TRAFFIC ENGINEERING - 17CV561 - Dec.2019/Jan.2020 - VTU Question paper Solution

CBCS SCHEME

USN 1 CR 17 CV 047 17CV561

Fifth Semester B.E. Degree Examination, Dec.2019/Jan.2020
Traffic Engineering

Time: 3 hrs. Max. Marks: 100

Note: *Answer FIVE full questions, choosing ONE full question from each module.*

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice

Module-1

1 a. Define traffic engineering and explain its scope. **(10 Marks)**
b. Explain the different resistances to be considered in vehicle movement. **(10 Marks)**

OR

2 a. In detail explain the road user characteristics. **(10 Marks)**
b. A vehicle of mass 1800 kg has to accelerate at 2 m/sec^2 from a speed of 12 KMPH to 22 KMPH in the first gear. The gradient is +1.2% and the co-efficient of rolling resistance is 0.025. The frontal area and co-efficient of air resistance are 2.38 m^2 and 0.37 respectively. Determine the engine horse power required. **(10 Marks)**

Module-2

3 a. List the objectives and uses of,
(i) Origin and destination studies.
(ii) Parking studies. **(10 Marks)**
b. Discuss the various traffic studies and what are the objects of carrying out traffic volume studies? **(10 Marks)**

OR

4 a. Write the objectives of accident studies, also mention the various causes of accidents. **(10 Marks)**
b. A vehicle of weight 2.0 tonnes skids through a distance equal to 40 m before colliding with another parked vehicle of weight 1.0 tonne, after equal to 12 m before stopping. Compare the initial speed of the moving vehicle. Assume co-efficient of friction as 0.5. **(10 Marks)**

Module-3

5 a. Explain the following with examples,
(i) Regulatory signs.
(ii) Warning signs.
(iii) Informatory signs. **(10 Marks)**
b. Briefly explain at grade and grade separated inter section. **(10 Marks)**

OR

6 a. List the advantages and disadvantages of traffic signals. **(10 Marks)**
b. The average normal flow on cross roads 'A' and 'B' during design period are 400 PCU and 250 PCU per hour. The saturation flows are 1250 PCU and 1000 PCU per hour respectively. The all red time required for pedestrian crossing is 12 seconds. Design a two phase signal by Webster's method. **(10 Marks)**

Module-4

7 a. Explain various design factors of road lighting. **(10 Marks)**
b. Discuss the effect of air pollutants. **(10 Marks)**

1 of 2

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17CV561

OR

8 a. Explain the measures to control the traffic noise. (10 Marks)
b. Write short notes on road safety audit. (10 Marks)

Module-5

9 a. Explain (i) TSM (Traffic System Management)
(ii) TDM (Traffic Demand Management) (10 Marks)
b. What are the applications of ITs? (10 Marks)

OR

10 a. Enumerate the basic principles of traffic regulation. (10 Marks)
b. Explain the factors determining skid resistance. (10 Marks)

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Module 1

1a) Define traffic engineering and describe its slope.

Traffic engineering is a branch of civil engineering that uses engineering techniques to achieve the safe and efficient movement of people and goods on roadways.

Scope of Traffic Engineering

The study of traffic engineering may be divided into 7 sections:

(i) Traffic characteristics – components of road traffic viz., road, road user and vehicle and their characteristics are quite complex. Human psychology, study of vehicular characteristics play an important role in as far as traffic flow is concerned.

(ii) Traffic studies and analysis – different traffic studies like speed and volume study, origin and destination study, accident studies and parking studies are required in determining the traffic stream characteristics.

(iii) Traffic operation (i) control and (ii) regulation – regulations may be in the form of laws and ordinances or other traffic regulations like speed limits etc. installation of traffic control devices like signals and traffic signs also help in regulating the traffic. Traffic management measures such as traffic control measures and traffic regulations also need special attention.

(iv) Planning and analysis – is a separate phase as far as expressways, national highways, state highways, major district roads and mass transit facilities are concerned.

(v) Geometric design - Highway geometric elements, sight distance, parking facilities etc needs to be planned and analysed for better performance.

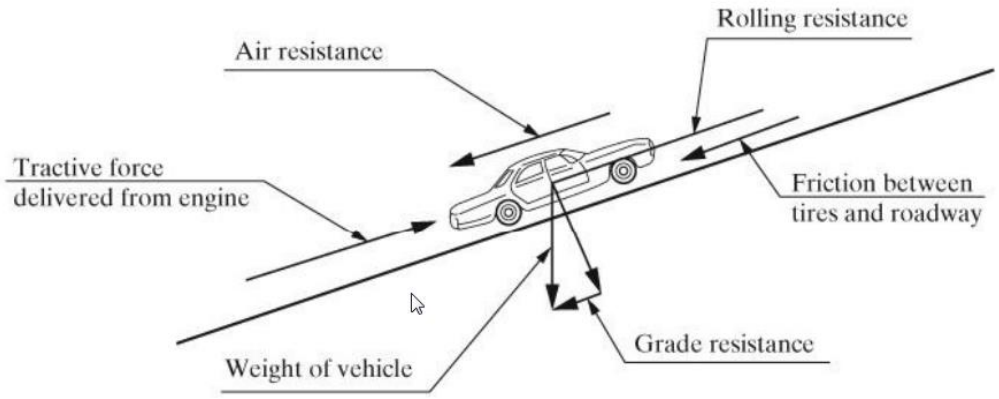
(vi) Administration and management – the various phases of traffic engineering are implemented through 3E's viz., engineering, enforcement and education. Education may be possible by sufficient publicity through schools and television. This improves the human factor in traffic performance. Engineering phase is constructive. It deals with improvement in road geometries , provision of additional road facilitiesand installation of suitably designed traffic control devices.

1b) Discuss various resistances in vehicular movement

Resistance: While a vehicle is in motion, the following forces act on it:

- Air resistance.

- Grade resistance.
- Rolling resistance.
- Inertia forces.



Air resistance (P_a):

The following resistances are observed:

1. Since air has less density, reaction pressure is exerted at the front of the vehicle when it moves at a speed.
2. Friction of air against the sides of the body causes resistances.
3. Eddying of the air stream behind the vehicle, under the body and around the wheels cause power loss.
4. Flow of air through the vehicle for ventilation, causes resistance to motion.

$$P_a = C_a A V^2$$

Where, $C_a$is the coefficient of air resistance, V is the speed in kmph, A is the projected frontal area.

Grade resistance (P_i):

As shown in the above figure, when the vehicle moves, additional force is required to move up the incline, since the movement is against gravity. Similarly, when the vehicle is coming down the lane, the force/acceleration required to move down decreases, since it adds on to the gravity component.

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

where , m is the mass of the vehicle, in kg;

G is the acceleration due to gravity; i % if the gradient

Rolling resistance (P_f):

Vehicles move on the surface of the road, surface irregularities and deformation/roughness of the surface cause a resistance to its motion. This rolling resistance depends upon the type of surfacing.

$$P_f = mgf$$

Where, *m*is mass of the vehicle, kg, *g* is the acceleration due to gravity, *f* is the coefficient of friction between pavement and surface.

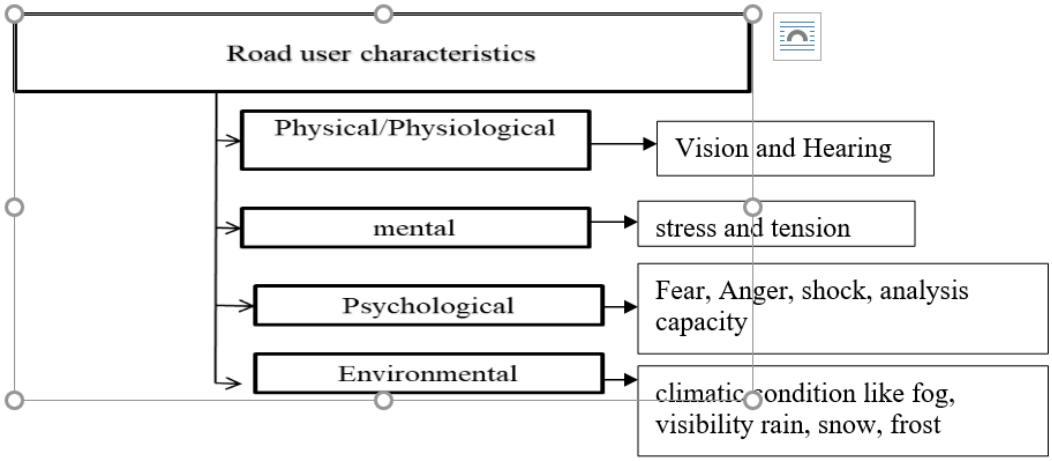
Inertia forces (P_j):

When the speed needs to be increased, additional power is needed to accelerate. Similarly from stopped position, if the vehicle has to gather a speed, additional force is needed to accelerate.

$$P_j = m\frac{dV}{dt} = ma$$

Where, *m*is mass of the vehicle, a is the acceleration of the vehicle.

2a) In detail explain road user chacarteristics.



Vision:

Acute or clear vision cone-3" to 10" around the line of sight; legend can be read only within this narrow field of vision.

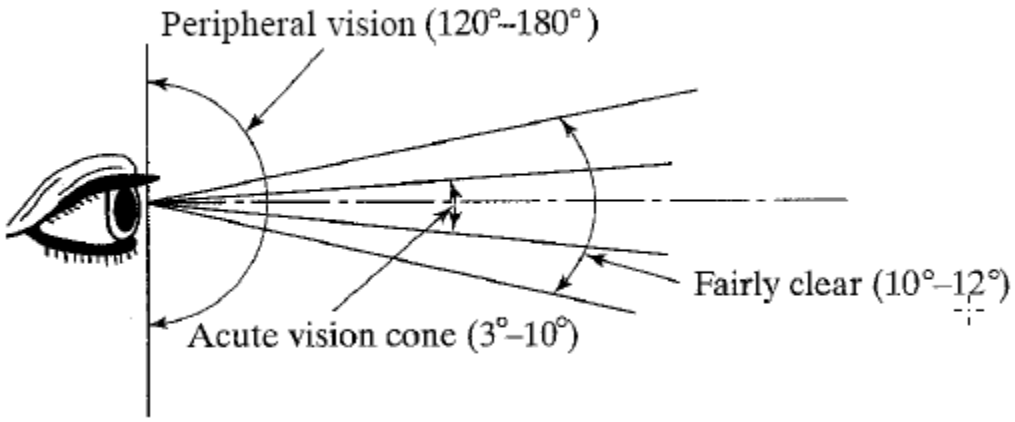
- Traffic signs are placed with in acute vision field
- Driver can see without changing his sight

Fairly clear vision cone-10" to 12" around the line of sight; color and shape can be identified in this field.

- Color and shapes can be identified

Peripheral vision-This field may extend up to 90" to the right and left of the centerline of the pupil, and up to 60" above and 70" below the line of sight.

- Stationary objects can not be detected but moving object can be
- Peripheral vision helps the driver for judgment of speed of moving vehicle

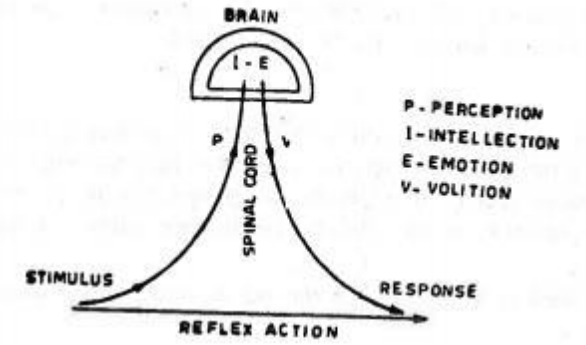


Hearing: Sound of nearing vehicles can alert the pedestrian. Elderly people with falling eye sight can better perceive through hearing.

PIEV theory:

It splits the reaction time of driver into 4 components.

- Perception : time required to perceive an object or situation. [function of eyes, ears]
- Intellection : time required for understanding the situation. [function of brain]
- Emotion : based on our emotions at the time [fear, anger etc] we reach the decision
- weather we want to stop or not. [function of brain]
- Volition : once the decision of stopping has been finalised, time required for moving the foot from the gas to the brake peddle. [Obeying orders of brain; function of legs and hands.



2b) A vehicle of mass 1800 kg has to accelerate at 2 m/s2 from a speed of 12 kmph to 22 kmph in the 1st gear. The gradient is +1.2% and coefficient of rolling resistance is 0.025. The frontal area and coefficient of air resistance are 2.38 m2 and 0.37 respectively. Determine engine horse power required.

Power developed = Pp x v; where Pp is the tractive force

Engine horse power= Power developed/ transmission efficiency

Tractive forcre (Pp)= Rolling resistance+ Air resistance+ garde resistance + Inertia forces due to acceleration

Rolling resistance: mgf = 1800 (kg) * 9.8 m/s^2 * 0.025 = 441 N

Air resistance: Ca Av^2 = 0.37 (kg/m^3) * 2.38 m^2 * $(4.72)^2$ $(m/s)^2$= 19.6 N

Grade resistance = mgi /100 = 1800 (kg) * 9.8 m/s2 * 1.2/100 = 211.89 N

Inertia forces due to acceleration = ma = 1800 (kg)*2 (m/s^2) = 3600 N

Pp = 441+19.6+211.89+3600= 4272.49 N

Power developed = Pp x v =4272.49 *4.72= 20166.15 watt

Power developed in horse power = 20183/735 =27.43 hp

Module 2

3a) Objective and Uses of Origin and destination survey and parking survey

O and D survey:

- ✓ To determine the amount of by passable traffic that enters a town and this establish the need of bypass
- ✓ To develop trip generation and trip distribution models in transport planning process

- ✓ To determine the extent to which present highway system is adequate and to plan new facilities
- ✓ To assess the adequacy of parking facilities and to plan in future

Parking survey:

- ✓ Parking is one of the major problems that is created by the increasing road traffic.
- ✓ It is an impact factor 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 (CBD)
- ✓ This affects the mode choice also. This has a great economical impact.

3b) Discuss different types of traffic studies and objective carrying out traffic volume study

There are different types of traffic studies. Those are speed, journey time and delay studies, Vehicles Volume Studies, Origin Destination studies, Parking Studies, Accident analyses studies.

Objective of traffic volume study

- ✓ Helps in understanding the efficiency at which system works at present
- ✓ Helps in estimating the quality of level of services at which the system works
- ✓ We can estimate if traffic is above or below capacity
- ✓ Helps in evaluating congestion (High congestion high operational costs)
- ✓ Helps to draw up schemes for improvement
- ✓ Helps in traffic forecasting, provided we know a reasonable traffic growth data based on past studies
- ✓ If the average flow and the length of highway are known, the annual vehicle miles of travel can be computed. This is used for accident studies.
- ✓ Pavement design requires traffic volume data
- ✓ Traffic regulatory and control measures are designed based on traffic flow data
- ✓ To evaluate financial viability of toll road traffic volume data are required
- ✓ No of people involved in travel is important for transport planning.

4a) Discuss objective of accident studies and causes of accident

Some objectives of accident studies are listed below:

➢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

➢To carry out before and after studies and to demonstrate the improvement in the problem.

The various **causes of road accidents** are:

Road Users - Excessive speed and rash driving, violation of traffic rules, failure to perceive traffic situation or sign or signal in adequate time, carelessness, fatigue, alcohol, sleep etc.

Pedestrians: Violating regulations, carelessness

Vehicle - Defects such as failure of brakes, steering system, tyre burst, lighting system

Road Condition - Skidding road, surface, pot holes, ruts.

Road design - Defective geometric design like inadequate sight distance, inadequate width of shoulders, improper curve design, improper traffic control devices and improper lighting

➢Environmental factors -unfavorable weather conditions like mist, snow, smoke and heavy rainfall which restrict normal visibility and makes driving unsafe.

➢Other causes -improper location of advertisement boards, gate of level crossing not closed when required etc

4b) A vehicle of weight 2 tons skids through a distance equal to 40 m before colliding with another parked vehicle of weight 1 ton, after equal to 12 m before stopping. Compare the initial speed of the moving vehicle. Assume coefficient of friction as 0.5.

After Collision

Loss of KE of both car= work done against skidding

$(2000+1000)(V_3^2 - V_4^2)/2 = (2000+1000)*0.5*12$

$V_4 = 0$

$V_3 = 3.46$ m/s

At collision

Momentum before impact = momentum after impact

$M_2V_2 = (M1+M2) \times V_3$

V_2 = 5.19 m/s

Before collision

Loss of KE for reducing speed from v1 to v2= work done against skidding

2000 (V_1^2 –V_2^2)/2= 2000*0.5*36

V_1= 7.93 m/s

Module 3

5a) Explain the informatory siogn, regulatory and warning sign with example.

Types of Traffic signs

1. Mandatory Signs /Regulatory
2. Cautionary Signs / Warning
3. Informatory Signs

Mandatory Signs / Regulatory Signs

- These signs are used to inform road users of certain laws and regulations to provide safety and free flow of traffic.
- These include all signs which give notice of special obligation, prohibition or restrictions with which the road user must comply.
- The violation of these signs is a legal offence.

Figure: Stop sign, give way sign, signs for no entry, sign indicating prohibition for right turn, vehicle width limit sign, speed limit sign

Cautionary Signs

These are used to war the road users of certain hazardous conditions that exist on or adjacent to the roadway. They are in the shape of an equilateral triangle with its apex pointing upwards. They have a white background, red borer and black symbols

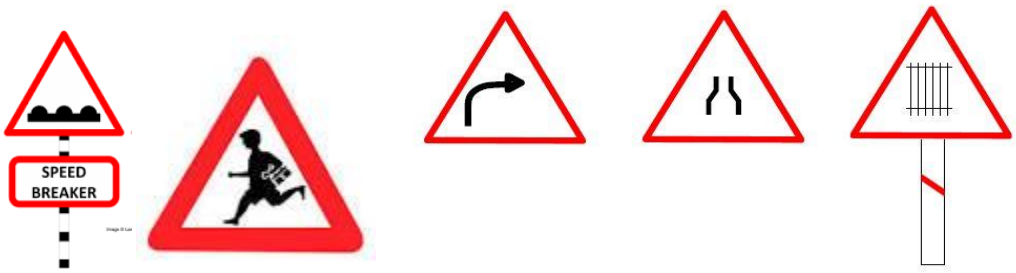


Figure: speed breaker, school, Right hand curve sign board, signs for narrow road, sign indicating railway track ahead)

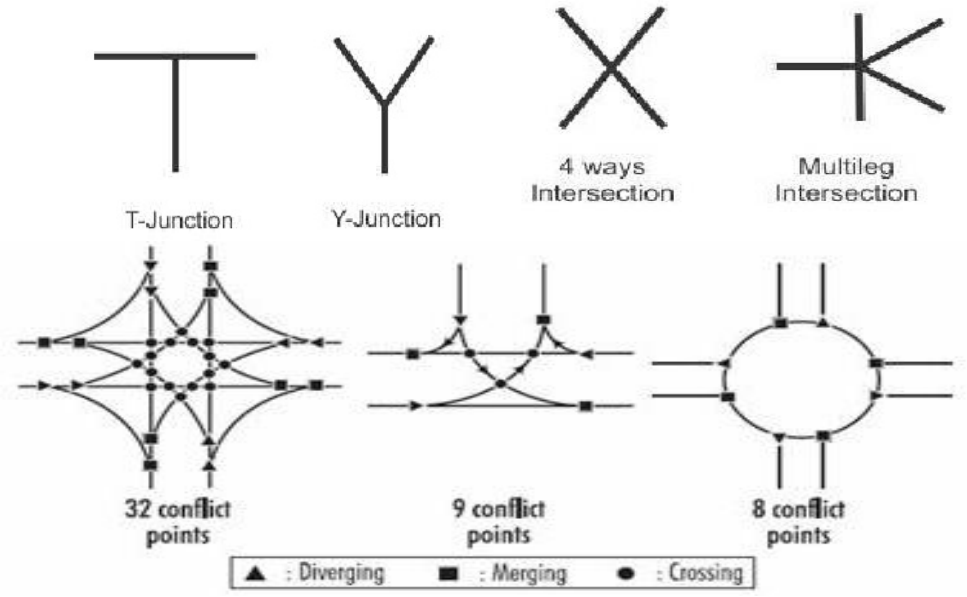
Informatory Signs: These signs provide information to the driver about the facilities available ahead, and the route and distance to reach the specific destinations

b) Breifly explain grade and grade separated intersections

At Grade intersections

An intersection is the area shared by the joining or crossing of two or more roads.
Requirements for good intersection design

- Number of intersections should be minimum.
- Geometric layout should be such that hazardous movements are eliminated.
- Design should permit the driver to discern quickly from the layout or from the traffic signs, the path he should follow and the actions of merging and diverging.
- Conflicting points should be minimum.
- Traffic path should be smooth without abrupt and sharp corners.
- Crossing traffic should be given adequate waiting space.



Levels of intersection control

Passive control : there is no explicit control on the driver.

- ✓ No control
- ✓ Traffic signs
- ✓ Traffic signs plus marking

Semi control: some amount of control on the driver is there from the traffic agency.

- ✓ Channelization:
- ✓ Traffic rotaries

Active control: means the movement of the traffic is fully controlled by the traffic agency and the drivers cannot simply manoeuvre the intersection according to his choice.

- ✓ Traffic signals
- ✓ Grade separated intersections

Grade separated intersections

- Interchange is a system where traffic between two or more roadways flows at different levels in the grade separated junctions.
- Trumpet interchange is a three leg interchange. If one of the legs of the interchange meets a highway at some angle but does not cross it, then the interchange is called trumpet interchange.

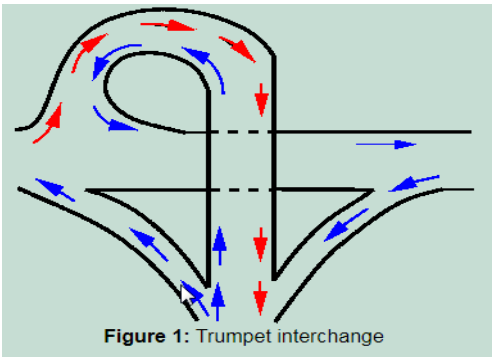


Figure 1: Trumpet interchange

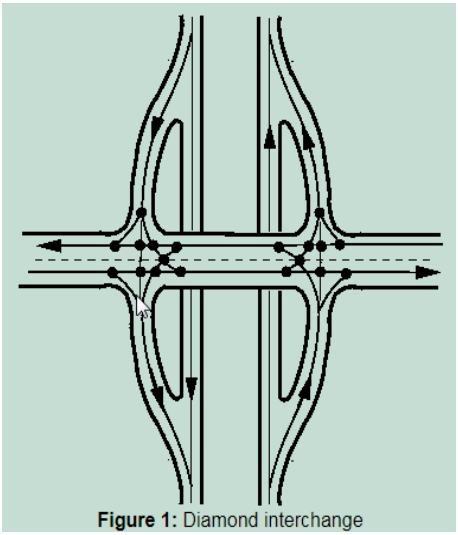


Figure 1: Diamond interchange

- Diamond interchange: Diamond interchange is a popular form of four-leg interchange found in the urban locations where major and minor roads crosses.
- Clover leaf interchange: It is a four leg interchange used when two highways of high volume and speed intersect each other with considerable turning movements. The main advantage of cloverleaf intersection is that it provides complete separation of traffic. In addition, high speed at intersections can be achieved. However, the disadvantage is that large area of land is required. Therefore, cloverleaf interchanges are provided mainly in rural areas.
- Partial Clover leaf interchange:

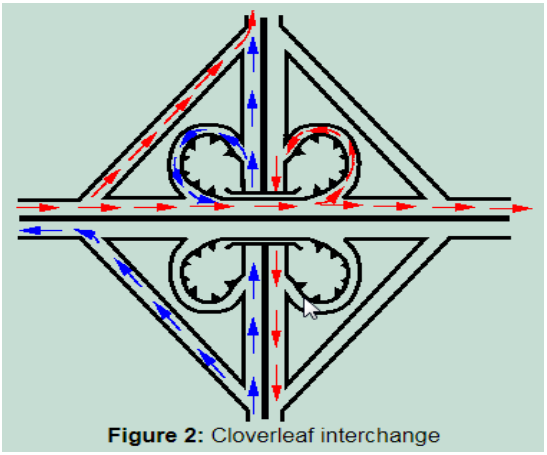
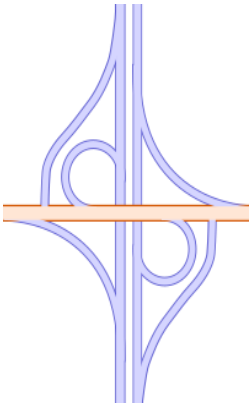


Figure 2: Cloverleaf interchange



Partial Clover leaf

6a) Advantage and disadvantages of traffic signal

Advantages of traffic signals

- Provide orderly movement of traffic at the intersection.
- The quality of traffic flow is improved by forming compact platoons of vehicles, provided all the vehicles move at approximately the same speed.
- Reduction in accidents due to crossing conflict, notably the right angled collisions.
- Traffic handling capacity is highest among the different types of intersections at-grade.
- Provide a chance to traffic of minor road to cross the continuous traffic flow of the main road at reasonable intervals of time.
- Pedestrians can cross the roads safely at the signalized intersection.
- When the signal system is properly co-ordinate, there is a reasonable speed along the major road traffic.
- Automatic traffic signal may work out to be more economical when compared to manual control.

Disadvantages of traffic signals

- The rear-end collisions may increase.
- Improper design and location of signals may lead to violations of the control system.
- Failure of the signal due to electric power failure or any other defect may cause confusion to the road users.
- The variation in vehicle arrivals on the approach roads may cause increase in waiting time on one of the roads and unused green signal time on other road, when fixed time traffic signals are used.
- Excessive delay of vehicle may be caused particularly during off-peak hours.
- Drivers may be induced to use less adequate and less safe routes to avoid delays at signals.

6b) The average normal flow on cross roads 'A' and 'B' during design period are 400 PCU and 250 PCU per hour. The saturation flows are 1250 PCU and 1000 PCU perhour respectively. The all red time required for pedestrian crossing is 12 seconds. Design a two phase signal by Webster's method.

Solution:

$$y_a = \frac{q_a}{s_a} = \frac{400}{1250} = 0.32$$

$$y_b = \frac{q_b}{s_b} = \frac{250}{1000} = 0.25$$

Y=0.32+0.35=0.57

L=2n+R= $2\times2+12=16\text{sec}$

$$C_0 = \frac{1.5L+5}{1-Y} = \frac{1.5\times16+5}{1-0.57} = 67.4 \approx 67.5\text{sec}$$

$$G_a = \frac{y_a}{Y}(C_0 - L) = \frac{0.32}{0.57}(67.5-16) = 29\text{sec}$$

$$G_b = \frac{y_b}{Y}(C_0 - L) = \frac{0.25}{0.57}(67.5-16) = 22.5\text{sec}$$

All red time for pedestrian crossing=12 secs

Providing Amber times of 2.0 secs. each for clearance, total cycle time =29+22.5+12+4=67.5 secs.

Module 4

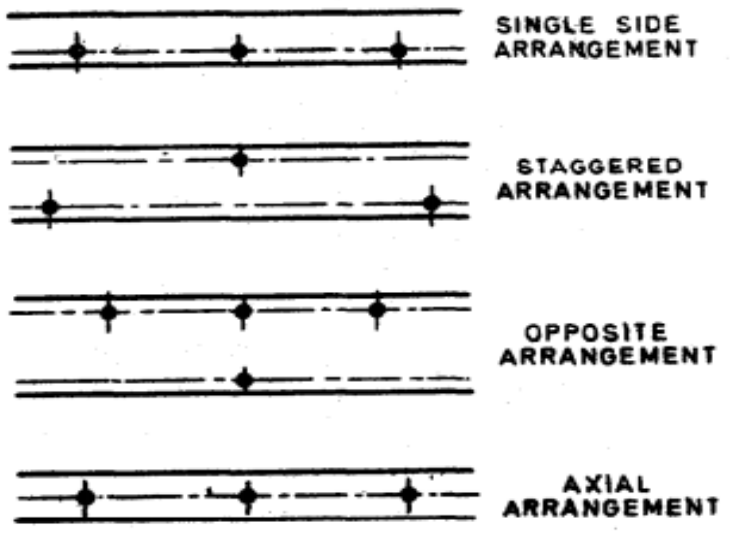
7a) various factors of road lightening

Design factors for highway lighting are

- Lamps – the various types of lamps in use for highway lighting are filament, fluorescent lamps, sodium or mercury vapour lamps.
- Luminaire distribution of light- the distribution of light should be downward so that high percentage of lamp light is utilized for illuminating the pavement and the adjacent areas. The distribution of luminaire should cover the pavement between the kerbs and provide adequate lighting the adjacent areas i.e., 3 m to 5 m beyond the pavement edges. According to Indian Standards Institution, an average level of

illumination of 30 lux on important roads carrying fast traffic and 15 lux on main roads, the ratio of minimum to average illumination being 0.4

- Spacing of lighting units – large lamps with high mountings and wide spacings would be preferred from economy point of view.
- Height and overhang of mounting – usually mounting height range from 6 m to 10 m.
- Lateral placement – the street lights should not be too close to the pavement edge. For roads with raised kerbs, the pole should be at a distance of 0.3 m to 0.6 m from the edge of the kerb.
- Lighting layouts – this can be either single sided, staggered or central.



Spacing (s) of street lamp can be computed as

- $\mathbf{S = \frac{Lamp\ lumen \times coeffecient\ of\ utilization \times Maintenance\ factor}{average\ flux \times width\ of\ the\ road}}$

7b) effects of air pollution

1. List the various causes of air pollution.

Pollutant	Source	Consequences
NO_2	Vehicular exhaust	It forms smog and ozone, It causes respiratory illness, pulmonary disease, bronchitis etc
CO	Vehicle's exhaust as a result of incomplete combustion, Emissions from trucks, autos are significant	It interferes with the blood's ability to carry oxygen to the brain, heart, and other tissues. Unborn or newborn children and people with heart disease are in greatest danger from this pollutant, but even healthy people can experience headaches, fatigue and reduced reflexes and even death
SO_2	Fuel containing sulfur is burned in diesel engines	Asthma, lung diseases, irritate mucus membrane, bronchitis, pulmonary diseases It can effect plants, animals and also properties
O_3	Secondary formation from the vehicular exhaust gases such as reaction of NO2	It forms smog, ozone reacts with lung tissue. It can inflame and cause harmful changes in breathing passages, decrease the lungs' working ability, and cause coughing and chest pains.
Particulate matter (PM)	Particulate matter includes microscopic particles and tiny droplets of liquid which comes from combustion of the fuel in vehicles	PM are very fine in size and they go deep into the lungs, where they may become trapped and cause irritation. Exposure to particulate matter can cause wheezing, asthma, respiratory illness, PM can serve as a vector for toxic air pollutants which may be carcinogenic
Lead	Lead can emitted from leaded petrol, However, usage of un leaded petrol resulted in significant drop in public exposure to outdoor lead pollution	Lead poisoning can reduce mental ability, damage blood, nerves, and organs, and raise blood pressure. Even small ingestions or inhalations of lead can be harmful because lead accumulates in the body
Hydrocarbons	Vehicular exhaust	Many hydrocarbons are carcinogenic

8a) measure to control the traffic noise

Measures to control noise pollution:

(i) Change in the design of vehicles- in India, Motor vehicles Act has made provisions to frame rules to control te noise produced by motor cycles.

(ii) Changes in tyre/ surface characteristics- smooth surfaces result in less noise.

(iii) Elimination of noisier vehicles- old vehicles produce more sound.

(iv) Modifications in traffic operations- rerouting commercial vehicles and buses from residential areas, providing by-pass to prevent high speed traffic from entering towns, ensure continuous and smooth and eliminate acceleration noise, prohibiting blow horns.

(v) Designing streets, buildings and areas for producing less noise- narrow streets create noise conditions (canyon effect). Hence, streets should be wide to reduce noise pollution. Shrubs, trees and grass on the side of the road act as sound barriers.

8b) Road safety audit

Road Safety Audit may be defined as the formal examination of the planning, design and construction of road projects to identify any potentially unsafe feature or operational arrangement that may adversely affect the safety of any road user by independent and qualified examiners and of the characteristics and operation of an existing road.

The goal of the RSA is translated into the following objectives:

1. To reduce the overall through life costs of a road project to the community.

2. To ensure that the safety requirements of all road users are explicitly considered in the planning, design, construction and operation of road projects.

Independence of Auditors: the credibility and effectiveness of RSA is greatly influenced by the degree of independence of the auditors from the planning, design or construction teams involved in the development of the project.

Skills and Experience are required: Usually people competent and experienced in the work associated with traffic accident investigations and countermeasures have most of the basic skills required for the road safety audit. Criteria of auditors

Arrangements for doing the audit: The arrangement for doing the project during the stages is involved three parties :- The designer of the project (Contractor), The

client (Road authority, represented by the Project manager) and The auditor (Consultant engaged by the client).

Accreditation of auditors: The individual people undertaking a RSA must have an accreditation for this work and be identified in the Audit Report which this accreditation be based on an assessment of the person's knowledge of road safety principles, practices , training courses and general knowledge and experience in road and highway engineering.

Stages of RSA Road Safety Audit Stage:

Feasibility & Planning Stage, Detailed Design Stage, The Pre-opening Stage, RSA of An Existing Road

Module 5

9a) i. TSM

Transportation systems management (TSM) involvesvirtually all aspects of traffic engineering in afocus on optimizing system capacity and operations.

TSM action involves:

1. **Traffic Management – this involves**
   - **Traffic Operations -** Intersection and roadway widening, One-way streets, Turn-lane installation, Turning-movement and land-use, New freeway lane using shoulders
   - **Traffic Control -** Local intersection signal improvement, Arterial signal system, Area signal system, Freeway diversion and advisory signing, Freeway surveillance and control
   - **Roadway Assignment-** Exclusive bus lane-arterial, restrictions, Take-a-lane, Add-a-lane, Bus-only street, Contraflow bus lane, Reversible lane systems, Freeway HOV bypass, Exclusive HOV lane-freeway, Take-a-lane, Add- a-lane
   - **Pedestrian and Bicycle** - Widen sidewalks, Pedestrian grade separation, Bikeways, Bike storage, Pedestrian control barriers
2. **Transit management-**
   - **Transit Operations -** Bus route and schedule modifications, Express bus service, Bus traffic signal predemption, Bus terminals
   - **Simplified FareCollection -** Marketing program, Maintenance improvements

- **Transit Management -** Vehicle fleet improvements, Operations monitoring program
- **Inter-Modal Coordination-** Park and ride facilities, Transfer improvements

3. **Demand management**
   - **Paratransit-** Carpool matching programs, Vanpool programs, Taxi/group riding programs, Dial-a-ride
   - **Work schedule -** Elderly and handicapped service, Staggered work hours and flex-time, Four-dav week
4. **Restrain measures**
   - **Parking Management-** Curb parking restrictions, Residential parking control,Off-street parking, restrictions, HOV preferential parking, Parking-rate changes
   - **Restricted Areas -** Area licensing, auto-restricted zones, Pedestrian malls, Residential traffic control
   - **Commercial Vehicle -** On-street loading zones, Off-street loading zones, Peak-hour on-street loading prohibition, Truck route system
   - **Pricing -** Peak-hour tolls, Low-occupancy vehicle tolls, Gasoline tax, Peaoff-peak transit fares, Elderly and handicapped fares, Reduced transit fares

9a)ii. TDM

TDM techniques are aimed at reducing the traffic flows, especially during the peak hour.
Direct methods are the methods that can be directly quantified/ visible by the road user itself.
Indirect methods are the methods which cannot be directly measured. Among the different techniques enlisted below, except road pricing all are direct methods.
The different techniques adopted are

1. Car pooling and other ride-sharing programmes
2. Peripheral parking
3. Chartered buses
4. Staggering of office hours
5. Internal shuttle service in CBD
6. Parking restraint
7. Road pricing
8. Entry fee
9. Priority for buses in traffic

9b) Application of ITS

Intelligent Transportation Systems **(ITS)** is the application of computer, electronics, and communication technologies and management strategies in an integrated manner to provide traveler information to increase the safety and efficiency of the surface transportation systems. These systems involve vehicles, drivers, passengers, road operators, and managers all interacting with each other and the environment, and linking with the complex infrastructure systems to improve the safety and capacity of road systems.

ITS user services

Some of the user services offered by ITS are described as follows:

1. Travel and traffic management

The main objective of this group of services is to use real time information on the status of the transportation system to improve its efficiency and productivity and to mitigate the adverse environmental impacts of the system. This includes pre-trip information, enroute information, route guidance, route matching and information, traveler service information etc.

2. Public transportation operations

This group of service is concerned with improving the public transportation systems and encouraging their use. This includes services like real time public transit services and its maintainence, enroute information,

3. Electronic payment:

This user service allows travellers to pay for transportation services with a common electronic payment medium for different transportation modes and functions. Toll collection, transit fare payment, and parking payment are linked through a multi-modal multi-use electronic system. With an integrated payment system a traveller driving on a toll road, using parking lot would be able to use the same electronic device to pay toll, parking price and the transit fare.

4. Commercial vehicle operations: The aim is to improve the efficiency and safety of commercial vehicle operations including freight mobility, automated road side safety inspection, etc.

5. Advance vehicle control and safety systems: This user service aims to improve the safety of the transportation system by supplementing drivers' abilities to maintain vigilance and control of the vehicle by enhancing the crash avoidance capabilities of vehicles.

6. Emergency management: This includes emergency notification and personal security on the occurrence of an accident as well as emergency vehicle management.

7. Information management: This service is aimed to provide the functionality needed to store and archive the huge amounts of data being collected on a continuous basis by different ITS technologies.

8. Maintenance and construction management: This user service is aimed to provide the functionality needed for managing the fleets of maintenance vehicles, managing the roadway with regards to construction and maintenance and safe roadway operations.

ITS Architecture

The ITS Architecture provides a common framework for planning, defining, and integrating intelligent transportation systems. It specifies how the different ITS components would interact with each other to help solving transportation problems.

ITS Planning

ITS planning is to integrate ITS into the transportation planning process

Module 5

10a) traffic regulation principle

In order to have safe traffic on roads, it is desirable to impose adequate traffic regulations and traffic control with the help of standard traffic control devices. The traffic regulations and control are implemented with the help of suitable regulatory signs, signals, marking, traffic islands and other devices. The various regulations imposed through the traffic control devices should fulfill the requirements such as: (i) Clear visibility during the day and night (ii) Easy to recognize and understand (iii) Sufficient time for the driver driving at the design speed or within the legal speed limit to react and follow the regulation. (iv) To ensure safety in general

Regulations on vehicles

1. Speed limits: this is generally controlled by the type and volume of traffic. This is also dependent upon
   Environment of roads
   Traffic composition
   Character of road
   Casualty
2. Enforcement of speed limits – violators will be summoned or arrested or punished. For enforcement, radar speedometers are installed.
3. Establishment of speed zones
4. Vehicle registration for different states, different purposes are categories with reference to registration plate number. The order of age can also be identified with reference to the alphabets associated with the number plate.

5. Construction and equipment of vehicles: regulations in this category include brake and starring system, length of the truck trailer unit if any, wheel loaf, wheel load, emission, use of horns, periodical testing and inspection of vehicles, prohibition on use of horns and so on.
6. Control of transport vehicles – regulations with reference to goods movement, competition among different modes and so on.
7. Insurance: mainly to cover the liability in respect of death or injury to persons or damage to any property

Regulations concerning the driver

1. Licensing of the driver – given to an individual after he passes a test of competence. He should be able to portray his ability as a driver as well as his knowledge in different rules and regulations.
2. Requirements of physical fitness – night blindness, epilepsy, inadequate perception, heart diseases etc make a person unfit for driving
3. Age of drivers – in india, an individual should be of 18 years of age to get adriving license, whereas he should be of minimum of 20 years to get license to drive transport vehicles.
4. Disqualification and endorsement of licenses- habitual drinking, dangerous dribing, offences and penalties make a person unfit for driving.

10b) Factors affecting skid resistance

The maximum friction offered by pavement surface or the skid resistance depends upon the following factors:

(i) Type of pavement surface namely, cement concrete bituminous, WBM, earth surface etc.

(ii) Macro-texture of the pavement surface or its relative roughness.

(iii) Condition of pavement namely, wet or dry, smoothened or rough, oil spilled, mud or dry sand on pavement.

(iv) Type and condition of tyre i.s. new with good treads or smoothened and worn out tyre.

(v) Speed of vehicle

(vi) Extent of brake application or brake efficiency

(vii) Load and tyre pressure

(viii) The temperature of tyre and pavement, and

(ix) The type of skid, if any

(x) Road geometry