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SCHOOL OF BUILDING AND ENVIRONMENT

DEPARTMENT OF CIVIL ENGINEERING

UNIT – I – TRAFFIC CHARACTERISTICS AND FORECASTING SCI1609

INTRODUCTION

It is a phase of Transportation Engineering which deals with planning and geometrical design of roads, streets, and adjoining lands and with traffic operations there on for safe, convenient and economic transportation of persons and goods is known as Traffic Engineering. Present day roads are to serve all types of traffic from pedestrian and animal driven traffic to automobile traffic including military vehicles and are thus liable to traffic congestion. So, to avoid traffic congestion and to provide efficient free and rapid flow of all types of traffic, the studies of traffic characteristics and traffic operations have become essential before planning and designing of any Transportation system. Now these aspects of planning and geometrical design of road and traffic studies have become so important that they constitute a separate branch of civil engineering, known as Traffic Engineering and the person who performs the traffic studies is called traffic engineer.

OBJECTS OF TRAFFIC ENGINEERING:-

- To provide efficient flow of traffic.
- To provide free flow of traffic.
- To provide rapid flow of traffic.
- To provide safety to the traffic.

SCOPE OF TRAFFIC ENGINEERING:-

Traffic Engineering includes the study of the following phases:-

- Traffic characteristics
- Traffic operations
- Traffic planning
- Traffic geometrical design
- Traffic administration.

Road user Characteristics (Traffic Characteristics)

Traffic Engineering is the branch of engineering which deals with the improvement of the traffic performance of road networks and terminals. For achieving that we have to perform systematic traffic studies, analysis and then its engineering application.

First of the most important scientific study is the study of the traffic characteristics. Traffic can be classified into two classes:

- Road Users.
- Vehicular traffic.

ROAD USER CHARACTERISTICS

Human beings performing different roles in the traffic are most important elements of the traffic and so we have to study their characteristics and behavior. Various roles of human are such as driver, pedestrians, cyclists etc. The physical, mental and emotional characteristics of human beings affect their ability to operate motor vehicle safely or to service as a pedestrian. Hence it is important for a traffic engineer to study the characteristics and limitations of the road users.

The various factors which affect road user characteristics may broadly be classified under four heads:

- Physical
- Mental
- Psychological
- Environmental

PHYSICAL CHARACTERISTICS: The permanent physical characteristics of the driver are vision, hearing, strength and the general reaction to the traffic situations.

- **Vision** include the acuity of vision, peripheral vision and eye movement; glare vision, glare recovery and depth judgement. Field of accurate, clear vision is about a 3 degrees cone however the vision is fairly satisfactory up

to 10 degrees in general and 20 degrees in horizontal plane. In vertical plane the vision may be limited to 2/3 of that in horizontal plane.

- **Hearing** is helpful for drivers but of more important for the pedestrians and cyclists.
- **Strength** is not an important factor in general; lack of strength may make parking maneuvers difficult, particularly for heavy vehicles.

MENTAL CHARACTERISTICS: Knowledge, skill, intelligence, experience and literacy can affect the road user characteristics. Knowledge of vehicle characteristics, traffic behavior, driving practice, rules of roads and psychology of road users will be quite useful for safe traffic operations.

PSYCHOLOGICAL FACTORS: This affect reaction to traffic situations of road users to a great extent. Attentiveness, anger, fear, anxiety, phobias, superstition, and impatience may affect the traffic performance to great extent.

ENVIRONMENT FACTORS: The various environmental conditions affecting the behavior of road user are traffic stream characteristics, facilities to the traffic, atmospheric conditions and locality. The traffic stream may consist of mixed traffic or heavy traffic whereas facilities to overtake to the faster vehicles may be limited. The behavior of the driver varies from one traffic stream to another. Similarly the facilities of the traffic separators, multi-lanes etc will affect the performance. Surrounding environment effect the performance of the traffic because one will get slower at the market places and will be faster at the open places.

HUMAN FACTORS AFFECTING TRANSPORTATION

Road users can be defined as drivers, passengers, pedestrians etc. who use the streets and highways. Together, they form the most complex element of the traffic system - the human element - which differentiates Transportation Engineering from all other

engineering fields. It is said to be the most complex factor as the human performances varies from individual to individual. Thus, the transportation engineer should deal with a variety of road user characteristics. For example, a traffic signal timed to permit an average pedestrian to cross the street safely may cause a severe hazard to an elderly person. Thus, the design considerations should safely and efficiently accommodate the elderly persons, the children, the handicapped, the slow and speedy, and the good and bad drivers.

VARIABILITY

The most complex problem while dealing human characteristics is its variability. The human characteristics like ability to react to a situation, vision and hearing, and other physical and psychological factors vary from person to person and depends on age, fatigue, nature of stimuli, presence of drugs/alcohol etc. The influence of all these factors and the corresponding variability cannot be accounted when a facility is designed. So a standardized value is often used as the design value. The 85th percentile value of different characteristics is taken as a standard. It represents a characteristic that 85 per percent of the population can meet or exceed. For example. if we say that the 85th percentile value of walking speed is about 2 m/s, it means that 85 per cent of people has walking speed faster than 2 m/s. The variability is thus fixed by selecting proper 85th percentile values of the characteristics.

CRITICAL CHARACTERISTICS The road user characteristics can be of two main types, some of them are quantifiable like reaction time, visual acuity etc. while some others are less quantifiable like the psychological factors, physical strength, fatigue, and dexterity.

REACTION TIME The road user is subjected to a series of stimuli both expected and unexpected. The time taken to perform an action according to the stimulus involves a series of stages like:

• Perception: Perception is the process of perceiving the sensations received through the sense organs, nerves and brains. It is actually the recognitions that a stimulus on which a reaction is to happen exists.

• Intellection: Intellection involves the identification and understanding of stimuli.

• Emotion: This stage involves the judgment of the appropriate response to be made on the stimuli like to stop, pass, move laterally etc.

• Volition: Volition is the execution of the decision which is the result of a physical actions of the driver. For example., if a driver approaches an intersection where the signal is red, the driver first sees the signal (perception), he recognizes that is a red/STOP signal, he decides to stop and finally applies the brake(volition). This sequence is called the PIEV time or perception-reaction time. But apart from the above time, the vehicle itself traveling at initial speed would require some more time to stop. That is, the vehicle traveling with initial speed u will travel for a distance, d = vt where, t is the above said PIEV time. Again, the vehicle would travel some distance after the brake is applied.

VISUAL ACUITY AND DRIVING

The perception-reaction time depends greatly on the effectiveness of drivers vision in perceiving the objects and traffic control measures. The PIEV time will be decreased if the vision is clear and accurate. Visual acuity relates to the field of clearest vision. The most acute vision is within a cone of 3 to 5 degrees, fairly clear vision within 10 to 12 degrees and the peripheral vision will be within 120 to 180 degrees. This is important when traffic signs and signals are placed, but other factors like dynamic visual acuity, depth perception etc. should also be considered for accurate design. Glare vision and color vision are also equally important. Glare vision is greatly affected by age. Glare recovery time is the time required to recover from the effect of glare after the light source is passed, and will be higher for elderly persons. Color vision is important as it can come into picture in case of sign and signal recognition.

WALKING

Transportation planning and design will not be complete if the discussion is limited to drivers and vehicular passengers. The most prevalent of the road users are the pedestrians. Pedestrian traffic along footpaths, sidewalks, crosswalks, safety zones,

islands, and over and under passes should be considered. On an average, the pedestrian walking speed can be taken between 1.5 m/sec to 2 m/sec. But the influence of physical, mental, and emotional factors need to be considered. Parking spaces and facilities like signals, bus stops, and over and under passes are to be located and designed according to the maximum distance to which a user will be willing to walk. It was seen that in small towns 90 per cent park within 185 m of their destinations while only 66 per cent park so close in large city.

OTHER CHARACTERISTICS

Hearing is required for detecting sounds, but lack of hearing acuity can be compensated by usage of hearing aids. Lot of experiments was carried out to test the drive vigilance which is the ability of a drive to discern environmental signs over a prolonged period. The results showed that the drivers who did not undergo any type of fatiguing conditions performed significantly better than those who were subjected to fatiguing conditions. But the mental fatigue is more dangerous than skill fatigue. The variability of attitude of drivers with respect to age, sex, knowledge and skill in driving etc. are also important. Two of the important constituents of transportation system are drivers and users/passengers. Understanding of certain human characteristics like perception - reaction time and visual acuity and their variability are to be considered by Traffic Engineer. Because of the variability in characteristics, the 85Th percentile values of the human characteristics are fixed as standards for design of traffic facilities.

VEHICLE FACTORS

It is important to know about the vehicle characteristics because we can design road for any vehicle but not for an indefinite one. The road should be such that it should cater to the needs of existing and anticipated vehicles. Some of the vehicle factors that affect transportation is discussed below.

DESIGN VEHICLES

Highway systems accommodate a wide variety of sizes and types of vehicles, from smallest compact passenger cars to the largest double and triple tractor-trailer combinations. According to the different geometric features of highways like the lane width, lane widening on curves, minimum curb and corner radius, clearance heights etc some standard physical dimensions for the vehicles has been recommended. Road authorities are forced to impose limits on vehicular characteristics mainly:

• To provide practical limits for road designers to work to,

• To see that the road space and geometry is available to normal vehicles,

• To implement traffic control effectively and efficiently,

• Take care of other road users also. Taking the above points into consideration, in general, the vehicles can be grouped into motorized two wheeler's, motorized three wheeler's, passenger car, bus, single axle trucks, multi axle trucks, truck trailer combinations, and slow non motorized vehicles.

Vehicle dimensions

The vehicular dimensions which can affect the road and traffic design are mainly: width, height, length, rear overhang, and ground clearance. The width of vehicle affects the width of lanes, shoulders and parking facility. The capacity of the road will also decrease if the width exceeds the design values. The height of the vehicle affects the clearance height of structures like over-bridges, under-bridges and electric and other service lines and also placing of signs and signals. Another important factor is the length of the vehicle which affects the extra width of pavement, minimum turning radius, safe overtaking distance, capacity and the parking facility. The rear overhang control is mainly important when the vehicle takes a right/left turn from a stationary point. The ground clearance of vehicle comes into picture while designing ramps and property access and as bottoming out on a crest can stop a vehicle from moving under its own pulling power.

Weight, axle configuration etc. The weight of the vehicle is a major consideration during the design of pavements both flexible and rigid. The weight of the vehicle is transferred to the pavement through the axles and so the design parameters are fixed on the basis of the number of axles. The power to weight ratio is a measure of the ease with which a vehicle can move. It determines the operating efficiency of vehicles on the road. The ratio is more important for heavy vehicles. The power to weight ratio is the major criteria which determines the length to which a positive gradient can be permitted taking into consideration the case of heavy vehicles.

TURNING RADIUS AND TURNING PATH

The minimum turning radius is dependent on the design and class of the vehicle. The effective width of the vehicle is increased on a turning. This is also important at an intersection, roundabout, terminals, and parking areas.

VISIBILITY The visibility of the driver is influenced by the vehicular dimensions. As far as forward visibility is concerned, the dimension of the vehicle and the slope and curvature of wind screens, windscreen wipers, door pillars, etc should be such that:

• visibility is clear even in bad weather conditions like fog, ice, and rain;

• it should not mask the pedestrians, cyclists or other vehicles;

• during intersection maneuvers. Equally important is the side and rear visibility when maneuvering especially at intersections when the driver adjusts his speed in order to merge or cross a traffic stream. Rear vision efficiency can be achieved by properly positioning the internal or external mirrors.

ACCELERATION CHARACTERISTICS

The acceleration capacity of vehicle is dependent on its mass, the resistance to motion and available power. In general, the acceleration rates are highest at low speeds, decreases as speed increases. Heavier vehicles have lower rates of acceleration than passenger cars. The difference in acceleration rates becomes significant in mixed traffic streams. For example, heavy vehicles like trucks will delay all passengers at an

intersection. Again, the gaps formed can be occupied by other smaller vehicles only if they are given the opportunity to pass. The presence of upgrades makes the problem more severe. Trucks are forced to decelerate on grades because their power is not sufficient to maintain their desired speed. As trucks slow down on grades, long gaps will be formed in the traffic stream which cannot be efficiently filled by normal passing maneuvers.

BRAKING PERFORMANCE

As far as highway safety is concerned, the braking performance and deceleration characteristics of vehicles are of prime importance. The time and distance taken to stop the vehicle is very important as far as the design of various traffic facilities are concerned. The factors on which the braking distance depend are the type of the road and its condition, the type and condition of tire and type of the braking system. The distance to decelerate from one speed to another is given by:

$d = (v\ 2 - u\ 2) / (f + g)$

where d is the braking distance, v and u are the initial and final speed of the vehicle, f is the coefficient of forward rolling and skidding friction and g is the grade in decimals. The main characteristics of a traffic system influenced by braking and deceleration performance are:

• Safe stopping sight distance: The minimum stopping sight distance includes both the reaction time and the distance covered in stopping. Thus, the driver should see the obstruction in time to react to the situation and stop the vehicle.

• Clearance and change interval: The Clearance and change intervals are again related to safe stopping distance. All vehicles at a distance further away than one stopping sight distance from the signal when the Yellow is flashed is assumed to be able to stop safely. Such a vehicle which is at a distance equal or greater than the stopping sight distance will have to travel a distance equal to the stopping sight distance plus the width of the street, plus the length of the vehicle. Thus the yellow and all red times should be calculated to accommodate the safe clearance of those vehicles.

• Sign placement: The placement of signs again depends upon the stopping sight distance and reaction time of drivers. The driver should see the sign board from a distance at least equal to or greater than the stopping sight distance. From the examples discussed above, it is clear that the braking and reaction distance computations are very important as far as a transportation system is concerned. Stopping sight distance is a product of the characteristics of the driver, the vehicle and the roadway. and so this can vary with drivers and vehicles. Here the concept of design vehicles gains importance as they assist in general design of traffic facilities thereby enhancing the safety and performance of roadways. 4.6 Road factors

ROAD SURFACE

The type of pavement is determined by the volume and composition of traffic, the availability of materials, and available funds. Some of the factors relating to road surface like road roughness, tire wear, tractive resistance, noise, light reflection, electrostatic properties etc. should be given special attention in the design, construction and maintenance of highways for their safe and economical operation. Unfortunately, it is impossible to build road surface which will provide the best possible performance for all these conditions. For heavy traffic volumes, a smooth riding surface with good all-weather anti skid properties is desirable. The surface should be chosen to retain these qualities so that maintenance cost and interference to traffic operations are kept to a minimum.

LIGHTING

Illumination is used to illuminate the physical features of the road way and to aid in the driving task. A luminary is a complete lighting device that distributes light into patterns much as a garden hose nozzle distributes water. Proper distribution of the light flux from luminaries is one of the essential factors in efficient roadway lighting. It is important that roadway lighting be planned on the basis of much traffic information such as night vehicular traffic, pedestrian volumes and accident experience.

ROUGHNESS

This is one of the main factors that an engineer should give importance during the design, construction, and maintenance of a highway system. Drivers tend to seek smoother surface when given a choice. On four-lane highways where the texture of the surface of the inner-lane is rougher than that of the outside lane, passing vehicles tend to return to the outside lane after execution of the passing maneuver. Shoulders or even speed change lanes may be deliberately roughened as a means of delineation.

Pavement colors When the pavements are light colored(for example, cement concrete pavements) there is better visibility during day time whereas during night dark colored pavements like bituminous pavements provide more visibility. Contrasting pavements may be used to indicate preferential use of traffic lanes. A driver tends to follow the same pavement color having driven some distance on a light or dark surface; he expects to remain on a surface of that same color until he arrives a major junction point.

NIGHT VISIBILITY

Since most accidents occur at night because of reduced visibility, the traffic designer must strive to improve nighttime visibility in every way he can. An important factor is the amount of light which is reflected by the road surface to the drivers' eyes. Glare caused by the reflection of oncoming vehicles is negligible on a dry pavement but is an important factor when the pavement is wet. 4.6.6 Geometric aspects. The roadway elements such as pavement slope, gradient, right of way etc affect transportation in various ways. Central portion of the pavement is slightly raised and is sloped to either sides so as to prevent the ponding of water on the road surface. This will deteriorate the riding quality since the pavement will be subjected to many failures like potholes etc. Minimum lane width should be provided to reduce the chances of accidents. Also the speed of the vehicles will be reduced and time consumed to reach the destination will also be more. Right of way width should be properly provided. If the right of way width becomes less, future expansion will become difficult and the development of that area will be adversely affected. One important other road element is the gradient. It reduces the tractive effort of large vehicles. Again the fuel consumption of the

vehicles climbing a gradient is more. The other road elements that cannot be avoided are curves. Near curves, chances of accidents are more. Speed of the vehicles is also affected.

SKID RESISTANCE

Has two components, commonly identified as adhesion and hysteresis. The adhesive part is the 'bonding' of the tyre as the vehicle brakes and the tyre is forced against the surface of the stone under significant pressure. The second component 'hysteresis' is a result of the deformation of the tyre between the stones and the resistance within the tyre to this deformation. These forces will cause heating which softens the tyre and does have an effect on the friction resistance.

SURFACE TEXTURE

The two components of skid resistance are related to the two types of texture. Both texture components will have an influence on skid resistance and the degree of influence will change depending upon the speed of the vehicle and the pavement surface characteristics.

MACRO-TEXTURE

Macro-texture is the visual texture, large irregularities, observed when examining the broad stone-binder matrix. It is the characteristic deviation of a pavement surface from the true planar surface within the wavelength of 0.5 and 50mm. This type of texture provides escape paths for water under a tyre and controls how rapidly skid resistance drops off with increase in speed due to lack of water egress. This texture of the road surface is associated with the hysteresis component of skid resistance.

Initially macro-texture was measured by manual means using the 'Sand Patch' method involving the use of a known volume of sand, spread evenly over the road surface and then measuring the size of the patch, finally giving a texture measure, TP346. Texture is now determined using automated laser based systems TP351 & TP352 enabling faster (more) and continuous data collection. This texture characteristic has a greater influence at higher speeds.

MICRO-TEXTURE

Micro-texture is the fine texture felt by running a finger over a stone surface and is not readily observable. It is defined as the characteristic deviation of a pavement surface from the true planar surface below 0.5mm, the finer irregularities of the surface of the stone (generally a result of quarry crushing). This texture will affect adhesion. It is also a function of the stones potential to polish. This characteristic has a greater influence at low speeds

TESTING OF SKID

Skid resistance can be determined by a number of pieces of equipment, all are measuring the frictional resistance of a rubber material (vehicle tyre) over the road surface. One of the long standing devices is the manually operated British Pendulum which has a small rubber foot (75x25 mm) attached to a pendulum that swings over the road surface (TP345). The frictional resistance is measured against a scale attached to the equipment.

Other more recent and automated devices use tyres that rotate at rates less than that of the tyres of the vehicle they are attached to, resulting in a braking/sliding action. The braking rate may be fixed or variable and the tyre may be straight or set at an angle. Recording of test results is now automated allowing for greater quantities of data to be collected and more easily analysed. Testing can be done using smooth or treaded tyres, but for better and more consistent results the smooth tyre is preferred. Automated testing within the Safety and Services Division utilises a Griptester (TP344). Suitable correlations have been made between the equipment used by DPTI.

Examples of automated devices are the Griptester, SCRIM (Sideways-force Coefficient Routine Investigation Machine), Norsemeter ROAR and the American ASTM E-274 braked wheel trailer.

Measurements of both characteristics are undertaken by Field Testing staff of the Pavements Engineering Unit, using automated laser based equipment for texture Laser Profilometer and WDM TM2 Texture Meter. Skid resistance testing is determined using a Griptester (general) or a British Pendulum (research & special projects).

RECOMMENDED INVESTIGATORY LEVELS

A number of recommended investigatory levels relative to the various tests and devices used by the Safety and Services Division have been determined for the use of road engineers when evaluating pavement condition. (see included tables) Such investigatory levels are comparable with other road authorities and have been in use for many years.

It is recommended that skid resistance maintenance strategies be based on the investigatory levels for skid resistance (micro-texture) and macro-texture. An understanding of the measuring device outputs with respect to intuitive investigatory levels will need to be a prerequisite to such exercises.

TABLE 1 RECOMMENDED SKID RESISTANCE INVESTIGATORY LEVELS (Grip tester)

Road Situation	**Minimum Grip No.**	**Maximum Vehicle Speed km/h**
Difficult sites - steep grades, traffic light approaches, tight bends, roundabouts.	0.50-0.55	60-80
Urban Arterial Roads	0.45	60
Rural Arterial Roads	0.45	60
Urban/Lightly Trafficked	0.40	60
Urban Arterial Expressway	0.45	90-100

Note:- The approximate conversion between the British Pendulum No. and the Grip No. is

Grip No. = 0.01x BP

TABLE 2 TYPICAL INDICATIVE INVESTIGATORY LEVELS FOR SURFACE TEXTURE

Road function	**Texture depth (mm)**
Freeways and other high-class facilities with free-flowing traffic conditions	0.4
Highways (greater than 80km/h) Other major main roads to stopping and turning (less than 80km/h)	0.6
Other local roads (sealed)	0.4

SKID RESISTANCE TEST Procedure (TRRL 1969)

- Select the spot in which the texture depth has been measured.
- Set the apparatus (Figure 2) on the road so that the slider will swing in the direction of traffic flow and level the base screws.
- Raise the swinging arm clear of the road and clamp in the horizontal position. Release the arm and check that the pointer reads zero.
- With the pendulum arm free and hanging vertically, place the spacer, attached to a chain on the base of the column, under the lifting handle setting screw to raise the slider. Lower the head of the tester so that the slider just touches the road surface and clamp in position. Remove the spacer.

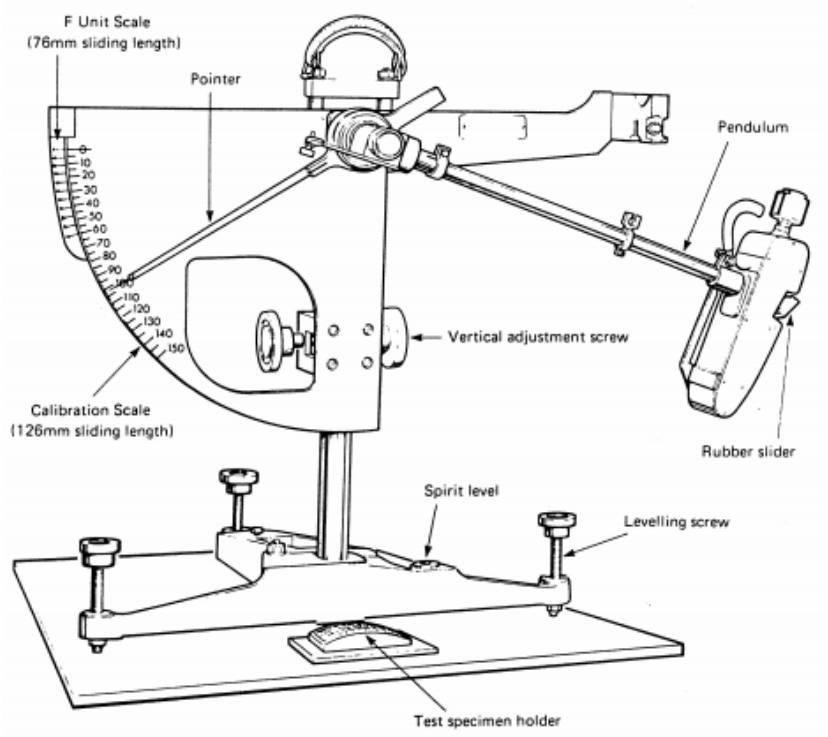

FIG.1 PENDULUM SKID RESISTANCE TESTER (BSI, 1990)

- Check the sliding length of the rubber slider over the road surface by gently lowering the pendulum arm until the slider just touches the surface first on one side of the vertical and then on the other. When passing the arm through the vertical, use the lifting handle so that the slider does not touch the road. The sliding length should be between 125 and 127 mm. If not, adjust by raising or lowering the head.
- Place the pendulum arm in the horizontal and clamp in position.
- Wet the road surface and slider with water.
- Bring the pointer to its stop then release the pendulum by pressing the button. Take care to catch the arm on its return swing before it hits the ground.
- Return the arm and pointer to the release position keeping the slider off the road surface by means of the lifting handle. Repeat the test, wetting the surface between swings. Record the mean of five successive readings, provided they do

not differ by more than three units. If the range is greater than this, repeat swings until three successive readings are constant; record this value.

- Record the temperature of the water on the road surface.

Results

The skid resistance value (SRV) is the mean of five readings or the constant of three readings as stated above. As the stiffness of the rubber slider will vary with temperature a correction has to be made if the temperature is not 20oC. Use the temperature curve (Figure 3) for this purpose.

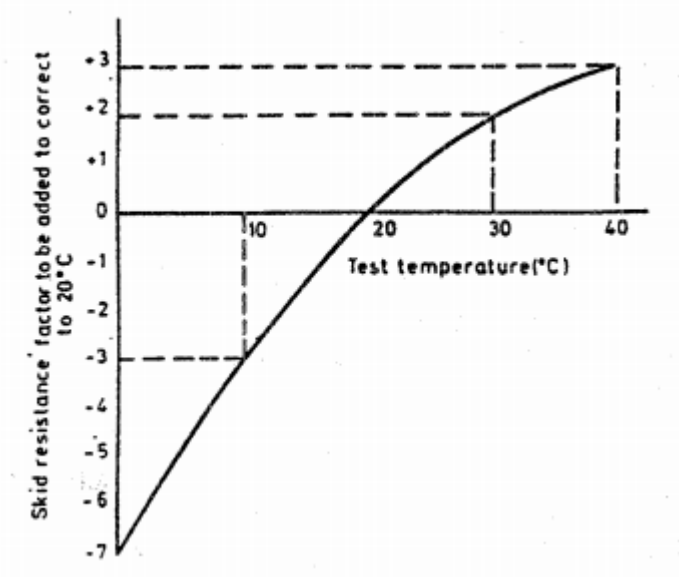

FIG. 2 SKID RESISTANCE/ TEMPERATURE CORRECTION RELATIONSHIP (TRRL, 1969)

Discussion – Texture depth and SRV

- Describe the site and the nature of the road surface, i.e. material state of wear, etc.
- Describe the average texture depth and texture classification.
- Report the temperature-corrected skid resistance value (SRV) and comment on suitability of this value for the current use of the road (see Table 1). Compare results obtained by other group(s).

TABLE 3. SUGGESTED MINIMUM VALUES OF 'SKID RESISTANCE' (MEASURED WITH THE PORTABLE TESTER) (TRRL, 1969)

Category	Type of site	Minimum skid resistance (surface wet)
A	Difficult sites such as: 1. Roundabouts 2. Bends with radius less than 150 m on unrestricted roads 3. Gradients 1 in 20 or steeper of lengths greater than 100 m 4. Approaches to traffic lights on unrestricted roads	65
B	Motorways, trunk and class 1 roads and heavily trafficked roads in urban areas (carrying more than 2000 vehicles per day)	55

POLISHED STONE VALUE

Procedure (BSI 1990)

- As the preparation of specimens and the polishing process (using accelerated polishing machine, as shown in Figure 4) takes many hours, this will have been done, in accordance with BS 812, in advance of the laboratory session.
- The specimen is clamped into the holder in such a way that the slider of the pendulum traverses it in the same direction as it has been trafficked in the polishing machine. The height of the suspension axis of the pendulum is then adjusted, as described for the road test, so that the slider traverses a length of 76 ± 0.5 mm.
- The specimen and the slider are then thoroughly wetted and five readings (F scale unit x 100) are taken as described for the road test. The specimen and

slider are thoroughly wetted before each reading. The mean of the last three readings is then recorded.

- The mean value as determined is reported as the PSV.

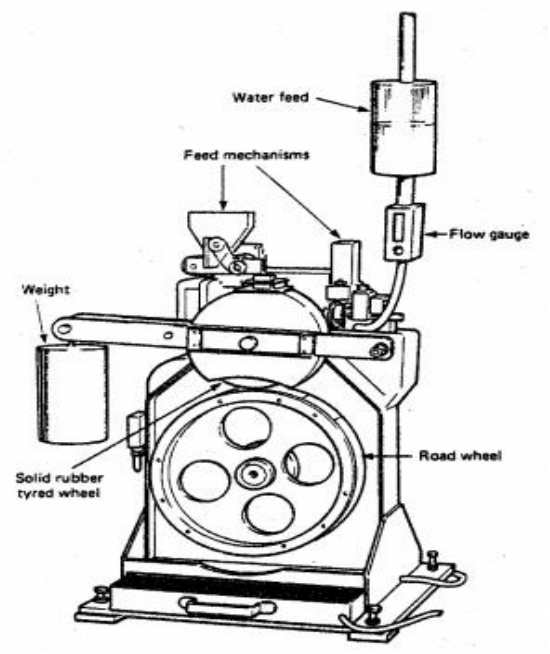

FIG.3 ACCELERATED POLISHING MACHINE (BSI, 1990)

BRAKING EFFICIENCY

The function of the vehicle brakes is to control the speed of the vehicle on hills, to reduce the speed when required and to stop the vehicle altogether and hold it stationary. How well a set of brakes fulfills this function depends on many factors; one of which - road surface condition- is in no way under the control of the driver; other factors such as tyre condition and gross vehicle weight, are not directly related to the design and condition of the brakes although they are the responsibility of the driver. The ability of the brakes to perform their function is popularly known as braking efficiency and in most countries, legally enforceable regulations require that all road vehicles have an efficient braking system. In assessing braking efficiency, it is usual to consider the effect which the brakes achieve when they are applied.

The action of applying the brakes sets up a force effective at the road surface, which acts in the opposite direction to the motion of the vehicle and causes it to slow down

or decelerate. This deceleration is normally compared to a standard value (the acceleration due to gravity g) and reported as a percentage of "g". Defining braking efficiency in such a way directly comparable standards of braking can be established of differing classes of vehicle. Dependent on whether metric or imperial units are used, "g" may be 9.81m/sec/sec or 32 ft/sec/sec in absolute terms. Vehicle construction legislation normally requires various classes of vehicle to have a braking system capable of producing a specific minimum deceleration. In modern vehicles, the braking system is designed so that, provided the vehicle is correctly maintained and the driver applies sufficient pedal pressure, the minimum braking efficiency will be achieved irrespective of whether the vehicle is loaded or not. Only in cases where the brakes are poorly maintained or where the vehicle is loaded significantly above the maximum gross design weight, will the weight of the vehicle affect the braking efficiency and the brakes be unable to achieve the minimum required efficiency. Within the above limits, considerations of the weight of the vehicle can be ignored, since for a particular minimum efficiency required by the regulations, the ratio “Braking force achieved to gross vehicle weight" will be constant.

INTERDEPENDENCE OF THE LAND USE AND TRAFFIC

In 1954, statement was made that urban traffic was a fiction of land-use. It paved the way for a new line of the thinking in urban transportation and land use planning.

Mitchell and Rapkin observed that various kinds of activities based on the land called land use- “generation” different amounts and kinds of traffic. Measures such as 1.regulation and control of traffic and 2. provisional improvement of physical channels of movement were effective in dealing with urban traffic, the most basic level of action for a long run solution of the traffic problem is the planning, guidance and control in the pattern of land use.

Buchanan has also emphasized the inter-relationship between traffic and buildings in a town. He states that in towns, traffic takes place because of buildings and all

movements in a town have an origin and destination in a building. The pattern traced by traffic is closely related to the manner in which buildings are arranged.Commuter flows are closely dependent upon the location and size of the work,places and of the home areas. School traffic is governed by the location of the school and the home areas.

Land use is a function of transport. New systems of transport are built, the land use pattern that follows has a close relation to the accessibility that has been made possible.

Interdependence is the keynote of modern transport planning. The early Detroit Area Transportation Study demonstrated the empirical validity of the proposition the transport was a function of land use.

LAND-USE TRANSPORT MODELS

Land use determines transport demand. System of transport planning known as the Urban Transport Planning Package(UTPP). The basic requirements in this is the land-use activities for the year being is studied. A criticism of this technique is travel demands estimated by it tends to be high in the principal travel corridors, with the results highly costly rapid transit systems become necessary. Another weakness of the UTPP is that it requires completely specified land-use allocation both at the production and at the attraction end of trips.

Selection of Land-use Transport Model

Variety of land use transport models have been develop in past 15 years. “Research model” having sensitive forecasting, while some are “operational models”. Former group of models require extensive data collected through special surveys, whereas the latter need data which are collected routinely by planning departments. The Lowry derivative models fall into the latter group and are very popular.

Consideration required for selecting a model

- Simplicity
- Modest Data Collection
- Adaptability
- Comprehensiveness
- Operationally and rapidity
- Computer cost.

Lowry Derivative Model

It is simple to use comprehensively and economically.

Features of the Lowry Model:

Lowry presented his model in 1964 for the spatial organisation of human activities in a metropolitan area.

Lowry model relates the three principal components of the urban area which are:

- Population
- Employment
- Communication between population and employment.

Activities identified in urban forms:

- Employment in basic industries
- Employment in service industries
- Household or population sector.

SKIDDING:

Road accidents are very commonly caused by pavement slipperiness which results in skidding of the vehicle. Accident statistics show that in U.K. 27% of the accidents involving vehicles was attributable to skidding. In India, not much attention seems to have been paid so far to this subject, though skidding can occur in our road in the rainy season.

The phenomenon of skidding:

When the driver moving at a speed applies the vehicle brake suddenly, the prime factor that governs the stability of the vehicle is the friction that develops at the tyre pavement interface. If the friction that can be mobilised is the greater than the deceleration force, the vehicle comes to a safe halt within certain distance. If the pavement is wet and slippery and the tyre bald, the friction that developed is much smaller decelerating force and the vehicle cannot be controlled by the driver. The wheel of the vehicle get locked due to the sudden braking and skidding results if the frictional resistance is too low.

U.S.A, the skid resistance is denoted by the skid number (SN) which is 100 times the friction factor. In U.K, the skid resistance is the coefficient of friction itself. If '//' is coefficient of friction developed at the time of skidding and '//' is the acceleration (or) deceleration of the vehicle, the following simple relation can be proved.

FACTORS DETERMINING SKID RESISTANCE:

Pavement:

Types of pavements like open textured permit carpet have a better skid resistance property than mastic asphalt. The micro-texture aids in puncturing the thin film of water on the surface and mobilising the adhesion component of friction.

Aggregates which polish under traffic into a smooth shape are not desirable when resistance to skidding is being sought. Ministry of Transport (U.K) specify the following minimum Polishing Stone Value (PSV) when measured by the portable tester:

	Description of site	Recommended minimum value of PSV
1.	Difficult sites	62
2.	Average	59

Effect of water on the surface:

The greatest danger of skidding is where the pavement is wet and the frictional resistance drops down. The tyre surface contact strip is divided into three zones. Zone 1 represents the zone of bulk displacement of water. Zone 2 represents the zone where the water film is much thinner and where the water carriers a portion of the load of the tyre. In zone 3, the water has been squeezed out and the tyre is in contact with the surface. As the speed of the vehicle increases, not enough time is available for the water to be squeezed out and the boundaries of zones move backwards. When the speed is very high a stage is reached when zone 2 and 3 completely vanish and only zone 1 is present. Remedy is to drain off the water from the road surface as soon as possible. Adequate camber on the road and a rough surface texture to be provided.

Speed:

As speed increases, the skid resistance drops.

Tyre characteristics

Land-use Transport Interaction Model

A System Approach

Major cities are struggling with high order of traffic, traffic congestion beyond tolerable level due to rapid urbanization. Ineffectiveness of the conventional transport planning approach is due to lack of proper appreciation of land use transport interaction. It is important to plan transport system in a co-ordinated manner in the urban transport planning process.

System Dynamics can be used. It is a feed back, object oriented and simulation approach, which handle complexity. It is an analytic tool which address the complex and dynamic character of interaction of various system. Population to be controlled to decongest traffic. Rapid growth of urban population over last 50 years . Double population over 2 decades.

1000 population rise generates 350 additional trips daily.
Each Rs.60/rise/head/day leads 100 additional trips.
Average trip length/head/day : 7.6km.
Number of vehicles in CMA 1.5L 1984, 6L 1992 growth 40%/year .
Number of T/W 87000, 1984 and 4.35L in 1992.
T/W is of 70% of total vehicle.
75 L trip per day generated CMT, work trip 22%, education trip 19%, V/C of many area 1.5
Traffic is joint consequence of land use activity levels and transport capability (1984).
TRAfFic problem in india

Is Chennai's traffic going from bad to worse?
Chennai has the highest vehicle density in India, as per a 2015 study.

Two-wheelers inch their way to every space available, climbing over footpaths as they brush past rear-view mirrors; drivers peek their heads out of the window, hurling the choicest abuse at the vehicle in front; horns blare from all sides, providing a surround

sound experience of cacophony to a helpless road user; a traffic policeman stands in the midst of the vehicle pile-up at his wits end, attempting to bring order to anarchy.

For any resident in Chennai, who ventures out during peak-hour traffic, this is an everyday nightmare that they are forced to put up with. Aakash Jacob, a 30-year-old operations manager at an IT firm spends 40 to 45 minutes every weekday morning navigating traffic to get to his office on Old Mahabalipuram Road. But this he says, is good time, as he's lucky not to have to go into work during morning peak hour. "Monday is the worst between 9am and 10:30am down OMR. Everyday 10.30am onwards it's slightly better and it takes me 40-45 minutes to cover 10kms," he says.

FIG.4 TRAFFIC CONDITION IN CHENNAI

Aakash points out that the evening rush hour is "even worse" with traffic stalled on Chennai's IT corridor between 5:45pm and 8pmevery day. And as far as weekend traffic goes, this long-time Chennai resident observes, "Saturday mornings are relatively free right up till about 3pm or 4pm. After that don't even think about

venturing out till 8pm on Saturdays." Fed up of sitting behind the wheel for over a 1.5hours on a Saturday evening, Aakash now takes a taxi back home from office unable to deal with the nightmarish traffic.

In T Nagar, considered the heart of Chennai, Vijay Anand, who also works in IT, blames poor road sense among drivers for the traffic woes. "The Road Transport Office should teach some road sense when giving licenses to people. Yesterday, I was stuck in a one-hour traffic jam on New Avadi Road because someone was driving on the wrong side of the road," he narrates.

While Vijay considers himself fortunate to skip morning peak hour traffic, spending only over 30 minutes driving an 8km stretch from Anna Nagar to T Nagar every day, he concedes that the city's traffic has become worse over the years. So, just why has Chennai's traffic gone from bad to worse?

While a number of residents blame the metro rail construction for the traffic on the streets, data presents a clearer picture. With a vehicle population of 3.7 million units, Chennai has the second highest number of vehicles on its roads, after capital New Delhi. But the reason the southern city's traffic jams feel never ending is because Chennai, as per a 2015 study, has the highest vehicle density in India with 2093 vehicles per kilometre of road. What's more alarming for motorists in Chennai is that, as per NCRB's 2014 data, the city has the deadliest roads in the country after New Delhi.

But it's not only the sheer number of vehicles on Chennai's roads. Urban planning expert and retired IAS officer MG Devasahayam points to four factors as to why the city's roads are bursting at the seams. "In an old city like Chennai, you can't widen roads. It must be optimized," he says. Devasahayam points out that no steps have been taken to regulate parking and that pro-rata space needs to be provided for pedestrians and cyclists, to ensure mobility.

Adding to Chennai's traffic woes is its management. Little has been done on the part of officials to manage traffic bottlenecks. Devasahayam says traffic policing should be professional and competent to deal with the peak hour rush. The urban planning expert also observes that the city's poor integrated transport system is another factor leading to an increase in vehicular traffic. He says, "Despite Chennai having a four-direction train system, there is no connectivity either with the sub-urban train, the MRTS or the metro." He also hits out at successive state governments for not implementing the Second Master Plan 2026, despite the issue of integrated transport being highlighted.

"What Chennai needs is soft solutions, not hard solutions," opines Devasahayam, who argues that the city does not need the metro or more flyovers. He concludes that more infrastructure is not always the solution but utilising what's already there is key for putting an end to Chennai's nightmarish traffic.

Chennai: 1985 and Today

Chennai, the birthplace of the Indian railway system, was also home to the nation's first electric trams, in 1895. Unfortunately, politicians chose to end the service in the early 1950s, with the idea of building "modern" roads and bridges for cars. By 1985, Chennai, then known as Madras, had seen its car and motorcycle populations accelerate to more than 200,000. It would rise to 600,000 by 1992, 3.6 million in 2012, and is nearly six million today. Combined with an emphasis on building roads and elevated highways, the city quickly began to see air quality worsen, and travel times grow, as the city lacks sufficient public transport options.

CHENNAI BEFORE

The capital of the state of Tamil Nadu, Chennai is a city of ten million, located on the Bay of Bengal in South India. Chennai is a tech hub, and home to Tamil Cinema Studios, as well much of India's automotive industry. Chennai is also a city at the forefront of climate change, with increased floods that cost lives and city damage. Fortunately, Chennai is beginning to move in the right direction, with an emphasis on

improved transport management, and a budget commitment to redesign streets to prioritize cycling and walking.

In 2015, Chennai began a redesign of kilometers of pedestrian paths and today has completed 100 kilometers, and began Car free Sundays. In the same year, Chennai opened a metro line, which now has grown to a daily ridership around 120,000. In 2019, Chennai opened a pedestrian plaza on a busy shopping street and has launched a bike share system with facilities close to other transit stations. These actions are important steps in creating a safer, more welcoming pedestrian and cycling environment, but are still not enough to transform the city away from cars. The vast majority of Chennaties travel by walking, two wheeled vehicles, or buses. The question is if Chennai can continue to create space on its streets for these users, rather than creating more and more space for cars.

CHENNAI TODAY

FIG.5 PEDESTRIAN VOLUME IN CHENNAI

FIG.6 FLOW VOLUME IN CHENNAI

Chennai in Numbers

To measure and study cities' growth objectively, metrics were employed looking at population, density, transit. Kilometers of rapid transit is defined as rapid transit that meets the definition of BRT basics in the BRT Standard, in Chennai kilometers of rapid transit grew from 54.1 in 1985 to 101.8 in 2018. While the kilometers doubled, so too did the population and built up area, meaning that service remained relatively the same. To study how a population is served by rapid transit, the Rapid Transit to Resident Ratio (RTR)compares the population with the length of rapid transit lines – this number shows how well a population is served by rapid transit. Unfortunately for Chennai residents, RTR has remained relatively unchanged in the past 35 years

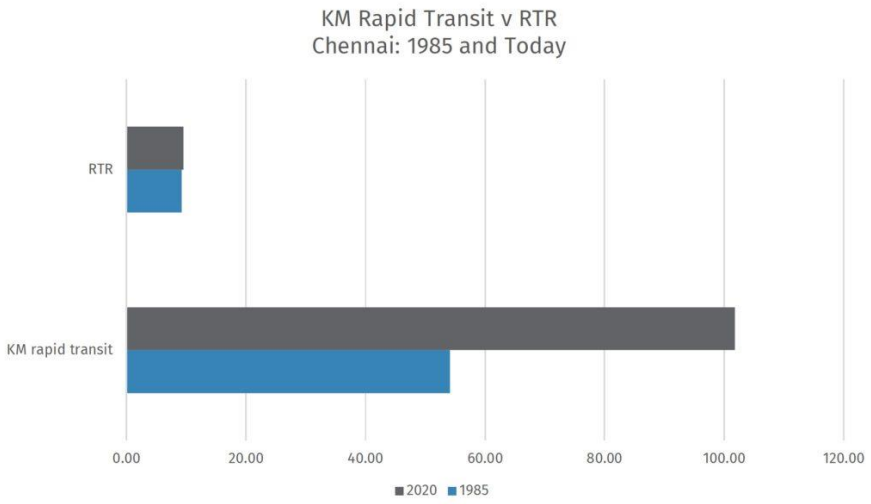

FIG.7 GROWTH OF VOLUME IN CHENNAI

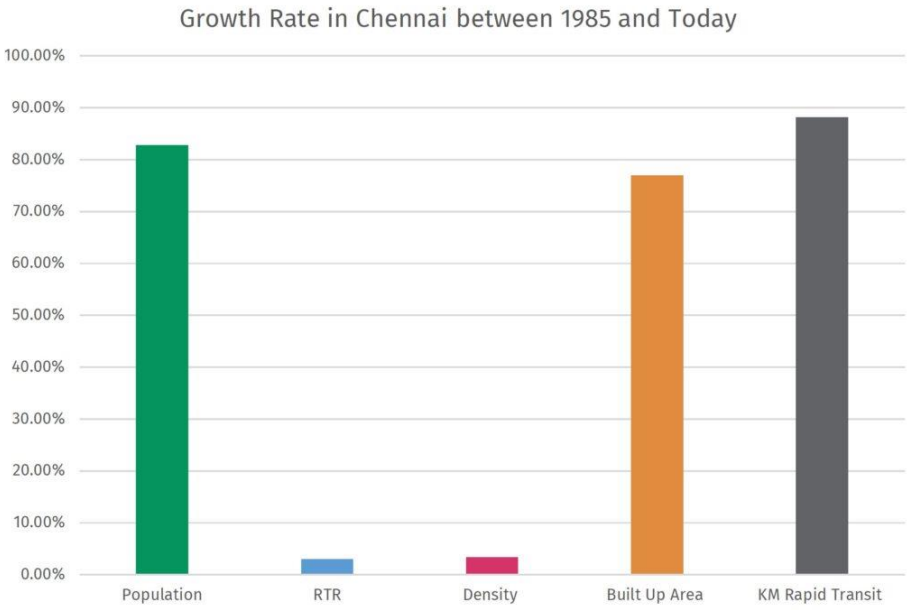

FIG.8 GROWTH RATE OF VOLUME IN CHENNAI

THE SLOWEST ROADS IN URBAN AREAS OF INDIA

Among the country's six metros, Kolkata and Mumbai have the slowest arterial roads, while Hyderabad and Chennai have the fastest ones

New Delhi: An unintended consequence of economic growth in cities is traffic congestion. Everyday, millions of vehicles across Indian cities are stuck in gridlock, but some cities seem to be more affected than others.

A Mint analysis of about 300 arterial roads across the country's six largest metropolitan regions (New Delhi, Mumbai, Kolkata, Chennai, Hyderabad and Bengaluru) shows that on an average, the slowest arterial roads are in Kolkata and Mumbai, while Hyderabad and Chennai have roads with the highest average speeds.

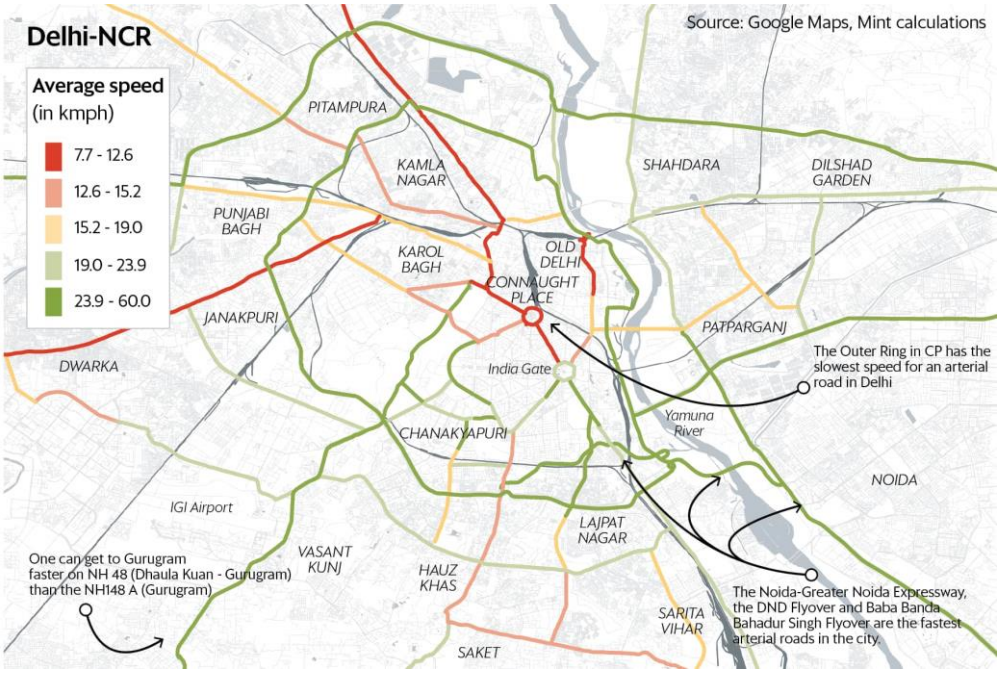

FIG.9 ROAD NETWORK IN DELHI

A 10km commute in Hyderabad takes 26 minutes on average. In Chennai and Delhi, it takes 29 minutes while the same distance takes 34 minutes in Bengaluru, 37 in Mumbai and 39 minutes in Kolkata. The average 10km urban commute takes 24 minutes, according to a World Bank study that calculated commute times across 154 Indian cities. In Singapore and London, the 10km commute takes an average of 21 minutes, show official documents.

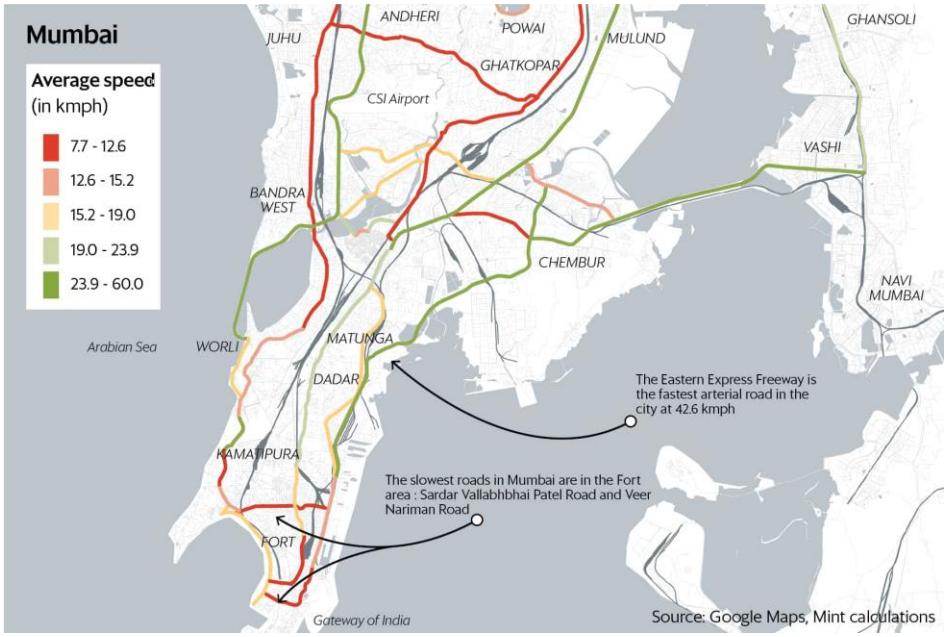

FIG.10 ROAD NETWORK IN MUMBAI

In India, official data on traffic and road speeds is often unavailable, and outdated when it is available. For this analysis, we identified arterial roads by referring to the Comprehensive Mobility Plan reports for these cities prepared by the respective municipal corporations and state governments. Using Google Maps data, we collected data on how long it would take to traverse these roads from end to end at hourly intervals from 4 August to 11 August this year. This weekly period represents a typical non-rainy week, and the average speeds in this week matched the “typical speed" ranges provided by Google Maps.

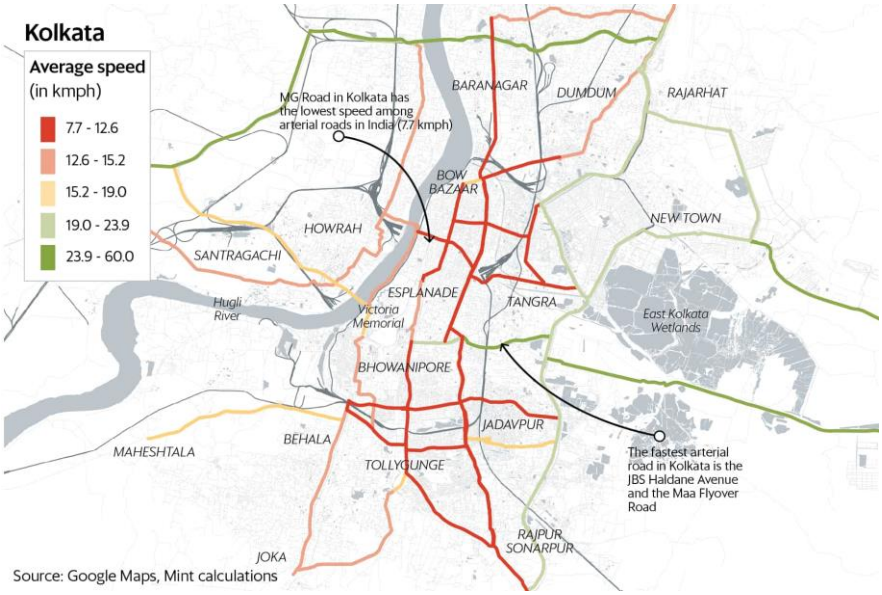

FIG.11 ROAD NETWORK IN KOLKATTA

The analysis suggests that morning commutes (8am -11am) are slightly faster than evening commutes (5pm-8pm). A 10km commute would take six minutes longer in the evenings on average, across all these cities.

Mahatma Gandhi Road in Kolkata (7.7km per hour) has the dubious distinction of being the slowest road considered in this analysis, followed by Sardar Vallabhbhai Patel Road in Mumbai (8.1 kmph) and the Kanakapura Road stretch from JP Nagar to Outer Ring Road (8.4 kmph) in Bengaluru.

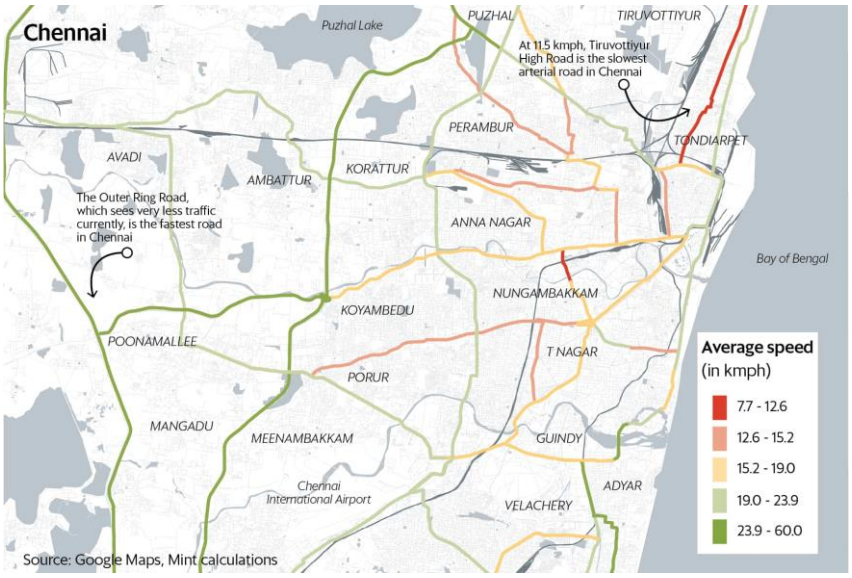

FIG.12 ROAD NETWORK IN CHENNAI

Kolkata has 11 of the slowest 20 roads across these cities, followed by six in Mumbai and three in Bengaluru.

Most of these roads are in the colonial-era neighbourhoods of these cities and are constrained by the fact that widening them is expensive. In Mumbai, the geography of the city itself is a constraint. A city with a narrow strip of densely populated land jutting out into the sea makes it more difficult to ease traffic pains.

The fastest arterial metro road in India is the Outer Ring Road in Hyderabad, where the average speed is 60 kmph. The much-maligned Noida-Greater Noida Expressway is a distant second at 52.7 kmph, followed by the Chennai Outer Ring Road at 48.5 kmph.

Eight out of the top 10 fastest arterial roads are access controlled (toll roads), which helps limit congestion and improve speeds. While this seems to work, it is not a sustainable solution. Expressways—even access controlled—can eventually fill up, as the demand for private vehicles rise when more and wider roads are built, suggests urban transportation research.

The most effective way to improve road speeds and reduce congestion is congestion pricing on key roads during rush hours, suggests research. Another solution is to build segregated bus lanes and encourage people to shift to public transportation modes. These solutions are yet to find support in India.

Advantages and Limitations of Forecasting

We know that planning is an important process in the management of any enterprise. It is the cornerstone of effective management. Forecasting is actually an integral part of the planning process. They both go hand in hand. Let us learn the meaning and advantages and limitations of forecasting

What is Forecasting?

Forecasting is essentially a process of analyzing the past and present business movements and trends to obtain some idea or clues regarding future trends and business movements. Forecasting is looking into the future so that we can accordingly plan for it.

However, forecasting is not a haywire process. It is a systematic approach with well thought-out, scientific methods and procedures. It involves a thorough and proper analysis of data and facts with the help of both quantitative and qualitative techniques

Advantages of Forecasting

- Assists in Planning

One of the biggest advantages of forecasting is that it enables the manager to plan for the future of the organization. Planning and forecasting actually go hand in hand. Without an idea of what the future hols for the company, we cannot plan for it. Thus, forecasting plays a very important role in planning.

- Environmental Changes

When done correctly, forecasts should be able to point out the upcoming changes in the environment. This means that it can allow the company to benefit from such environmental changes. When the changes are favorable to the company it can expand and grow its business. And in conditions that are adverse, it can plan and prepare to protect itself.

- Identifying Weak Spots

Another advantage of forecasting is that it will help the manager identify any weak spots, or ignored areas that the organization may have. Once attention has been drawn to these areas, the manager can put into effect effective controls and planning techniques to rectify them.

- Improves Co-ordination and Control

Forecasting requires information and data from a lot of external and internal sources. This information is collected by the various managers and staff from various internal sources. So almost all units and verticals of the organization are involved in the process of forecasting. This allows for better communication and coordination amongst them.

Limitations of Forecasting

Along with the benefits, there are also some limitations of forecasting. Let us take a look at a few of them,

- Just Estimates

The future will always be uncertain. Even if use the best of forecasting techniques and account for every aspect imaginable, a forecast is still just an estimate. One can never predict future events with 100% success. So even the best-laid plans may amount to nothing. This will always remain one of the biggest limitations of forecasting.

- Based on Assumptions

The basis of any forecasting method is assumptions, approximations, normal conditions, etc. This makes these forecasts unreliable. So one must always keep in mind the inherent limitations of forecasting and be cautious in being over-reliant on them.

- Time and Cost Factors

The data and information required to make formal forecasts are generally a lot. And the collection and tabulation of such data involve a lot of time and money. The conversion of qualitative data into quantitative data is also another factor. One must be careful that the time, money and effort spent forecasting must not outweigh the actual benefits from such forecasts.

Question on Limitations of Forecasting

Q: A forecast involves no guesswork at all. True or False?

Ans: The statement is False. While a forecast is done with meticulous scientific process and application of methods, it does involve some guesswork on the part of the manager

URBAN TRAFFIC PROBLEMS IN INDIA

Cities are locations having a high level of accumulation and concentration of economic activities and are complex spatial structures that are supported by transport systems. The larger the city, the greater its complexity and the potential for disruptions, particularly when this complexity is not effectively managed.

Among the most notable urban transport problems are:

- Congestion and parking
- Longer commute
- Inadequate public modes
- Difficult in non motorized vehicles
- Minimum public space
- High maintenance cost

Among the most notable urban transport problems are:

- Environmental impact and energy consumption
- Accident and safety
- Land consumption fright distribution
- Dependent on automobile
- On par with congestion people are spending an increasing amount of time commuting between their residence and workplace
- Public Transport Inadequacy
- During peak hours, crowdedness creates discomfort for users as the system copes with a temporary surge in demand.

- Difficulties for non-motorized transport

These difficulties are either the outcome of intense traffic, where the mobility of pedestrians, bicycles and vehicles is impaired

Environmental impacts and energy consumption

- Pollution, including noise, impediment to the quality of life and the health of urban populations.
- Energy consumption by urban transportation has increased and so the dependency on petroleum.
- public transit will bring down this issue.

Accidents and safety

- Growing traffic in urban areas is linked with a growing number of accidents and fatalities, in developing countries.
- Accidents account for a significant share of recurring delays.
- As traffic increases, people feel less safe to use the streets.

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SCHOOL OF BUILDING AND ENVIRONMENT

DEPARTMENT OF CIVIL ENGINEERING

UNIT – II – **TRAFFIC SURVEY**

INTRODUCTION

TRAFFIC SURVEY

Traffic Study is carried out

- To obtain the knowledge of type and volume of traffic at present and to estimate future traffic that the road is expected to carry.
- To determine the facilities provided on the roads such as traffic regulation and intersections, so that improvement on the basis of traffic density.
- To design the geometric features and pavement thickness on the basis of traffic surveys.
- To design bridges & culverts.
- Survey related to accidents helps in redesigning of roads, increasing road width and to maintain regulation and controls.

Different traffic studies

- Traffic Volume study
- Speed Studies
- Spot speed study
- Speed and delay study
- Origin and destination study (O & D)
- Traffic flow characteristics
- Traffic capacity study
- Parking study
- Accident study.

Traffic flow

Counting the number of vehicles on a road

- Flow
- Volume

Flow is defined as the number of vehicles that pass a point on a highway or a given lane or direction of a highway during a specific time interval.

The measurement is carried out by counting the number of vehicles, passing a particular point in one lane in a defined period t.

Then the flow q expressed in vehicles/hour is given by

$$q = nt/t$$

Traffic Volume

- The variation of volume with time, i.e. month to month, day to day, hour to hour and within a hour is also as important as volume calculation.
- Volume variations can also be observed from season to season. Volume will be above average in a pleasant motoring month of summer.
- It will be more pronounced in rural than in urban area.

Classified volume count

- It is the most common highway design
- Volume or flow is expresses in vehicles per hour or vehicles per day.
- In India the survey is to convert the mixed traffic into passenger car unit (PCU).
- Peak hour traffic is needed for the design of intersections, whereas for determine the number of lanes in the carriage way the daily traffic is needed.
- The traffic counts are taken by noting the number of vehicles of various classes that

passes the count point in each direction during periodic time intervals.

- Traffic census is taken regularly on NH network twice a year, for seven consecutive days in each round
- One round covers peak season and other the lean season.
- The average of seven days traffic is average daily traffic.
- If the traffic is taken continuously for all the days in a year the average traffic is known as AADT annual average daily traffic.

Types of volume measurements

Average Annual Daily Traffic (AADT): The average 24-hour traffic volume at a given location over a full 365-day year, i.e. the total number of vehicles passing the site in a year divided by 365.

Average annual flow: Expressed in vehicles per year.

Hourly flow: Expressed in vehicles per hour

Average Daily Traffic (ADT): An average 24-hour traffic volume at a given location for some period of time less than a year. It may be measured for six months, a season, a month, a week, or as little as two days. An ADT is a valid number only for the period over which it was measured.

Average Weekday Traffic (AWT): An average 24-hour traffic volume occurring on weekdays for some period of time less than one year, such as for a month or a season.

Traffic Volume study

Traffic Volume is the number of vehicles crossing a section of road per unit time at any selected period. The commonly used units are vehicles per day and vehicles per hour.

vehicle volume count, occupency

volume of traffic - vehicle/hr, vehicle/day,

traffic composed with many modes, convert flow with equivalent passenger car unit

Methods available for Traffic Counts

- Manual methods.
- Combination of manual and mechanical methods.
- Automatic devices.
- Moving observer method.
- Photographic methods

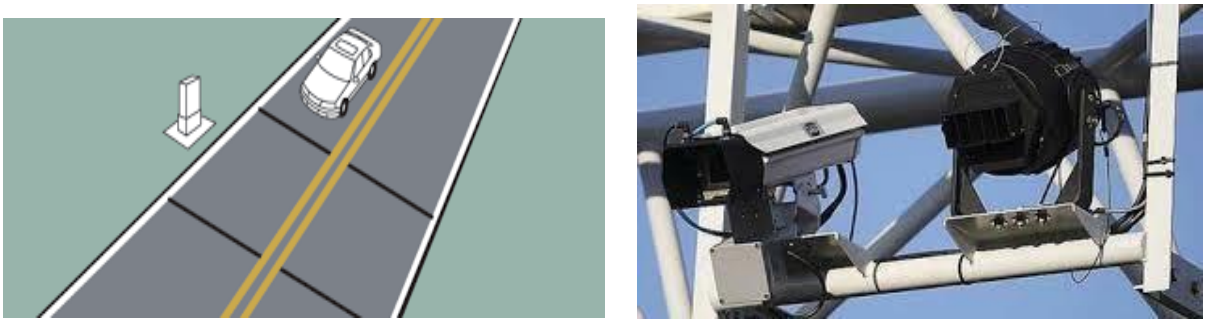

FIG.1 AUTOMATIC VOLUME COUNT METHOD

Capacity

Traffic capacity is the ability of a roadway to accommodate traffic volume. It is expressed as maximum number of vehicle in a lane. Capacity depends on number of prevailing roadway and traffic conditions.

Highway Capacity

1. **Traffic conditions**: It refers to the traffic composition in the road such as the mix of cars, trucks, buses etc in the stream. It also includes peaking characteristics, proportions of turning movements at intersections etc.

2. **Road way characteristics**: This points out to the geometric characteristics of the road. These include lane width, shoulder width, lane configuration, horizontal alignment and vertical alignment.

3. **Control conditions**: This primarily applies to surface facilities and often refers to the signals at intersections etc. Again capacity can be defined for a point or uniform section.

Capacity is estimated for segments having uniform conditions

- Points where these conditions change represent the boundaries where separate analysis may be required.
- Capacity is the maximum flow rate that a facility can afford. This maximum flow rate is taken for the worst 15 minutes of the peak hours while finding out the capacity.
- Capacity is measured as a reasonably expected value and not the maximum flow rate ever observed in the facility.

- This is because the measured capacity at a single location will show significant variation from day to day. Further, local driving habits also produce variations in the observed capacity.

Speed is one of the most important characteristic of traffic and is measured frequently. It is the rate of movement of traffic and expressed in metric unit kilometers per hour (K.P.H).

TYPES OF SPEEDS USED IN TRAFFIC ANALYSIS

- **Spot Speed** – Instantaneous speed of a vehicle at a specified location.
- **Time mean speed** - Average speed of all the vehicles passing a point on a highway over some specified time period.

- **Space mean speed** - Average speed of all the vehicles occupying a given section of a highway over some specified time period (or) average of the speed measurements at an instant of time over a space.
- **Running speed** - average speed maintained by a vehicle over a given course while the vehicle is moving.

Running speed = Length of course / running time
= Length of course / (journey time – delay)

- **Journey speed** - It is the effective speed of the vehicle between two points Journey speed =distance / total time (including delay)

Distance Over Which Observations are made = 100 m

Time Mean Speed = 19/3 = 6.33 m/sec Space Mean Speed = 300/55 = 5.45 m/sec

Uses of spot speed

- For geometric design of roads, design speed can be selected and the horizontal curvature, vertical profile, sight distance and super elevation can be estimated.
- For regulation and control of traffic operation, size of signals.
- For analysis the causes of accident.
- Studies of improvement of roads.
- Problems of congestion.

Uses of Journey speed and delay

- Cost of journey

- Congestion, capacity and level of service
- Transportation planning and Studies of improvement of roads
- Design and installation of traffic control devices.

SPEED AND DELAY SURVEY

Survey is carried on the existing road system are needed for assessing the loses (in travel time) caused by the congested condition. Separate recording sheets are maintained for each direction of movement for a specified time interval.

Methods of Speed and delay survey

- Floating car or riding check method
- License plate or vehicle number method
- Interview technique
- Elevation observation
- Photographic techniques
- Floating car or riding check method

Methods of measuring spot speed

- Observation of time taken by a vehicle to cover by a known distance
  - Timed over a long distance
    - Direct timing
    - Endoscope
    - Pressure contact tubes
  - Timed over a short distance
- Radar speedometer
- Photographic method

Methods for measurement of Running Speed and Journey speed

- Moving observer method
- Registration number method
- Elevated observer method.

Spot speed:

Spot speed is the instantaneous speed of a vehicle at a specified section or location.

Methods of measuring Spot Speeds:

- Long base methods
- Short base methods
- Spot speed by Endoscope

It is one of the simplest methods of finding spot speed. Its principle is the observer is stationed on one side of the road and starts a stop watch when a vehicle crosses that section (i.e., observer). The endoscope is placed at a convenient distance say30m to 50m, the moment when the vehicle crosses the section where endoscope is fixed, the stopwatch is stopped.

Time required to cross the known length is found and is converted to speed in KMPH

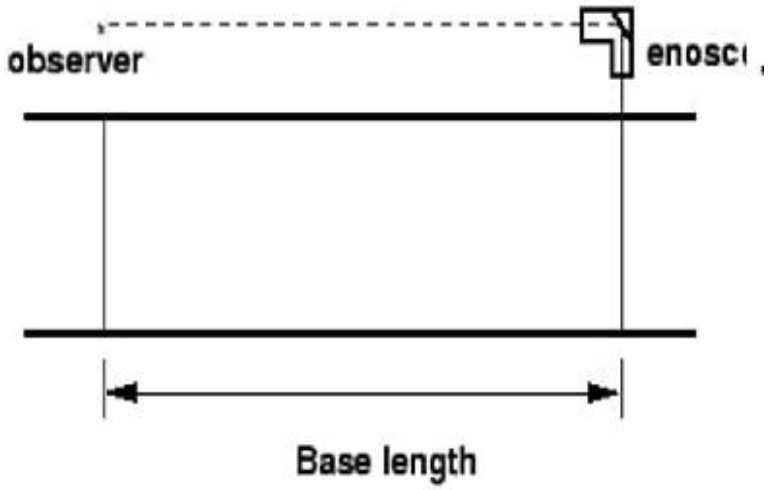

FIG.2 ENOSCOPE METHOD

Cumulative speed distribution

85th percentile speed:

It is the speed at or below 85 percentage of the vehicle are passing the point on the highway. Only 15 % of the vehicles exceed the speed at that spot. The driver exceeding 85th percentile speed are usually consider to drive faster than the safe speed under existing condition hence speed is adopted as safe speed limit. 98th percentile speed is taken for highway geometric design

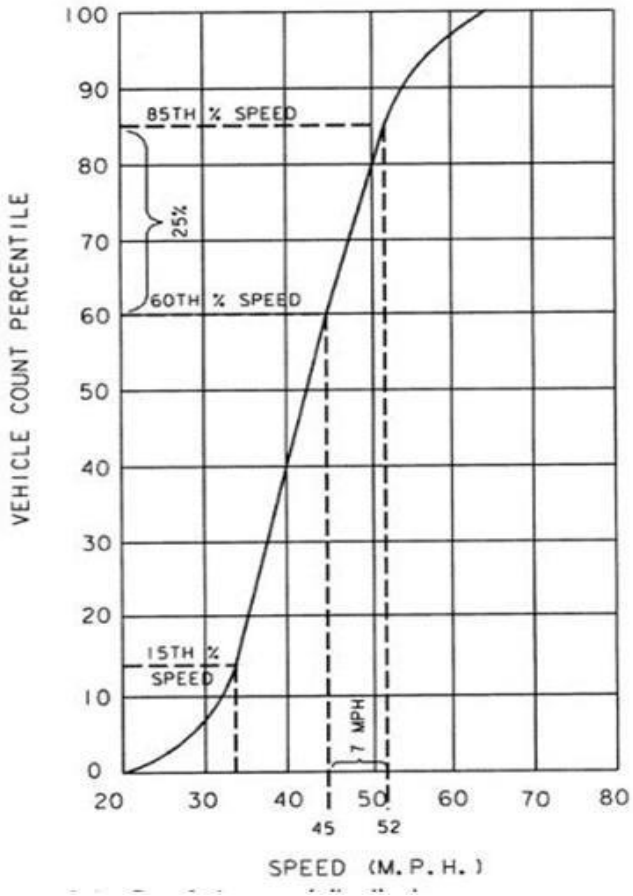

FIG.3 VGHICLE AND SPEED RELATIONSHIP

Origin and Destination Studies:

The O & D studies of vehicular traffic determine their number, their origin and destination in each zone under study. The various applications of O & D studies may be summed up as follows:

It is carried out for assessing the by passable traffic at towns and for planning new facilities like expressways.

It is done by many methods by registration number matching, Road side interview and post card questionnaires.

Origin and destination survey

- To locate expressway or major routes along the desire lines.
- To judge the adequacy of parking facilities and to plan for future.
- To locate intermediate stops of public transport.
- To establish preferential routes for various categories of vehicle including by pass

INFORMATION TO BE COLLECTED IN O-D SURVEYS

- Origin
- Destination
- Purpose of Trip
- Frequency
- Travel Time
- Travel Cost
- Route Preferred

Methods for collecting the O & D data

- Home interview method

- Full interview technique
- Home – questionnaire technique

- Road-side interview method
- Registration number plate method
- Return post card method
- Tag-on-car method and

Road-side interview method:

The vehicles are stopped at previously decided interview stations, by a group of persons and the answers to prescribed questionnaire are collected on the spot. The information collected include the place and time of origin and destination, route, locations of stoppages, the purpose of the trip, type of vehicle and number of passengers in each vehicle noted

License plate method:

The entire area under study is cordoned out and the observers are simultaneously stationed at all points of entry and exit on all the routes leading to and out of the area. Each party at the observation station is given synchronized time pieces and they note the license plate numbers (registration numbers) of the vehicle entering and leaving the cordoned area and the time

Presentation of O and D Data:

The data are presented in the following forms

- Origin and destination tables are prepared showing number of trips between different zones.
- Desire lines are plotted which a graphical representation is prepared in almost all O & D surveys.

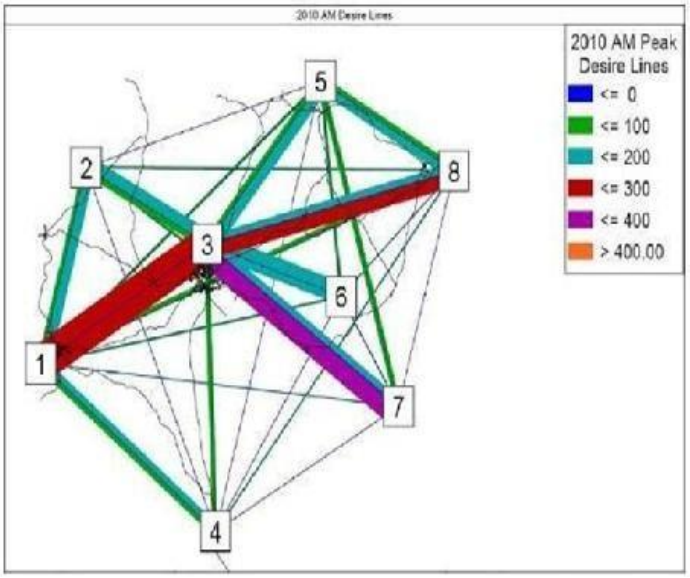

FIG.4 ORIGIN AND DESTINATION SURVEY RESULT

Desire lines are the lines connecting the origin points with the destination points.

Parking

Parking is one of the major problems that is created by the increasing road traffic. It is an impact of transport development. The availability of less space in urban areas has increased the demand for parking space especially in areas like Central business district. This affects the mode choice also. This has a great economical impact.

Parking system

On street parking: On street parking means the vehicles are parked on the sides of the street itself. This will be usually controlled by government agencies itself. Common types of on-street parking are as listed below. This classification is based on the angle in which the vehicles are parked with respect to the road alignment. As per IRC the standard dimensions of a car is taken as 5X 2.5 meters and that for a truck is 3.75X 7.5 meters.

Parallel parking: The vehicles are parked along the length of the road. Here there is no backward movement involved while parking or unparking the vehicle. Hence, it is the most safest parking from the accident perspective. However, it consumes the maximum curb length and therefore only a minimum number of vehicles can be parked for a given

kerb length. This method of parking produces least obstruction to the on-going traffic on the road since least road width is used. Parallel parking of cars is shown in figure.

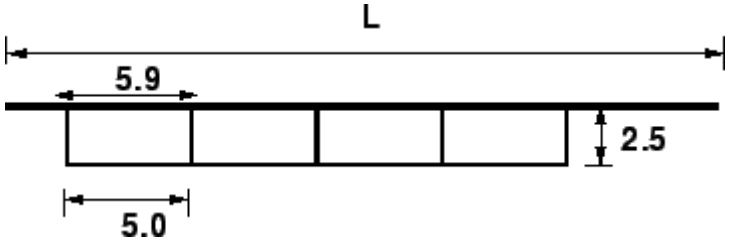

FIG.5 PARALLAL PARKING

The length available to park N number of vehicles, L = N/5.9

30° parking: In thirty degree parking, the vehicles are parked at 30° with respect to the road alignment. In this case, more vehicles can be parked compared to parallel parking. Also there is better maneuverability. Delay caused to the traffic is also minimum in this type of parking. An example is shown in figure. From the figure,

$$AB = OB\sin 30° = 1.25,$$

$$BC = OP\cos 30° = 4.33,$$

$$BD = DQ\cos 60° = 5,$$

$$CD = BD - BC = 5 - 4.33 = 0.67,$$

$$AC = AB + BC = 1.25 + 4.33 = 5.58$$

For vehicles, L = AC + (N-1)CE = 5.58 + (N-1)5 = 0.58 + 5N

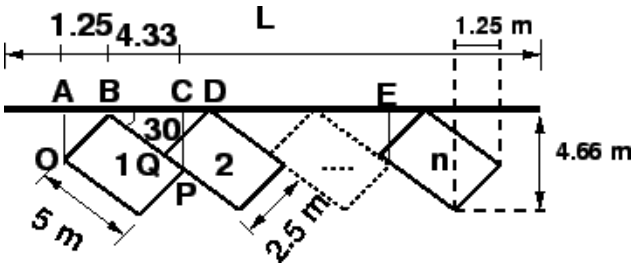

FIG.6 ANGULAR PARKING (30^{O})

- **45 parking**: As the angle of parking increases, more number of vehicles can be parked. Hence compared to parallel parking and thirty degree parking, more number of vehicles can be accommodated in this type of parking. From figure, length of parking space available for parking N number of vehicles in a given kerb is L= 3.54 N+1.77

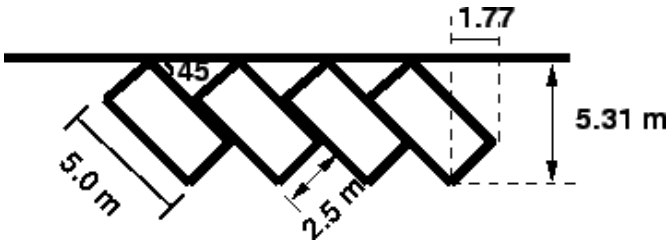

FIG.7 ANGULAR PARKING (45^{O})

- **60 parking**: The vehicles are parked at 60 to the direction of road. More number of vehicles can be accommodated in this parking type. From the figure, length available for parking N vehicles =2.89N+2.16.

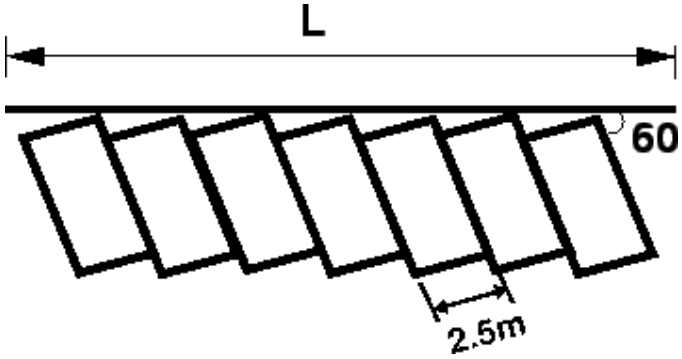

FIG.8 ANGULAR PARKING (60^{O})

Right angle parking: In right angle parking or 90 parking, the vehicles are parked perpendicular to the direction of the road. Although it consumes maximum width kerb length required is very little. In this type of parking, the vehicles need complex maneuvering and this may cause severe accidents. This arrangement causes obstruction to the road traffic particularly if the road width is less. However, it can accommodate

maximum number of vehicles for a given kerb length.

An example is shown in figure. Length available for parking number of vehicles is = 2.5N.

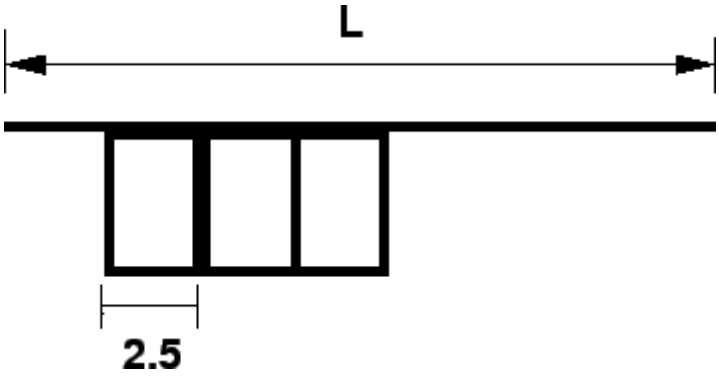

FIG.9 PERPENDICULAR PARKING

Off street parking

In many urban centers, some areas are exclusively allotted for parking which will be at some distance away from the main stream of traffic. Such a parking is referred to as off-street parking. They may be operated by either public agencies or private firms. A typical layout of an off-street parking is shown in figure.

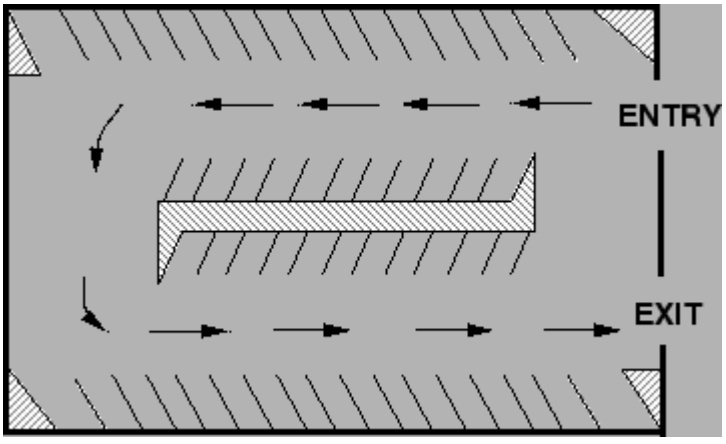

FIG.10 OFF STREET PARKING

Parking requirements

There are some minimum parking requirements for different types of building. For

residential plot area less than 300 sq.m require only community parking space. For residential plot area from 500 to 1000 sq.m, minimum one-fourth of the open area should be reserved for parking. Offices may require at least one space for every 70 sq.m as parking area. One parking space is enough for 10 seats in a restaurant where as theatres and cinema halls need to keep only.

parking space for 20 seats. Thus, the parking requirements are different for different land use zones.

Ill effects of parking

Parking has some ill-effects like congestion, accidents, pollution, obstruction to fire-fighting operations etc.

- Congestion: Parking takes considerable street space leading to the lowering of the road capacity. Hence, speed will be reduced; journey time and delay will also subsequently increase. The operational cost of the vehicle increases leading to great economical loss to the community.
- Accidents: Careless maneuvering of parking and unparking leads to accidents which are referred to as parking accidents. Common type of parking accidents occur while driving out a car from the parking area, careless opening of the doors of parked cars, and while bringing in the vehicle to the parking lot for parking.
- Environmental pollution: They also cause pollution to the environment because stopping and starting of vehicles while parking and unparking results in noise and fumes. They also affect the aesthetic beauty of the buildings because cars parked at every available space creates a feeling that building rises from a plinth of cars.
- Obstruction to fire fighting operations: Parked vehicles may obstruct the movement of firefighting vehicles. Sometimes they block access to hydrants and access to buildings.

Parking statistics

Before taking any measures for the betterment of conditions, data regarding availability of parking space, extent of its usage and parking demand is essential. It is also required to estimate the parking fares also. Parking surveys are intended to provide all these information. Since the duration of parking varies with different vehicles, several statistics are used to access the parking need. The following parking statistics are normally important.

- **Parking accumulation**: It is defined as the number of vehicles parked at a given instant of time. Normally this is expressed by accumulation curve. Accumulation curve is the graph obtained by plotting the number of bays occupied with respect to time.
- **Parking volume**: Parking volume is the total number of vehicles parked at a given duration of time. This does not account for repetition of vehicles. The actual volume of vehicles entered in the area is recorded.
- **Parking load**: Parking load gives the area under the accumulation curve. It can also be obtained by simply multiplying the number of vehicles occupying the parking area at each time interval with the time interval. It is expressed as vehicle hours.
- **Average parking duration**: It is the ratio of total vehicle hours to the number of vehicles parked.

$$\text{parking duration} = \frac{\text{parking load}}{\text{parking volume}}$$

- **Parking turnover**: It is the ratio of number of vehicles parked in duration to the number of parking bays available. This can be expressed as number of vehicles per bay per time duration.

$$\text{parking turnover} = \frac{\text{parking volume}}{\text{no. of bays available}}$$

- **Parking index**: Parking index is also called occupancy or efficiency. It is defined as the ratio of number of bays occupied in a time duration to the total space available. It gives an aggregate measure of how effectively the parking space is utilized. Parking index can be found out as follows

$$\text{parking index} = \frac{\text{parking load}}{\text{parking capacity}} \times 100$$

Types of Parking Surveys

- Parking space inventory
- Parking usage survey by patrol
- Questionnaire type parking usage survey
- Cordon count.

Photographic Techniques

The different methods involving the principle of photography in traffic studies are:

- Continuous stereoscopic strip photography from moving aeroplanes or helicopters.
- Stereo-camera photos from a stationary object on the ground.
- Conventional air photography from aeroplanes or helicopters.
- Time-Lapse photography from aeroplane, balloons or helicopters.
- Time-Lapse photography from fixed position of the ground.
- Video system.

Accident Studies

The problem of accident is very acute in highway transportation due to complex flow patterns of vehicular traffic presence of mixed traffic and pedestrians.

Objectives of the accident studies

- To study the causes of accidents and to suggest corrective treatment at potential location.

- To evaluate existing design
- To support proposed designs
- To carry out before and after studies and to demonstrate the improvement in the problem
- To make computations of financial loss and
- To give economic justification for the improvements suggested by the traffic engineer.

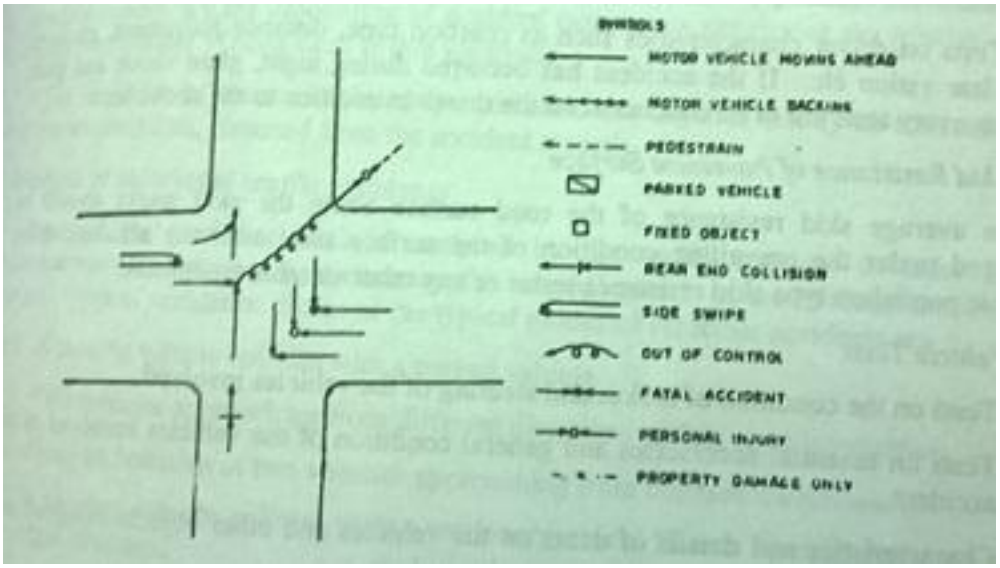

FIG.11COLLISION AND ITS SYMBOLS

Causes of accidents

There are four basic elements

- Road users
- Vehicles
- Road and its condition and
- Environmental factor- traffic, weather etc.

Highway Capacity and Level of Service

Road capacity is the maximum potential capacity of a given roadway. It can be

expressed in terms of vehicles per hour or per day. Road capacity for the purpose of limiting traffic to reduce congestion or environmental problems.

TABLE 1 RELATIOSHIP BETWEEN LEVEL OF SERVICE AND SPEED

Level of Service	Speed (Km/H)	Time spent (%)
A	90	35
B	80	50
C	70	65
D	60	80
E	Lesser than 60	More than 80
F	Flow exceeds Capacity	

- Typically three parameters are used under this and they are speed and travel time, density, and delay.
- One of the important measures of service quality is the amount of time spent in travel. Therefore, speed and travel time are considered to be more effective in defining LOS of a facility.
- Density gives the proximity of other vehicles in the stream. Since it affects the ability of the driver to plan in the traffic stream, it is also used to describe LOS.

Factors affecting level of service

- Speed and travel time
- Traffic interruptions/restrictions
- Freedom to travel with desired speed
- Driver comfort and convenience
- Operating cost

Highway Capacity Manual (HCM)

Travel speed and volume by capacity ratio (v/c ratio) to distinguish between various levels of service. The value of v/c ratio can vary between 0 and 1. Depending upon then travel speed and v/c ratio, HCM has defined six levels of service, level A to level F based on a graph between operating speed and v/c ratio

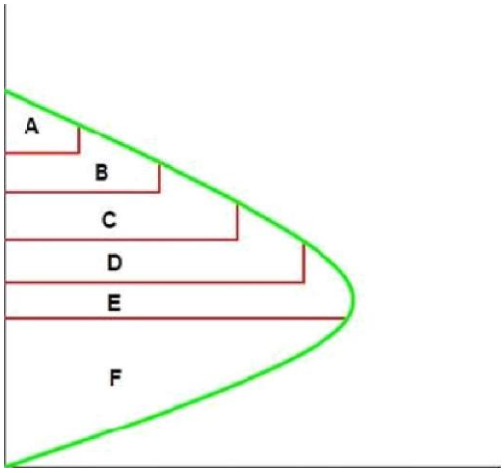

FIG.12 VOLUME TO CAPACITY RATIO

TABLE 2 TRAFFIC CONDITION WITH LEVEL OF SERVICE

Lovel of service (LOS)	Description of Traffic Conditions
A	LOS "A" describes primarily hollow operations at average travel speeds, usually about 90 percent of the Free Flow Speed {FFS) for the given street class. Vehicles are completely unimpeded in their ability to maneuver within the traffic stream. Control delay at signalized intersections is normal.
B	LOS "B" describes reasonably unimpeded operations at average travel speeds, .usually about 70 percent of the FFS for the street class. Vehicles are completely unimpeded in their ability to maneuver with the traffic street. Control delay at signalized intersections is minimal.
C	LOS "C" describes stable operators: however, ability to maneuver and change lanes in midblock locations may be more restricted that at LOS •B," and longer queues, adverse signal coordination, or both may contribute to lower average travel speeds of about 50 percent of the FFS for the street class.
D	LOS "D" border on s range in which small increases in flow rnoy Cause substantial increases in delay and decreases in travel speed. LOS "D' may be due to adverse signal progression, inappropriate signal timing, high volumes, or a combination of these factors. Average travel

	speeds are about 40 percent of FFS.
E	LOS "E" is characterized by significant delays and average travel speeds of 33 percent or less of the FFS. Such operations are caused by a combination of adverse progression, high signal density, high volumes, extensive delays at critical intersections, and inappropriate signal timing.
F	LOS "F" is characterized by urban street flow at extremely low speeds, typically one-third to one-fourth of the FFS. Intersection Congestion is likely at critical signalized locations with high delays, high volumes and extensive queuing.

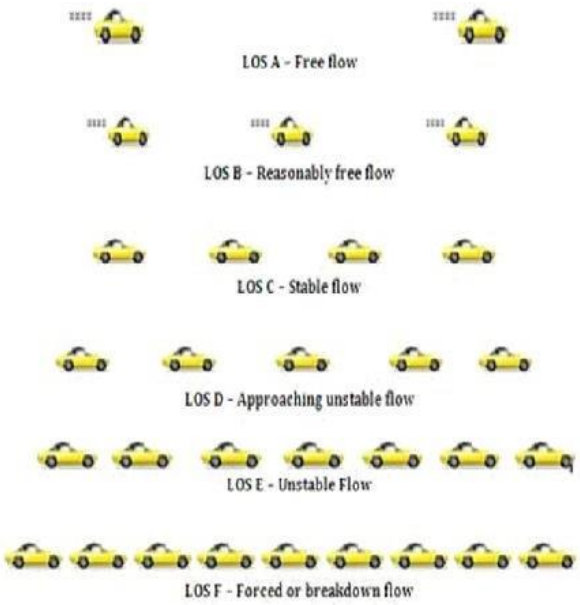

FIG.13 CONGESTION WITH LEVEL OF SERVICE

Level of service A

- Level of service A represents the zone of free flow.
- Here the traffic volume will be less, traffic will be experiencing free flow also the drivers will be having the complete freedom to choose their desired speed.
- Even at maximum density, for this LOS the average spacing between vehicles is 167m
- Lane changes within the traffic stream, as well as merging and diverging movements, are made relatively easy.
- The effect of minor incidents and point breakdowns are easily aborted at this level.

Level of service B

- Level of service B represents zone of reasonably free flow. Free flow speeds are still maintained at this level of service.
- The drivers freedom to choose their desired speed is only slightly restricted.
- The lowest average spacing between vehicles is about 100 m.
- The effects of small incidents and point breakdowns are still easily contained

Level of service C

- At level of service C, the presence of other vehicles begins to restrict the maneuverability within the traffic stream.
- Average speeds remain at or near the free flow speed level, but significant increase in driver alertness is required at this level.
- Minimum average spacing between the vehicles is in the range of 67 m.
- Queues may be expected to form behind any significant blockage.

Level of service D

- At level of service D, the average speeds begin to decline with increasing flows. Freedom to maneuver within the traffic stream is noticeably restricted.
- At this level, density deteriorates more quickly with flow.

- The spacing between the vehicles is about 50 m.
- As the traffic stream has little space to absorb disruptions, minor incidents can lead to queuing of vehicles.

Level of service E

- Level of service E define operation at capacity.
- At this level, the stream reaches its maximum density limit.
- There will be no usable gaps in the stream and even slight disruptions will cause a breakdown, with queues forming rapidly behind the disruption.
- Maneuvering within the traffic stream becomes extremely difficult.

Level of service F

- Level of service F describes conditions in a queue that has formed behind a point of breakdown or disruption.
- As vehicles through the queue, there may be periods when they move quickly, and others when they are stopped completely.
- Thus this level of service is used to describe the point of breakdown as well, even though operations downstream of such a breakdown may appear good.
- Level of service F represents the region of forced flow, having low speed.

Uninterrupted flow

- Uninterrupted flow is the flow of traffic in which there is no obstructions to the movement of vehicles along the road.
- Freeway is one example for this type of Facility.
- In a freeway, when a vehicle enters a freeway, there is no need for the vehicle to stop anywhere till it leaves the freeway.
- There are three sections in a freeway - basic unit, weaving section and ramps (on/off).
- Vehicles will be entering the freeway through ramps. Ramps used for entering the freeway is called on-ramps and those used for exiting the freeway are called off-ramps.

- Freeways generally have 4, 6, or 8 lane alignments. Multi lanes also provide uninterrupted flow. In many roads, there will be signalized as well as un signalized Intersections.

Interrupted flow

- Interrupted flow refers to the condition when
- This is experienced in signalized intersections, un signalized intersections, arterials etc
- At signalized intersections, there will be some kind of active control and the vehicle will have to stop or sometimes to reduce its speed and the flow of traffic is interrupted.

STATISTICAL APPLICATIONS IN TRAFFIC STUDIES

Ref: https://www.sciencedirect.com/book/9780128115558/statistical-techniques-for-transportation-engineering ScienceDirect

- An Overview of Statistical Applications
- Preliminaries
- Probability
- Random Variables
- Curve Fitting
- Correlation and Regression
- Sampling
- Hypothesis Testing
- Chi-Square Distribution
- Test of Significance—Small Samples
- ANOVA (Analysis of Variance)
- Index Numbers

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SCHOOL OF BUILDING AND ENVIRONMENT

DEPARTMENT OF CIVIL ENGINEERING

UNIT – III TRAFFIC REGULATORY MEASURES – SCI1609

INTRODUCTION

TRAFFIC SIGNS

Traffic signs are signs erected at the side of or above roads to give instructions or provide information to road users.

Importance of traffic Signs:

- Give timely warning of hazardous situations
- Great help in regulating traffic
- Information about highway routes, directions, and points of interest.

Principles of Traffic Signs:

- Traffic sign should be installed only by the authority of law
- For imparting a sense of respect towards signs, proper enforcement measures should be undertaken
- Signs should be put up only after traffic engineering studies and sound engineering judgment
    - Excessive use of signs should be resorted to.
    - Signs should be designed for the foreseeable traffic conditions and speeds
    - Legible to those who using it.

Types of traffic Signs:

- Danger signs (or) Warner signs (or) cautionary signs
- Regulatory signs
    - Prohibitory signs
    - Mandatory signs
    - Information signs
    - Indication signs

- Advance direction signs
- Place and route identification signs

Danger signs

- Warning signs or cautionary signs give information to the driver about the impending road condition
- advice the driver to obey the rules
- These signs are meant for the own safety of drivers.
- Colour 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

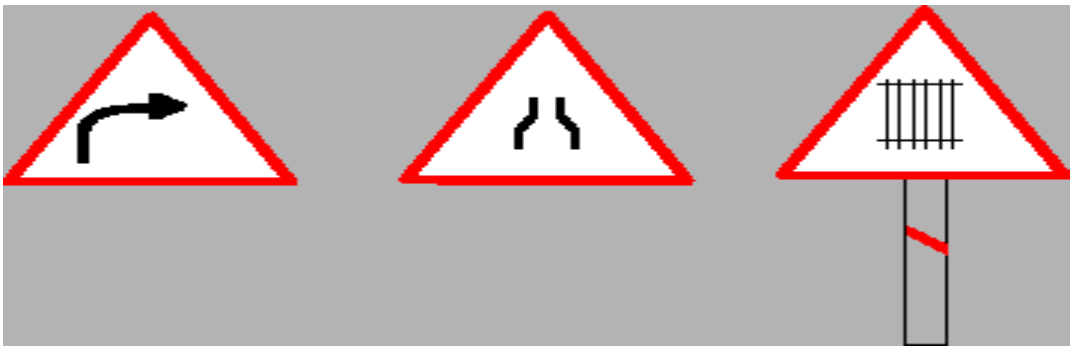


FIG.1 CAUTION SIGN

Prohibitory Signs

- Inform highway users of traffic laws (or) regulations
- Gives negative instructions.

Types:

- Movement prohibition – turns, entry, overtaking, one-way etc
- Waiting restriction signs – prohibited waiting etc.
- Restrictions on dimensions, weight (or) speed of vehicle.

Specifications:

Shape – circular, diameter – 0.6m

Border – red, Background – White = speed control

Blue = waiting & parking restriction

Blue = direction control and other specifications.

Symbols – black = prohibitory signs

White = direction control signs

No stopping sign

No left turn

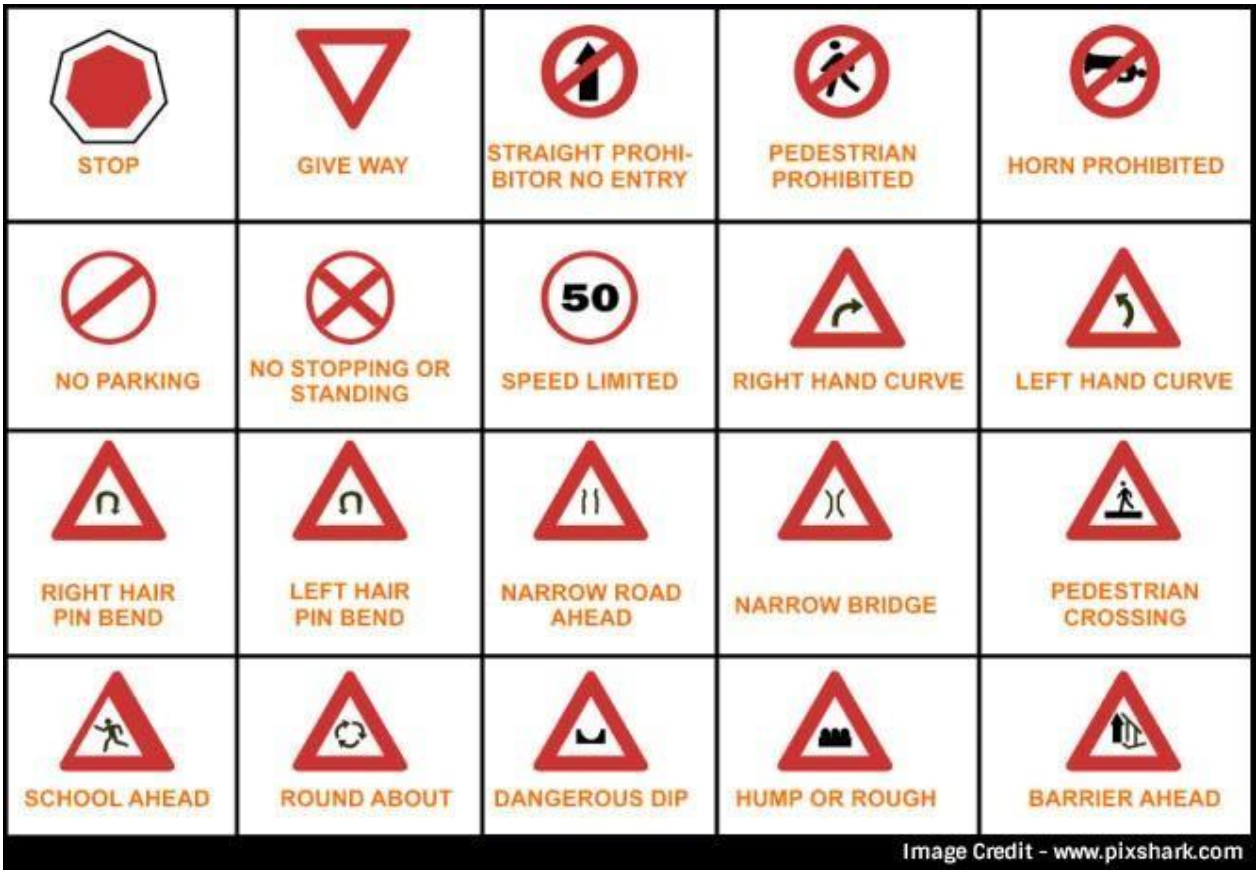


FIG. 2 MANDATORY SIGN

- Part of regulatory signs
- Convey positive instructions

Types:

- STOP sign
- YIELD (or) GIVEWAY sign

  - Used to assign right-of-way to traffic on certain approaches to an intersection
  - Used under following conditions:
    - On a minor road at the entrance to an intersection
    - When an acceleration lane is not provided
    - Where there is a separate (or) channelized left-turn lane, without an adequate acceleration lane
    - Where problem exists
  - Should not be used
    - To control the major flow of traffic at intersections
    - On the approaches of more than one of the intersection
    - On the through roadways (or) expressways.

FIG.3 YIELD AND STOP SIGNS

Symbol – downward pointing equilateral triangle Border – red
Background – white

Informatory Signs:

Intended to guide the motorist along streets and highways.

Indication Signs:

Provides information such as hospitals, filling station, telephone etc. Symbol – Black, white rectangle with blue background

Types of Indication sign:

- Direction sign
    - Rectangular shape
    - Arrow head
    - Gives directions

FIG.3 DIRECTION SIGN

- Advance direction Signs
    - Necessary at intersection of roads
    - Rectangular in shape

FIG.4 DIRECTION SIGNS

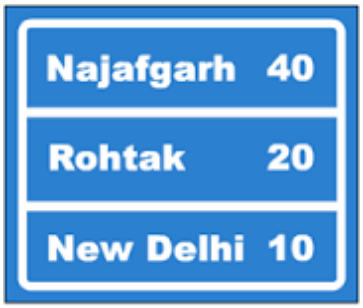
- Place Identification Signs

FIG.5 INDICATION SIGN

- Indicates the names of places and directions
- Destination Sign

FIG. 6 DESTINATION SIGN

b) Reassurance Sign



- Reassures the traveller about the places ahead and te distances thereto

Overhead Signs

Overhead signs are provided at locations where the following consideration exists,

- Traffic volume at (or) near capacity
- Complex interchange
- Three or more lanes in each direction
- Closely spaced interchanges
- Restricted sight distance
- Multi-lane exists
- Large percentage of trucks
- Street lighting background
- High speed traffic
- Consistency of sign message
- Insufficient space for ground mounted signs
- Junction of an interstate route with another freeway

FIG.7 ROUTE INDICATION SIGN

- Right exit ramps

Route Marker Signs

- Shield painted on a rectangular plate
- Background – yellow, border letter – black

FIG.8 ROUTE MARKER SIGN

ROAD MARKINGS:

Road markings are used as a means of controlling and guiding the traffic.

Types of Road markings:

Carriageway markings

- Centre line
  - Marking provided to demarcate the centre of a carriageway ant to separate the traffic in opposite directions.
  -

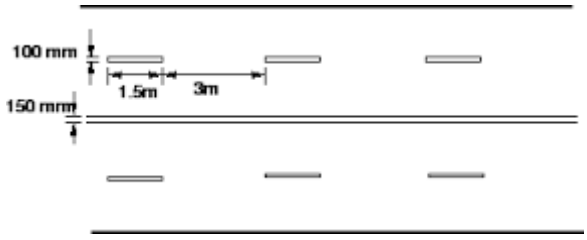


FIG.9 CENTRE LINE ON ROAD

- Traffic lane lines
  - Broken lines which permit lane changing with caution

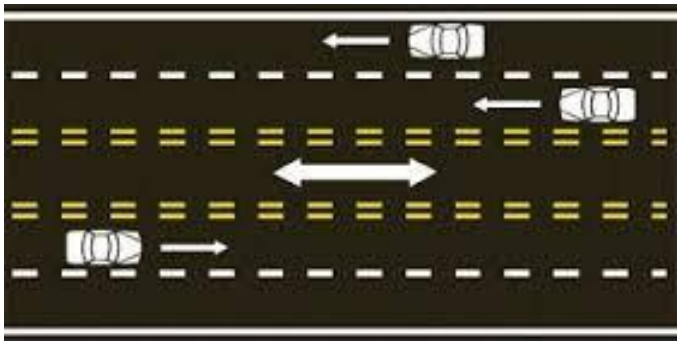


FIG.10 TRAFFIC LANE LINES ON ROAD

- No overtaking zone markings
  - Marking for a “no overtaking” zone consists of a combination line along with the centre line.

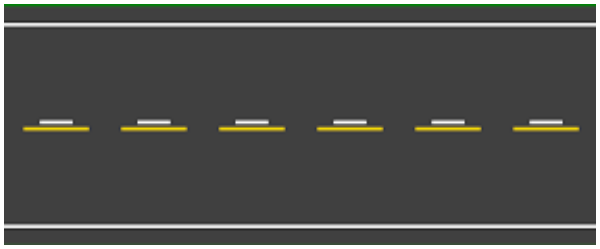


FIG.11 NO OVERTAKING ZONE LINE ON ROAD

- Pavement edge lines

  Used to indicate the edges of carriageway which have no kerbs
- Carriageway width reduction transition markings

  Reduction in the width is made known by a combination of carriageway markings and road signs.

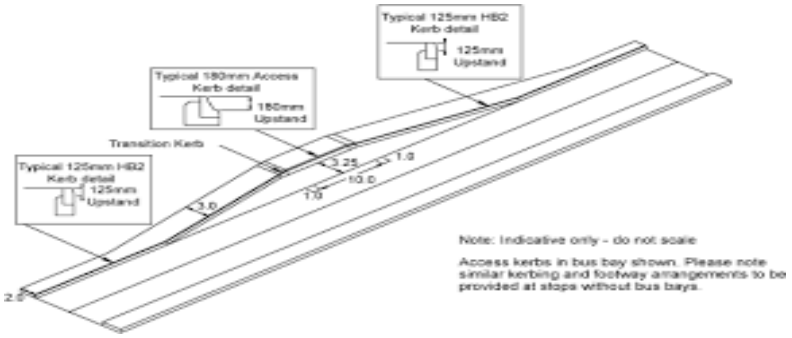


FIG.12 BUS-BAY PROVISION

- Obstruction approach markings

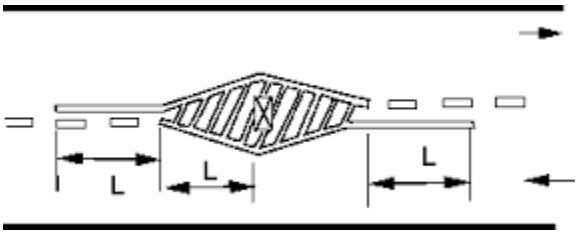


FIG. 13 OBSTRUCTION APPROACH ON ROAD

Necessary to guide traffic on approach to fixed obstructions within the carriage way.

- Stop lines

Solid white lines provide transversely to the carriageway

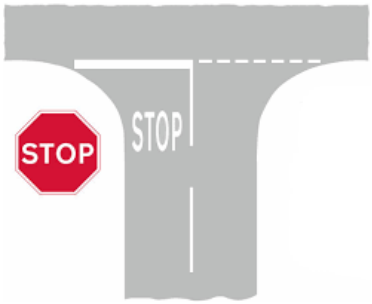


FIG.14 STOP LINE MARK ON ROAD

Used to indicate the point behind which vehicles are required to stop

- Pedestrian crossings

  Guide pedestrians in the proper paths

- Cyclist

  Width equal to cycle tracks

FIG.15 CYCLE TRACK

Marked by means of squares

- Route direction arrows

  Used to guide effectively the traffic in the correct directions and lanes

- Word messages

  Used to convey information to guide, warn or regulate traffic

  Common messages used are STOP, SLOW, SPEED25 etc.

- Marking at approaches to intersections

  It can be a combination of centre-lines, turn markings, lane markings, stop lines, route direction arrows etc.

- Parking space limits
- Bus stops

- Object markings
  - Objects within the carriageway
  - Kerb marking for visibility
  - Objects marking for parking restriction

- Objects adjacent to the carriageway.

General principles of pavement markings:

- Solid lines are restrictive in nature and its an offense to cross such line
- Broken lines are restrictive in nature and vehicles can cross this lines with safety
- Double lines indicate maximum restrictions

Materials for Road markings:

Paint – hot applied thermoplastic paints with retro- reflective

stripes Colour – white and yellow

TRAFFIC SIGNALS: To control and regulate traffic

Advantages:

- Orderly movement of traffic
- Increase traffic handling capacity at intersections
- Reduce frequency of certain types of accidents
- Continues movement of traffic at a definite speed
- Interrupt heavy traffic to permit pedestrian to cross
- Dispense with police control and hence economical

Disadvantages:

- Delay to vehicles
- Encourage disobedience of signal indication
- Drivers induced to take less adequate and less safe routes to avoid signals.
- Rear – end type accident increases
- When installation break down, total and widespread confusion and difficulties can result

Signal Indications:

Pedestrian Signal Indication:

FIG.15 PEDESTRAIN SIGNAL

Flashing amber

Hazard identification used to warn obstruction and intersection.

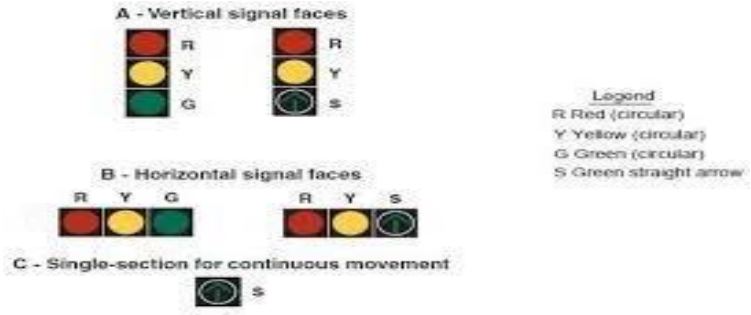


FIG.16 VERTICAL AND HORIZONTAL SIGNAL

Signal face:

Off- set:

Defined as the difference between the start of green time at the successive upstream and downstream signal.

Clearance Amber:

The **amber interval** is a transition interval between termination of related green movement and exhibition of a red indication and commencement of related green movement. In the first case it's called "Clearance **Amber**' and in the second case, it's called "**Initial Amber**". The amber period is generally 2 seconds.

Types of Signals:

- **Fixed time Signal**
  - Signals those are in the green periods, and hence the cycle lengths are predetermined and of fixed duration.
- **Vehicle Actuated Signal**
  - Signals in which the green periods vary and are related to actual demands made by traffic. Made possible by installing detectors on all the approaches.
- **Semi – vehicle actuated signal**
  - Signals in which the right of way normally rests with the main road and detectors are located only on the side roads.

TABLE 2 ADVANTAGES AND DISADVANTAGES OF SIGNALS

Type	Advantages	Disadvantages
Fixed time	Simple in construction Relatively inexpensive	Inflexible and hence may cause avoidable delay. Require careful setting
	Most successfully used in linked systems requiring a fixed cycle length for a given pattern and speed of progression.	Require careful setting
Vehicle – actuated signal	They are flexible and are able to adjust to changing traffic conditions automatically. Delay is held to a minimum and maximum capacity is achieved.	Require costly equipment such as detectors and Sophisticated controllers. Cannot provide signal co-ordination.
semi – vehicle – actuated signal	Useful for a junction of a side street having low traffic volume with a main street having heavy flow.	They are believed to cause high accident rates at times of light traffic

DESIGN OF TRAFFIC SIGNAL:

Steps in Design:

- Determination of cycle time

  The following equation is obtained for determining the cycle time,

$$C_0 = \frac{1.5L+5}{1-Y}$$

seconds

Where, C_o = optimum cycle time

L = total lost time per cycle (in seconds) $Y = y_1 + y_2 + \quad + y_n$

$y_1 + y_2 + \ldots\ldots + y_n$ are the maximum ratios of flow to saturation flow for phases

1,2……n

Determination of Lost time L

The lost time for the phase can be, $l = k+a-g$

Where, l = loss time for the phase k = green time for the phase

a = amber time for the phase g = effective green time = b/s

b = number of vehicles discharged on the average during a saturation flow s = saturation flow

Determination of total cost time L

$= nl + R$

Where, n = phases in the cycle

R = time during each cycle when all signals display red

Determination of least overall delay to the traffic using intersection:

$g_1 : g_2 \ldots\ldots g_n = y_1 : y_2 \ldots\ldots\ldots\ldots y_n$

where, $g_1, g_2 \ldots\ldots g_n$ = effective green times allotted to phases 1,2, …., n respectively.

$y_1, y_2 \ldots\ldots\ldots y_n$ = maximum of y values =

Determination of Saturation Flow: s = 525w PCU/hour

where, s =saturation flow

w = width of approach road in metres measured kerb to inside of pedestrian refuge or centre line, whichever is nearer, or to the inside of the central reserve in case of a dual carriageway.

The above formula is valid for widths from 5.5 to 18m. For lesser widths the values may be obtained from the following table,

TABLE 3 CAPACITY WITH ROAD WIDTH

Width w in metres	3.0	3.5	4.0	4.5	5.0	5.5
s (PCU/hour)	1850	1890	1950	2250	2250	2900

- The effect of composition of vehicles can be accounted for in measuring the flow and saturation flow by converting into PCE equivalent as per values given in the following table

TABLE 4 PCE FACTOR OF VARIOUS MODES

Types of vehicles	**PCE Equivalent**
Heavy or medium goods vehicles	1.75
Light goods vehicles	1.00
Bus	2.25
Motor cycle, moped or scooter	0.33
Pedal cycle	0.20

Co-ordinate control of Signals:

Need for co-ordinated control:

- To pass the maximum amount of traffic without enforced halts
- To have minimum overall delay to traffic streams, both in the main and side roads.
- To prevent the queue of vehicle at one intersection from extending and reaching the next intersection.

Types of Co-ordinate signal system:

- Simultaneous system (or) synchronized system
- Alternate system 9or) limited progressive system
- Simple progressive system
- Flexible progressive system
- Simultaneous system
  - All the signals along a given street always display the same indication to the same traffic at same time.

Disadvantages:

- Not conductive to give continuous movement of vehicles
- Overall speed is often reduced
- Difficulty for side street vehicles in turning into (or) crossing the main side street.

- Alternate system
  - Consecutive signal installation along a given road show contrary indications at same time.

Disadvantages:

- Green times for both, main and Side Street have to be equal, resulting inefficiency at intersections.
- When block lengths are unequal, system is not well suited
- Adjustments are difficult for changing traffic conditions.

- Simple Progressive System
  - The various signals along a street display green aspects in accordance with a time schedule to permit
  - Cycle division remains fixed throughout the day
- Flexible Progressive System

  This system is improvement over the simple progressive system with the following provisions,
  - Possible to vary cycle time based on traffic
  - Possible to vary offset

- Possible to introduce shut down (or) flashing during off-set hours.

MISCELLANEOUS TRAFFIC CONTROL AIDS AND STREET FURNITURE

The term **street furniture** covers a wide variety of terms that are needed to support the main function of streets which is the movement of vehicles and pedestrians. The common types of street furniture found on streets are,

Traffic Aids:

- Roadway delineators
- Safety barriers
- Barricades and channelizes
- Railings
- Traffic signs
- Overhead signs
- Traffic signal posts
- Traffic impact attenuators
- Traffic aid posts
- Hazard markers and object markers
- Speed breakers

Road Beautification:

- Tree guards
- Planters

Facilities:

- Bus stands
- Taxi stands
- Roadside toilet

- Roadside rest areas

Information providers:

- Roadside advertisement

Principles of street furniture design:

- Only those items which are absolutely necessary should be provided
- Initial cost and cost of maintaining the facilities must be given due considerations. The materials selected should be durable
- Design should be vandal proof
- Designs should be aesthetically pleasing and match with the surroundings.

Roadway Delineators:

- Intended to provide visual aids to drivers concerning the alignment of road at night.
- Reflectiorised for better visibility during night
- Form – guide posts of metal, concrete, timber (or) cut stone
- Have circular, rectangular (or) triangular cross section
- Alternative – empty bitumen drums

FIG.17 ROADWAY DELINEATORS

Use of roadway delineators under following

situations, Curved sections:-

- Horizontal curves of radius 1000m (or) less
- Vertical curves with inadequate

visibility Straight sections:-

- Sections where visibility is poor
- Alignment uncertain to driver
- Sections subjected to frequent submergences and ponding
- Approaches to narrow bridges and culverts
- Valley side of hill roads
- Road embankments exceeding 3m in height
- Approaches to important intersections
- Special problem points such as causeways and tunnels.

Hazard Markers:

Intended to define obstructions like guard rails and abutments adjacent to the carriageway.

FIG.18 HAZARD MARKERS (a)

Object Markers

Used to indicate hazards and obstructions within the

vehicle path. Applicable in following locations

- Traffic islands at approaches to intersections Around periphery of rotary islands

- Medium openings
- Facing approaching traffic at islands forming left infiltration lane On medians/ islands on far side of intersections
- At points where traffic divided into different directions On far side of T-junctions and street dead-ends.

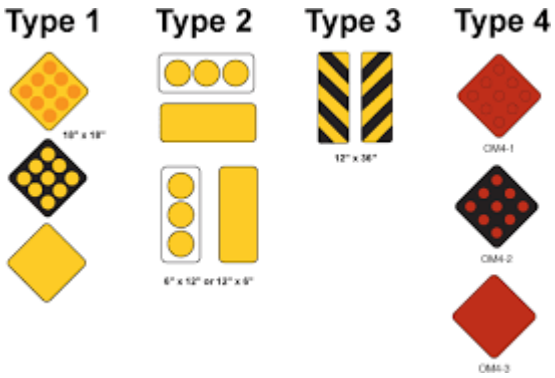


FIG.19 HAZARD MARKERS (b)

Speed breakers:

- Also known as speed control humps

FIG.20 SPEED BREAKERS

- Used on private access roads and near schools and universities in urban situations.

Rumple Strips:

- Speed breakers are sometimes hazardous, as a substitute rumple strips, which are corrugated surfaces producing noise and as physical sensation on the steering are provided.
- Rumple strips are made by making changes in pavement texture 5-10 strips at suitable intervals are placed to reduce speed.

FIG.21 RUMPLE STRIPS

STREET FURNITURE:

Street furniture is a collective term for objects and pieces of equipment installed on streets and roads for various purposes. It includes benches, traffic barriers, bollards, post boxes, phone boxes, streetlamps, lights, bus stops, tram stops, taxi stands, public lavatories, fountains, watering troughs, memorials, public sculptures, and waste receptacles. An important consideration in the design of street furniture is how it affects road safety.

Guard rails for Guiding pedestrians:

- Needed for guiding pedestrians to subways, footbridges and surface crossings and for preventing them from spilling into the carriageway.

FIG.22 GUARD RAIL

Safety Barriers:

- Intended to prevent vehicles accidently leaving the highway

FIG.23 SAFETY BARRIERS

- Mainly constructed at approaches to bridges and high embankments.

Barricades and Channelisers:

Required to control and divert traffic on construction zones and temporary diversions.

FIG.24 BARRICADES

Traffic Attenuators:

Required for absorbing the energy of impact of vehicles that go out of control

FIG. 25 TRAFFIC ATTENUATORS

Litter Bins:

Needed for collecting the trash thrown away by road users.

FIG. 26 LITTER BINS

STREET LIGHTING:

Street lighting is primarily intended to enable the road users to see accurately and easily the carriageway and the immediate surroundings in darkness.

Decrement by Artificial Lighting:

Can be possible by three ways,

- By silhouette – the brightness of object must be lesser than the background (pavement)
- By reverse silhouette – used when brightness of object greater than background
- By surface detail – a portion of object facing the observer is illuminated by a high order of illumination, the other portions being not illuminated.

Lantern Arrangements:

- Single sided – leaves one side of road dark, suitable for narrow roads
- Staggered – widely used
- Central – more light reaches centre way and footpaths, installation and maintenance costly

- Opposite – uniform luminance over full pavement width at high cost
- Combination of ii, iii and iv.

Types of Lamps:

- Tungsten filament
- Tubular fluorescent
- Sodium vapor discharge
- High pressure mercury discharge

Recent Trends in Signal Controlling The Traffic:

- **Controlling of signal lights:**

The signaling is cyclic in clockwise direction starting from first road, through fourth sequentially. The timing is set after its calculation from the estimated density with the help of image processing technique on the captured image. Digital monochrome or color camera is used. The timing calculated is passed on to Microcontroller. Microcontroller operates the signal lights with the help of necessary driver circuitry. We are using single camera at present, which is placed at the centre of intersection mounted on rotary platform at sufficient height to get enough elevation for vision that is required to view predefined length of vehicles. The camera is rotated by a DC motor driven by microcontroller via driver circuit

- **Emergency**

GSM technique is used to handle emergency. The authorized emergency vehicle like Police, firefighter or ambulance are given priority to cross the intersection after the request raised by them with the help of SMS send as it approach the intersection. The signal remains on till it crosses the junction and can be put off to resume the normal operation by sending other SMS At vehicle end we have GSM transmitter and at Intersection we have receiver. Correct lane number

to intersection will have to be transmitted to raise priority. In case of more than one

emergency arise, then first come first serve mechanism is exercised in setting the priority. This scenario is rare but provision is made to make system more clever decision.

- **Image processing**

The steps followed in processing of a captured image includes experimentally found out results along with simplified consideration. i. Fixing queue area: The predefined length L1 as queue length and road width gives maximum area of queue. „T, is time required to clear the 100% queue area, and this will be maximum time setting for the control of signal at that intersection. This area of interest can be obtained by installation of camera at height and angle facing towards road. Hence L and T are experimentally found. ii. Region of interest (ROI) : Area of queue is region of interest (ROI) and could be freezed by generating a cropped image of empty road or normal image scene.

Benefits of Advanced Traffic Signal Control Systems

In general, each traffic signal control system is designed to meet the specific social and political objectives of each community.

- Fundamentally, however, traffic signal control systems strive to achieve the following: ¨ Maximize traffic flow efficiency and public safety. ¨
- Accurately monitor traffic flows and make appropriate traffic control decisions in a timely manner. ¨
- Moderate fuel consumption and environmental impact of stop-and-go traffic through improvements to traffic flow efficiency.

INTERSECTION DESIGN ELEMENTS

Intersections are a critical aspect of street design as the point where motorist, bicycle, and pedestrian movements converge. Successful intersection design addresses all mobility and safety goals as well as opportunities to enhance the public realm. This section explores intersection design and operation, from signal timing to crosswalks, and investigates each concept as it relates to citywide goals for safety, mobility, and more vibrant, accessible public spaces.

SUBSECTIONS:

Crosswalks and Crossings
Conventional Crosswalks
Midblock Crosswalks
Pedestrian Safety Islands
Corner Radii
Visibility/Sight Distance
Traffic Signals
Signalization Principles
Leading Pedestrian Interval
Signal Cycle Lengths
Fixed vs. Actuated Signalization
Coordinated Signal Timing

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SCHOOL OF BUILDING AND ENVIRONMENT

DEPARTMENT OF CIVIL ENGINEERING

UNIT – IV – TRAFFIC SAFETY AND ENVIRONMENT

SCI1609

INTRODUCTION

ACCIDENT STUDIES

Start Early, Ride Slowly and Reach Safely.

Objectives of **accident studies**

- To study the causes of **accidents** and suggest corrective measures at potential location.
- To evaluate existing design.
- To compute the financial losses incurred.
- To support the proposed design and provide economic justification to the improvement suggested by the traffic engineer

Following are eight of the most common causes of accidents in the workplace:

- Lifting. ...
- Fatigue. ...
- Dehydration. ...
- Poor Lighting. ...
- Hazardous Materials. ...
- Acts of Workplace Violence. ...
- Trips and Falls. ...
- Stress

ACCIDENT STUDIES, CAUSES, EFFECT AND PREVENTION OF ROAD ACCIDENTS

Road accident is most unwanted thing to happen to a road user, though they happen quite often. The most unfortunate thing is that we don't learn from our mistakes on road. Most of the road users are quite well aware of the general rules and safety measures while using roads but it is only the laxity on part of road users, which cause accidents and crashes. Main cause of accidents and crashes are due to human errors. We are elaborating some of the common behaviour of humans which results in accident.

Over Speeding

Drunken Driving

Distractions to Driver

Red Light Jumping

Avoiding Safety Gears like Seat belts and Helmets

Non-adherence to lane driving and overtaking in a wrong manner

Various national and international researches have found these as most common behavior of Road drivers, which leads to accidents.

FIG.1 OVER SPEED

Over Speeding:

Most of the fatal accidents occur due to over speeding. It is a natural psyche of humans to excel. If given a chance man is sure to achieve infinity in speed. But when we are sharing the road with other users we will always remain behind some or other vehicle. Increase in speed multiplies the risk of accident and severity of injury during accident. Faster vehicles are more prone to accident than the slower one and the severity of accident will also be more in case of faster the severity of accident will also be more in case of faster vehicles. Higher the speed leads greater the risk. At high speed the vehicle needs greater distance to stop i.e. braking distance. A slower vehicle comes to halt immediately while faster one takes long way to stop and also skids a long distance due to law of notion. A vehicle moving on high speed will have greater impact during the crash and hence will cause more injuries. The ability to judge the forthcoming events also gets reduced while driving at faster speed which causes error in judgment and finally a crash.

FIG.1 SKID BY OVER SPEED

Drunken Driving:

Consumption of alcohol to celebrate any occasion is common. But when mixed with driving it turns celebration into a misfortune. Alcohol reduces concentration. It decreases reaction time of a human body. Limbs take more to react to the instructions of brain. It hampers vision due to dizziness. Alcohol dampens fear and incite humans to take risks. All these factors while driving cause accidents and many a times it proves fatal. For every increase of 0.05 blood alcohol concentration, the risk of accident doubles. Apart from alcohol many drugs, medicines also affect the skills and concentration necessary for driving. First of all, we recommend not to consume alcohol. But if you feel your merrymaking is not complete without booze, do not drive under the influence of alcohol. Ask a teetotaler friend to drop you home.

FIG.3 DRUNK AND DRIVE

Distraction to Driver:

Though distraction while driving could be minor but it can cause major accidents.

Distractions could be outside or inside the vehicle. The major distraction now a days is talking on mobile phone while driving. Act of talking on phone occupies major portion of brain and the smaller part handles the driving skills. This division of brain hampers reaction time and ability of judgement. This becomes one of the reasons of crashes. One should not attend to telephone calls while driving. If the call is urgent one should pull out beside the road and attend the call. Some of the distractions on road are:

1.Adjusting mirrors while driving
2.Stereo/Radio in vehicle
3.Animals on the road
4.Banners and billboards.

The driver should not be distracted due to these things and reduce speed to remain safe during diversions and other kind of outside distractions.

FIG.4 DISTRACTION TO DRIVER

Red Light jumping:

It is a common sight at road intersections that vehicles cross without caring for the light. The main motive behind Red light jumping is saving time. The common conception is that stopping at red signal is wastage of time and fuel. Studies have shown that traffic signals followed properly by all drivers saves time and commuters reach destination safely and timely. A red light jumper not only jeopardizes his life but also the safety of other road users.

This act by one driver incites other driver to attempt it and finally causes chaos at crossing. This chaos at intersection is the main cause of traffic jams. Eventually everybody gets late to their destinations. It has also been seen that the red light jumper crosses the intersection with greater speed to avoid crash and challan but it hampers his ability to judge the ongoing traffic and quite often crashes.

FIG.5 JUMP OF SIGNAL

Avoiding Safety Gears like seat belts and helmets:

Use of seat belt in four-wheeler is now mandatory and not wearing seat belt invites penalty, same in the case of helmets for two wheeler drivers. Wearing seat belts and helmet has been brought under law after proven studies that these two things reduce the severity of injury during accidents. Wearing seat belts and helmets doubles the chances of survival in a serious accident. Safety Gears keep you intact and safe in case of accidents. Two wheeler deaths have been drastically reduced after use of helmet has been made mandatory. One should use safety gears of prescribed standard and tie them properly for optimum safety.

Detrimental effects of traffic on environment

- Safety
- Noise
- Land Consumption
- Air Pollution
- Degrading the Aesthetics

How different factors of Roads contribute in Accidents:

Drivers: Over-speeding, rash driving, violation of rules, failure to understand signs, fatigue, alcohol.

Pedestrian: Carelessness, illiteracy, crossing at wrong places moving on carriageway, Jaywalkers.

Passengers: Projecting their body outside vehicle, by talking to drivers, alighting and boarding vehicle from wrong side travelling on footboards, catching a running bus etc.

Vehicles: Failure of brakes or steering, tyre burst, insufficient headlights, overloading, projecting loads.

Road Conditions: Potholes, damaged road, eroded road merging of rural roads with highways, diversions, illegal speed breakers.

Weather conditions: Fog, snow, heavy rainfall, wind storms, hail storms.

Preventive measures for accidents:

- Education and awareness about road safety
- Strict Enforcement of Law
- Engineering:
  (a) Vehicle design (b) Road infrastructure

Direct Consequences of Accidents:

- Fatality (Death)
- Injury
- Property Damage

HUMAN FACTORS, VEHICLES, ROAD AND ITS CONDITION

Number of road accidents caused by vehicle defect factors in UK

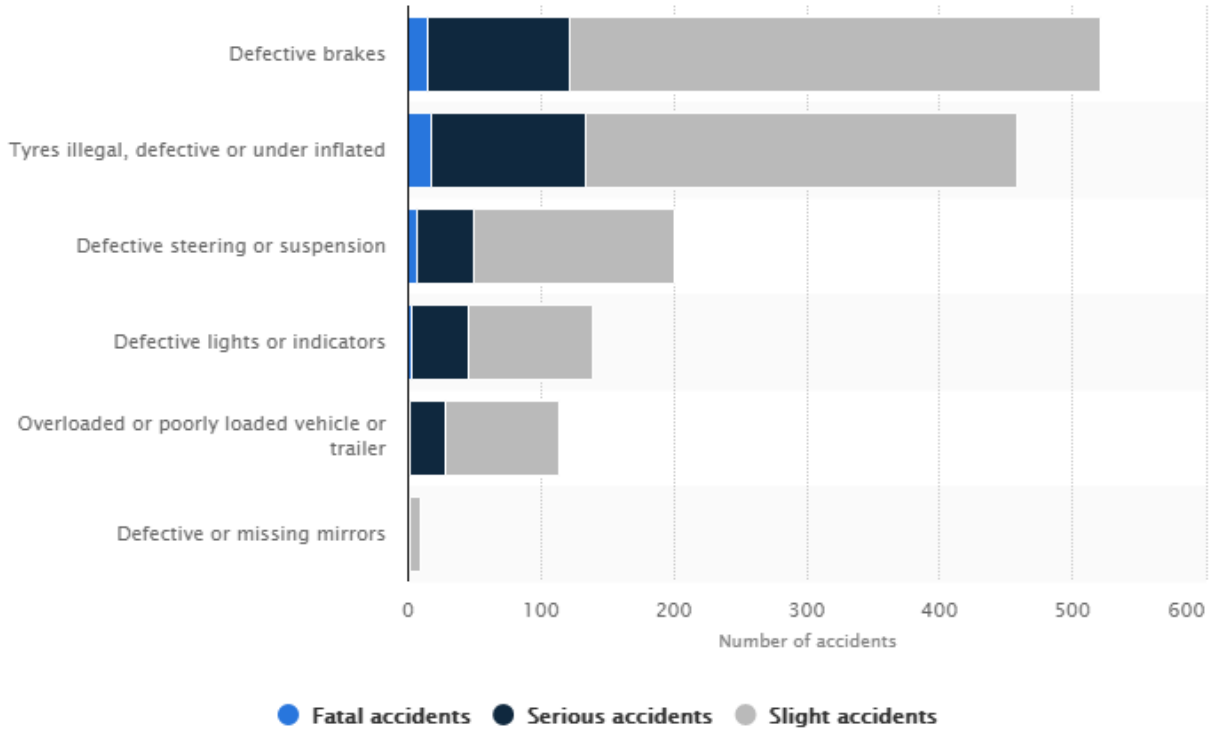

FIG.6 NUMBER OF ACCIDENTS BY VARIOUS FACTORS

Road accidents in India have declined from 42 per 1,00,000 population in 2010 to 36 in 2017, according to the ministry of **road** transport and **highways**. Even in absolute terms, **road accidents** have been falling since 2015, and the 2017 figure — 4,64,910, or 53 every hour — is the lowest since 2006. Mar 17, 2019

Over 50% of road accidents due to bad roads: Traffic cops (Hindu 12/10/2017)

FIG.7 PATCHES ON ROAD WHICH LEAD ACCIDENTS

A traffic police officer says many key roads have been rendered 'unmotorable'

On the day that Bangalore Development Minister K.J. George said that all the road accidents over the last week could not be attributed to potholes alone, senior traffic officers gave a contrarian view. Many traffic police officers claimed that at least half of the accidents in Bengaluru are due to bad roads. The remaining, for the most part, is because of rash and negligent driving. "Bad road engineering, made worse due to incessant rains that we've been seeing, is the cause for 50% of the accidents. Many key roads have been rendered unmotorable," said a traffic police officer. With the situation becoming increasingly politicised and the Chief Minister pulling up the civic body for its inability to solve the problem, police officers spoke to The Hindu on condition of anonymity.

The Road Accidents in India Report of 2015 by the Ministry of Road Transport and Highways noted that in Karnataka, the number of fatalities in road accidents was 10,856 and injuries was 56,971. While 465 accidents and 82 deaths in the State were caused due to the road being under repair/construction, 248 accidents occurred because of 'loose surface', resulting in 55 deaths. Another 182 accidents were caused by potholes. Prof. M.N. Sreehari , traffic advisor and consultant, blamed apathy and the inability of the police to book civic agencies. "Though there is a provision for the traffic police to book civic agencies for negligence. The police are not doing it regularly," he said. Even as the blame game continues, there is little immediate relief for motorists and pedestrians.

How to make roads safer

In her report to the select committee examining the Motor Vehicle (Amendment) Bill, 2016, Commissioner for Traffic and Road Safety D. Roopa submitted 16 points for the safe movement of traffic, including making the civic agencies concerned criminally liable in case of accidental deaths due to bad roads. Other highlights:

- Punishment for hit-and-run case should be increased
- City municipal corporations, while giving approval for building plans, should ensure that the road on which the building is coming up can take the traffic load

- Parking space should be mandatory during registration of vehicles. Those who have provision for parking space should only be allowed for registration

Deaths since October 3

October 10: Kavitha, 20, who was riding pillion, was killed and the rider was injured after the duo slipped and fell on the road while negotiating a bad stretch near Shettarahalli Gate in Devanahalli. Kavitha was run over by a truck. Her sister Vijayalakshmi escaped with minor injuries

October 8: Radha, 47, who was riding pillion came under the wheels of a truck when her nephew Ravi Kumar lost control of the scooter while negotiating a bad stretch at Nayandahalli junction. Ravi sustained injuries

October 3: A couple was killed and their grandson was injured when a Tamil Nadu-bound bus hit their motorcycle on the busy K.R. Market flyover when the rider was trying to negotiate a bad stretch

ROAD ACCIDENTS

Poor enforcement, training: The reasons why there are so many road accidents in India

India's traffic laws are stricter than those of other countries, but these laws are not enforced

Road accidents cost India 3-5% of gross domestic product every year, and are avoidable if India could improve its roads and city planning, train its drivers better, and enforce traffic laws properly, an India spend analysis shows. India's young, productive population, aged 18-45 years, is involved in 70% of road accidents, according to data from Road Accidents in India 2018, a report published by the Ministry of Road Transport and Highways. Over a period of 24 years from 2014 to 2038, if India could halve the deaths and injuries due to road traffic, its GDP could increase by 7%, a 2018 World Bank report said.

In 2018, India had 467,044 reported road accidents, an increase of 0.5% from 464,910 in 2017, according to the road ministry's data. India has 1% of the world's vehicles but accounts for 6% of the world's road traffic accidents, according to data from a 2018 World Health Organization report. As many as 73% of all deaths due to road traffic accidents in 2018 in the South and South-East Asia region happened in India, the report said. Road accidents are one

of the 12 most common causes of deaths in India, the ninth most common cause of premature deaths, and the 10th most common reason for disability, according to the 2017 WHO Global Health Estimates. In 2018, of all road deaths, the most were of those riding two-wheelers (36%), followed by pedestrians (15%), ministry data shows.

Speed and drink driving

The two most frequent causes of road deaths are speeding and drunk driving, followed by a lack of lane discipline (driving on the wrong side), jumping the red light and the use of a mobile phone while driving, data shows.

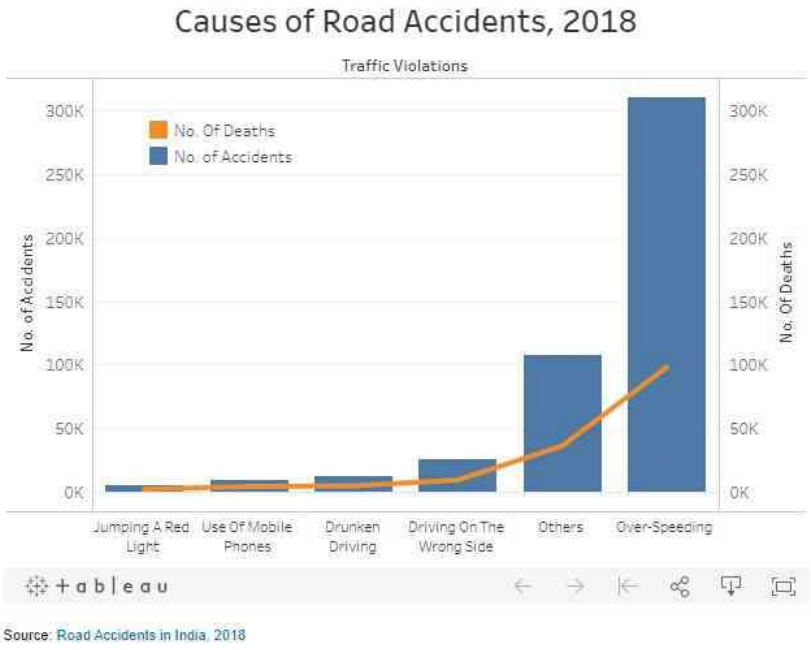

FIG.8 CAUSES OF ROAD ACCIDENTS

Over speed is the most common cause of deaths on roads in India, with 64% of road deaths because of speeding. Sixty per cent of the accidents in India occur on highways, mostly because of speeding, said Piyush Tewari from Save a Life Foundation. The most deaths due to speeding were in Rajasthan (9,618 deaths), followed by Tamil Nadu (9,224 deaths) and Karnataka (8,714 deaths). The fine for speeding has increased from Rs 500 to Rs 5,000 since September, 2019 under the new Motor Vehicles Act of 2019. In addition, drivers could also be imprisoned for three months for speed racing – an illegal race – if it is their first offence, and for a period of one year if it is the second offence, according to the law. The current speed limit in the country is 80 km per hour on a 4-lane highway. However, the WHO

has recommended that if we reduce the speed limit to about 55-57 km per hour, we could save around 30%-37% lives, said Patanjali Nayyar, regional advisor for the WHO.

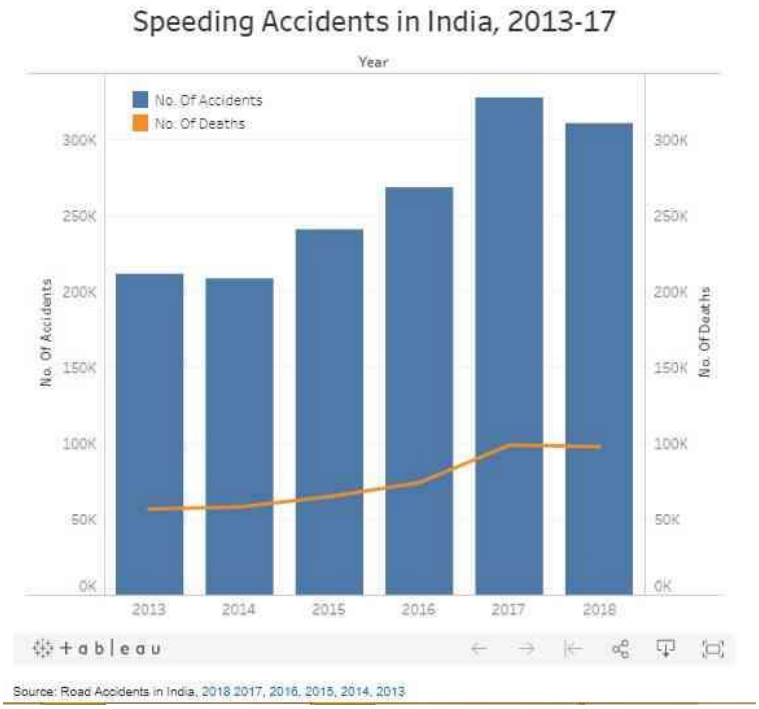

FIG.9 ACCIDENTS DUE TO OVER SPEED

Accidents due to drunk driving – under the influence of alcohol or drugs – declined by 14% between 2017 and 2018 because of an increase in fines and better implementation of laws, mostly in metro cities, and because of greater media coverage of the issue, according to experts. The new motor vehicles law increased punishment for the first offence to imprisonment up to six months and/or fine up to Rs 10,000, and for the second offence to two years and/or fine of Rs 15,000. Earlier, the fine was Rs 2,000 or six months for the first offence and Rs 3,000 or two years imprisonment, according to the Motor Vehicles Act 1989.

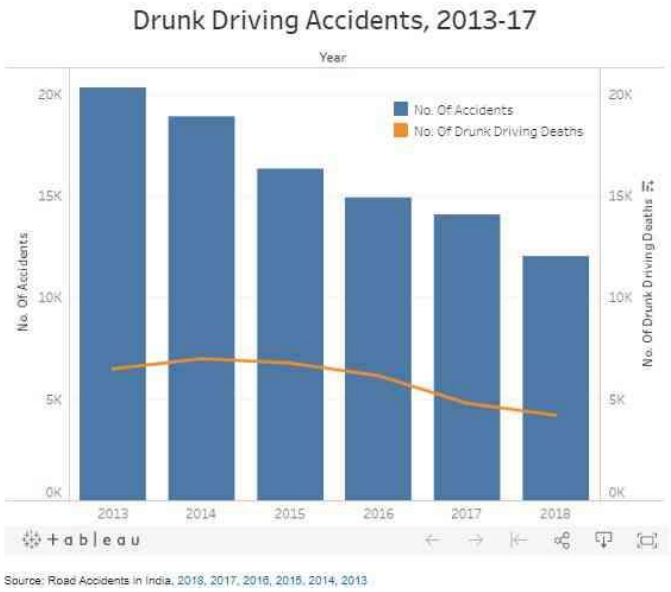

FIG.9 ACCIDENTS DUE TO DRUNK AND DRIVE

Poor enforcement

India's traffic laws are stricter than those of other countries but these laws are not enforced. In many other countries, such as the UK, Australia, New Zealand, where they have better enforcement, the alcohol is limit is 0.08 mg/l, higher than the 0.05 mg/l in India, said Nayyar of the WHO. "In many countries crashes due to alcohol have been reduced due to enforcement of their laws and education." India's enforcement of laws on speeding and drunk driving are rated 3 and 4 out of 10, respectively, compared to 8 and 9 in China and 9 (for both) in Sri Lanka, by the Global Road Safety Report 2018, that analysed traffic laws of 175 countries.

India has a paucity of traffic police – 30% of 85,144 traffic policemen positions and 39% of 58,509 sanctioned traffic constable positions were vacant in 2018, according to data from the Bureau of Police Research and Development. Enforcement of laws can reduce drunk driving, said Tewari of Save a Life Foundation, and gave the example of Satyendra Garg, who was the joint commissioner of traffic in New Delhi in 2012 and would conduct random "anti-drink and drive drives" almost every day. Because of the fear of these checks, people stopped drinking and driving, Tewari said. Over 12,000 people were prosecuted for drunk driving in New Delhi in 2011, up from 8,648 in 2010, according to data from the International Road Federation, a global non-profit working on road safety.

prone to corruption," said Tewari. He suggests using artificial intelligence, in the form of road sensors to detect speed, and adaptive traffic lighting (in which traffic signal timing changes, or adapts, based on actual traffic demand) for enforcing traffic laws, such as in Sri Lanka and Bhutan.

City planning

On many roads there are no traffic-calming measures such as speed humps before intersections or median barriers, Tewari said. Roads should be made not just for use by four-wheelers but also for two-wheelers and pedestrians, and towns should be planned not just for expressways and commercial areas but also for hawkers and vendors, Nayyar said. For instance, safer highways should be created by adding underpasses for pedestrians, especially those that are vulnerable, such as pregnant women and the elderly. Nayyar gave the example of the Delhi-Agra highway where the highway has divided villages, but there are no pedestrian crossings. "How do we expect people whose village has been divided by that highway to crossover to their fields everyday? There are some villages on this stretch of the highway that are villages of widows due to the deaths caused by road accidents," Nayyar said.

Driver training

In 2018, in 26% of all road accidents, drivers who were in an accident did not have a valid license or were driving with a learner's license, ministry data shows. In any case, licences are not a sign that the driver is qualified, experts said. For example, if we go out and ask drivers about the three-second rule (which ensures driving at a safe speed, and the distance between two vehicles) or whether they are aware of a blindspot in their vehicle while driving, 99% will not know because they have not received any sort of formal training, said Tewari. "Basically we made a road and allowed untrained drivers...Drivers need hard skills training on driving, not just ads and awareness," he said. "We have announced that we will reduce traffic deaths by 50%. This is a joke unless and until we combine efforts in the four E's: engineering, enforcement, education, and emergency response," Tewari said.

Data management systems

India had about 300,000 road deaths in 2016, almost double the government estimate of 151,000 deaths, according to the 2018 Global Road Safety report of the WHO,

highlighting the lack of quality road accident data. “The data is deeply fractured… The biggest challenge in data collection in road accidents is the crash investigation report. When a crash occurs very little is done to determine the cause of the crash. Attempt is made to fix the responsibility on the driver of the bigger car,” said Piyush Tewari. For instance, in states where alcohol is banned, such as Bihar, Nagaland and Gujarat, there has been a decline in accidents due to drunk driving, data shows.

“My sense is that the more you ban something, the more people are likely to do it,” Tewari said. But not all states have a good data management system, so they might be under-reporting accidents or not managing the data well, he explained. “The state of Kerala has banned alcohol, but it also has a very good data recording system,” Tewari said. In Kerala, drunk driving accidents increased from 35 in 2014 to 133 in 2017. Alcohol was banned in the state between 2014 and 2017. Goa, with the highest per capita availability of alcohol, had no road deaths due to drunk driving in 2016, which is likely to be because of an error in collecting information on accidents, Tewari said. In 2018, Goa reported nine accidents due to drunk driving and four deaths.

Often, traffic police do not have the necessary equipment to determine the cause of an accident. For instance, most police report a case of drunk driving only through smelling, since most of them do not have a breathalyzer, especially in smaller cities, said Patanjali Dev Nayyar, the regional advisor for disability, injury prevention and rehabilitation at WHO. “If the police arrive late at the scene of the accident, it is difficult to determine whether alcohol was involved,” Daniel Keniston, an assistant professor at Yale University, told IndiaSpend in July 2017. This article first appeared on India spend, a data-driven and public-interest journalism non-profit

ENVIRONMENTAL STUDIES, AIR AND NOISE POLLUTION, CAUSES

The impact of environmental factors on traffic accidents in Iran

According to the recently published World Health Organization (WHO) global status report on road safety, annually road traffic crashes (RTCs) injure about 50 millions and kill as many as 1.2 million people worldwide. Exposure to RTCs is a serious public health challenge in Iran because of a variety of reasons. These include the tendency of young population to adventurous driving, low gas price, the use of private vehicles rather than public transport,

and non-standard safety designs. Also, with respect to the oil and gas economy, the growth of Iran's automotive industry led to a significant increase in the number of registered vehicles to 17 millions in 2008. The WHO report shows that 22,918 road traffic fatalities occurred in Iran during 2007-2008. According to the estimate reported in 2005, the mortality due to traffic crashes in Iran rated highest among all countries of the world.

The effect of environment on several health issues has been an interesting topic for researchers for a long time. For instance, meteorological factors are known to modulate human health status. In the field of RTCs, a growing body of studies has reviewed the relationship between environmental factors and RTCs. Some reports analyzed pedestrian volume, traffic volume, roadway geometrics, weather and other seasonal effects as environmental factors. Others discussed the effect of light condition during day and night on RTCs. Several studies have focused on different aspects of RTCs in Iran during recent years. However; there is no published report on the impact of environmental factors on RTCs. The aim of the present study was to determine the association between environmental factors and RTCs in Iran so as to provide an insight into potential effect of environmental factors on RTCs and to improve preventive measures.

METHODS

This cross-sectional study was conducted in Iran from March 21, 2010 to December 30, 2010. The most recent and reliable RTC data were obtained from the center for information and communication technology (ICT) of the Traffic Police Department. These included 542,863 RTC records which were classified to control for the main confounders associated with crash type involving death in the scene of crash, injurious and benign traffic accidents and roadway-associated environmental factors. Roadway environmental factors involve light in the scene of crash (daytime, nighttime, sunrise and sunset), weather conditions such as clear, foggy, snowy, rainy, stormy, cloudy, and dusty, place of crash (motorway, road shoulder, middle lane, roadside, outside of road limit and unknown), roadway conditions (good, damaged, defective traffic signs, road narrowing, bumps, unstable shoulders or lack of shoulders, absence of standard road guard, partial road collapse, defective pavements, acute angle, non-standard grading, defective lighting, slippery and unknown), roadway geometrics (straight and flat, straight with uphill/downhill orientations, winding and flat road, winding and uphill/downhill road) and roadway surface (dry, wet, freezing and snowy, sandy, muddy, and oily). The characteristics of each confounder were

then determined to analyze the association between roadway environmental factors and RTCs.

All data were analyzed using SPSS statistical software, version 11.5. The results are reported as descriptive indices such as frequency (percentage). Comparisons between the type of crash and other variables were done using chi-squared test. Multinomial logistic regression was used to assess the odds of type of crash (injury and death in scene) relative to the reference group of non-injured vehicular crash. P value less than 0.05 was considered significant.

RESULTS

The crash and environment-related information of the total RTCs and and33 represent a compilation of the type of crash according to a number of environment and road- related factors. Of all entities demonstrated in foregoing Tables, scene light, weather condition, place of crash, roadway defect, roadway geometrics and roadway surface were significantly associated with type of crash. A total of 393,310 (72.45%) RTCs occurred at daytime, followed by 122,957, (22.65%) at night time. As observed in Table 2, the proportion of RTCs which led to injury (24.44% at sunrise and 27.16% at sunset) and death (5.43% at sunrise and 1.43% at sunset) were significantly higher than those occurring during daytime (20.50% injury and 0.55% death, $P < 0.001$). The odds of injury and death in scene were higher at night, sun rise and sun set than daytime. In this respect, crash was more dangerous at sunrise.

The greatest number of crashes was 471,759 (86.90%) which took place in clear weather and only 0.04% of RTCs occurred in dusty weather, which had the highest rate of death compared to other weather conditions (5.07%,$P <0.001$). The odds of injury was higher in dusty weather and lower in foggy, snowy, rainy and cloudy weather than the clear weather. The odds of death in scene was higher in dusty, foggy, snowy, rainy and stormy weather than in clear weather. Crash was more dangerous in dusty weather. In terms of road surface, 492,757 (90.77%) crashes occurred on dry surfaces, while oily surfaces caused the highest rate of mortality (3.45%, $P<0.001$).

In regard to RTC- related defects, defective traffic signs (30,046, 5.58%) and road narrowing (22,775, 4.23%) were the most frequently identified defects. Flat straight and winding uphill/downhill road were two roadway geometrics representing the highest and lowest proportions of crashes (346,168, 63.77% and 4,862, 0.90%, respectively). In contrast,

these two roadway geometrics inflicted the minimum (0.74 %) and maximum (3.09%) RTC-related deaths P<0.001).

DISCUSSION

To our knowledge, similar studies on the association between environmental factors and RTCs have not been reported from Iran. Our study showed that most crashes occurred during daytime hours, which were considerably higher than those observed at sunrise or sunset. The working day traffic accounts for greater number of crashes. In an earlier study in Iran, the number of RTCs was reported to depend on the time of the day, where higher incidence of car crashes was found during rush hour.

We found that the proportion of RTCs which led to injury and death was significantly higher at sunrise or sunset than daytime hours. The highest rates of RTC fatalities at sunrise could be due to poor visibility because of insufficient light at sunrise and driver's sleepiness, inattention and lack of alertness at sunrise which resulted from sleep deprivation during the night. Previous studies reported the higher risk of death or severe injury due to RTC, which was significantly related to driving in poor visibility and also driving at night time.

Weather is usually clear and sunny in most days. Iran's climate ranges from arid or semiarid in most parts and the mean annual rainfall is reported 332 millimeters. Clear weather had the lowest death rate among all weather conditions. In this context, dusty weather had the highest death rate compared to other weather conditions. According to the study of Shankar et al., the maximum rainfall played a significant role in road traffic crashes.[9] The higher rates of RTC fatalities in non-clear weather could be explained by (a) poor visibility due to rainy, snowy or sandy weather (b) the road surface which may be more slippery in non-clear weather, thus reducing the vehicle-roadway friction. Previous study by Hijar et al., in Mexico showed a definite association of adverse environmental conditions such as rain, fog, and wet pavement as well as driving in daylight with traffic crash. Kashani et al., in their recent study revealed that weather and road surface conditions, shoulder type and road width, lighting as well as location type are less important variables, influencing the injury severity by traffic crashes than the use of seat belt, cause of crash and collision type.

In our study, winding uphill/downhill road was the roadway geometry with the highest rate of RTC- related death. This roadway geometry limits the driver's vision and causes difficult control of vehicle at crash time with subsequent increase in fatal RTC risk.

For RTCs associated with known roadway defect, we found defective traffic signs and road narrowing to be the most frequent defects. Traffic signals and signs are universally accepted interventions which are effective in reducing RTC- related injuries and deaths. In a recent study conducted on the main factors affecting traffic crashes in Iran, it was observed that most rural accidents occurred in the main roads and highways. The main accident-related factors were wider roads, denser traffic, road narrowing and ignoring traffic regulations. The crashes occurring in highway resulted from the lack of appropriate road repair and installing suitable traffic signs.[24]

In conclusion, in our analysis of traffic crash in Iran, we found light in the scene of crash, weather condition, roadway geometrics and road surface to be the important contributors to traffic crash injuries and deaths. Based on the results obtained, it is recommended to introduce changes to the road-associated environmental conditions, a measure highly beneficial to reducing RTC-related injuries and deaths. Air pollution has many sources, but mainly stems from industry, transport, energy production and agriculture. ... Environmental **noise** levels are rising in urban areas, mainly as a result of increasing traffic volumes and intensifying industrial and recreational activities.

What causes the most pollution in the air?

Most of this air pollution we cause results from the burning of fossil fuels, such as coal, oil, natural gas, and gasoline to produce electricity and power our vehicles. Carbon dioxide (CO_2) is a good indicator of how much fossil fuel is burned and how much of other pollutants are emitted as a result.

Is noise an air pollutant?

World Health Organization (WHO) highlights in recent reports that environmental noise can be considered as a pollutant that has a significant impact on public health.

Noise pollution, also known as environmental noise or sound pollution, is the propagation of noise with ranging impacts on the activity of human or animal life, most of them harmful to a degree. The source of outdoor noise worldwide is mainly caused by machines, transport, and propagation systems. Poor urban planning may give rise to noise disintegration or pollution, side-by-side industrial and residential buildings can result in noise pollution in the residential areas. Some of the main sources of noise in residential areas

include loud music, transportation (traffic, rail, airplanes, etc.), lawn care maintenance, construction, electrical generators, explosions, and people.

Documented problems associated with noise in urban environments go back as far as ancient Rome. Today, the average noise level of 98 decibels (dB) exceeds the WHO value of 50 dB allowed for residential areas. Research suggests that noise pollution is the highest in low-income and racial minority neighborhoods, and noise pollution associated with household electricity generators is an emerging environmental degradation in many developing nations. High noise levels can contribute to cardiovascular effects in humans and an increased incidence of coronary artery disease. In animals, noise can increase the risk of death by altering predator or prey detection and avoidance, interfere with reproduction and navigation, and contribute to permanent hearing loss. A substantial amount of the noise that humans produce occurs in the ocean. Up until recently, most research on noise impacts has been focused on marine mammals, and to a lesser degree, fish. In the past few years, scientists have shifted to conducting studies on invertebrates and their responses to anthropogenic sounds in the marine environment. This research is essential, especially considering that invertebrates make up 75% of marine species, and thus compose a large percentage of ocean food webs. Of the studies that have been conducted, a sizable variety in families of invertebrates have been represented in the research. A variation in the complexity of their sensory systems exists, which allows scientists to study a range of characteristics and develop a better understanding of anthropogenic noise impacts on living organisms.

While the elderly may have cardiac problems due to noise, according to the World Health Organization, children are especially vulnerable to noise, and the effects that noise has on children may be permanent. Noise poses a serious threat to a child's physical and psychological health, and may negatively interfere with a child's learning and behaviour. Noise pollution affects both health and behavior. Unwanted sound (noise) can damage physiological health. Noise pollution is associated with several health conditions, including cardiovascular disorders, hypertension, high stress levels, tinnitus, hearing loss, sleep disturbances, and other harmful and disturbing effects. According to a 2019 review of the existing literature, noise pollution was associated with faster cognitive decline.

Across Europe, according to the European Environment Agency, an estimated 113 million people are affected by road traffic noise levels above 55 decibels, the threshold at which noise becomes harmful to human health by the WHO's definition. A sound level meter,

is one of the main tools for measuring sounds in the environment and the workplace. Sound becomes unwanted when it either interferes with normal activities such as sleep or conversation, or disrupts or diminishes one's quality of life. Noise-induced hearing loss can be caused by prolonged exposure to noise levels above 85 A-weighted decibels. A comparison of Maaban tribesmen, who were insignificantly exposed to transportation or industrial noise, to a typical U.S. population showed that chronic exposure to moderately high levels of environmental noise contributes to hearing loss.

Noise exposure in the workplace can also contribute to noise-induced hearing loss and other health issues. Occupational hearing loss is one of the most common work-related illnesses in the U.S. and worldwide. It is less clear how humans adapt to noise subjectively. Tolerance for noise is frequently independent of decibel levels. Murray Schafer's soundscape research was groundbreaking in this regard. In his work, he makes compelling arguments about how humans relate to noise on a subjective level, and how such subjectivity is conditioned by culture. Schafer also notes that sound is an expression of power, and as such, material culture (e.g., fast cars or Harley Davidson motorcycles with aftermarket pipes) tend to have louder engines not only for safety reasons, but for expressions of power by dominating the soundscape with a particular sound. Other key research in this area can be seen in Fong's comparative analysis of soundscape differences between Bangkok, Thailand and Los Angeles, California, US. Based on Schafer's research, Fong's study showed how soundscapes differ based on the level of urban development in the area. He found that cities in the periphery have different soundscapes than inner city areas. Fong's findings tie not only soundscape appreciation to subjective views of sound, but also demonstrates how different sounds of the soundscape are indicative of class differences in urban environments.

Noise pollution can have negative effects on adults and children on the autistic spectrum. Those with Autism Spectrum Disorder (ASD) can have hyperacusis, which is an abnormal sensitivity to sound. People with ASD who experience hyperacusis may have unpleasant emotions, such as fear and anxiety, and uncomfortable physical sensations in noisy environments with loud sounds. This can cause indiuals with ASD to avoid environments with noise pollution, which in turn can result in isolation and negatively affect their quality of life. Sudden explosive noises typical of high-performance car exhausts and car alarms are types of noise pollution that can affect people with ASD.

The Hierarchy of Controls concept is often used to reduce noise in the environment or the workplace. Engineering noise controls can be used to reduce noise propagation and protect individuals from overexposure. When noise controls are not feasible or adequate, individuals can also take steps to protect themselves from the harmful effects of noise pollution. If people must be around loud sounds, they can protect their ears with hearing protection (e.g., ear plugs or ear muffs). In recent years, Buy Quiet programs and initiatives have arisen in an effort to combat occupational noise exposures. These programs promote the purchase of quieter tools and equipment and encourage manufacturers to design quieter equipment.

Noise from roadways and other urban factors can be mitigated by urban planning and better design of roads. Roadway noise can be reduced by the use of noise barriers, limitation of vehicle speeds, alteration of roadway surface texture, limitation of heavy vehicles, use of traffic controls that smooth vehicle flow to reduce braking and acceleration, and tire design. An important factor in applying these strategies is a computer model for roadway noise, that is capable of addressing local topography, meteorology, traffic operations, and hypothetical mitigation. Costs of building-in mitigation can be modest, provided these solutions are sought in the planning stage of a roadway project. Aircraft noise can be reduced by using quieter jet engines. Altering flight paths and time of day runway has benefited residents near airports

LEGAL STATUS

India

Noise pollution is a major problem in India. The government of India has rules and regulations against firecrackers and loudspeakers, but enforcement is extremely lax. Awaaz Foundation is a non-governmental organization in India working to control noise pollution from various sources through advocacy, public interest litigation, awareness, and educational campaigns since 2003. Despite increased enforcement and stringency of laws now being practiced in urban areas, rural areas are still affected. The Supreme Court of India had banned playing of music on loudspeakers after 10pm. In 2015, The National Green Tribunal directed authorities in Delhi to ensure strict adherence to guidelines on noise pollution, saying noise is more than just a nuisance as it can produce serious psychological stress. However, implementation of the law continues to remain poor.

MEASURES TO PROMOTE PUBLIC TRANSPORT

These are some of the top strategies they discussed:

- Make **public transport** more cost-effective. ...
- Make active **transport** more seamless at your facilities. ...
- Provide discounted bike-share or car-share memberships. ...
- Advocate for sustainable **transport** infrastructure in your neighborhood. ...
- Foster carpooling. ...
- Disincentivize driving.

Why promote public transport?

By encouraging staff to use public transport, employers can:

- Reduce transport impacts and worksite parking demand
- Promote employee health and wellbeing through physical activity (walking or cycling to stops), making better use of travel time and reducing their travel costs.

How to promote public transport?

There are many ways to promote public transport in your workplace.

Use workplace media such as your intranet, staff newsletters and noticeboards to promote awareness of public transport services and build using public transport as a positive norm. Staff inductions and workplace relocation can also provide an opportunity to promote public transport for work-related trips.

Messages to communicate with staff could include:

- Colleagues use public transport - Use personal profiles to showcase employees who catch the bus, train or ferry to commute to work or for business trips
- Local services – highlight proximity of your workplace to bus, train or ferry services, this could include high frequency services, free transit zone and CAT buses, and the destinations they connect with

- Use your time – commuting by public transport can provide employees with time they can use, e.g. catching up on social media, reading or relaxing
- Save money – public transport may be cheaper than driving, especially if staff use Smart Riders with auto load.

- Help is at hand – Transport offers many ways to access information including the Transperth website, Your Move Info Line, the Transport App. Employees can sign up to My Account to manage their SmartRider and hear about service changes. There are many safety measures across the Transport system too use the streets.

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SCHOOL OF BUILDING AND ENVIRONMENT

DEPARTMENT OF CIVIL ENGINEERING

UNIT – V – TRAFFIC MANAGEMENT SCI1609

INTRODUCTION

TRANSPORTATION SYSTEM MANAGEMENT

Transportation System Management (TSM) is a package of short term measures to make the most productive and cost-effective use of existing transportation facilities, services and modes.

SCOPE OF TRAFFIC MANAGEMENT MEASURES TRAFFIC MANAGEMENT MEASURES

- Restrictions on turning movements
- One – way streets
- Tidal-flow operations
- Exclusive bus lanes
- Closing side streets

Restrictions on turning movements

- Problem posed by turning traffic
- Prohibited right-turning movement
- Prohibited left-turning movement

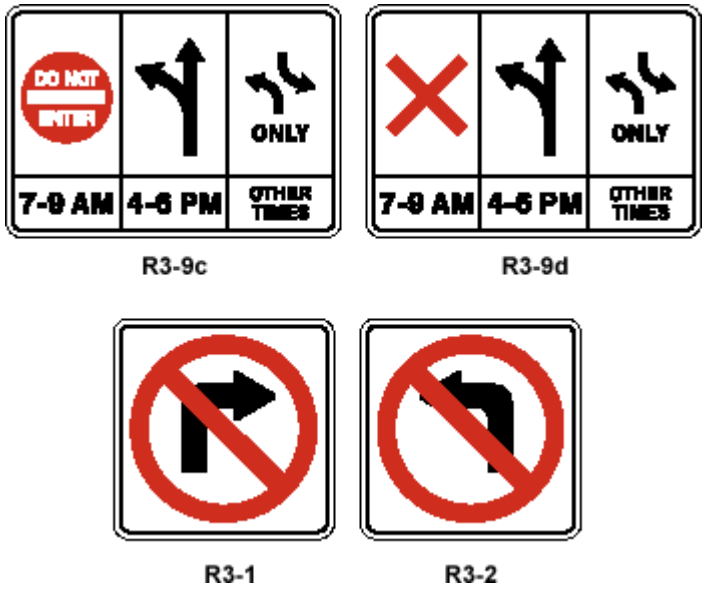


FIG.1 TURNING RESTRICTION

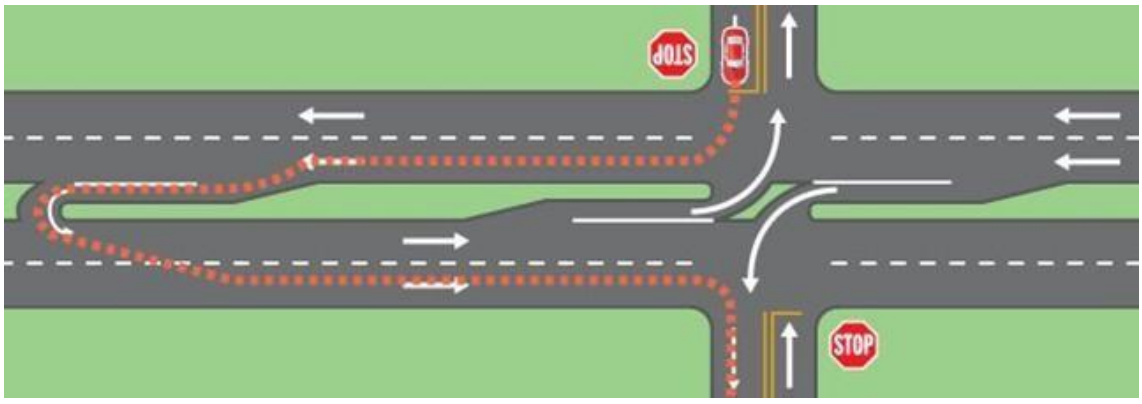


FIG.2 TURNINGS ALONG TWO-WAY ROAD

One – way streets

Advantages:

- Reduction in the points of conflict
- Increased capacity
- Increased speed
- Facilities the operation of a progressive signal system
- Improvement in parking facilities
- Elimination of dazzle and head-on collision

TIDAL-FLOW OPERATIONS

Tidal flow operation is a traffic management process whereby the carriageway width is shared between the two directions of travel in near proportion to the flow in each direction.

FIG.2 TIDAL FLOW MOVEMENT

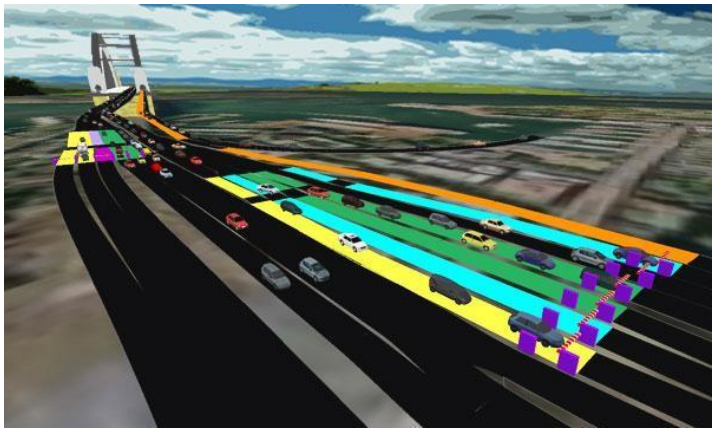


FIG.3 TOLL PLAZA WITH TIDAL FLOW

A bus lane or bus only lane is a lane restricted to buses, often on certain days and times, and generally used to speed up public transport that would be otherwise held up by traffic congestion. Certain other vehicles may also be permitted, such as taxis, high occupancy vehicles, motorcycles, or bicycles.

FIG.3 EXCLUSIVE BUS LANE

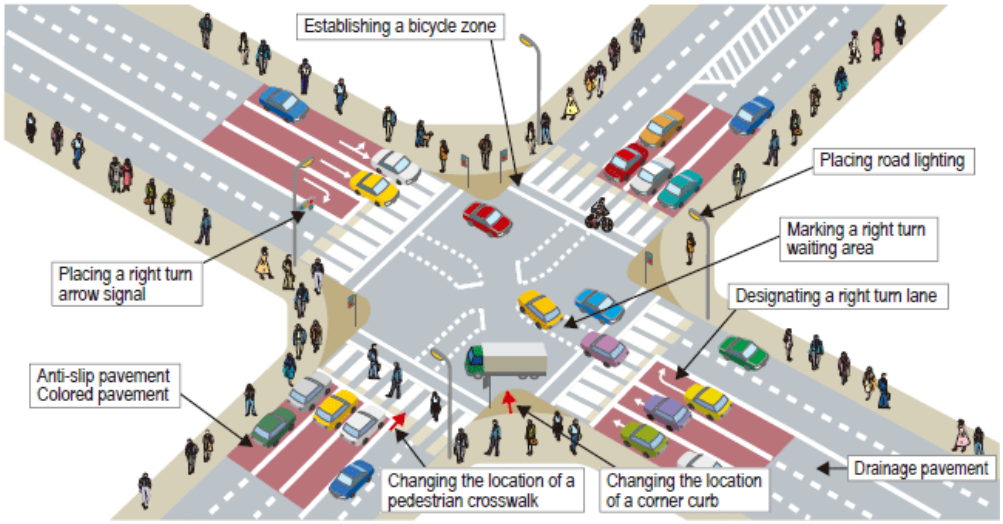


FIG.4 MEASURES IN HIGH ACCIDENT ZONE

TRAVEL DEMAND MANAGEMENT

List of Techniques commonly adopted:

- Car pooling and other ride-sharing programmes
- Peripheral parking schemes
- Chartered buses (Institutional buses) to serve areas of trip origins to common work place
- Staggering of office hours and flexible time to work
- Internal shuttle service in CBD
- Parking restraint
- Road Pricing
- Entry fee
- Priority for buses in traffic
- Restrictions on entry of trucks during day time

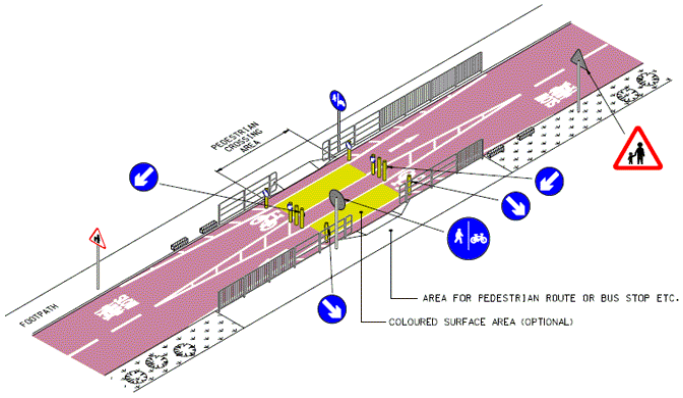
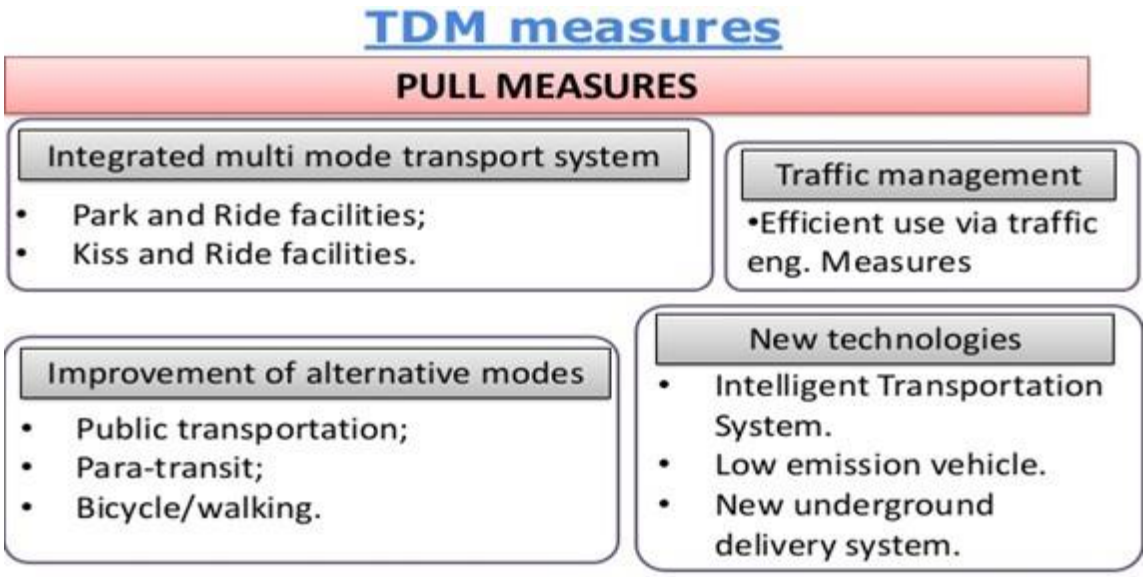


FIG.5 BUS BAYS

TDM measures

PULL MEASURES	PUSH MEASURES
•Traffic management. •Improvement of alternative modes. •Integrated multi mode transport system. •New technologies.	•Increasing vehicle occupancy. •Influencing time and need of travel. •Creating deterrence by introducing charges. •Imposing restrictions. •Land use and urban planning

•**Pull measures** aims at **attracting** the road users to alternative modes, whereas **push measures** tries to **demoralize car users**.	Demand side •Reducing the vehicle by modal change and HOV. •Redistributing the vehicles by changing time and space of travel.



INTRODUCTION TO MODERN DEVELOPMENT IN TRAFFIC ENGINEERING

FIG.6 INTELLIGENT TRANSPORTATION

ITS is an emerging transportation system which is comprised of an advanced information and telecommunications network for users, roads and vehicles. ITS is the integrated application of advanced Technologies using electronics, computers, communications, and advanced sensors.

Program Areas includes different ITS applications:

- Freeway management
- Incident management
- Transit management
- Arterial management
    - Emergency management
    - Electronic payment
    - Traveller information
    - Crash prevention and safety
    - Operations and maintenance
    - Road weather management

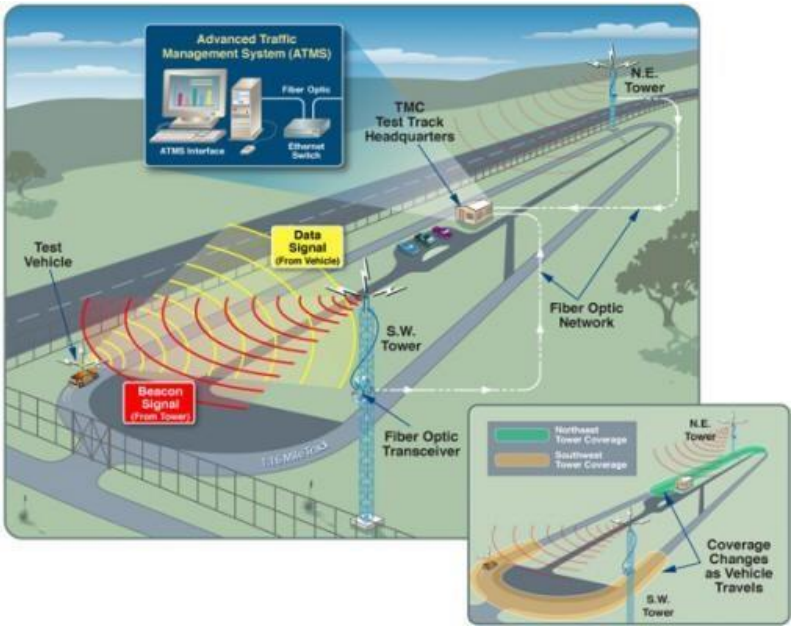


FIG.7 ADVANCED TRAFFIC MANAGEMENT SYSTEM

Benefits of ITS

- Safety improvements
- Delay savings
- Throughput
- Customer satisfaction
- Cost savings
- Environmental
- Other.

Advanced Traffic Management System (ATMS)

ATMS integrates various sub-systems such as CCTV, vehicle detection, communications, variable message systems, etc into a coherent single interface that provides real time data on traffic status and predicts data for more efficient planning and operations.

Advanced Traveler Information System (ATIS)

It provides to the users of transportation system, travel related information to assist decision making on route choices, estimate travel times and avoid congestion. This can enable by providing different information using various technologies such as,

- GPS enabled in-vehicle navigation system
- Dynamic road message signs for real time communication of information on traffic congestions, bottlenecks, accidents and alternate route information during road closure and maintenance.
- Website to provide a colour-coded network map showing congestion levels on highways.

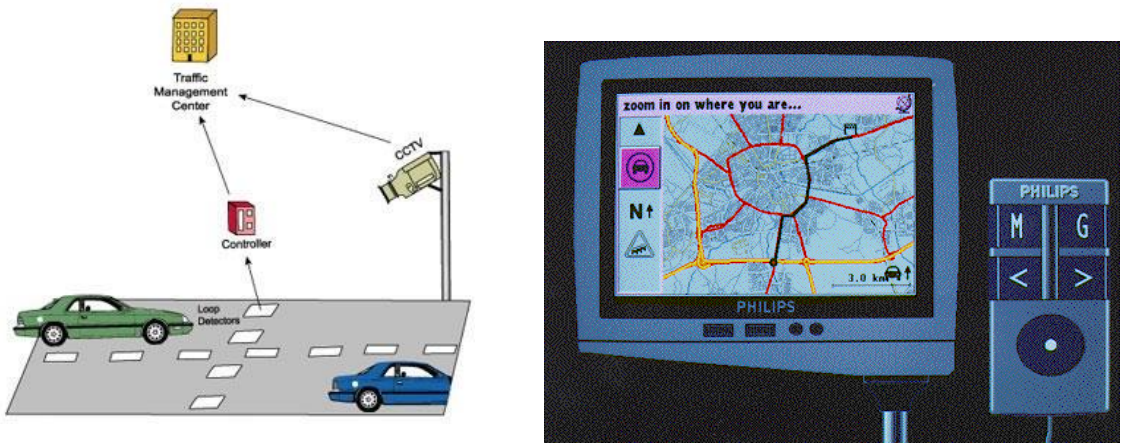


FIG. 8 ADVANCED TRAVELLER INFORMATION SYSTEM

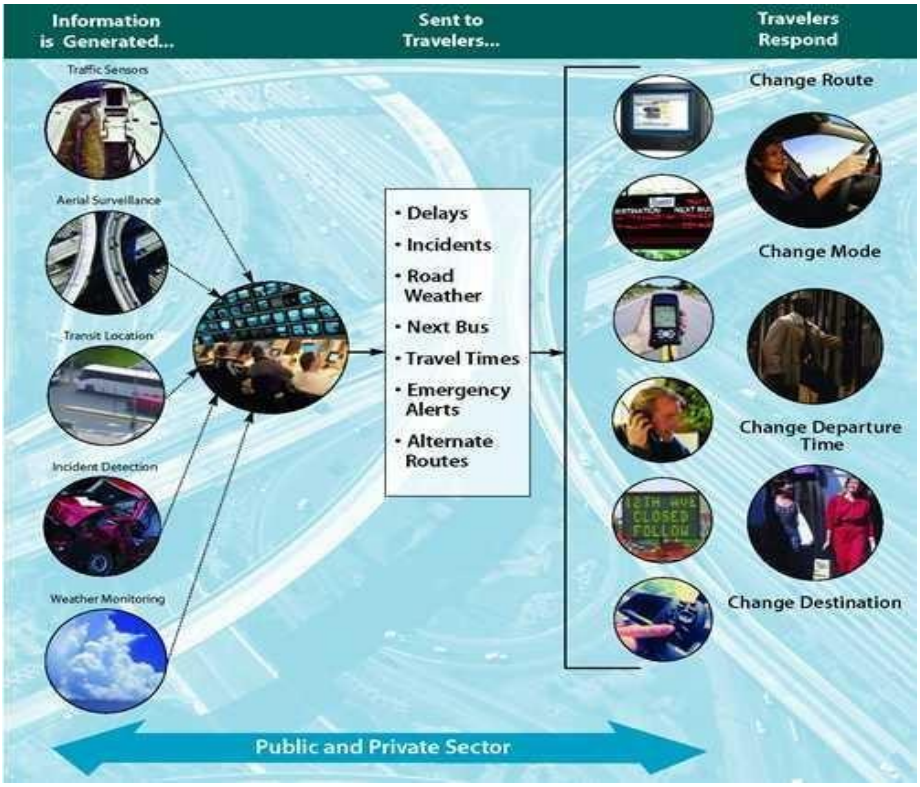


FIG. 8 ITS COMPONENTS

Advanced Vehicle Control System (AVCS)

These are the tools and concepts that enhance the driver's control of vehicle to make travel safer and more efficient. In vehicle Collision warning System alert the driver to a possible imminent collision. In more advanced AVCS applications, the vehicle could automatically break or steer away from a collision, based on input from sensors on the vehicle.

FIG. 8 ADVANCED VEHICLE CONTROL SYSTEM

Commercial Vehicle operations (CVO)

It comprises an ensemble of satellite navigation systems, a small computer and a digital radio, which can be used in commercial vehicles such as vans, trucks and taxis. This system affords constant monitoring of truck operations by the central office and provides safety and traceability.

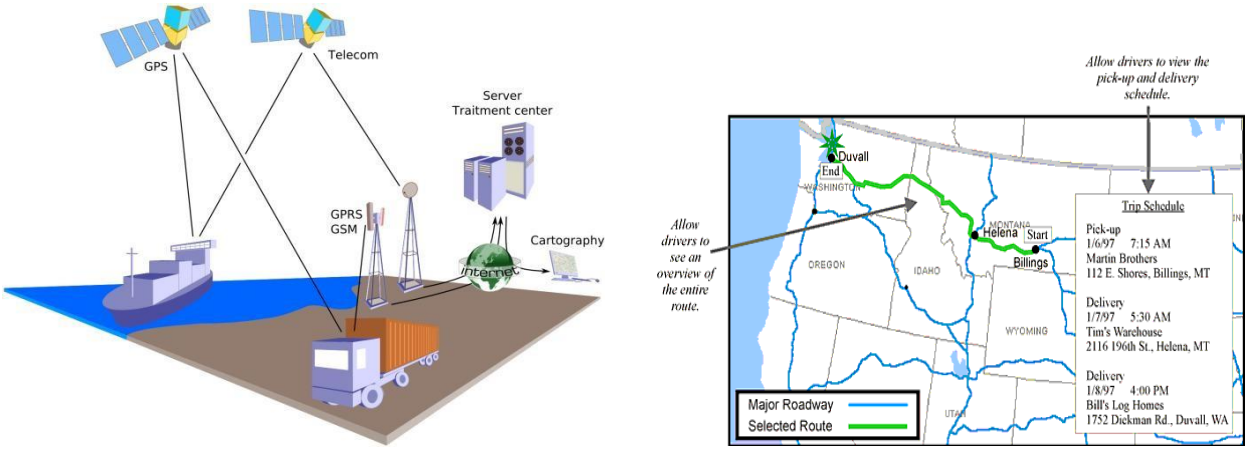


FIG. 8 COMMERCIAL VEHICLE OPERATION

Advanced Public Transportation Systems (APTS)

It includes,

- Real time passenger information system
- Automatic vehicle location system
- Bus arrival notification system
- System providing priority of passage to buses at signalized intersections

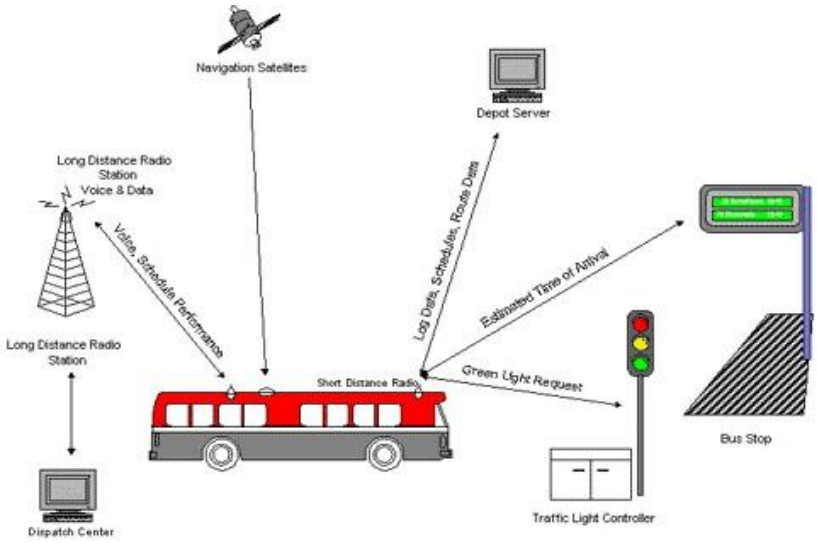


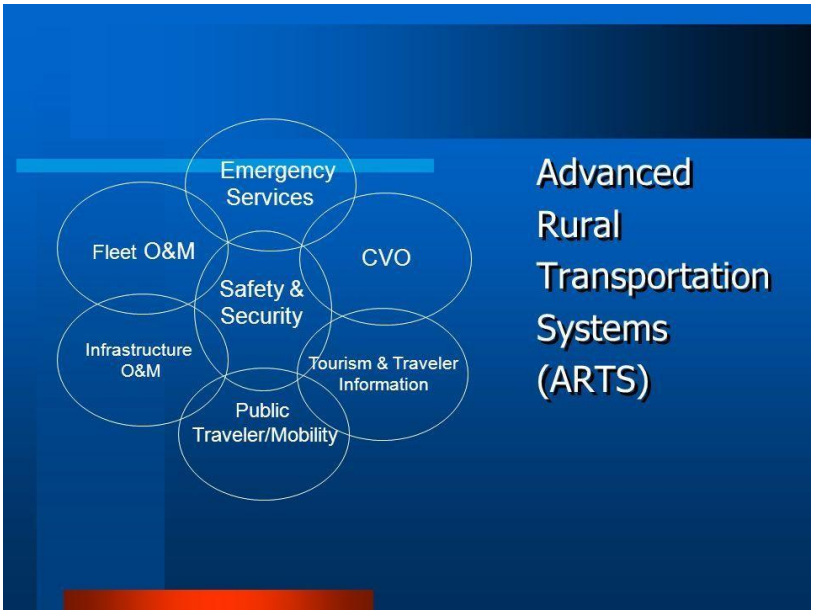
FIG.9 ADVANCED PUBLIC TRANSPORTATION SYSTEM

Advanced Rural Transportation System (ARTS)

It provides information about remote road and other transportation systems. It includes automated roads and weather conditions reporting and directional information. this type of information is valuable to motorists travelling to remote or rural areas. It will be a valuable asset to countries like India where rural areas are widely distributed.

Ottumwa's rural ITS deployment includes MDTs, which are used for communication between drivers and dispatchers and for pre-trip inspections.

FIG.10 ADVANCED RURAL TRANSPORTATION SYSTEM



INTELLIGENCE TRANSPORT SYSTEM (ITS) AND ITS FUNCTIONAL AREAS

What is Intelligent Transport System and how it works?

With the conception of smart city transmuting cities into digital societies, making the life of its citizens easy in every facet, Intelligent Transport System becomes the indispensable component among all. In any city mobility is a key concern; be it going to school, college and office or for any other purpose citizens use transport system to travel within the city. Leveraging citizens with an Intelligent Transport System can save their time and make the city even smarter. Intelligent Transport System (ITS) aims to achieve traffic efficiency by minimizing traffic problems. It enriches users with prior information about traffic, local convenience real-time running information, seat availability etc. which reduces travel time of commuters as well as enhances their safety and comfort.

FIG.11 INTELLEGENT TRANSPORTATION SYSTEM

Intelligent Transport System (ITS) aims to achieve traffic efficiency by minimizing traffic problems. It aims to reduce time of commuters as well as enhances their safety and comfort. The application of ITS is widely accepted and used in many countries today. The use is not just limited to traffic congestion control and information, but also for road safety and efficient infrastructure usage. Because of its endless possibilities, ITS has now become a multidisciplinary conjunctive field of work and thus many organizations around the world have developed solutions for providing ITS applications to meet the need. One such example is the city of Glasgow. In the city, Intelligent Transport System gives regular information to the daily commuters about public buses, timings, seat availability, the current location of the bus, time taken to reach a particular destination, next location of the bus and the density of passengers inside the bus.

Iain Langlands, GIS and Data Manager, Glasgow City Council explains, bus operators in the city have the sensors in their buses. So, if the bus is going to be early to the next bus stop the bus is temporarily and very slightly is slowed down at the red light little longer than it should be to make sure the bus is on time and do not ahead of the schedule". The system has been designed so smartly that passengers and even drivers are unaware of the delay as they are very little delays.

Application areas of Intelligent Transport System

The entire application of ITS is based on data collection, analysis and using the results of the analysis in the operations, control and research concepts for traffic management where location plays an important role.

READ MORE: GIS in Transportation

Here sensors, information processors, communication systems, roadside messages, GPS updates and automated traffic prioritization signals play an imperative role in the application of:

- Advanced Traffic Management System
- Advanced Traveller Information System
- Advanced Vehicle Control system
- Advanced Public Transportation System
- Advanced Rural Transportation Systems
- Advanced Commercial Vehicles Operations system

How Intelligent Transport System works?

Traffic Management Centre (TMC) is the vital unit of ITS. It is mainly a technical system administered by the transportation authority. Here all data is collected and analyzed for further operations and control management of the traffic in real time or information about local transportation vehicle. Well-organized and proficient operations of Traffic Management Centre depend on automatized data collection with precise location information than analysis of that data to generate accurate information and then transmitting it back to travellers. Let's understand the entire process in a more detailed way.

Futuristic transportation technologies that will transform the world

Data collection: Strategic planning needs precise, extensive and prompt data collection with real-time observation. So the data here is collected via varied hardware devices that lay the base of further ITS functions. These devices are Automatic Vehicle Identifiers, GPS based automatic vehicle locators, sensors, camera etc. The hardware mainly records the data like traffic count, surveillance, travel speed and travel time, location, vehicle weight, delays etc. These hardware devices are connected to the servers generally located at data collection centre which stores large amounts of data for further analysis.

Data Transmission: Rapid and real-time information communication is the Key to proficiency in ITS implementation so this aspect of ITS consists of the transmission of collected data from the field to TMC and then sending back that analyzed information from TMC to travelers. Traffic-related announcements are communicated to the travelers through internet, SMS or onboard units of Vehicle. Other methods of communications are dedicated short-range communications (DSRC) using radio and Continuous Air Interface Long and Medium Range (CAILM) using cellular connectivity and infra-red links.

Data Analysis: The data that has been collected and received at TMC is processed further in various steps. These steps are error rectification, data cleaning, data synthesis, and adaptive logical analysis. Inconsistencies in data are identified with specialized software and rectified. After that data is further altered and pooled for analysis. This mended collective data is analyzed further to predict traffic scenario which is available to deliver appropriate information to users.

Traveller Information: Travel Advisory Systems (TAS) is used to inform transportation updates to the travelling user. The system delivers real-time information like travel time, travel speed, delay, accidents on roads, change in route, diversions, work zone conditions etc. This information is delivered by a wide range of electronic devices like variable message signs, highway advisory radio, internet, SMS, automated cell.

With urbanization expanding with speedy stride, number of vehicles on road is also increasing. Combination of both in return puts enormous pressure on cities to maintain a better traffic system so that the city keeps on moving without any hassle. For the purpose application of Intelligent Transport System is the only solution. ITS is a win-win situation for both citizens and city administrators where it provides safety and comfort to citizens and easy maintenance and surveillance to city administrators

INTRODUCTION TO SOFTWARE APPLICATIONS IN TRAFFIC ENGINEERING

CISCO SYSTEMS INC

Cisco offers comprehensive solutions for the traffic management market. Cisco's Smart+Connected traffic management solutions encapsulate Cisco's IP camera, sensors, applications, and digital network architecture. The solution allows transit agencies and governments to monitor the city traffic in real time, and provides detailed urban traffic insights for better decision making and planning. The solution has features such as traffic monitoring, incident detection and management, administration, and analytics. Additionally, Cisco connected roadways to improve traffic flow, reduce roadside incidents, and provide a centralized control system for highways.

SWARCO AG

SWARCO is a one-stop solution and service provider in the traffic management market. The company offers a wide range of solutions and services, such as equipment supply, installation, commissioning, and life cycle maintenance support. SWARCO categorizes its traffic management solutions into urban and interurban. For urban traffic management, the company offers traffic lights, traffic detectors, LED variable message signs, and actros traffic controllers. OMNIA and UTOPIA are the key products in the urban traffic management segment. OMNIA provides a user-friendly user interface to traffic management authorities for traffic control and management.

SIEMENS AG

Siemens has an extensive product portfolio for the management and control of urban and non-urban traffic. The company offers the traffic control center platform,

infrastructure and urban traffic control solutions, and tools for urban traffic control. The traffic control center platform provides flexibility, modularity, and scalability to traffic management authorities. The major products included in the traffic control center platform are Sitraffic Scala, Sitraffic Concert, Sitraffic Guide, and Sitraffic smartGuard.

IBM CORPORATION

IBM offers end-to-end solutions for the traffic management market. IBM has intelligent transportation solutions, integrated fare management, traffic prediction tool, and intelligent operation center solutions for traffic management. The company's offerings are backed by its strong analytics solutions. The intelligent transportation solution has features that include predictive insights, traffic control, automatic incident detection, active traffic management, and incident and special event traffic management. Additionally, the solution also provides system-wide visibility and traffic behavior patterns for better control and measurement of traffic

KAPSCH AG

Kapsch TrafficCom AG has a wide array of traffic management products. The company offers development, installation, and operations of traffic management systems and covers the entire value chain of traffic management markets. The company's product portfolio includes highway traffic management, EcoTrafiX, managed lanes solutions, tunnel and bridges solutions, road safety enforcement, commercial vehicle enforcement, and electronic vehicle registration. Additionally, the company offers tolling, smart mobility, and connected vehicle solutions. The EcoTrafiX traffic management system is its core product that provides comprehensive solutions for urban traffic control and management.

JENOPTIK AG

Jenoptik AG try to maintain optimum client and supplier relationships by serving high-level solutions to reach demands. To maintain an improving environment for road safety, JENOPTIK AG's Traffic Management Software carries a variation of devices that might elect to the technical solutions by analyzing and scheming concerning the hereditary condition. The simple to operate software has also efficient in evaluating traffic offences.

Q-FREE ASA

Q-Free provides advanced traffic management technology and solutions. The offering comprises Electronic Toll Collection solutions, parking guidance and parking management systems, traffic/intersection controllers and software, highway Traffic Management Centers, traffic/bicycle/pedestrian detection, weighin- motion systems, cooperative ITS stations etc. All these solutions comprise data processing technologies, sensors, communication tools, and information systems, to gather, process, and deliver real-time information to the traffic management authorities. Furthermore, the company offers data hosting services and enables its customers to optimize their capital and operating expenditures.

FLIR SYSTEMS INC

The intelligent transportation system of FLIR is a complete platform for anyone seeking to manage the traffic. FLIR is becoming a common platform that is in use by various public transport management. It is due to the availability of powerful software with robust hardware that offers competent management for traffic. From pedestrians to heavy vehicles, an enterprise will be able to manage anything swiftly. Getting insights with sensors is easy.

METRO INFRASYS PRIVATE LIMITED

Metro Infrasys has a wide array of offerings for traffic management systems. Its offerings cover the entire traffic management ecosystem. The company's highway traffic management system comprises emergency call box, variable message sign, speed enforcement, video incident detection system, metrological data system, automatic traffic counter and classifier, close circuit TV, and central control room.

LG

LG CNS has expertise in providing end-to-end services and solutions for traffic management. The company offers holistic consulting services for traffic management system design and analysis to improve existing operations processes. The company's solutions portfolio comprises traffic information and data analysis system, traffic flow monitoring and incident management system, advanced traffic signal control system,

traffic violation and enforcement system, urban traffic management system, and freeway traffic management system.

ACCENTURE PLC

Offering innovative solutions has been the key priority of Accenture. Accenture has delivery centers across the globe that are committed toward offering innovative solutions as per the client requirements. These delivery centers help the company to deliver its product across all geographic regions. Accenture serves the traffic management market by offering the Dynamic Transport Solution and Fare Management Solution. Accenture Dynamic transportation solutions facilitate effective decision making and assist in planning the transport network. They also help in efficiently managing the traffic issues Accenture Fare Management is an electronic ticketing solution with multiple customer payment options and service channels, such as web portals, interactive voice response, and short message service.

ATKINS GROUP

Atkins is one of the most significant and dominating parts of transportation management systems. With decades of experience and complete professionals, it delivers exceptional performance. The range of its services in the traffic sector covers the entire spectrum from commercial, residential, professional, and other fields, including military operations. It covers every possible data field from work and traffic insights to accident and safety. It is one-stop for all the traffic management requirements.

ITERIS INC

Iteris segments its offerings into roadway sensors, transportation systems, and performance analytics. These offerings cover the entire traffic management ecosystem. The roadway sensors segment provides solutions for traffic intersection control, incident detection, and roadway traffic data collection. The major products in the roadways sensors segment are Vantage, VantageNext, VersiCam, Vantage Vector, SmartCycle, SmartSpan, Pegasus, Velocity, P10, P100, and Abacus products. The transportation systems segment comprises engineering and consulting services, and it helps in the development of transportation management and travel information systems.

CUBIC CORPORATION

Cubic Transportation Systems is a subsidiary of Cubic Corporation, and it offers intelligent traffic and transportation management solutions. It has high breadth of offerings, bundles various solutions into one solution, and offers an integrated traffic management system to its client. For monitoring and controlling urban and semi-urban traffic, the company integrates traffic and incident management, decision support, bus tracking, and passenger information with its traffic management system.

INDRA SISTEMAS SA

Indra is the second largest R&D investor company in Europe, and it offers innovative solutions to its clients. The company offers a comprehensive range of products in the traffic management market that includes smart semaphoric management systems, variable signaling, dynamic and adaptive control of lanes, advanced devices for real-time information on traffic and highways, and prioritization and traffic routing systems.

EFKON AG

EFKON AG, being one of the largest providers of Intelligent Transportation System and Electronic toll collection system all over the world even leads in providing the engineers and designers with the best traffic management software often known as telematic traffic solutions. Active bidirectional high-speed communication is supplied by EFKON AG, which enables the client to get the best of the transportation system is a transportation system utilizing satellite. The software is wholly intended to offer smarter, safer as well as efficient solutions.

SAVARI INC

Savari Inc. started with the mission of linking automotive and making cities smart and its transportation efficient and safe and also providing solutions for car creators. It has been building sensors which are both software and hardware-oriented, since then. SAVARI INC's Traffic Management Software collaborated with numerous universities, transport department and automobile producers to bring an end product of delivering a smooth flow of transport through innovative solutions.

CITILOG

CITILOG offers solutions which help create a safer road network for millions of drivers. With their services, it is easier to ensure that travel is as safe as it can, whether it is across bridges or inside tunnels. Cititlog's Traffic Management Software is designed to help create a more reliable network with features such as Automatic Incident Detection and License Plate Identification. Citilog's Traffic Management Software is the driving force behind better local support and services for drivers who may be in need.

ESRI

The ESRI introduced GIS as a singular traffic management software that would help manage the transportation cycle better. It is easier to plan with the software and monitor all the activities. Thus, allowing for easy management of the entire system. With the power of location intelligence, it will deliver better decision-making results with satisfactory performance. Its compatibility will enable it to work on any medium or device for quick information anytime

IMTAC LLC

IMTAC (Industrial Management Technology and Contracting) is one of the best investment arms of large diversified companies across 14 countries, including significant parts of Asia, Africa and the Middle East. IMTAC are experts in making CAD (computer-aided design) traffic management software which helps in laying the road maps or the road layouts, sign designing, and installation and even in the maintenance of highways. The engineers and designers enjoy the majority of the benefits.

PTV AG

With PTV AG's traffic management software, it is easier to manage traffic in real-time. With PTV Ag's prediction system, users can view traffic forecast for 5, 10 and even 30 minutes. With PTV Ag's Traffic Management Software, traffic predictions and real-time data are integrated to come up with the best solution which can help reduce congestion and obstruction in a road network and to help traffic move smoothly.

LANNER INC

Lanner offers a complete traffic management software that meets the demands of the modern world. From the data analysis to management and offer operations, it has integrated all of the features. It is easier to manage the entire transportation at the

disposal of the enterprise. A complete mobile surveillance options with easy stock compilation. It also offers an in-vehicular broadcast for seamless communication capabilities. The robust ITS system also works in military vehicles.

TRANSCORE LP

After providing years of excellent services in radio identification in tolls and access controls, TransCore LP's prime objective is to provide coherent transportation systems. Carrying a task on its shoulder to ensure safer travel through road, highways, tunnels. Pioneered to meet extravagant traffic management remedies TransCore's Traffic Management Software is perfect enough to provide field-proven solutions for all ITS devices. It includes signal controllers, control over CCTV, incident controlling and feedback, management of lanes, inscribed dynamic signs.

CELLINT

Cellint has a flagship product for traffic management, and it is widely accepted throughout the world. Cellint is the only company that has developed an area-wide traffic information system. It has created a strong foothold in the traffic management market with its leading TrafficSense and NetEyes traffic management solution. TrafficSense is a road information system that delivers real-time speed, travel time, and traffic congestion information. Furthermore, it provides micro-level origin-destination analysis for traffic signal timing to control and monitor the city traffic.

INTELLIVISION TECHNOLOGIES PRIVATE LIMITED

Intellivision's Transportation Software is commonly known as a Smart City software as it offers video analytics and intelligent transport system. It reduces the requirement of expensive and robust hardware by incorporating the power of software analytics into the system. Due to the features of the software, it can perform detection, scanning, analysis, and other functioning without relying on the hardware. As it works in combination with cameras, an organization can use it anywhere from ports to streets