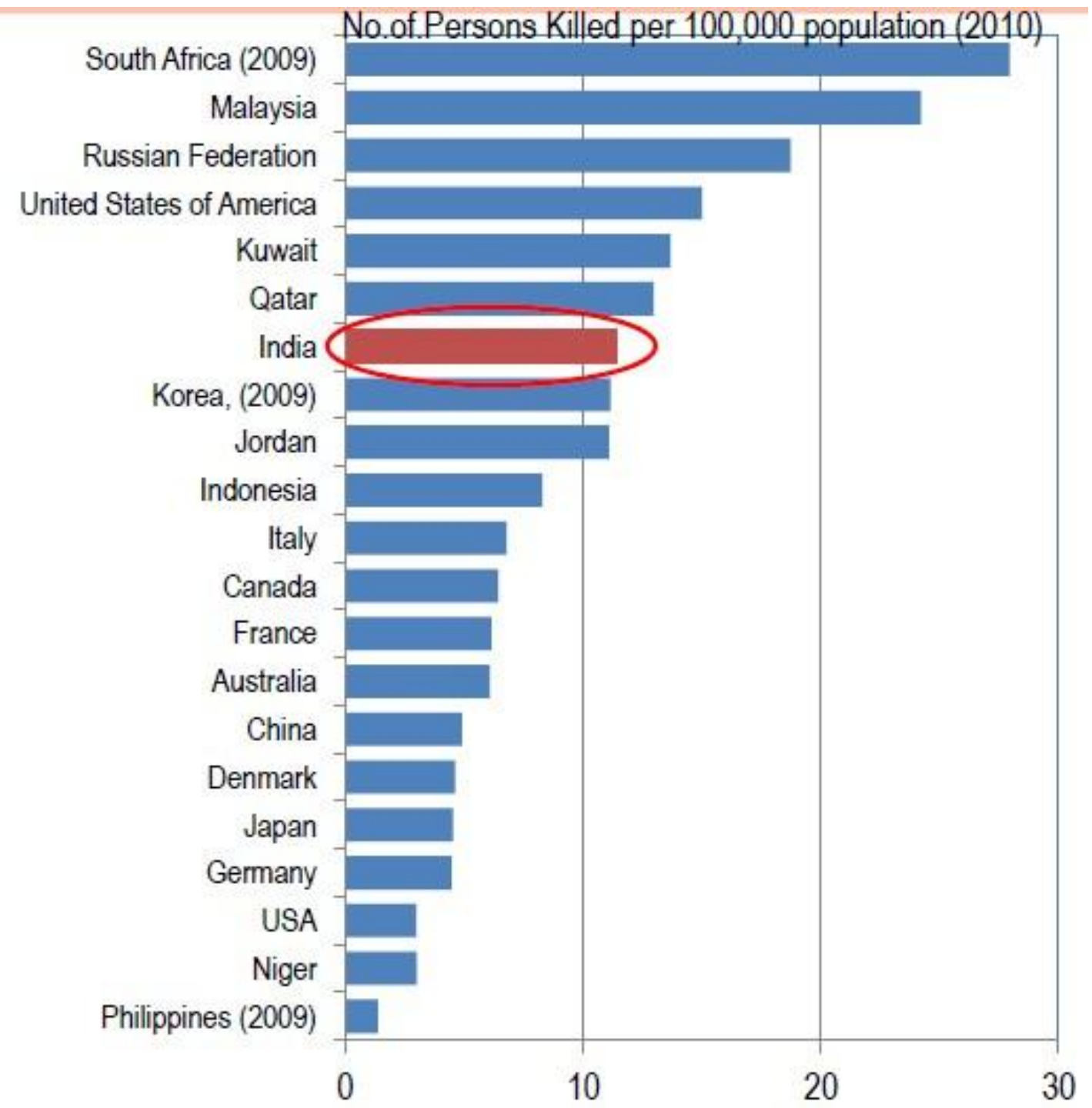
# Present scenario for the cause of Road Accidents.



# Road Safety scenario in India



# Road Safety scenario in India



1,50,785 deaths/yr (2016)

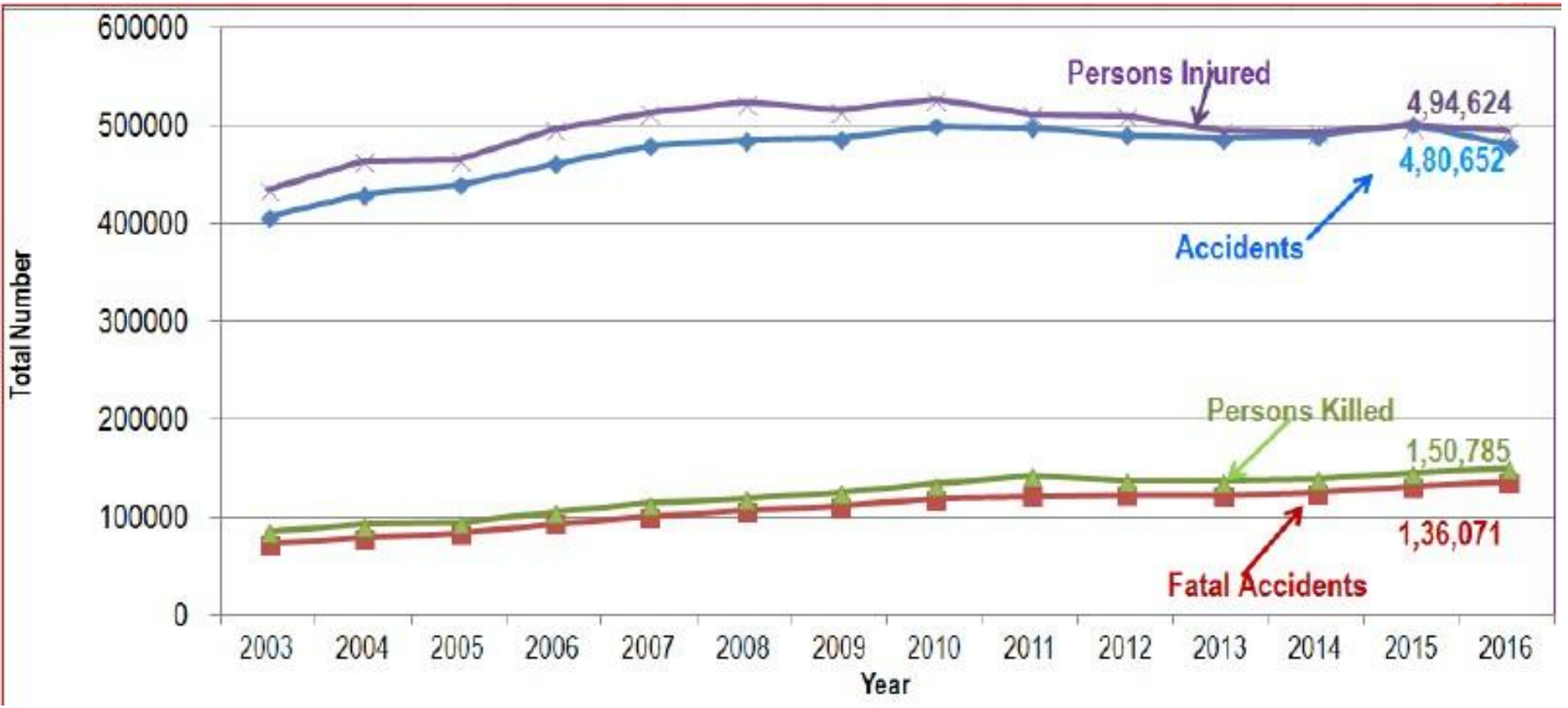
10% of World Road deaths

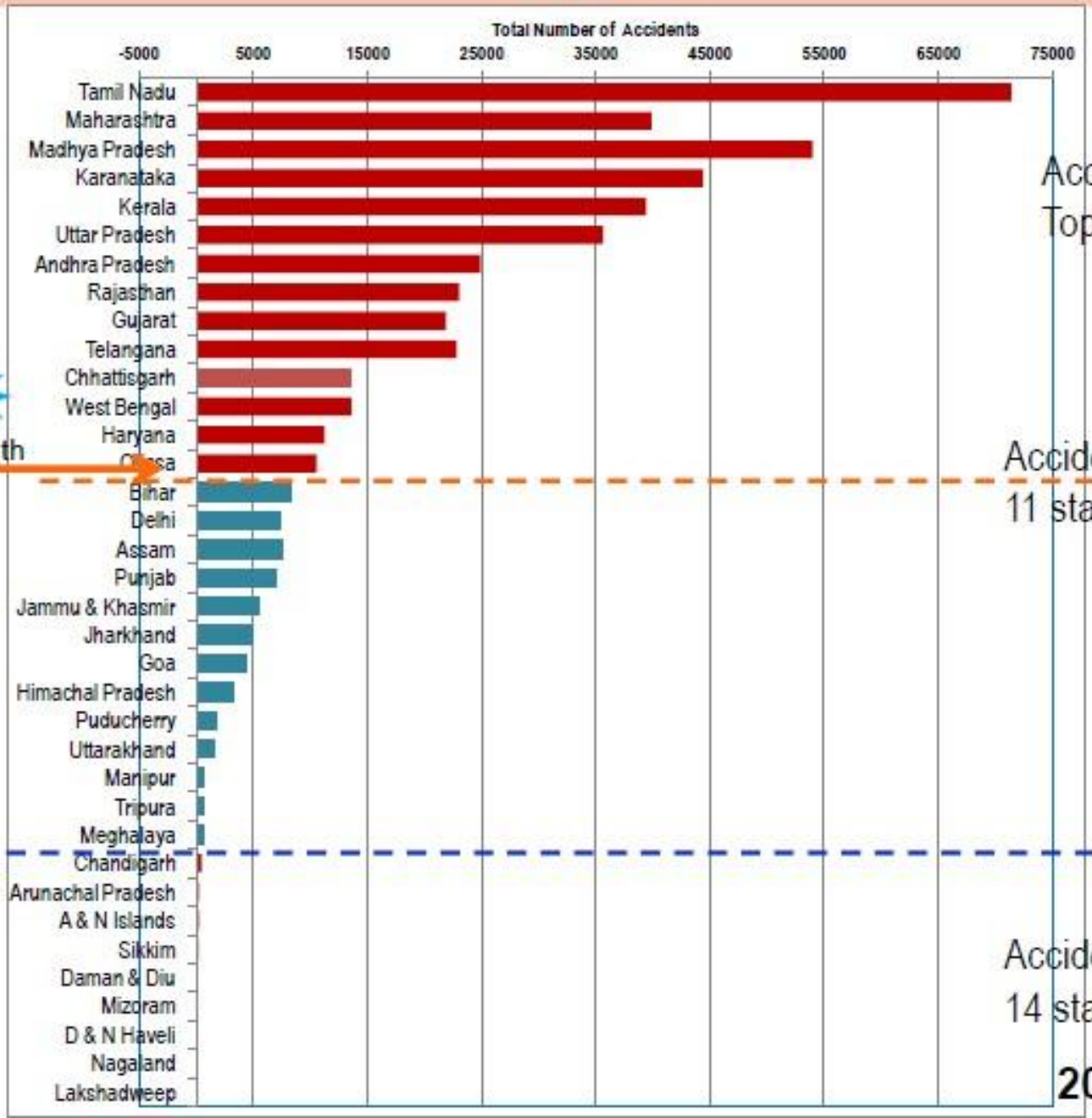
**413** deaths /day- Equivalent to Jumbo jet crash

**17** deaths /hr , **One death /every 4 minutes**

One of the Top three cause for death for age group 5-44 yrs


| | 2015 | 2016 |
|---|---|---|
| Accidents | 5,01,423 | 4,80,652 |
| Fatal Accidents | 1,31,726 | 1,36,071 |
| Persons Killed | 1,46,133 | 1,50,785 |
| Persons Injured | 5,00,279 | 4,94,624 |






2.19%

14th

Accidents > 10,000
Top 14 states - 89%

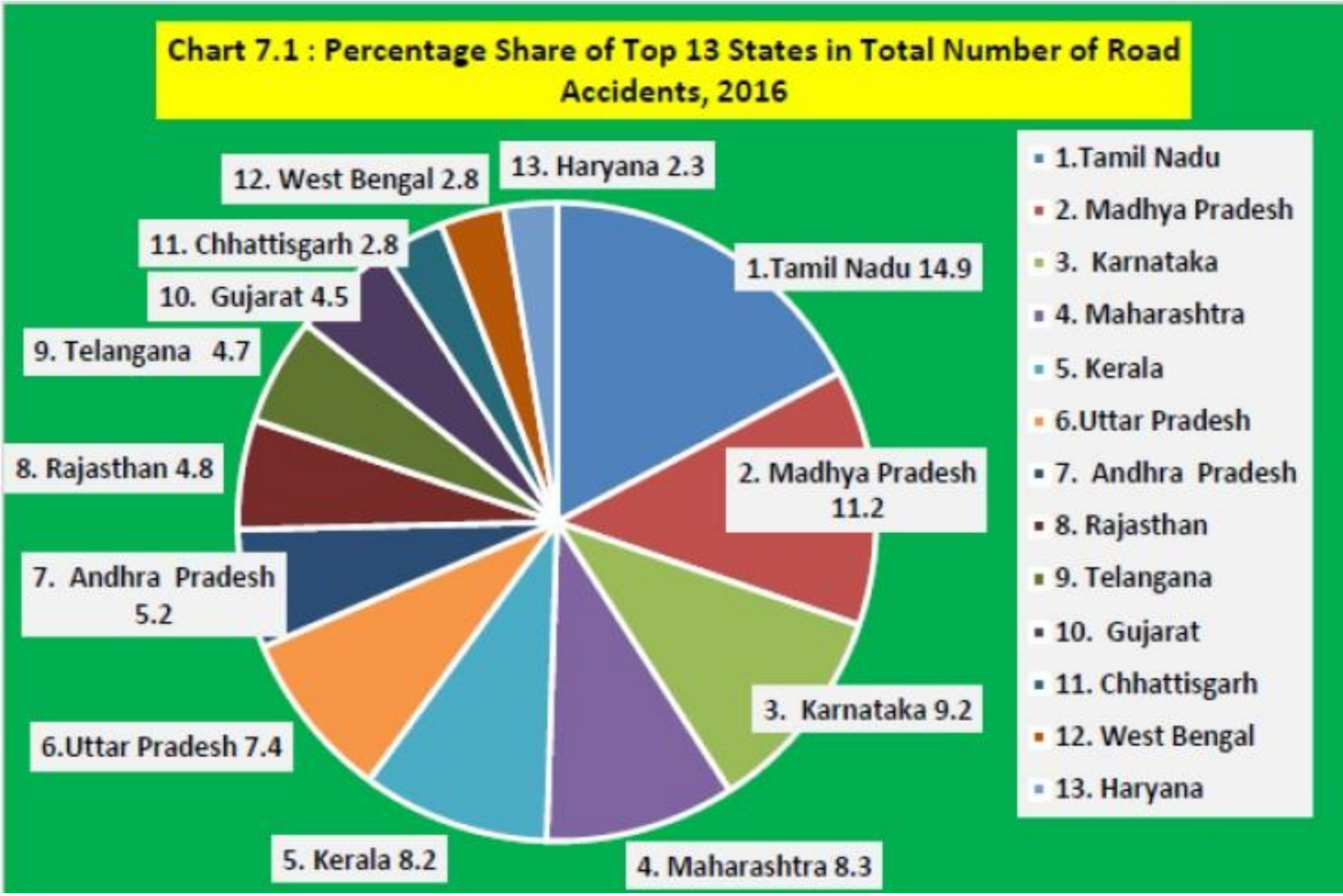
Accidents :500 - 10,000
11 states - 10%

Accidets < 500
14 states / Uts <1%

2016 MoRTH Data

CSIR CRRI

## Chart 7.1 : Percentage Share of Top 13 States in Total Number of Road Accidents, 2016



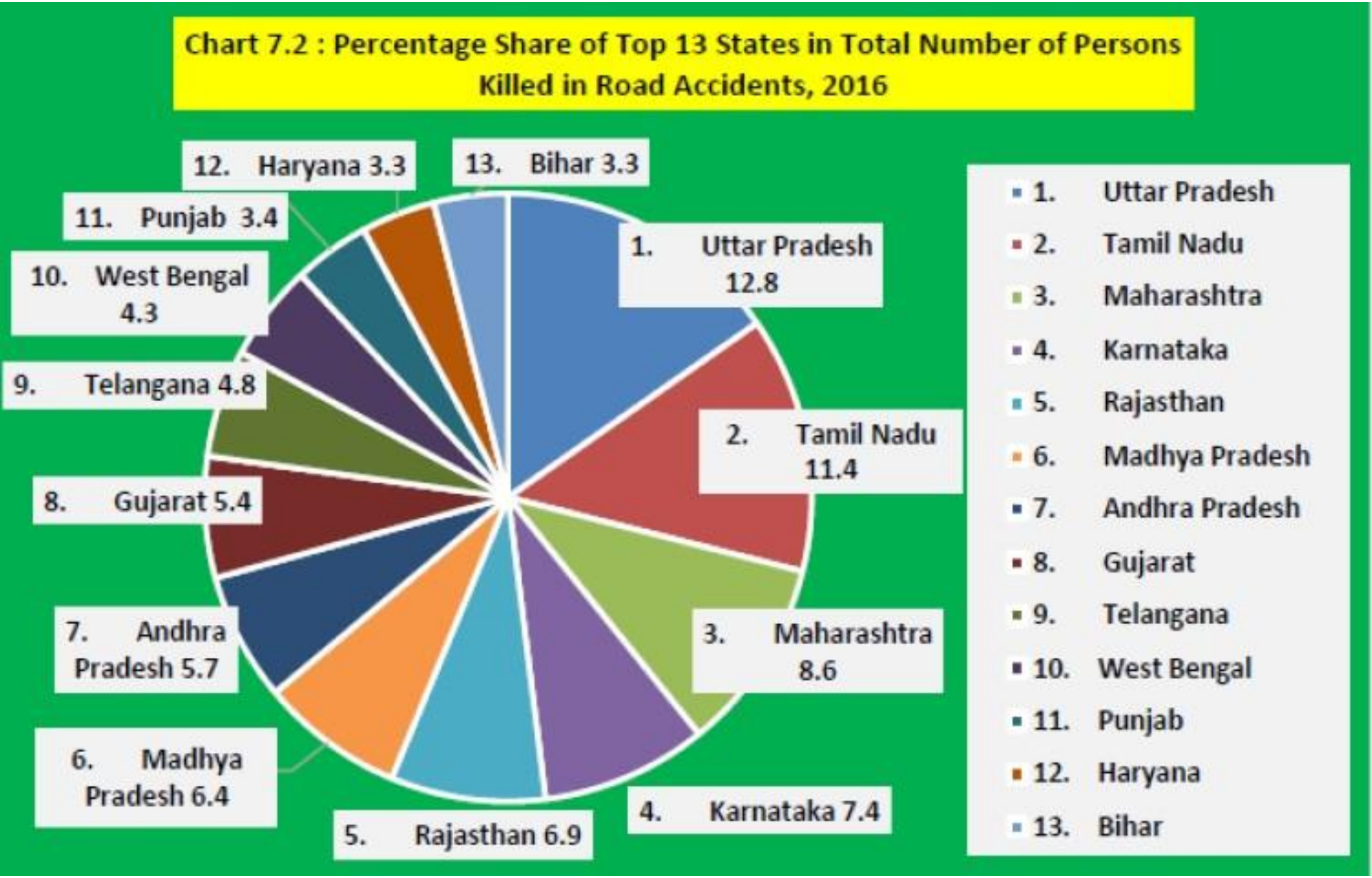
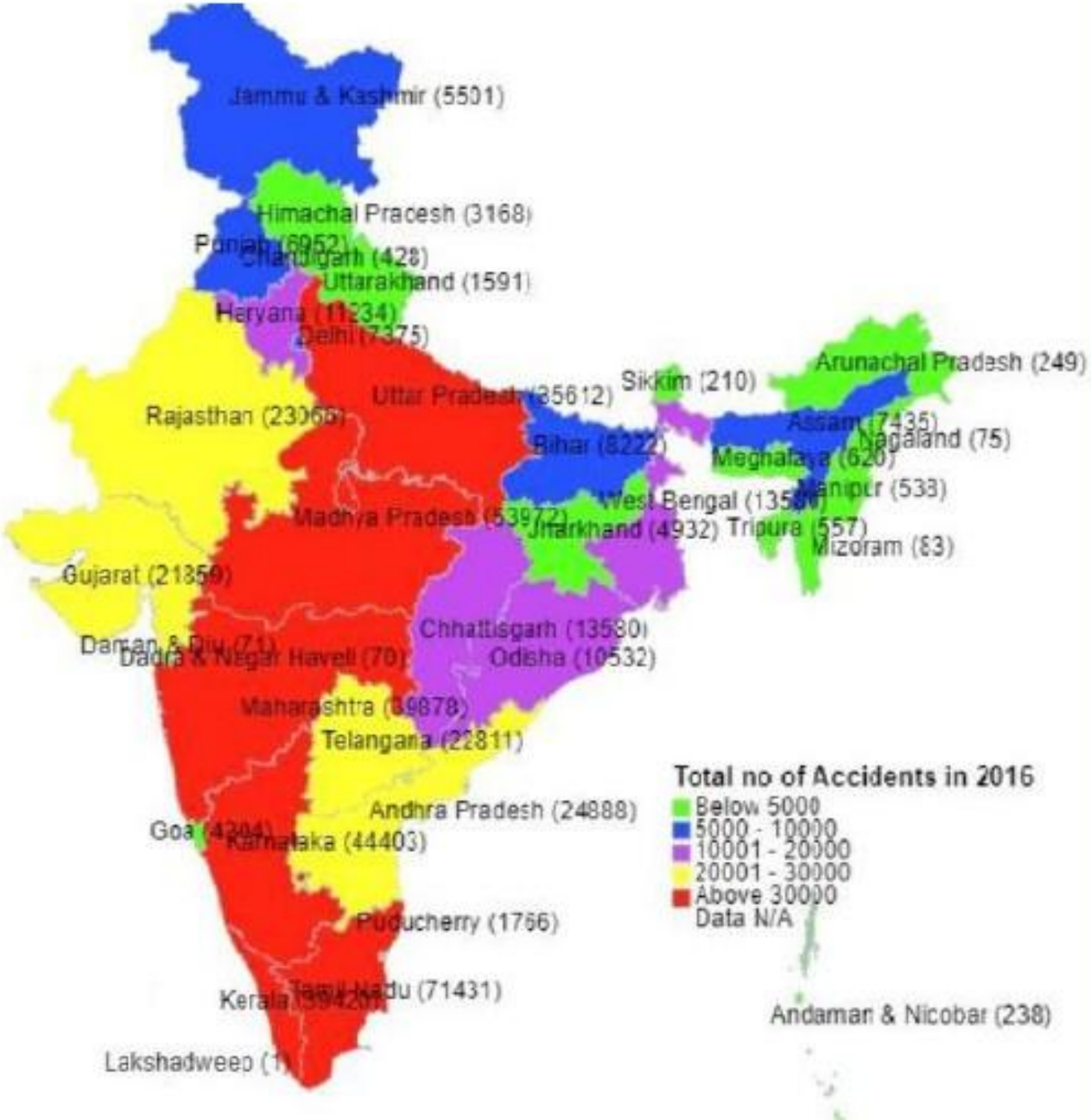
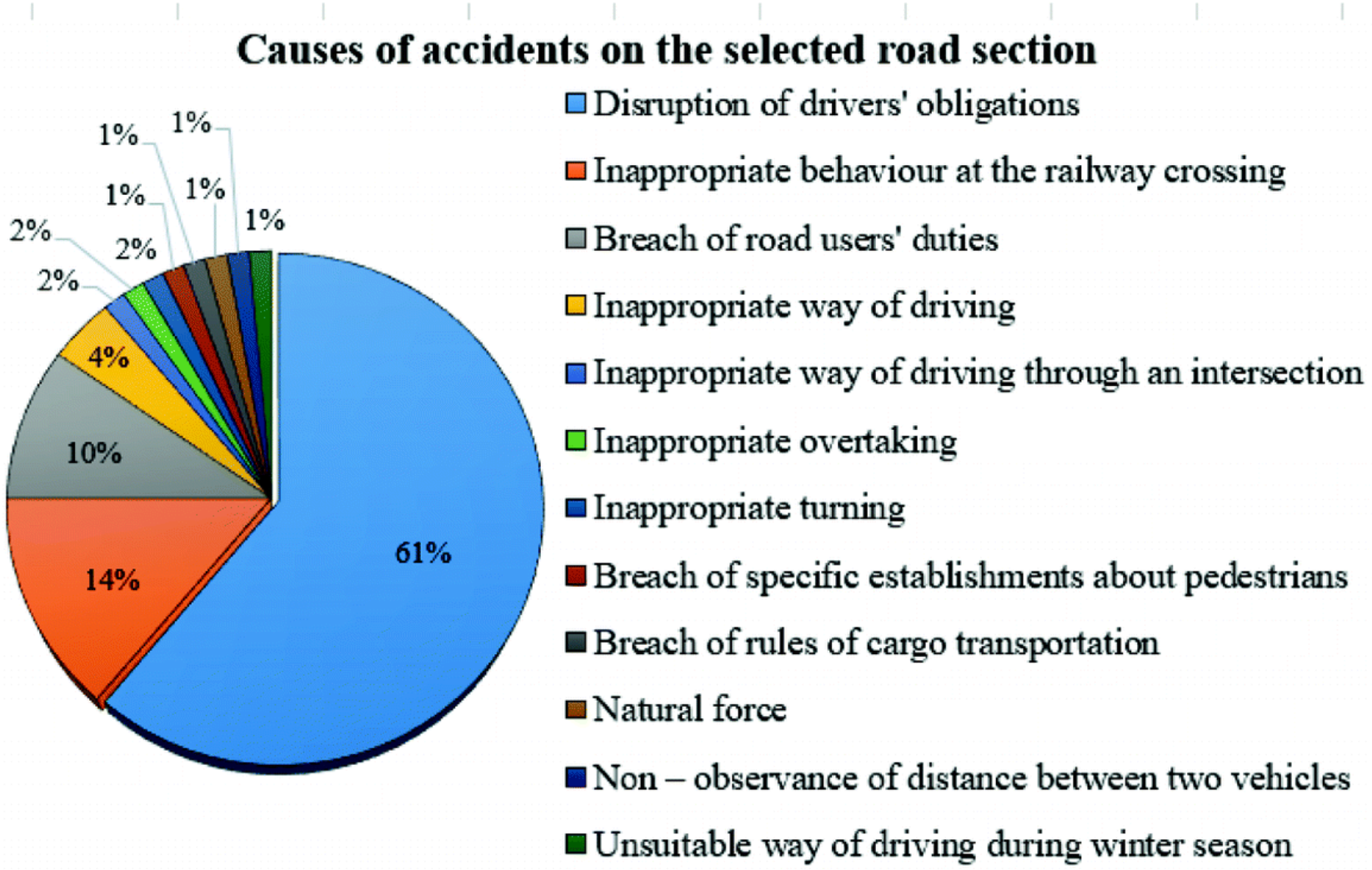


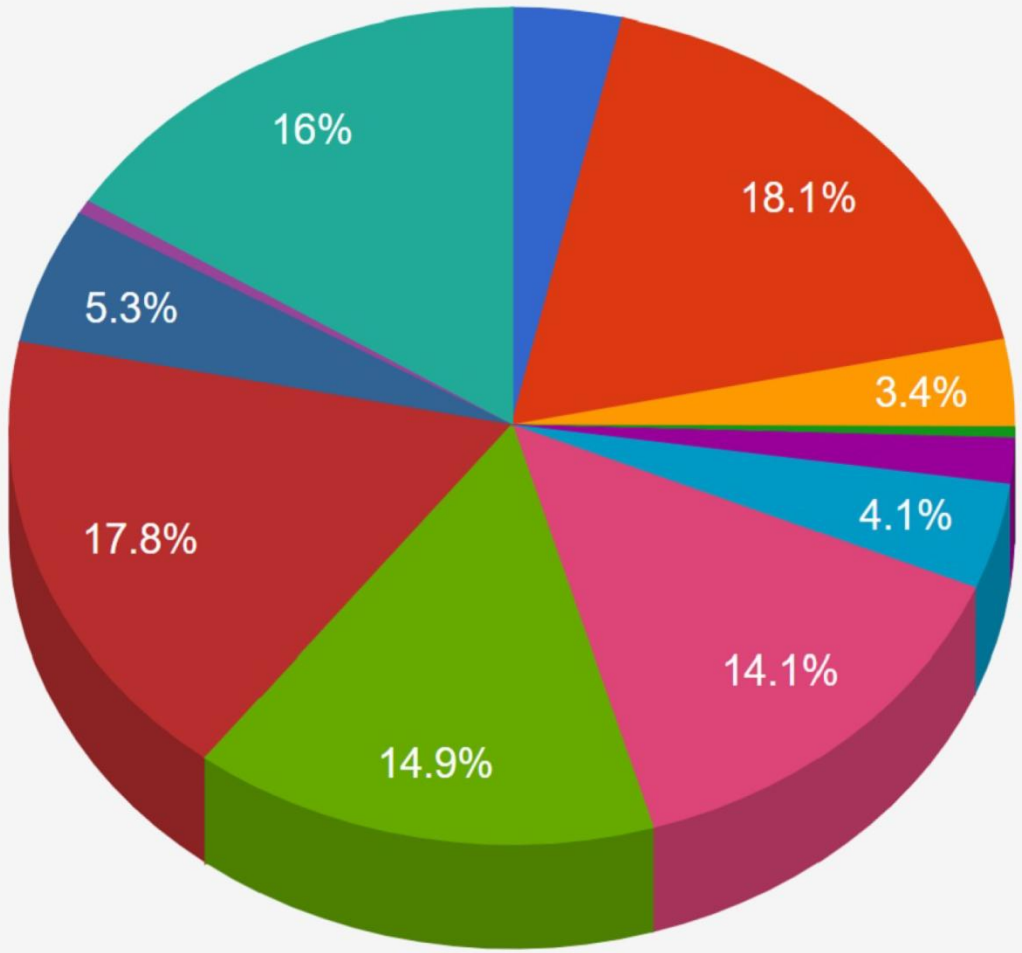
Chart 7.2 : Percentage Share of Top 13 States in Total Number of Persons Killed in Road Accidents, 2016
1. Uttar Pradesh 12.8
2. Tamil Nadu 11.4
3. Maharashtra 8.6
4. Karnataka 7.4
5. Rajasthan 6.9
6. Madhya Pradesh 6.4
7. Andhra Pradesh 5.7
8. Gujarat 5.4
9. Telangana 4.8
10. West Bengal 4.3
11. Punjab 3.4
12. Haryana 3.3
13. Bihar 3.3
1. Uttar Pradesh
2. Tamil Nadu
3. Maharashtra
4. Karnataka
5. Rajasthan
6. Madhya Pradesh
7. Andhra Pradesh
8. Gujarat
9. Telangana
10. West Bengal
11. Punjab
12. Haryana
13. Bihar


Jammu & Kashmir (5501)
Himachal Pracesh (3168)
Punjab (6952)
Chandigarh (428)
Uttarakhand (1591)
Haryana (11234)
Delhi (7375)
Rajasthan (23066)
Uttar Pradesh (35612)
Bihar (8222)
Sikkim (210)
Arunachal Pradesh (249)
Assam (7435)
Nagaland (75)
Meghalaya (620)
Manipur (533)
West Bengal (13580)
Tripura (557)
Mizoram (83)
Jharkhand (4932)
Madhya Pradesh (53972)
Gujarat (21359)
Daman & Diu (71)
Dadra & Nagar Haveli (70)
Chhattisgarh (13580)
Odisha (10532)
Maharashtra (39878)
Telangana (22811)
Andhra Pradesh (24888)
Goa (4304)
Karnataka (44403)
Puducherry (1766)
Tamil Nadu (71431)
Kerala (39420)
Lakshadweep (1)
Andaman & Nicobar (238)
Total no of Accidents in 2016
Below 5000
5000 - 10000
10001 - 20000
20001 - 30000
Above 30000
Data N/A

# Characteristics and Causes of Road Accidents

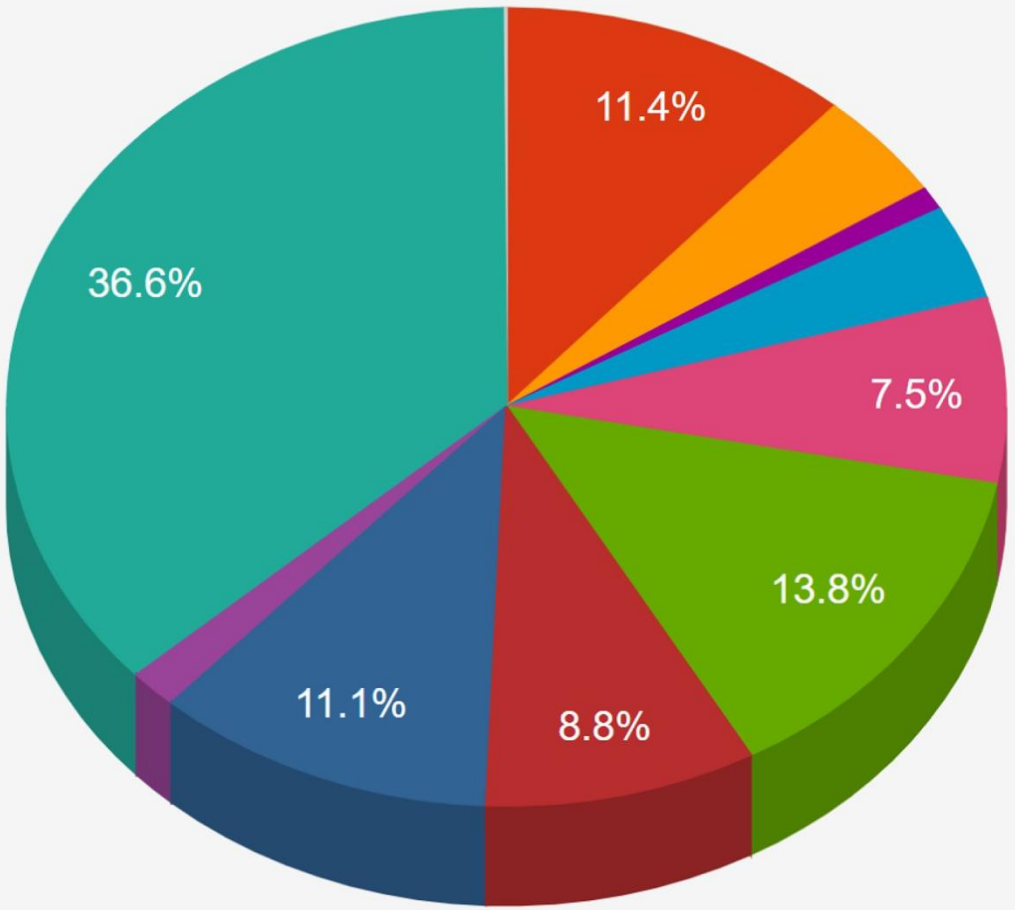


**Causes of Accidents on Passenger Car vehicle type between 2008 and 2017**




- Influence of Alcohol
- Error when leaving a road
- Error when Overtaking
- Influence of Other intoxications
- Fatigue/Physical or Mental problems
- Incorrect road use
- Inappropriate speed
- Distance error
- Failure to observe Right of way
- Incorrect behavior towards Pedestrians
- Technical faults
- Other drivers error

**Causes of Accidents on Motor Bus vehicle type between 2008 and 2017**




- Error when leaving a road
- Error when Overtaking
- Fatigue/Physical or Mental problems
- Incorrect road use
- Inappropriate speed
- Distance error
- Failure to observe Right of way
- Incorrect behavior towards Pedestrians
- Technical faults
- Other drivers error
- Other

# Traffic Safety Analysis

- Data analysis for traffic safety studies refers to the use of data from one or more data sources to describe a traffic safety situation and to understand factors contributing to occurrences and outcomes of crashes using numbers.

- Basic Characteristics of Motor-Vehicle Traffic,
- Highway Capacity,
- Applications of Traffic Control Devices,
- Design of Parking Facilities,
- Traffic Engineering Studies

Fundamentals of Traffic Engineering :

Basic Road safety (5E’s of ROAD SAFETY)

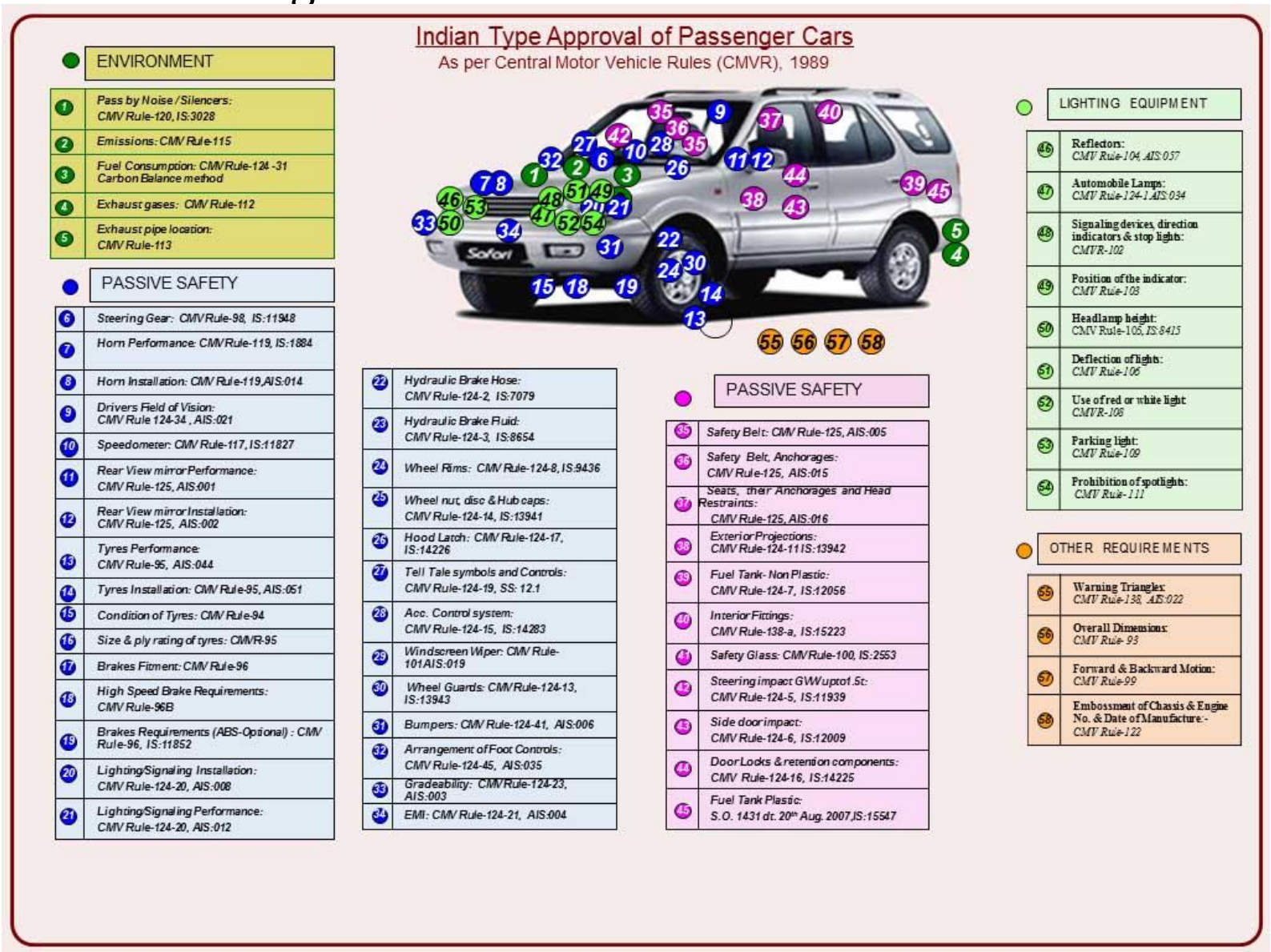
1. Engineering (Roads).
2. Engineering(Vehicles).
3. Enforcement.
4. Education.
5. Emergency.

1. **Engineering (Roads)**
   - –Road Design and Maintenance
   - – Segregation of traffic
   - – Lighting system
   - – Speed
   - – Double white lines
   - – Alignment
   - – Road Surface
   - – Margins


50
SAFETY FIRST
STOP

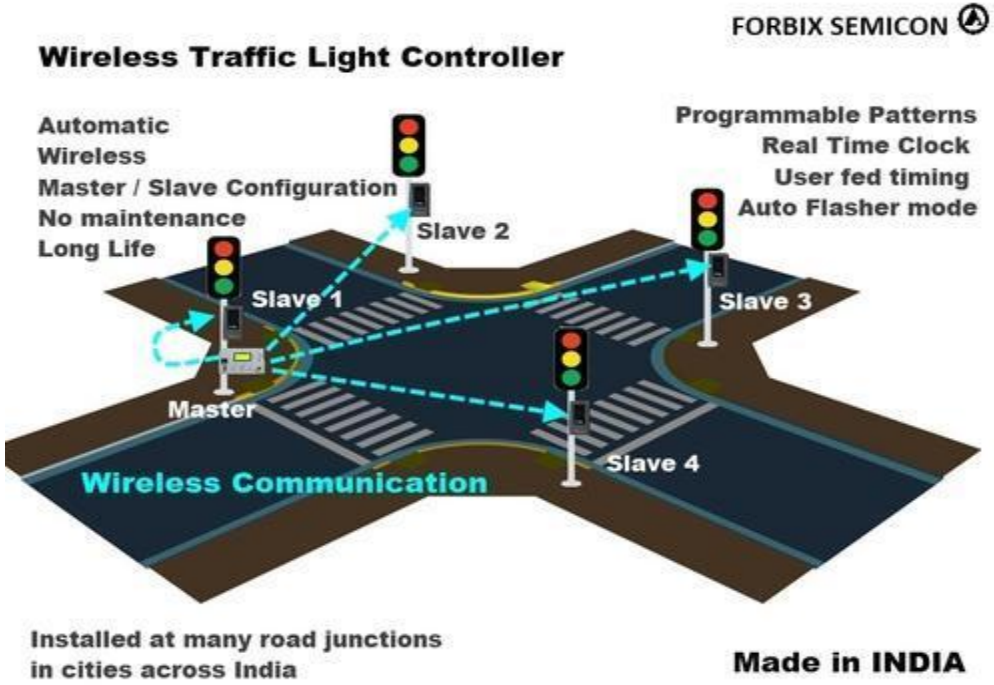
# 2. Engineering (Vehicles)

- Vehicle Design and maintenance



## 3. Enforcement

- Speed control
- Traffic control
- Training and supervision
- Medical check
- Compulsion to wear Helmet, seat belt


Wear a Helmet
Pune Police
Buckle your Seatbelt
Make Your Road Safety Plan Strategic,
To Avoid Becoming Just Another Statistic
#RoadSafety

## 4. Education

- Road users (pedestrians, drivers) training, education
- Traffic rules, traffic safety week programs etc.


CALL 108
EMERGENCY


POLICE

# 5. Emergency


DISASTER
RESPONSE FORCE


PORT HARDY FIRE RESCUE


SYED TOWING SERVICE
24/7

- Road vehicle traffic -

The aggregation of vehicles coming and going in a particular locality.

The aggregation of things (pedestrians or vehicles) coming and going in a particular locality during a specified period of time.

## Highway Capacity

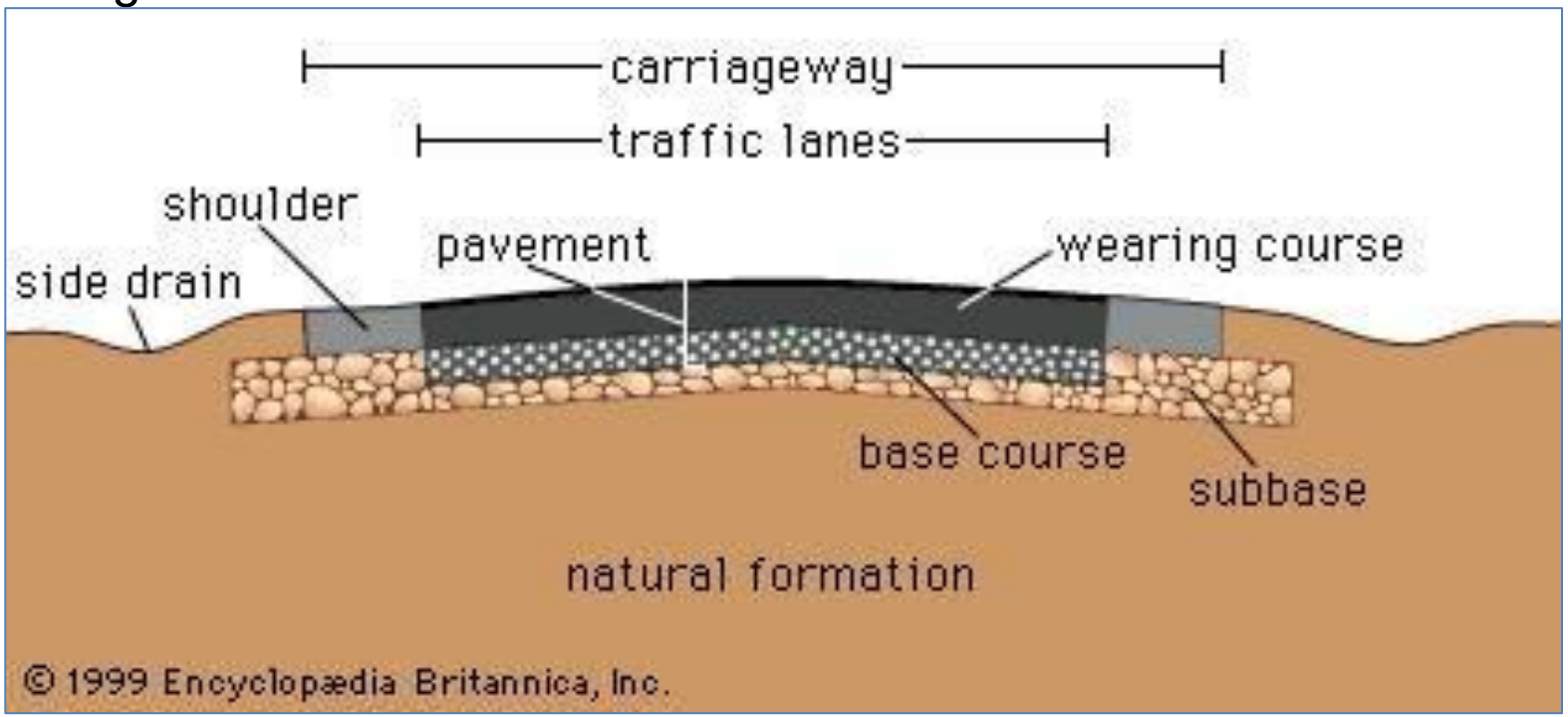
- It is the ability of a road to accommodate traffic volume.
- It is the maximum hourly rate at which vehicles can reasonably be expected to cross a point on a roadway during a given time period under prevailing traffic roadway and control condition.

## Road traffic control devices

- These are markers, signs and signal devices used to inform, guide and control traffic, including pedestrians, motor vehicle drivers and bicyclists. These devices are usually placed adjacent, over or along the highways, roads, traffic facilities and other public areas that require traffic control.

# –Elements of Road

- Carriage way
- Shoulder
- Right of Way
- Median
- Kerb
- Guard Rail
- Building Lane



# Road Marking

- Role of Road markings,
- Classification, visibility
- Edge line, center line, no overtaking lines, junction and pedestrian markings
- On sharp curves
- At bridge approaches
- At intersections
- At pedestrian crossings
- Hot applied thermo-plastic material

# Traffic signs

- Give information about the road conditions ahead,
- Provide instructions to be followed at the major crossroads or junctions,
- Warn or guide drivers,
- Ensure proper functioning of road traffic

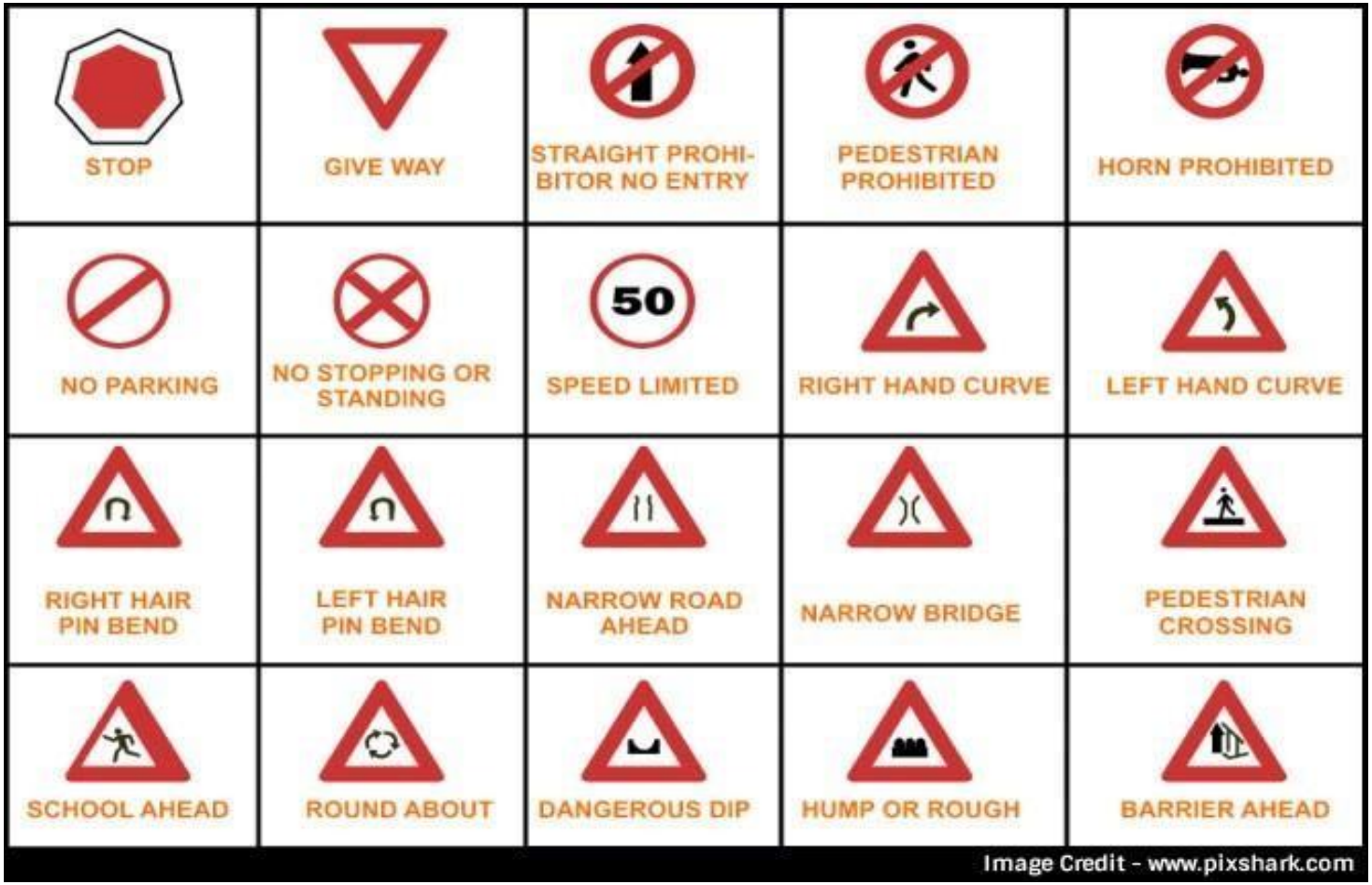
– **It can lead to loss of life and property.**

–A person is supposed to be familiar (get through a written or oral test) with the traffic signs and symbols before acquiring a driving license in India.

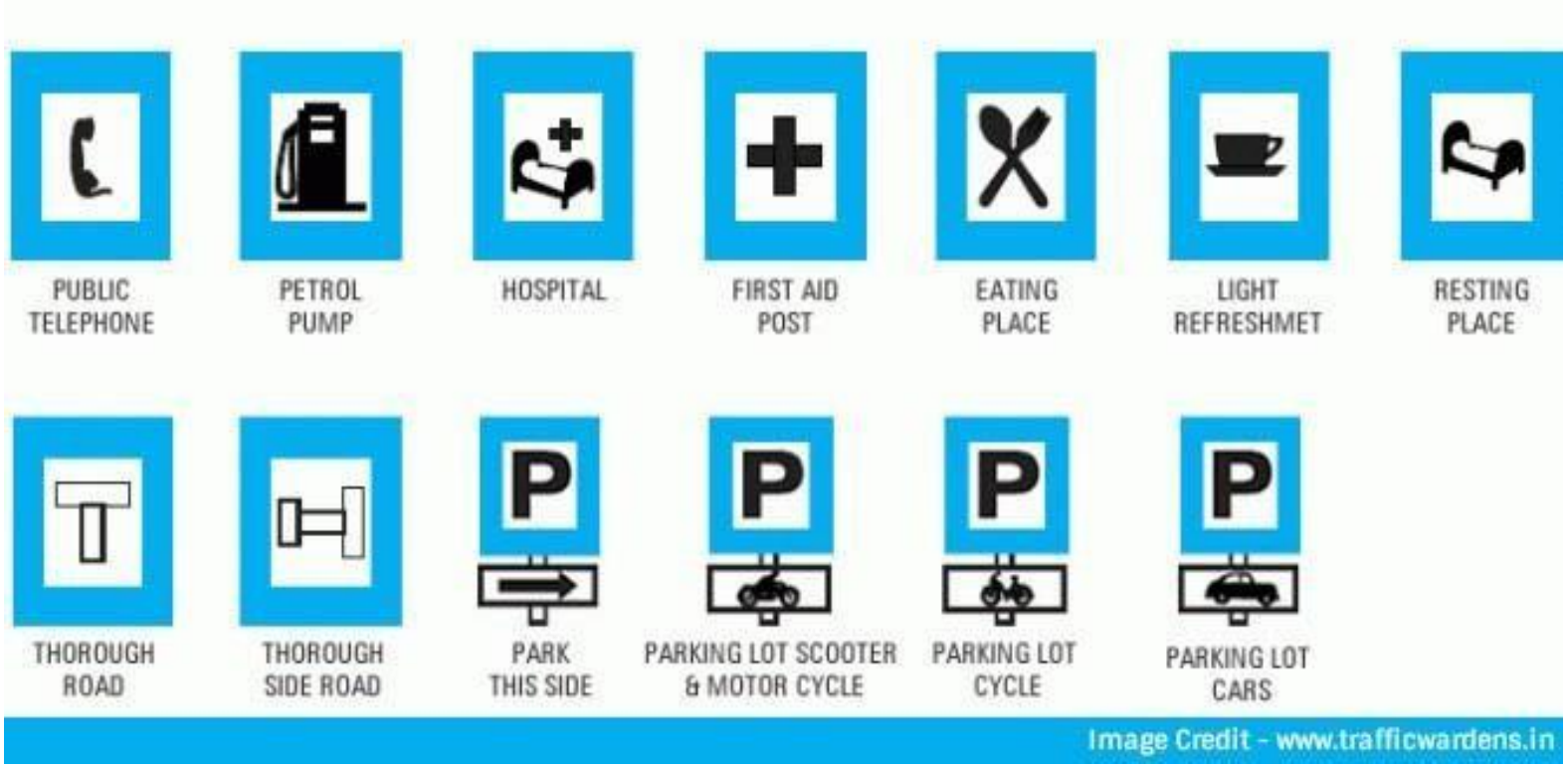
# Traffic signs - Classification

- **Mandatory / Regulatory Signs -** These signs require the driver to obey the signs for the safety of other road users.
- **Cautionary / Warning Signs -** These signs are for the safety of oneself who is driving and advice the drivers to obey these signs.
- **Informatory Signs -** These signs provide information to the driver about the facilities available ahead, and the route and distance to reach the specific destinations

# Mandatory / Regulatory Signs



# Informatory Signs



# Traffic signs

- In addition special type of traffic sign - work zone signs used to give warning to the road users when some construction work is going on the road.
- Placed only for short duration and will be removed soon after the work is over and when the road is brought back to its normal condition.

# Regulatory signs

- mandatory that the drivers must obey these signs.
- If the driver fails to obey them, the control agency has the right to take legal action against the driver.
- These signs are primarily meant for the safety of other road users.
- These signs have generally black legend on a white background.
- circular in shape with red borders.

# Right of way series:

- Mandatory that the drivers must obey these signs.
- two unique signs that assign the right of way to the selected approaches of an intersection.
  - GIVE WAY sign and
  - STOP sign
- For example, when one minor road and major road meets at an intersection, preference should be given to the vehicles passing through the major road.
- Hence the give way sign board will be placed on the minor road to inform the driver on the minor road that he should give way for the vehicles on the major road.

- In case two major roads are meeting, then the traffic engineer decides based on the traffic on which approach the sign board has to be placed.
- Stop sign is another example of regulatory signs that comes in right of way series which requires the driver to stop the vehicle at the stop line

## Speed series:

- speed signs may be used to limit the speed of the vehicle on the road.
- speed limit signs, truck speed, minimum speed signs etc.
  - Speed limit signs - to limit the speed of the vehicle to a particular
  - speed for many reasons.
  - truck speed limits are applied on high speed roadways where heavy commercial vehicles must be limited to slower speeds than passenger cars for safety reasons.
  - Minimum speed limits are applied on high speed roads like expressways, freeways etc. where safety is again a predominant reason.
  - Very slow vehicles may present hazard to themselves and other vehicles also

## Movement series:

- Signs that affect specific vehicle maneuvers.
- These include turn signs, alignment signs, exclusion signs, one way signs etc.
  - ❖ Turn signs include turn prohibitions and lane use control signs.
  - ❖ Lane use signs make use of arrows to specify the movements which all vehicles in the lane must take.
  - ❖ one way signs are used to safely accommodat in un signalized intersections.

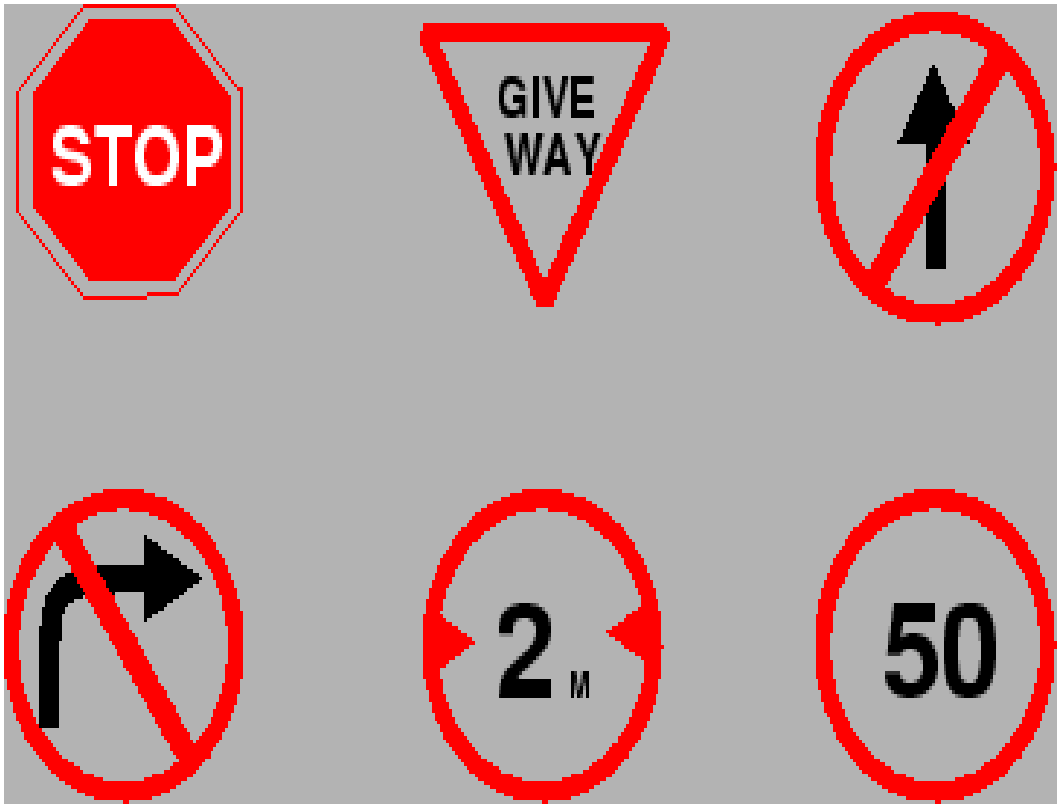
# Pedestrian series:

- They include parking signs which indicate not only parking prohibitions or restrictions, but also indicate places where parking is permitted, the type of vehicle to be parked, duration for parking etc.

# Parking series:

- They include both legend and symbol signs.
- These signs are meant for the safety of pedestrians and include signs indicating pedestrian only roads, pedestrian crossing sites etc.

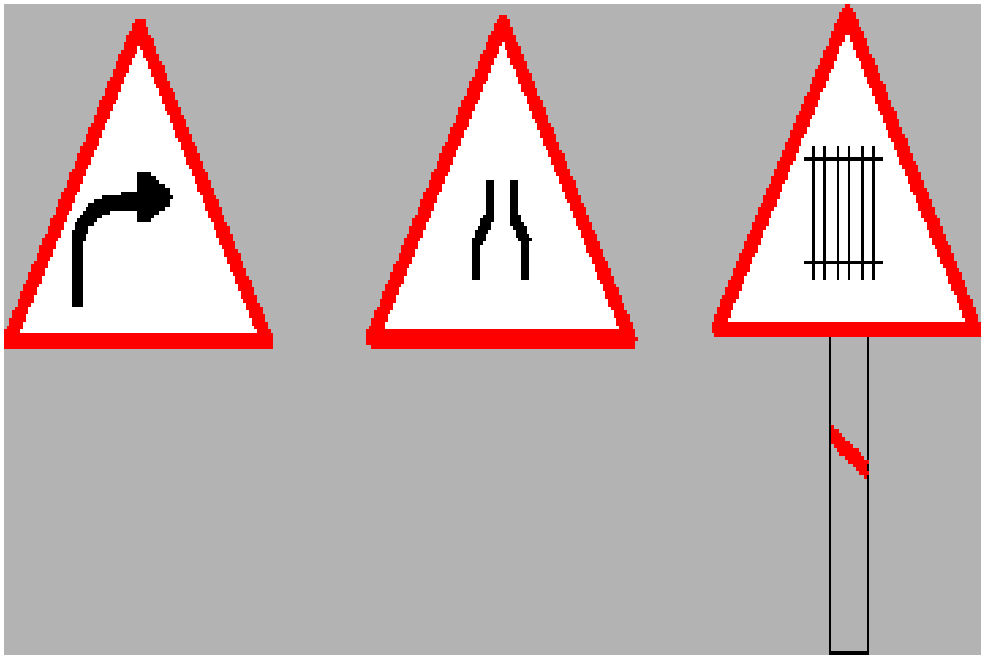
- Examples of regulatory signs ( stop sign, give way sign, signs for no entry, sign indicating prohibition for right turn, vehicle width limit sign, speed limit sign)



# Warning signs or cautionary signs

- Give information to the driver about the impending road condition.
- They advice the driver to obey the rules.
- These signs are meant for the own safety of drivers.
- They call for extra vigilance from the part of drivers.
- The color convention used for this type of signs is that the legend will be black in color with a white background.
- The shape used is upward triangular or diamond shape with red borders.

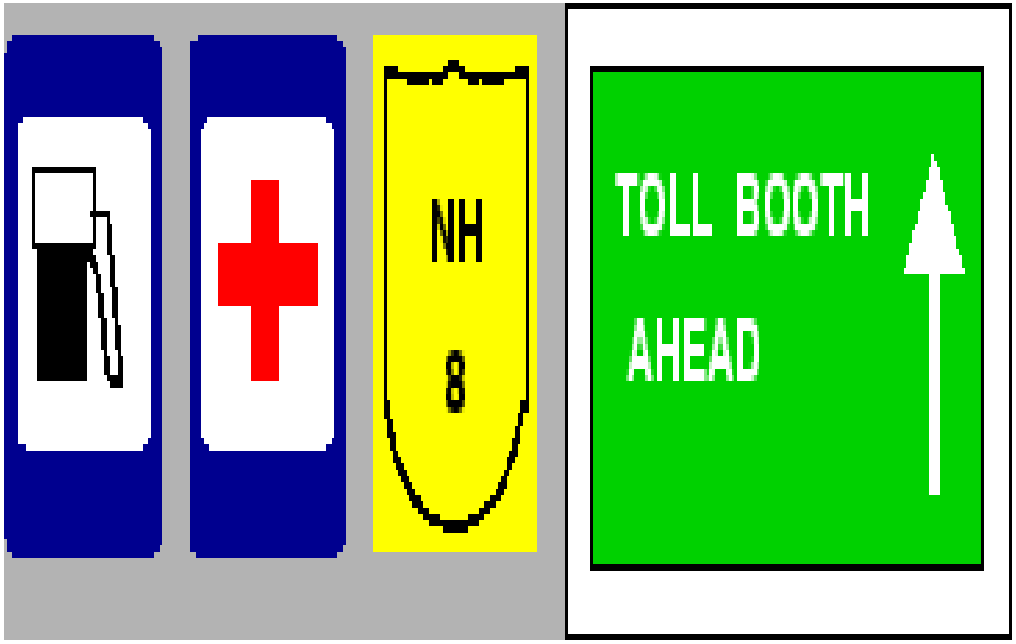
- Examples of cautionary signs ( right hand curve  sign board, signs for narrow road, sign indicating  railway track ahead)



# Informative signs

- Guide signs, are provided to assist the drivers to reach their desired destinations.
- These are predominantly meant for the drivers who are unfamiliar to the place.
- The guide signs are redundant for the users who are accustomed to the location.

- Examples of informative signs (route markers, destination signs, mile posts, service centre information etc)



- Type of signs are route markers, destination signs, mile posts, service information, recreational and cultural interest area signing etc.
- Route markers are used to identify numbered highways.
- They have designs that are distinctive and unique.
- They are written black letters on yellow background.
- Destination signs are used to indicate the direction to the critical destination points, and to mark important intersections.
- Distance in kilometers are sometimes marked to the right side of the destination.

- They are, in general, rectangular with the long dimension in the horizontal direction.
- They are color coded as white letters with green background.
- Mile posts are provided to inform the driver about the progress along a route to reach his destination.
- Service guide signs give information to the driver regarding various services such as food, fuel, medical assistance etc.
- They are written with white letters on blue background.
- Information on historic, recreational and other cultural area is given on white letters with brown background.

# Location of signs

- The sign boards should be placed at a distance such that the driver could see it and gets sufficient time to respond to the situation.
- The sign should be placed in such a way that the driver requires no extra effort to see the sign.
- For commanding attention, proper visibility should be there.
- Also the sign should be distinctive and clear.

# Measures of Sign effectiveness

- Clarity and simplicity of message is essential for the driver to properly understand the meaning in short time.
- The use of color, shape and legend as codes becomes important in this regard.
- The legend should be kept short and simple so that even a less educated driver could understand the message in less time.
- Overuse, misuse and confusing messages of devices tends the drivers to ignore them.

# Color:

- It is the first and most easily noticed characteristics of a device.
- Usage of different colors for different signs are important.
- The most commonly used colors are red, green, yellow, black, blue, and brown .
- Consistent use of colors helps the drivers to identify the presence of sign board ahead.

# Shape:

- It is the second element discerned by the driver next to the color of the device.
- The categories of shapes normally used are circular, triangular, rectangular, and diamond shape.
- Two exceptional shapes used in traffic signs are octagonal shape for STOP sign and use of inverted triangle for GIVE WAY sign. Diamond shape signs are not generally used in India.

# Legend:

- For the easy understanding by the driver, the legend should be short, simple and specific so that it does not divert the attention of the driver.
- Symbols are normally used as legends so that even a person unable to read the language will be able to understand that.

# Word messages:

- capital letters.
- As brief as possible
- More than three words
- STOP, SLOW, SCHOOL, RIGHT TURN ONLY etc.

# Road marking

- The road markings are defined as lines, patterns, words or other devices, except signs, applied or attached to the carriageway or kerbs or to objects within or adjacent to the carriageway, for controlling, warning, guiding and informing the users.

# Road Marking

Lane line.
Line dividing traffic lanes

Centre line.
Line dividing two-way traffic

Hazard warning line
Lane or centre line near hazard

Hazard warning area
Do not enter

Edge of carriageway

Edge of carriageway

Edge of the road at a Junction

Edge of the road at a Lay-by etc

Warning of 'Give way' Line


Warning of 'Stop' sign

Get over to the Left

Entrance to deceleration lane

# Role of Road marking

- The essential purpose of road markings is to
  - Guide and control traffic on a highway.
  - Serve as a psychological barrier
  - To delineation of traffic path and its lateral clearance from traffic hazards.
  - ensure the safe, smooth and harmonious flow of traffic.

# Pattern:

- It is normally used in the application of road markings.
- Generally solid, double solid and dotted lines are used. Each pattern conveys different type of meaning.
- The frequent and consistent use of pattern to convey information is recommended so that the drivers get accustomed to the different types of markings and can instantly recognize them.

# Types of marking

- Various types of road markings is to warn the driver about the hazardous locations in the road,

- They are
  - Longitudinal markings
  - Transverse markings
  - Object markings
  - Special markings (word messages, marking for parking's, marking at hazardous locations)

## Longitudinal markings

- Placed along the direction of traffic on the roadway surface for the purpose of indicating to the driver his proper position on the roadway.
- Provided for separating traffic flow in the same direction
- Predominant color used is white.
- Yellow color is used to separate the traffic flow in opposite direction and also to separate the pavement edges.

- The lines can be either broken, solid or double solid.
- Broken lines are permissive in character and allows crossing with discretion, if traffic situation permits.
- Solid lines are restrictive in character and does not allow crossing except for entry or exit from a side road or premises or to avoid a stationary obstruction.
- Double solid lines indicate severity in restrictions and should not be crossed except in case of emergency.

- There can also be a combination of solid and broken lines.
- In such a case, a solid line may be crossed with discretion, if the broken line of the combination is nearer to the direction of travel.
- Vehicles from the opposite directions are not permitted to cross the line.
- Different types of longitudinal markings are centre line, traffic lanes, no passing zone, warning lines, border or edge lines, bus lane markings, cycle lane markings


# Centre line

- Separates the opposing streams of traffic and facilitates their movement.
- Usually no centre line is provided for roads having width less than 5 m and for roads having more than four lanes.
- The centre line may be marked with either single broken line, single solid line, double broken line, or double solid line depending upon the road and traffic requirements.
- On urban roads with less than four lanes, the centre line may be single broken line segments of 3 m long and 150 mm wide.
- The broken lines are placed with 4.5 m gaps
- On curves and near intersections, gap shall be reduced to 3 metres

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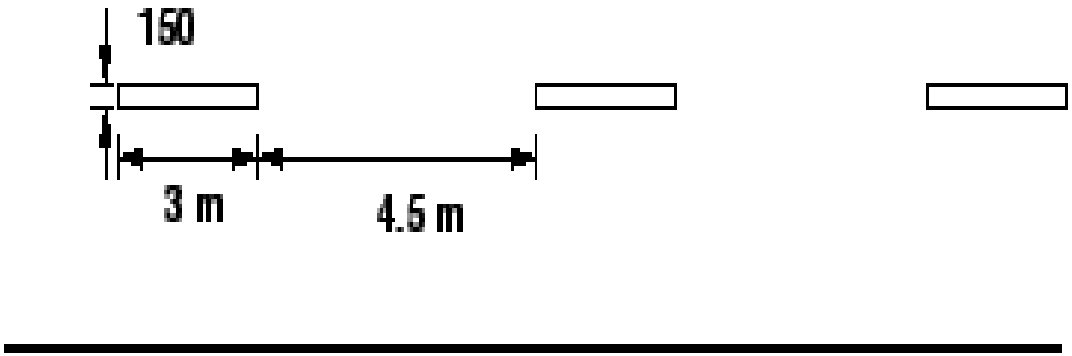
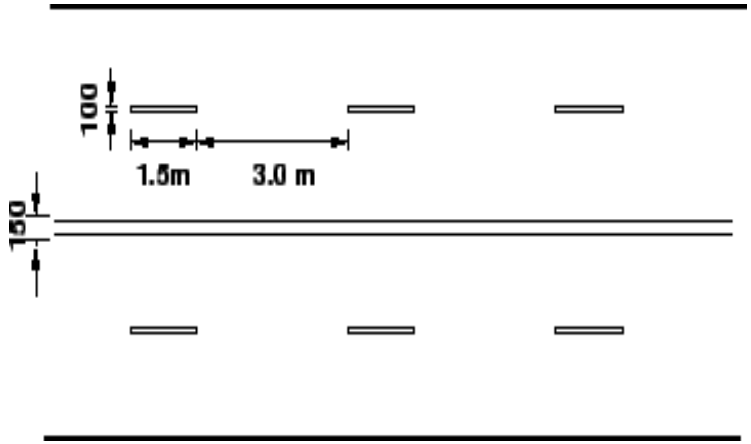
- On curves and near intersections, gap shall be reduced to 3 metres.



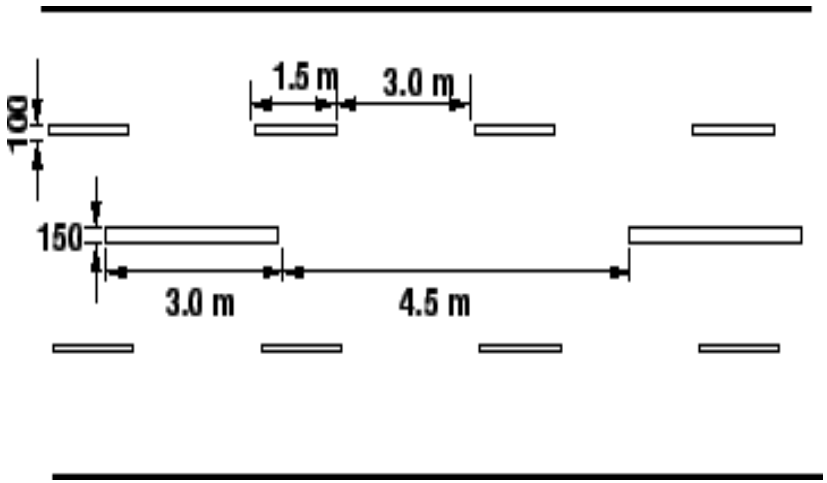
# ii) Traffic lane lines

- The subdivision of wide carriageways into separate lanes on either side of the carriage way helps the driver to go straight and also curbs the meandering tendency of the driver.

## Lane marking for a four lane road with solid barrier line



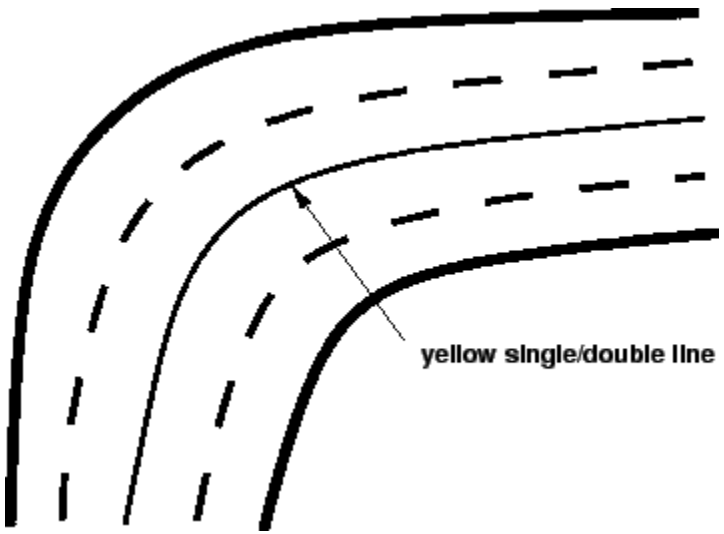

## Traffic lane marking for a four lane road with broken centre line



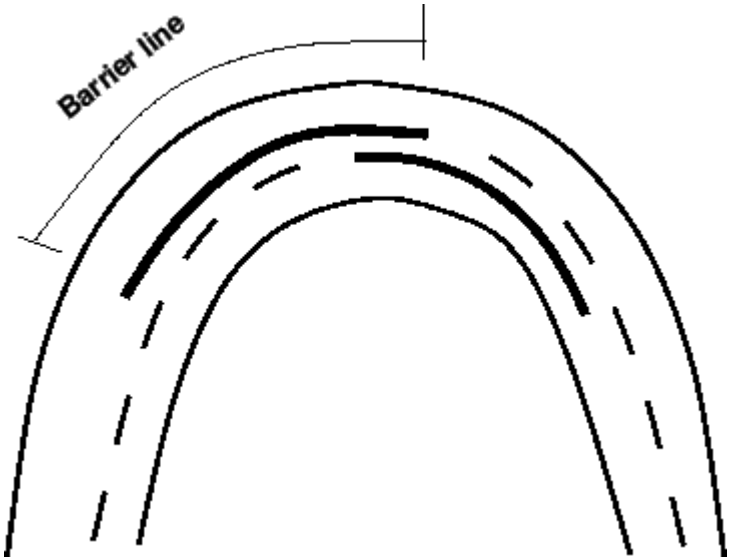
# iii) No passing zones

- No passing zones are established on summit curves, horizontal curves, and on two lane and three lane highways where overtaking maneuvers are prohibited because of low sight distance.
- It may be marked by a solid yellow line along the centre or a double yellow line.

## Barrier line marking for a four lane road

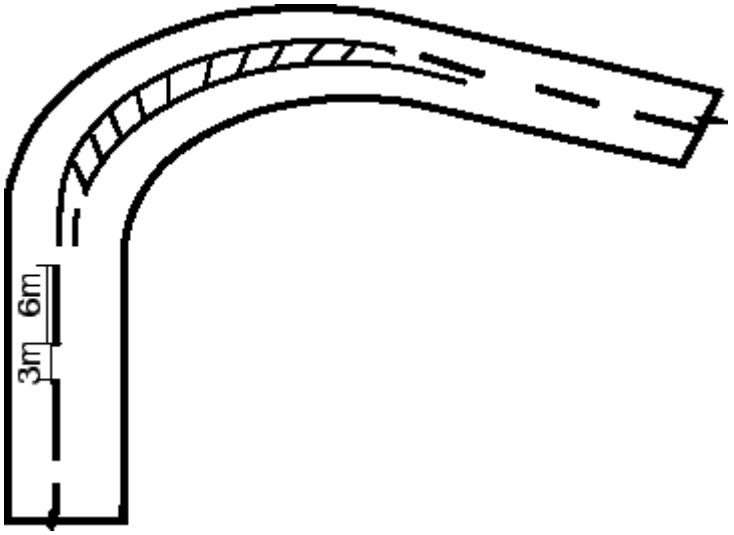



## No passing zone marking at horizontal curves



# iv) Warning lines

- Warning lines warn the drivers about the obstruction approaches.
- They are marked on horizontal and vertical curves where the visibility is greater than prohibitory criteria specified for no overtaking zones.



## v) Edge lines

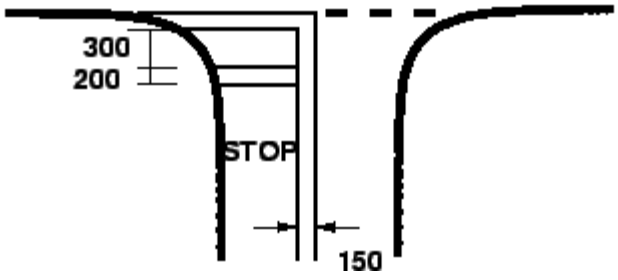
- Edge lines indicate edges of rural roads which have no kerbs to delineate the limits upto which the driver can safely venture.
- They should be at least 150 mm from the actual edge of the pavement.
- They are painted in yellow or white.

# 2. Transverse markings

- Transverse markings are marked across the direction of traffic.
- They are marked at intersections etc.
- The site conditions play a very important role.
- The type of road marking for a particular intersection depends on several variables such as speed characteristics of traffic, availability of space etc.
- Stop line markings, markings for pedestrian crossing, direction arrows, etc. are some of the markings on approaches to intersections.

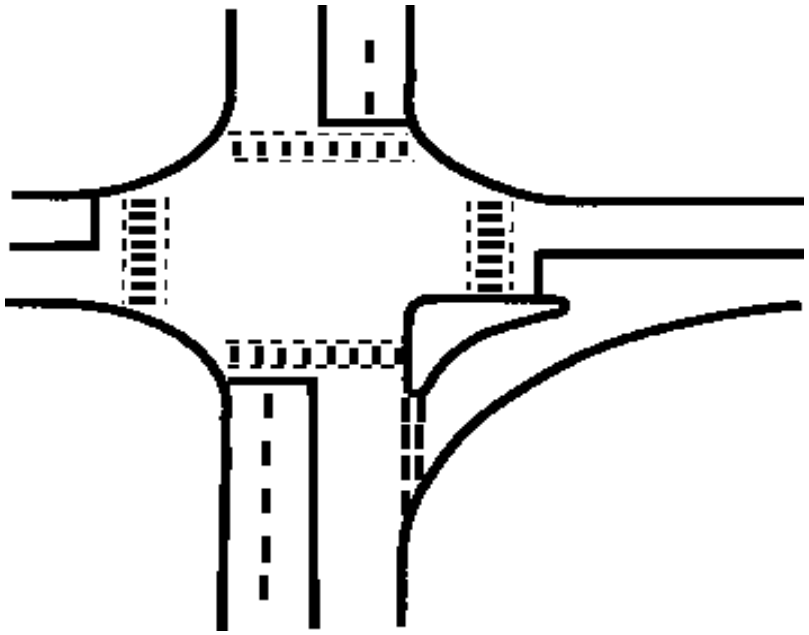
## i) Stop line

- Stop line indicates the position beyond which the vehicles should not proceed when required to stop by control devices like signals or by traffic police.
- They should be placed either parallel to the intersecting roadway or at right angles to the direction of approaching vehicles.



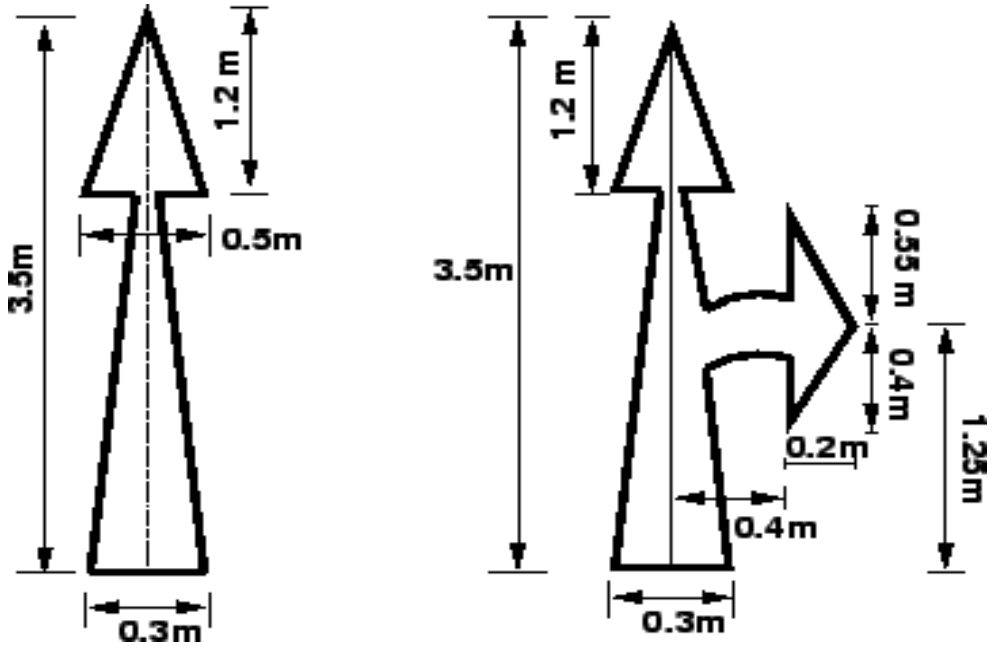
## ii)Pedestrian crossings

- Pedestrian crossings are provided at places where the conflict between vehicular and pedestrian traffic is severe.
- The site should be selected that there is less inconvenience to the pedestrians and also the vehicles are not interrupted too much.



# iii) Directional arrows

- Used to guide the drivers in advance over the correct lane to be taken while approaching busy intersections.



## 3. Object marking

- Physical obstructions in a carriageway like traffic island or obstructions near carriageway like signal posts, pier etc. cause serious hazard to the flow of traffic and should be adequately marked.

## i)Objects within the carriageway

- The obstructions within the carriageway such as traffic islands, raised medians, etc. may be marked by not less than five alternate black and yellow stripes.
- The stripes should slope forward at an angle of 45 with respect to the direction of traffic.

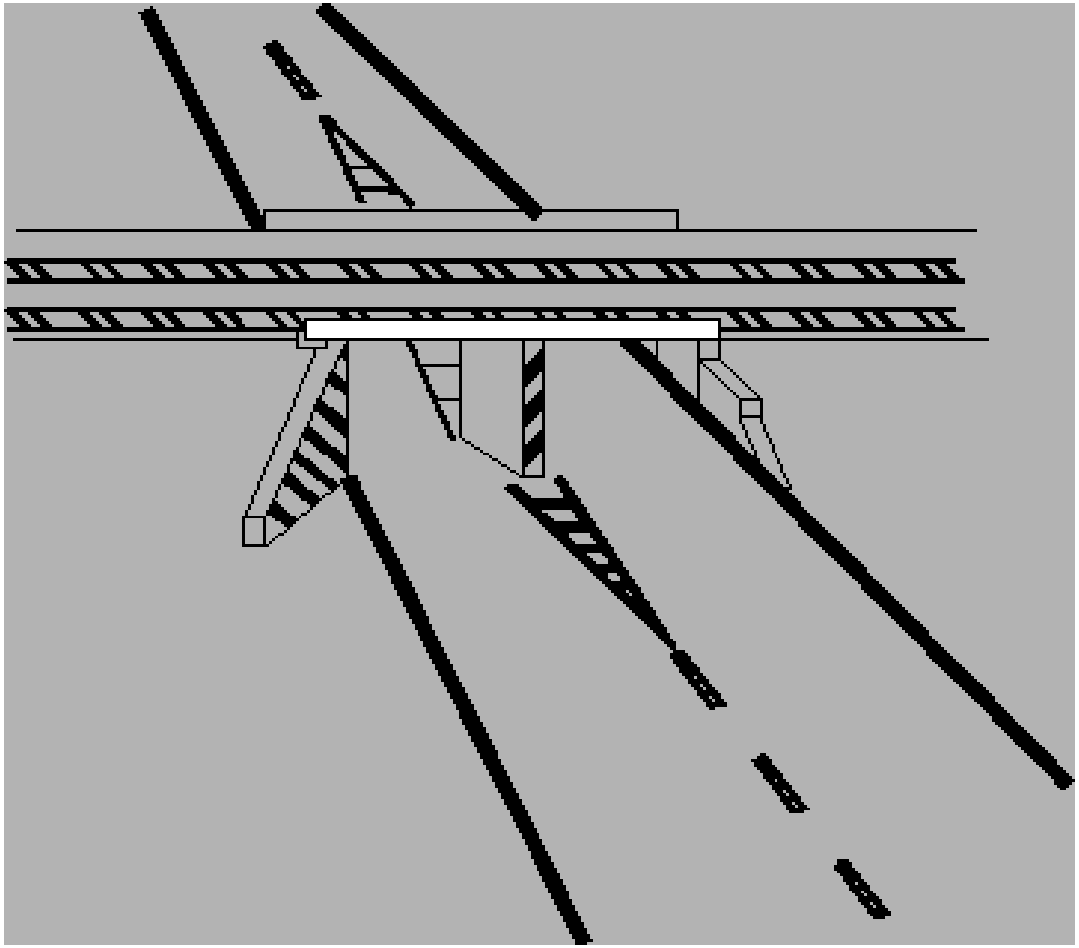
## ii)Objects adjacent to carriageway

- Sometimes objects adjacent to the carriageway may pose some obstructions to the flow of traffic.
- Objects such as subway piers and abutments, culvert head walls etc. are some examples for such obstructions.
- They should be marked with alternate black and white stripes at a forward angle of 45 with respect to the direction of traffic.
- Poles close to the carriageway should be painted in alternate black and white up to a height of 1.25 m above the road level.

- Other objects such as guard stones, drums, guard rails etc. where chances of vehicles hitting them are only when vehicle runs off the carriageway should be painted in solid white.

- Kerbs of all islands located in the line of traffic flow shall be painted with either alternating black and white stripes of 500 mm wide or chequered black and white stripes of same width.

# Object marking for central pier and side walls of an underpass



# 4.Parking

- marking of the parking space limits on urban roads promotes more efficient use of the parking spaces and tends to prevent encroachment on places like bus stops, fire hydrant zones etc. where parking is undesirable.
- Such parking space limitations should be indicated with markings that are solid white lines 100 mm wide.
- Words TAXI, CARS, SCOOTERS etc. may also be written if the parking area is specific for any particular type of vehicle. To indicate parking restriction, kerb or carriage way marking of continuous yellow line 100 mm wide covering the top of kerb or carriageway close to it may be used.

# 5.Hazardous location

- Wherever there is a change in the width of the road, or any hazardous location in the road, the driver should be warned about this situation with the help of suitable road markings.
- Road markings showing the width transition in the carriageway should be of 100 mm width. Converging lines shall be 150 mm wide and shall have a taper length of not less than twenty times the off-set distance.

# TRAFFIC SIGNALS

- Control devices which alternately direct the traffic to stop and proceed at intersections using red and green traffic light signal automatically.
- **Red light** indicates **STOP**
- **Yellow** amber light indicates the **clearance time** for the vehicles which have entered the intersection area by the end of green signal
- **Green light** indicates **GO**

# Types of traffic signals

## I. FIXED TIME SIGNALS

- These signals are set to repeat regularly a cycle of red, amber yellow and green lights.
- Depending upon the traffic intensities, the timings of each phase of the cycle is predetermined.
- Fixed time signals are the simplest type of automatic traffic signals which are electrically operated.
- **Draw backs of the signals:**
  - The cycle of red, yellow and green goes on irrespective whether on any road, there is any traffic or not.
  - Traffic in the heavy stream has to stop at end phase

# Types of traffic signals

## II. TRAFFIC ACTUATED SIGNALS

- In these signals the timings of the phase and cycle are changed according to traffic demand.
- In **semi-actuated signals**, the normal green phase of a traffic stream may be extended upto a certain period of time for allowing the vehicles to clear off the intersection.
- In **fully-actuated signals**, computers assign the right of way for the traffic movement on turn basis of traffic flow demand.

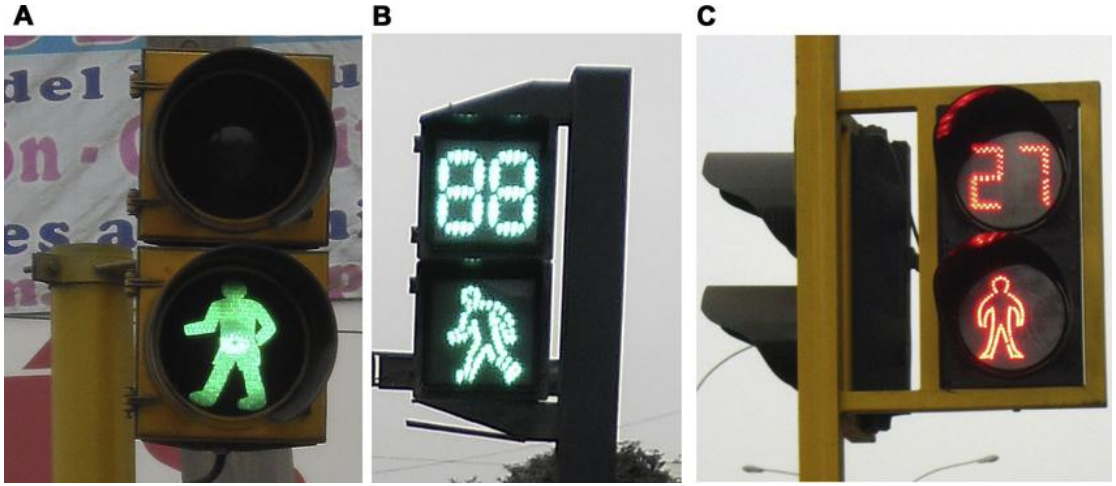
# Types of traffic signals

## III MANUALLY OPERATED SIGNALS

- In these types of signals, the traffic police watches the traffic demand from a suitable point during the peak hours at the intersection and varies the timings of these phases and cycle accordingly.

# 2. PEDESTRIAN SIGNALS

- When the vehicular traffic remains stopped by red or stop signal on the traffic signals of the road intersection, these signals give the right of way of pedestrians to cross a road during the walk period.



# 3.SPECIAL SIGNALS OR FLASHING BEACONS

- These signals are used to warn the traffic.
- When there is a red flashing signal, the drivers of vehicles must stop before entering the nearest cross walk at the intersection or at a stop line where marked.
- Flashing of yellow signals are used to direct the drivers of the vehicular traffic to proceed with caution.

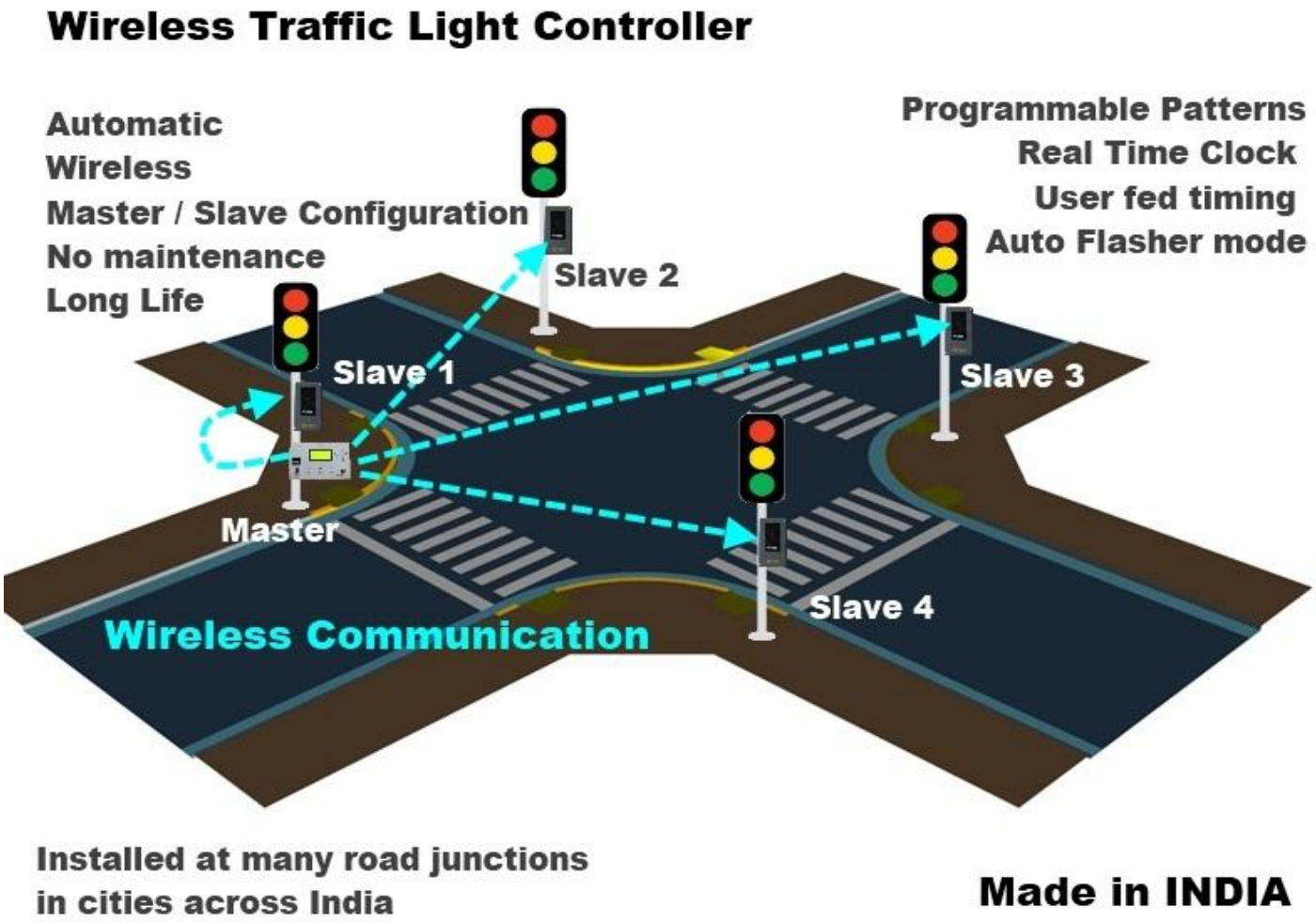
# Area Traffic Control

- ATC systems are intelligent real-time dynamic traffic control systems which are designed to effectively respond to rapid variations in dynamic traffic conditions.
- It is an advanced process to control the traffic.
- digital computer could be used to control many traffic signals from one location, allowing the development of control plans.
- Uses Vehicle Detectors, Intersection Controller, Communication Network, Application Software, Central (Regional) Control System.

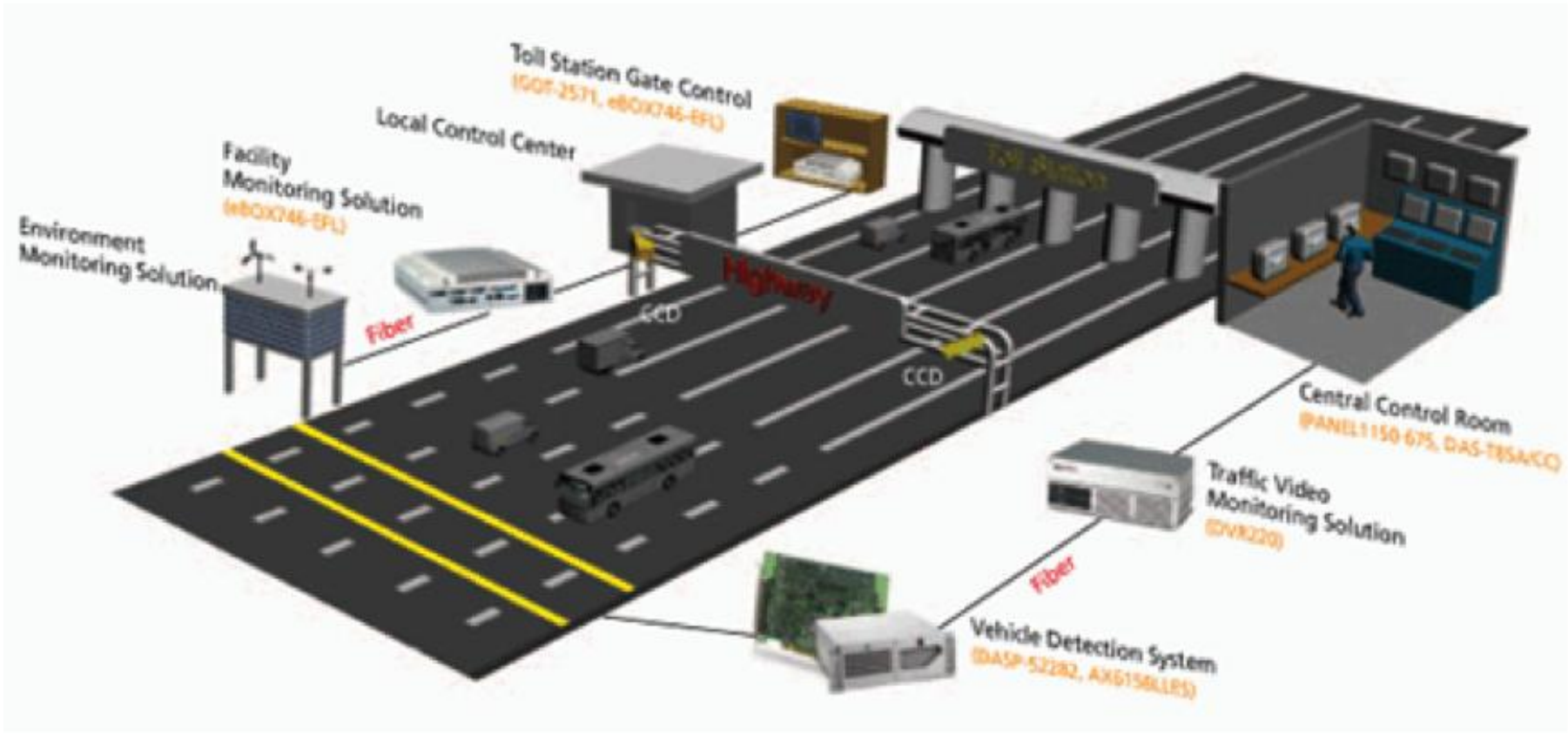
# Wireless Traffic Controller (WI-TRAC)

- The WiTraC system is a vehicle actuated road traffic signal controller that takes the ownership of the signal lamps through wireless signals.
- The WiTraC system is ATCS aka Area Traffic Control System capable of operating independently or as a part of synchronized chain of controllers. Other features of WiTraC include remote monitoring and management of signal plans, GPS / Server based distributed time sync, pole mountable miniature architecture etc.
- There’s a provision for a camera to keep an eye on the traffic conditions and monitors every vehicle. The camera itself can be monitored from a centralized control room.

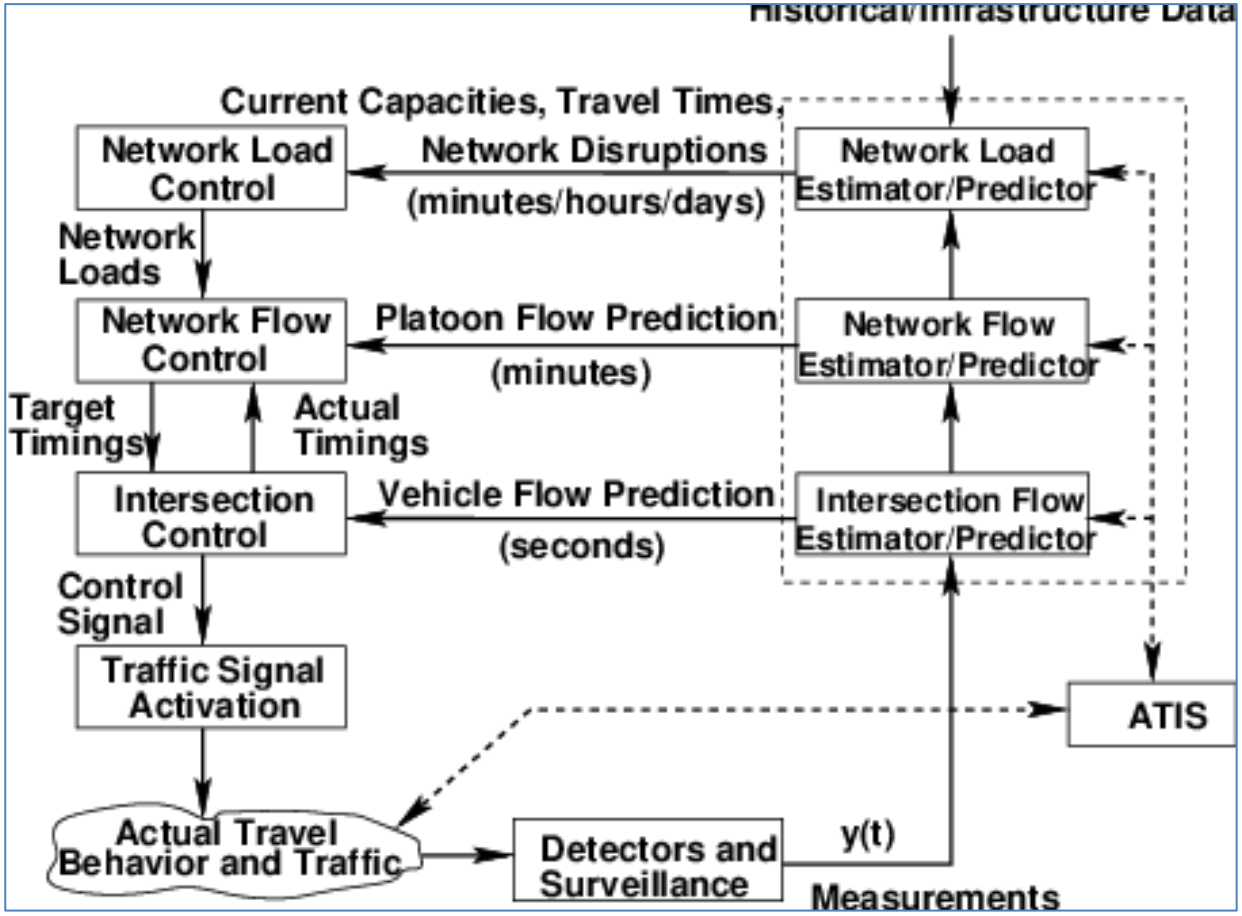
# Wireless Traffic Controller (WI-TRAC)



# Area Traffic Control



# Area Traffic Control



## Advantages

- Minimizing journey time for vehicles
- Reducing accidents
- Increasing average saving in fuel

## Disadvantages

- Very costly
- Very complex
- Suitable only for lane following traffic