TRAFFIC ENGINEERING

Gowtham. B

MODULE:1 - TRAFFIC PLANNING AND CHARACTERISTICS

Definition of Traffic Engineering:

Traffic Engineering is that branch of engineering which deals with the improvement of traffic performance of road networks and terminals.

It deals with the application of scientific principles, tools, techniques and findings for safe, rapid, convenient and economic movement of people and goods.

Various definitions for traffic Engineering:

(1) Institute of Traffic Engineers, USA defines:

"Traffic Engineering is that phase of Engineering which deals with the planning and geometric design of streets, highways, abutting lands and with traffic operation, as their use is related to the safe, convenient and economic transportation of persons and goods."

(2) Professor Ross Blunden of California University has proposed a modified definition:

"Traffic Engineering is the science of measuring traffic and travel, the study of the basic laws relating to traffic flow and generation and application of this knowledge to the professional practice of planning, designing and operating traffic systems to achieve safe and efficient movement of persons & goods."

Objectives of Traffic Engineering:

(1) To make efficient movement of traffic
(2) To increase the traffic safety by reducing accidents.
(3) Ensure rapid traffic flow.
(4) To improve operational characteristics of transportation.
(5) To improve parking system, Bus stand facility & truck ~~terminals~~ terminals.
(6) To provide good geometric design, traffic regulation, better traffic signals.
(7) To reduce operational cost.
(8) To improve aesthetic look of whole traffic system.

Scope of Traffic Engineering:

The scope of traffic Engg can be understood by following parameters or points:

(1) Traffic characteristics:
Includes study of road users characteristics, vehicular characteristics etc.

(2) Traffic Analysis:
Includes traffic speed, volume, accident study etc.

(3) Traffic operation and control:
Includes study of traffic control signals, signal design, traffic signs and traffic regulation and rules.

4) Traffic Plan:

This includes study of planning of traffic for different system of roads and goods. It also includes study of terminals, traffic layout, effective land usage for better traffic flow design of oneway streets etc.

5) Geometric design:

Includes design of roads with different geometric parameter, curves, superelevation, camber etc. For safe and easy movement of traffic.

(6) Traffic Administration and Management:

Includes study of traffic control organising body, traffic rule, implementation, management of highway, management of traffic etc.

Duties or function or role of traffic Engineering:

(1) Collection analysis & interpretation of traffic data:

Includes traffic volume surrey speed and study pedestrian, behaviour study, accident statistics.

(2) Traffic and Transportation planning:

Traffic Engg concerned with the preparation of traffic and transportation, planning to ensure safe, orderly integrated transportation system. This also includes right use of land for transportation and street design.

(3) Traffic design:

Includes geometrical design, design of parking systems, design of traffic junction etc.

(4) Measures for operation of traffic:

It includes enforcement of regulating measures in traffic system legislation, related to users and vehicles. This includes proper management of streets like oneway road, two way road etc, traffic signs, traffic signals, pavements etc.

(5) Administration:

One of the function of traffic engineers is to organise and administrate various program intended to make safe and efficient traffic system in a town. Traffic Engg is also involved in legal and administrative frame work of the city departments

The three E's which helps in the implementation of traffic Engineering are:

(1) Engineering: It is the one which is constructive. It deals with improvement of road geometrics, providing additional road facilities and installation of suitably designed traffic control devices.

(2) Enforcement: It is usually made through traffic laws, regulations and control.

(3) Education: It is possible by sufficient publicity and through schools and television. It aims at improving the human factor in traffic performance.

TRAFFIC CHARACTERISTICS

Introduction:

Study of traffic characteristics:

It is most essential requirement for the improvement of traffic facilities, planning and designing.

There are two types of traffic characteristics:

(1) Road user characteristics.
(2) Vehicular characteristics.

(1) Road user characteristics:

The human element is involved in all actions of the road users either as pedestrian, cyclist, car driver or motorist.

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

(1) Physical characteristics.
(2) Mental characteristics.
(3) Psychological characteristics
(4) Environmental characteristics.

(1) Physical characteristics:

(a) It may be either permanent or temporary.
(b) The physical characteristics are the vision, hearing, strength and the general reaction of traffic situations.
(c) Vision plays the most important role of all these

(d) Vision include the activity of vision, peripheral vision and eye movement and also glare vision, glare recovery and depth judgement. For vision diagram refer pg-28

(e) These factors are particularly taken care of while designing and installing control devices.

(f) Hearing helps drivers in a way, though it is more important for pedestrians and cyclists.

(g) Strength is not an important factor but still in general lack of strength may make parking difficult, particularly for heavy vehicles.

(h) The general reaction to traffic situation and to take the appropriate action.

(i) The temporary physical characteristics of the road users affecting their efficiency are fatigue, alcohols alcohols or drugs and illness. All these reduce alertness and increase the ~~situation~~ reaction time and also affect the quality of judgement in some situations.

(2) Mental characteristics:

(a) Knowledge, skill, intelligence, experience and Literacy can affect the road user characteristics.

(b) Knowledge of vehicle~~s~~ characteristics, traffic behaviour, driving practice, rules of roads and Psychology of road users will be quite useful for safe traffic operations.

(c) Reactions to certain traffic situations become more spontaneous with experience.

(d) Understanding the traffic regulation and special instruction and timely action depends on intelligence and literacy.

3) Psychological characteristics:

(a) The emotional factors such as attentiveness, fear anger, superstition impatience, general attitude towards traffic and regulations and maturity affects the road users to a great extent.

(b) Distraction by non-traffic events and worries reduce attentiveness to traffic situations.

(c) Dangerous actions are likely due to impatience.

(d) Some road users do not pay due regard to the traffic regulations and donot have the right attitude towards the traffic.

4) Environmental factors:/ characteristics

(a) The various environmental conditions affecting the behaviour of road user are traffic stream characteristics, facilities to the traffic, atmospheric conditions and the locality.

(b) The location of shopping centre or place with other distractions affects the behaviour of road users.

(c) The other environmental factors are the weather visibility and other atmospheric conditions.

(2) Vehicular characteristics:

(1) It is quite important to study the various vehicular characteristics which affect the design and traffic performance.

(2) It will not be economically feasible to keep on increasing the geometric standards and thickness of pavement from time to time to meet the needs of a few vehicles whose dimensions and weight are increased.

(3) Hence the vehicle standards should be uniform at least within a country, keeping in view the large percentage of existing vehicles and those likely to be manufactured in the near future.

(4) The standards for the dimensions and weights of vehicles should be consistent with the road facilities now available or could be made available in the near future

The ~~vehicle~~ vehicular characteristics are classified in two types:

(1) Static characteristics.

(2) Dynamic characteristics.

(1) Static characteristics:

(a) Static characteristics of vehicles affecting the road design are the dimensions, weight and maximum turning angle.

(b) The height of the vehicle affects the clearance of the overhead structures.

(c) The height of driver seat affects the visibility distance and the height of head light affects the head light sight distance at valley curves.

(d) The length of vehicle affects the capacity, overtaking distance and maneuverability of vehicles.

(e) The minimum turning radius depends on the length of wheel base and the features of the steering system and this affects design of sharp curves for the manoeuvre of vehicles at slow speeds.

(f) Gross weight, axle and wheel loads of vehicle govern the structural design of pavement and cross drainage structures.

2) Dynamic characteristics: (Explain Power Performance & relations also in the Exam for dynamic char)

(a) Dynamic characteristics of vehicles affecting road design are speed, acceleration and braking characteristics and some aspects of vehicle body design.

(b) The speed and acceleration depends upon the power of the Engine.

(c) The deceleration and braking characteristics guide safe vehicle operation.

(d) The stability of vehicle and its safe movement on horizontal curves are affected by the width of wheel base and height of centre of gravity.

(e) The riding comfort on vertical curves depends on the design of suspension system of the vehicle.

(f) The impact characteristics on collision and the injuries to the occupants depends on the design of the bumper and body of the vehicle.

Vehicle dimensions:

The dimensions to be mainly considered are the overall width, height and length of different vehicles, particularly of the largest ones.

The width of the vehicle affects the width of the traffic lanes, shoulders and parking facilities. Height of the vehicle affects the clearance to be provided under structures such as overbridges, underbridges, electric and other service lines. Length affects the safe overtaking distance, capacity of a road and parking facilities. Length of the vehicle is an important factor in the design of horizontal alignment as it effects the extra width of pavement and minimum turning radius.

The max^{m} allowable width, height and length of vehicles have been standardized by the Indian Road Congress and are as given in table below.

Table: Max^{m} dimension of Road vehicles

Power performance of Vehicles:

Power performance of a vehicle is necessary to determine the vehicle running costs and the geometric design elements like grades.

Resistance to motion of a vehicle:

The power developed by the engine (P_P) should be sufficient to overcome all resistance to motion at the desired speed and to accelerate at any desired rate to the desired speed.

The following forces have to be overcome for this purpose:

(1) Rolling resistance (P_f)
(2) Air resistance (P_a)
(3) Grade resistance (P_i)
(4) Inertia forces during acceleration and deceleration (P_j)
(5) Transmission losses.

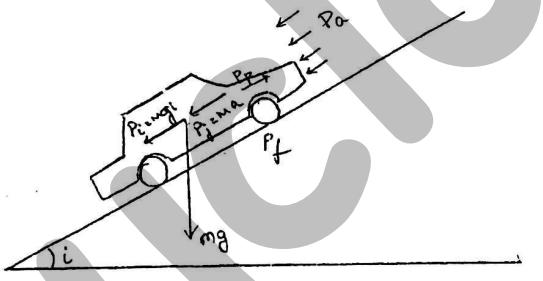

Fig: Forces acting on vehicle.

(1) Rolling resistance (P_f):

(a) When the vehicle wheels roll over the road surface, the irregularities and the roughness of the surface cause of deformation of the tyres. The road surface itself may undergo deformation.

(b) Shocks and impacts are caused by such a motion and these hinder rolling motion of the wheels.

(c) The rolling resistance varies with the type of surfacing.

~~Research~~ The rolling resistance is given by

$$P_f = mfg$$

where, P_f = rolling resistance in N

m = mass of the vehicle in kg

f = co-efficient of rolling resistance

g = accln due to gravity in m/sec^2

Table: Values of Rolling Resistance coefficient from Indian studies

Type of Surface	Rolling resistance coefficient
(1) Asphaltic concrete	0.01 - 0.02
(2) Premixed carpet in good condition	0.016
(3) Premixed carpet in bad condition	0.022
(4) Water bound macadam in good condition	0.025
(5) Water bound macadam bad condition	0.037
(6) Gravel	0.046
(7) Earth	0.055

(2) Air resistance (Pa):

When a vehicle is in motion, air resists it in the following ways:

(a) Since air has density, it exerts a reaction pressure against the front of the vehicle when it moves at speed.

(b) The friction of air against the sides of the vehicle body causes resistance.

(c) The eddying of air stream behind the vehicle, under the body and around the wheels causes power loss.

(d) The flow of air through the vehicle for ventilating and cooling causes resistance to motion.

The following formula can be used to determine the air resistance, Pa:

$$Pa = Ca A v^2$$

where Pa = air resistance in N

A = projected front area of the vehicle in m^2 on a plane at right angles to the direction of motion, for Indian vehicles it can be taken from table below.

V = speed of the vehicle relative to air in m/s.

Ca = co-efficient of air resistance, can have values from table below.

g = accln due to gravity, 9.81 m/s^2.

Table: Values of Frontal area and coefficient of air resistance

Type of vehicle	Frontal area (m^2)	Mass (kg)	Coefficient of resistance Ca (kg/m^3)
(1) Premier Padmini Car	1.63	1065	0.42
(2) Ambassador Car	2.15	1365	0.39
(3) Jeep	2.38	1200	0.37
(4) Tata Truck	5.37	6120	0.48
(5) Ashok Leyland Truck	5.37	8125	0.48
(6) Maruti Car	1.54	880	0.40

(3) Grade resistance (P_i):

(a) When a vehicle which was moving on a level stretch at a particular speed has to move up an incline, additional work has to be done in keeping the vehicle at the same speed as in the level stretch.

(b) The additional work is equal to the work that will be needed to lift the vehicle through a height represented by the inclination.

(c) If the horizontal distance is unity (i.e 1 metre) and the slope is i percent, the rise will be $i/100 \cdot m$.

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If the mass of the vehicle is m kg, the additional force to move the vehicle up the incline, P_i is given by

$$\pm P_i = \frac{mig}{100}$$

It may be noted that if the slope becomes downward, i becomes -ve, and P_i also becomes -ve, representing a reduction in the force to move the vehicle

(4) Inertial forces during acceleration and deceleration: (P_j)

When the speed of a moving vehicle needs to be increased some additional power is needed to accelerate. Similarly if the vehicle has to gather a desired speed from a stopped position, additional force is needed to accelerate. The additional force P_j is given by

Force = mass x acceleration

Hence, $\pm P_j = ma = m \cdot \frac{dv}{dt}$

where P_j = Force to accelerate, N.

m = Mass of the vehicle, kg.

a = Average accln to the vehicle, m/sec²

$a = \frac{dv}{dt}$

The value of P_j will be +ve if the vehicle is to accelerate and -ve if the vehicle is to decelerate.

(5) Transmission losses:

These are the losses which occurs during the transmission of power from the engine to the gare system and or in the gare system itself. These losses are considered in the design of engine.

To find out Engine horse power and speed of the Engine:

(1) Tractive force / Power:

$$P_p = P_t + P_a \pm P_i \pm P_j$$

(2) Power output: $= P_p \times v$

$$v = \frac{V \times 1000}{3600} = \frac{V}{3.6} \quad \text{---} \quad (1)$$

$$\therefore \text{power output} = \frac{P_p \times V}{3.6}$$

$$v = \frac{2\pi r_w n}{60\, G_t G_a} \quad \text{---} \quad (2)$$

Equating (1) & (2)

Or

$$V = \frac{0.377 \times r_w n}{G_t G_a}$$

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$$\text{Power output} = \frac{P_p \times 0.377 \times r_w \times n}{G_t \times G_a} \text{ in watts}$$

$$r_w = \lambda r_0$$

where r_0 = radius of the tyre.

λ = tyre deformation factor will have a value of 0.945 - 0.950 for high pressure air tyres and 0.930 - 0.935 for low pressure tyres on hard surfaces.

$$\text{Engine power (in watts)} = \frac{\text{Power output}}{k}$$

$$= \frac{P_p \times 0.377 \times r_w \times n}{G_t \times G_a \times k}$$

where V = Speed of the vehicle in kmph

v = speed of the vehicle in m/s

n = speed of the engine in R.P.M

k = transmission efficiency.

$$\text{Engine horse power} = \frac{\text{Engine power}}{735}$$

Problem:

(1) A passenger car weighing 2 tonnes is required to accelerate at a rate of 3 m/sec^2 in the first gear from a speed of 10 kmph. The gradient is +1% and the road has a black topped surface. The frontal projection area of the car is 2.0 m^2. The car tyres have radius of 0.33 m.

The rear axle gear ratio is 3.82:1 and the first gear ratio is 2.78:1. Calculate the engine horse power needed and the speed of the engine. Make suitable assumptions.

Soln:

Tractive force needed

$P_p = P_f + P_a \pm P_i \pm P_j$

$P_f = mgf$

From table $f = 0.02$

$P_f = 2000 \times 9.81 \times 0.02$

$\boxed{P_f = 392.4\ N}$

$P_a = C_a A v^2$

From table $C_a = 0.39$

$A = 2.5\ m^2$

$V = 10$ kmph initially and increased to 20 kmph eventually. So, assume average value of 15 kmph.

$P_a = 0.39 \times 2.5 \times \left(\frac{15}{3.6}\right)^2$

$\boxed{P_a = 33.54\ N}$

$P_i = mgi$

$= 2000 \times 9.81 \times \frac{1}{100}$

$\boxed{P_i = 196.2\ N}$

$P_j = ma$

$= 2000 \times 3$

$\boxed{P_j = 6000\ N}$

$P_p = 392.4 + 13.54 + 196.2 + 6000$

$\boxed{P_p = 6602.14\ N}$

Power output $= \frac{P_p \times V}{3.6}$

$= \frac{6602.14 \times 10}{3.6}$ (V = 10 km/ph initially)

$\boxed{\text{Power output} = 18339.2\ W}$

Engine power $= \frac{\text{Power output}}{k}$

$= \frac{18339.2}{0.9}$

$\boxed{\text{Engine power} = 20376.9\ W}$

Engine horse power $= \frac{\text{Engine power}}{735}$

$= \frac{20376.9}{735}$

$\boxed{\text{Engine horse power} = 27.72\ hp}$

$$V = \frac{0.377\, r_w\, n}{G_t\, G_a}$$

$$n = \frac{V\, G_t\, G_a}{0.377\, r_w}$$

$r_w = \lambda r_0 = 0.935 \times 0.33$ (assume $\lambda = 0.935$)

$$\boxed{r_w = 0.308\text{m}}$$

$$n = \frac{10 \times 2.78 \times 3.82}{0.377 \times 0.308}$$

$$\boxed{n = 915 \text{ rpm}}$$

When the vehicle is travelling at particular speed is suddenly allowed to coast by switching off the engine and putting the gear to neutral, deceleration is caused. Then,

$$P_p = P_f + P_a \pm P_i \pm P_j$$

Since $P_p = 0$, and i(gradient) $= 0$

$$P_i = P_f + P_a$$

$$m \cdot \frac{dv}{dt} = mfg + C_a A v^2$$

$$\boxed{\frac{dv}{dt} = fg + \frac{C_a A v^2}{m}}$$

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Problem:

An Ambassadar car travelling at a speed of 60 kmph on a level WBM road in good condition is suddenly allowed to coast by switching off the engine and putting the gear in neutral. What is the deceleration caused?

Soln:

$$\frac{dv}{dt} = \frac{C_a \cdot A \cdot V^2}{m} + fg$$

For an Ambassadar car.

$C_a = 0.39\ kg/m^3$, $A = 2.15\ m^2$, $m = 1365\ kg$

For a WBM road

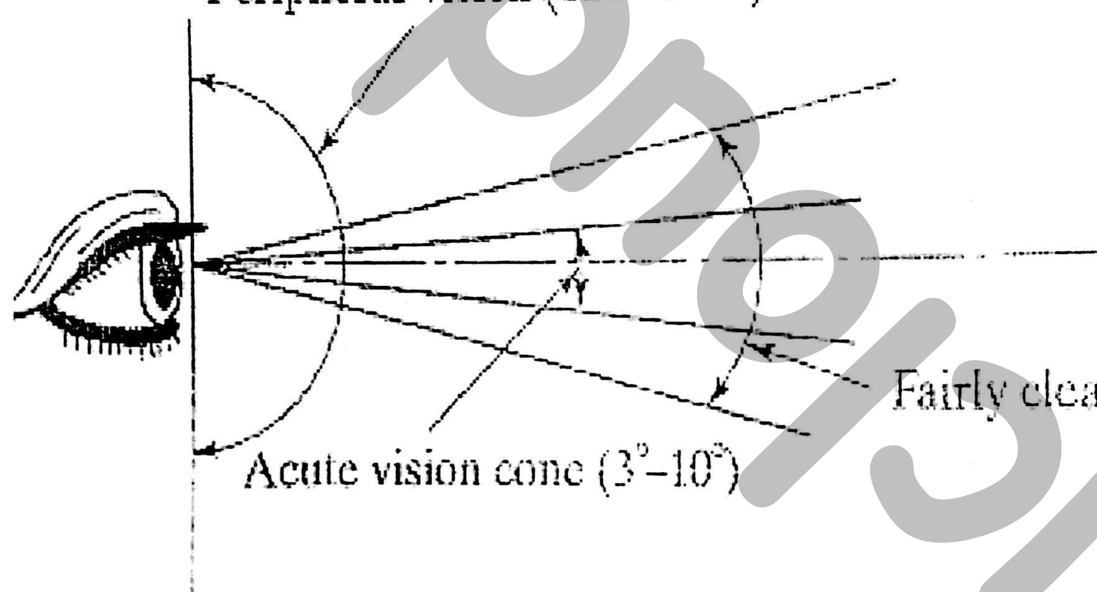
$f = 0.025$

$$\frac{dv}{dt} = \frac{0.39 \times 2.15}{1365} \times \left(\frac{60}{3.6}\right)^2 + 0.025 \times 9.81$$

$$= 0.17 + 0.25$$

$$\boxed{\frac{dv}{dt} = 0.42\ m/sec^2}$$

Field of Vision



Reaction time of the driver:

Reaction time of the driver is the time taken from the instant the object is visible to the driver to the instant the brakes are effectively applied. The stopping distance increases with increase in reaction time of the driver.

The total reaction time may be split up into two parts:

(1) Perception time
(2) brake reaction time.

(1) **Perception time**: It is the time required for a driver to realise that brakes must be applied. It is the time from the instant the object comes on the line of sight of the driver to the instant he realises that the vehicle needs to be stopped.

The perception time varies from driver to driver and also depends on several other factors such as speed of the vehicle, distance of object and other environmental conditions.

(2) **Brake reaction time**: It is the time from the instant the brakes are applied to the instant that the vehicle completely stops.

It depends on several factors including the skill of the driver, the type of the brakes and various other environmental factors.

PIEV theory: According to this theory the total reaction time of the driver is split into four parts:

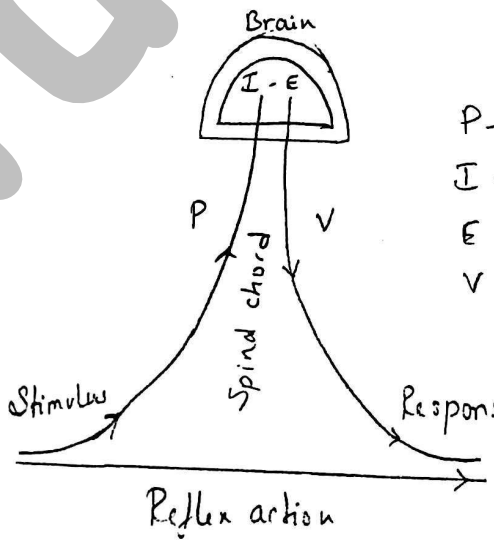
(1) Perception
(2) Intellection
(3) Emotion
(4) Volition.

(1) Perception time: It is the time required to perceive an object or situation. It is the time required for the sensations received by the eyes or ears to be transmitted to the brain through the nervous system and spinal chord.

(2) Intellection time: It is the time required for understanding the situation.

(3) Emotion time: It is the time elapsed during emotional sensations and disturbance such as fear, anger or any other emotional feelings such as superstition etc with reference to the situation.

(4) Volition time: It is the time taken for the final action.



P - Perception
I - Intellection
E - Emotion
V - Volition.

The PIEV time of a driver depends on several factors such as

→ physical and psychological characteristics of the driver.
→ type of the problem involved
→ environmental condition.
→ temporary factors such as motive of the trip, travel speed, fatigue consumption of alcohol etc.

The total reaction time of an average driver may vary from 0.5 second for simple situations to as much as 3 to 4 seconds or even more in complex problems.

Traffic Flow Theories

6th sem

Scope:

→ The theory of traffic flow can be defined as a mathematical study of the movement of vehicles over road network.

→ The subject is a mathematical approach to define, characterise and describe different aspects of vehicular traffic.

→ The subject has virtually grown from the measurement in the field of the various characteristics of the traffic and the urge to describe these observed characteristi in precise mathematical language, with a view to understand traffic behaviour better.

→ The study is of great importance to a traffic engineer as it provides him with a comprehensive knowledge of vehicular traffic, leading to improved techniques for the control, regulation and management of traffic.

Definitions:

Traffic flow theory is mainly concerned with three measurable characteristics of road traffic i.e, speed, flow and concentration.

Speed (v) : It is the rate of movement of traffic or of specified components of traffic and is expressed in metric units in kilometers per hour.

Time mean speed (v_t): is the avg of the speed measurements at one point in space over a period of time.

Space-mean speed (v_s): is the avg of the speed measurements at an instant of time over a space.

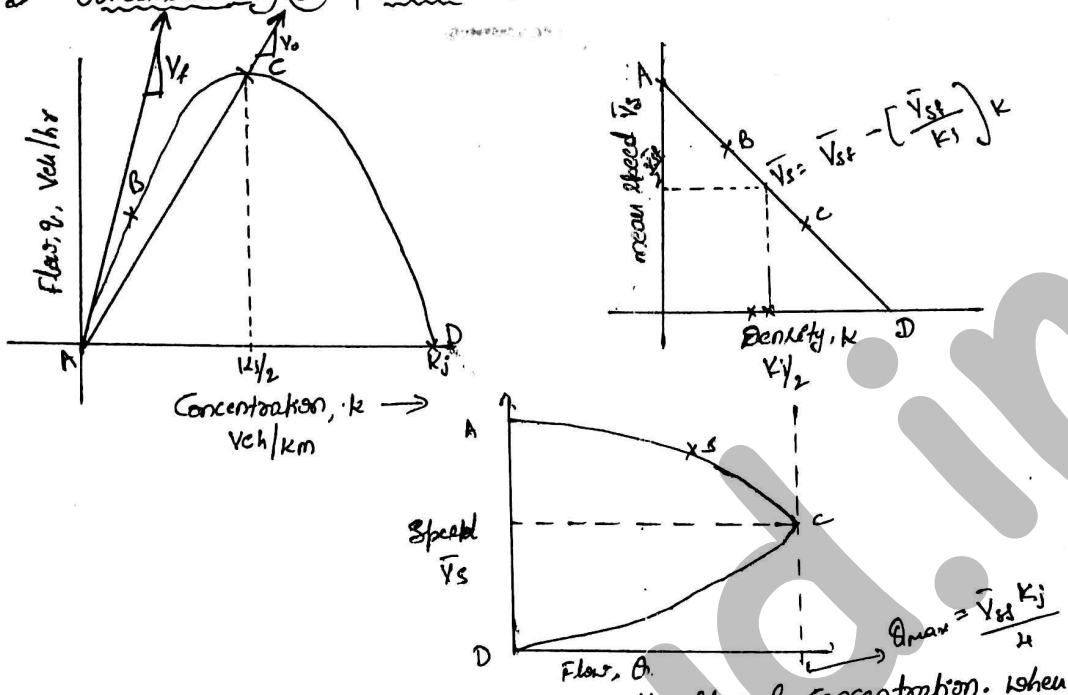
Flow: It is also known as volume (Q) is the number of vehicles passing a specified point during a stated period of time. It is usually to express it in vehicles per hour.

Concentration, also known as density, (K) is the number of vehicles present in a stated length of road at an instant. It is usually expressed in vehicle per kilometer length of road per lane. It is given by. $(q = vk)$ k → Average density.
where, q - rate of flow/hr
v - speed in kmph

Space Headway (s): It is the distance b/w the fronts of successive vehicles. It is measured in metres.

Time Headway or simply headway (h): It is the time interval b/w the passage of the fronts of successive vehicles at a specified point. It is measured in seconds.

Fundamental diagram of Traffic flow:- (Relation between Speed flow & Concentration) (or) Parabolic model:-



→ The diagram shows the relation between the flow & concentration. When the vehicles are parked from end to end the flow q is zero. So also when the concentration is zero naturally flow is also zero.

→ The relationship between the flow & the density for a particular highway is represented by parabola. As the flow increases, the density also is also increased, until the capacity of the highway is reached. The point of maximum flow corresponds to the optimal density is shown in the fig. From this point onwards to the right, the flow decreases as the density increases.

→ At the Jam density (K_j) the flow is about zero, on a free lane this point may be linked to the traffic coming to a halt. Where the lane appears to be a parking lot.

Hypothetical diagrams connecting mean speed, density & the flow, these diagrams are discussed as follows,

(a) At the point A, the density is close to zero, there are only few vehicles & hence the volume is also zero, which indicates that few vehicles on the road can choose their own individual speeds & change lanes with no restrictions.

(b) At the point B, the number of vehicles slightly being increased but still there is a condition of free flow & no restrictions.

(c) From the point B to C the flow conditions may be called as normal however a density is increased & the drivers experience significant lack of freedom to manevour, switching & shifting of the lanes & changing the speed.

(d) Around the point C, the traffic conditions begin to show the science of instability & their will be a change in the speed, fluctuations in the density. The point C is the point of maximum volume & further increase in the density reduces the speed considerably. This situation is called forced flow. It is observed from the point C to D almost the cars are piled up almost bumper to bumper & hence the point D is known as Jam density.

Greenshield's model - Linear relationship b/w speed & concentration

Copy same figure of fundamental diagram of traffic flow.

Diagram

To prove,

$$q_{max} = v_{smax} \times k_{max}$$

ie $$\left[q_{max} = \frac{\bar{v}_{sf}}{2} \times \frac{k_j}{2} \right]$$

The equation given by Greenshield's is in the following form

$$\left[\bar{v}_s = \bar{v}_{sf} - \left[\frac{\bar{v}_{sf}}{k_j} \right] k \right] \quad - (1)$$

where $\bar{v}_{sf}$ → Space mean speed for free flow condition

k_j → Jamming Concentration

k → Concentration

$\bar{v}_s$ → Space mean speed

We know that, $\bar{v}_s = \frac{q}{k} \quad - (2)$

Substituting equation-(2) in equation-(1)

$$\frac{q}{k} = \bar{v}_{sf} - \left[\frac{\bar{v}_{sf}}{k_j} \right] k$$

$$q = \bar{v}_{sf} k - \left[\frac{\bar{v}_{sf}}{k_j} \right] k^2$$

Differentiate w.r.t 'k' & equating to zero

$$\frac{dq}{dk} = \bar{v}_{sf} - \frac{\bar{v}_{sf}}{k_j} \cdot 2k = 0$$

$$\bar{v}_{sf} = 2 \cdot k \cdot \frac{\bar{v}_{sf}}{k_j}$$

$$k_j = 2k$$

$$\left[k = k_{max} = \frac{k_j}{2} \right] \quad - (3)$$

Now, W.K.T, $\bar{V}_s = \frac{\theta}{K} \quad \therefore \left[K = \frac{\theta}{\bar{V}_s} \right]$ - (ii)

Substituting equation (ii) in equation (i)

$$\bar{V}_s = \bar{V}_{sf} - \left[\frac{\bar{V}_{sf}}{K_j} \right] \frac{\theta}{\bar{V}_s}$$

i.e., $\left(\frac{\bar{V}_{sf}}{K_j} \right) \frac{\theta}{\bar{V}_s} = \bar{V}_{sf} - \bar{V}_s$

(or) $\theta = \frac{\bar{V}_{sf} \cdot K_j \bar{V}_s}{\bar{V}_{sf}} - \frac{K_j \bar{V}_s^2}{\bar{V}_{sf}}$

Differentiate w.r.t $\bar{V}_s$ & equating to zero

$$\frac{d\theta}{d\bar{V}_s} = K_j - \frac{K_j}{\bar{V}_{sf}} 2\bar{V}_s = 0$$

$$K_j = \frac{K_j}{\bar{V}_{sf}} 2\bar{V}_s$$

$$\bar{V}_{sf} = 2\bar{V}_s$$

$$\left[\bar{V}_s = V_{smax} = \frac{\bar{V}_{sf}}{2} \right] \text{ - (iii)}$$

$\therefore \theta_{max} = V_{smax} K_{max}$

$$\boxed{\theta_{max} = \frac{\bar{V}_{sf}}{2} \times \frac{K_j}{2}}$$

Integrated planning of town, country, regional and all Urban infrastructure

- India's rapid growth, there are two critical aspects of urban planning that focus on our attention: the development of new cities and the modernization of existing urban systems.
- To enhance the quality of life for our citizens, we must prioritize essential factors such as safe and reliable infrastructure, efficient power distribution, robust transportation networks, and effective waste and water management based on mutual coordination and national interest.
- To achieve integrated planning, town, state, and regional planning boards are required to plan development programs together
- Preparation of metropolitan, regional and area plans by authorities
- Setting up of metropolitan, regional and area planning development authorities for different urban and rural areas within the state to undertake developments and to Coordinating the planning and implementation of developed plans
- Integrating urban planning enhances efficiency, aligns capital allocation, boosts customer satisfaction, and strengthens safety measures.
- Integrated planning helps India's vast geography and population, a significant policy overhaul is imperative to ensure a long-term, successful, sustainable, secure, and safe future for its citizens and transport network.

Landuse and transport (Interdependence of landuse and transport)

- Transportation planning was done through measurement of traffic using streets, identifying those sections were present traffic has exceeded the capacity and undertaking improvement measures to relieve congestion and bottle necks in the smooth traffic flow. This simplest approach failed to deal with complex transport problems and only provided short term solutions. This approach is eventually abounded.
- 1. In 1954, Mitchell and Rapkin made a statement **that 'Urban transport was a function of land use'.** It paved the way for a new line of thinking in urban transportation and land use planning.
- Mitchell and Rapkin observed the various kind of activities based on the land called land use such as **Agricultural land use, Industrial land use, Residential landuse, Commercial landuse etc.,** which generates' different amount and kinds odf traffic.
- They concluded that type of land use and its prediction for the future will give channel of movement and regulation and also control of traffic were effective in dealing with urban traffic.

- But the most basic level of action for a long run solution of traffic problem is the planning, guidance and control of land use pattern for future.
- 2. Buchannan has also emphasised the inter-relationship between traffic and buildings in town. He states that 'In towns, traffic takes place because of buildings in fact all movements in town have an origin and destination in building'. The pattern traced by traffic is thus closely related to the manner in which buildings are arranged.
- In the other context improvisation of the road network also increases the different landuse patterns.

Modal integration:

"Modal integration refers to the integration or Coordination of all of the different public transport modes **(trains, buses and taxis)** in both a strategic and operational way"

The goal of integration is

1) to improve access and coverage, while avoiding duplication of service

2) to make trips as short as possible, in both time and distance, while minimizing the number of transfers.

The convenience of the transfer will impact the customer's decision on whether to take a particular mode or trip. This convenience depends on two main things

1.the wait time for the next service and the physical connection, including level changes, walking distance, and ambiance of the transfer (such as protected from rain, climate controlled, etc.).

2.Customers are willing to transfer if the frequency of the connecting service is high so the customer is guaranteed a short wait time, and if the transfer process is easy.

3.The ideal (Bus Rapid System) BRT system is fully integrated within the larger circulation network, from airports and rail station, to public bikes, neighborhood walkways, and to cater the city.

4. BRT can connect with include:

Airport; Bike (bikeway, public bikes); Bus (city, school, jitney); Coach (long distance, inter-city, charter); Ferry (seaport) Light Rail (tram, streetcar); Metro (skytrain, elevated); Train (inter-city, suburban); Walking (footpaths, connections to buildings, crosswalks, bridges).

Three main forms of integration include:

Physical Integration

This describes location of various transit system near to mass transit systems, example, Taxi stands near the bus station or railway stations

Information Integration

Intermodal facilities are the result of transport planners purposely linking the operational characteristics of one mode to another. Like bus stations and Railway stations together so that customers to transfer between BRT services and to access services of other modes.

Fare Integration

For the customer, it makes it easier to use the entire transport system by simplifying the way the customer pays to use those services or allows easy switching or transfer between modes. Example, Integrated tickets, this aloowa customer to travel in Airways, metros, Bus etc.,

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3) Explain various urban transport problems.

1) Growth of towns:

Because of urbanisation, the existing transport network, which was adequate for the needs of the town of the past, becomes overloaded & turns out to be incapable of handling the newly created transport demand.

2) Urban Sprawl & increasing in Energy Consumption:-

→ The inability of the transport network to cater to the high demand often leads to relaxation (or) dispersal of activities at the edges of town, where land is still cheap & transport capacity exists for each movement of people & goods.

→ The above urban sprawl leads to following transportation problems.

* It increases distance to be travelled by people going to work, recreation, shopping (or) business.

* Impact on primary services such as water supply, Sanitary services, telecommunications, restaurants, shops & service industries.

* City can survive only if cheap source of oil to run the motor vehicle can be assured.

3) Growth of Traffic & Increase in traffic congestion:

→ Because of travel as you like facility & frees the traveller from sub service to rigid schedules of bus transport, the private car is the most versatile transport equipment was devised by man.

→ The most serious effect of increasing urbanisation & accelerated growth in traffic is the severe traffic congestion on the streets.

→ Congestion results in delays & time losses, Driver stresses are caused by frustration & delays.

4) parking problems:-

→ Due to increase in number of vehicles parking at a safe place is almost an impossibility in some areas of the city.

→ Second problem is parking facility is provided very far from the working place because of increased congestion.

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5) An inevitable result of growth of traffic has been the increase in road accidents, which take a great toll of human life every year. (Lack of Safety)

6) Air & Noise pollution:-

→ The deterioration of the environment due to traffic has been causing Serious Concern

→ The noise in the Streets & adjoining trees has been growing up to intolerable levels.

→ The exhaust from the vehicles pollutes the atmosphere with fumes & Smell.

(Below answer can be write for MODAL Integration also)

6) Explain Co-ordination between different system & Define Coordinated Transportation

Def'n:- "Co-ordination means pooling the transportation resources and activities of several human Service agencies with one another (or) with mass transit operations in order to achieve best benefits"

Explanation on Co-ordination between different system.

→ presently different agencies independent of each other are operating different Services in indian cities.

→ There is an urgent need for a transportation system that is Seamlessly Integrated across all modes. The various modes of public transport, including intermediate public transport, have to work in tandem, they should complement rather than involve themselves in competition.

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→ For Example, in Delhi metro rail is operated by Delhi Metro rail Corporation Ltd. Sub urban rail Service by Northern Railway, bus transport Service by Delhi transport Corporation, & taxi & auto-rickshaw by private operators.
→ There is a lack of Co-ordination among those agencies.
→ Since the ultimate objective is to provide an adequate & efficient transport system, there is a need to have a Coordinating authority with the assigned role of coordinating the operations of various modes.
→ this Co-ordinating authority may be appointed by the Central & State government & may have representatives from various Stakeholders Such as private taxi operators, bus operators, railways & State government.
→ The key objective should be to attain the integration of different modes of transport to improve the efficiency of Service delivery & Comfort for commuters.
→ At the Same time, a Single ticket System, where Commuters Can buy a transport ticket that is valid throughout the public transport network within the Coordinating authority's jurisdiction, Should also be developed & promoted.