TRANSPORTATION ENGINEERING - I

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A Handbook on

Transportation Engineering-i

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TOPICS

- INTRODUCTION
- HIGHWAY DEVELOPMENT & PLANNING
- HIGHWAY ALLIGNMENT & SURVEYS
- HIGHWAY GEOMETRIC DESIGN
- TRAFFIC ENGINEERING
- ROAD ACCIDENT
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মো: রবিউল ইসলাম
রাজেশাহী প্রকৌশল ও প্রযুক্তি বিশ্ববিদ্যালয়
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রোল নং: ১৩০১১০

MAH
part

CE - 3205 - Transportation Engineering - I

Introduction

Q. What do you mean by transportation?

Answer: **Transportation:** Transportation engineering or simply transportation is the system by which persons and goods can be shifted from one place to another by any kind of vehicle.

" As blood transportation through arteries is essential for well being of the human being similarly good system of transportation is essential for well being of nation.

Q. Discussed what important roles played by transportation. 2009

⇒ Role of Transportation:

(a) Transportation contributes to the economic, industrial, social and cultural development of any country.

(b) Transportation is vital for the economic development of any region.

(c) Every commodity produced whether it is food, clothing, industrial products or medicine needs transport at all stages from production to distribution.

(d) In the production stage, transportation is required for carrying raw materials like seeds, manure, coal, steel etc.

(e) In the distribution stage, transportation is required from the production centres.

(f) The inadequate transportation facilities retard the process of socio-economic development of the country.

(g) The adequacy of transportation system of a country indicates its economic and social development.

⇒ All the advantages of transportation may now be summarized:-

(I) Transportation is for advancement of the community.

(II) Transportation is essential for the economic prosperity and general development of the country.

(III) Transportation is essential for strategic movement in emergency for defence of the country and to maintain better law and order.

Q. 2015,14,05,04
Describe the role of Transportation in Rural Development.

Role of Transportation in Rural Development :-

(a) More than 75% of the population of the country living in the villages, the development in urban centres alone do not indicate the overall development of the country.

(b) Only with the improvement in transportation facilities in rural areas, there could be faster development of the rural centres.

(c) The fertilizers and other inputs for agriculture and cottage industries could reach the rural population easily.

(d) The products can be sold at the nearest marketing centres for more remunerative price resulting in faster economic growth and decreased wastage.

(e) With improved facilities for education, health care and other social needs in the villages, the urge for the migration to urban centres decreases.

Thus helping in balance development of the country as a whole.

Question: What are different Modes of Transportation? Explain their functions. 2003,04,08,09,10

Answer:

Modes of Transportation:

Three major modes of transportation are present.

(i) Land transportation → Roadways / Highways
                        → Railways.

(ii) Water transportation.

(iii) Air transportation.

Other modes include:- MPCABE MAP BEC

(I) Pipe lines (II) Elevators (III) Belt conveyors

(IV) Cable cars (V) Aerial ropeways (VI) Monorails.

There specific functions are given below:-

Roadways: Roadways are the means of transportation on lands. This is the only mode that can give maximum service to one and all and it is possible to provide door to door service by this mode only.

Railways: Railways are advantageous for longer distances. The train can run at much higher speed than the pneumatic tyre vehicles and energy required is comparatively less.

Waterways: Waterways are effective in transportation with foreign countries. It needs minimum energy.

Air way: Air ways are effective in travelling a great distance in shortest time but highly cost.

Pipe lines: Pipe lines are used for transportation of water, gas, oil etc.

Belt conveyors: Belt conveyors are used for carrying goods in various industries such as suger mill and so on.

Aerial ropeways: Rope ways are used for transportation of goods ~~in various~~ as well as people in hilly areas.

2015, 14, 13, 11, 10, 09, 07, 06, 05

Q. Briefly discuss the characteristics of road transportation.

Characteristics of Road Transportation:- 2015

The characteristics of road transport are briefly listed here:-

FUDIS

(a) **USES:** Roads are used by various types of road vehicles.

(b) **Investment:** Road transport requires a relatively small investment for the (Motor vehicles are much cheaper than other carries). construction and maintenance of roads is also cheaper.

(c) **Freedom to users:** Road transport offers a complete freedom to road users to transfer the vehicle from one lane to another according to the need and convenience.

(d) **Saving in time and Money:** In particular for short distance travel, road transport saves time.

(e) **Degree of accidents:** Road transport is subjected to a high degree of accidents due to the flexibility of movements offered to the road users.

(f) Road transport is the only means of transport that offers itself to the whole community alike of all the system of transportation.

2004, 05, 14

Q. Write short notes on following.

(I) Economic activity & Transportation.

(II) Social effects & Transportation.

(III) Rural development & Transportation. → अगले page पर →

14, 13, 11

Economic activity & Transportation: The cost of a commodity is influenced to a great extent by the cost of its transportation. If near a big city a adequate system of transportation connects the villages around it, the produce of villages can be brought to the city, where the need of the city for that produce can be fulfilled and the villagers may get a remunerative price for their produce as vegetable, milk, food articles, etc. In this way the economy of villagers may improve.

Thus for the economic development of a region, adequate and effective system of transportation is essential.

Social effects & Transportation: When people go out and meet people of different region, they get a chance to understand each others style of living and other problems.

Due to the cheap and time saving transportation system people from near by areas can go for work in cities and can improve their living conditions. It can also help in reducing the slumps in the cities.

The rapid and efficient transport system is essential for long distance travel for business needs, social visits, tourists activities. This also encourages people to live away from their place of work and thus helps in reducing the population density of the city.

Q. "The development of Bangladesh is dependent on the development of its transportation system." Explain.

Answer: Bangladesh is a developing country. Agriculture is the greatest source of income in our country. Over 75% of people in our country are livers in villages. Due to the absence of good transportation system, the villagers do not get sufficient price for their goods. As a result rural development is hamperd. So, for a rural development of Bangladesh, development of transportation system is necessarry

There are several sources of natural resource in our country but we can not explore and use them because of the defficienty of well planned transportation system. To utilize the natural resources of Bangladesh development of transportation is very important.

Not only the rural development, urban development of Bangladesh also depends on the development of transportation because a good and well planned transportation system helps to develop the economic condition of a town.

Natural calamities like flood, storm .etc are very common in Bangladesh. A good transportation system is essential for fighting with natural calamities.

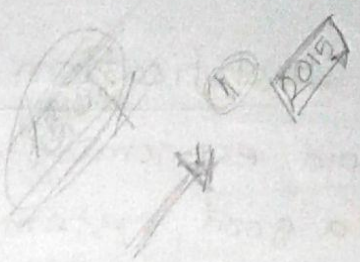
Also economic condition, social condition etc. of Bangladesh is largely depends on the transportation system.

So, we can conclude that development of our country is impossible without the development of transportation system.

Q. Write the name of road based on function & location? 2015

Answer: Based on function and location, various types of road are given below:-

(a) National Highway (NH)
(b) State Highway (SH)
(c) Major District Road (MDR)
(d) Other District Road (ODR)
(e) Village Road (VR)



Q. Discuss the scope of highway engineering.

Answer: Scope of Highway Engineering:-

Highway engineering deals with,

(I) development, planning and locations or alignment of roads.
(II) Geometric ~~degin~~ design and structural ~~design~~ design of roads.
(III) Traffic operation and its control.
(IV) Road materials, construction and maintenace of roads.
(V) Economic condition, finance and administration related to road and road users.
(VI) Problems related to development and construction of hill road; roadside development etc.

Q. "As blood circulation through body arteries is essential for well being of a human being, similarly a good systems of transportation is essential for well being of nation". Justify it

Answer: Justification :-

For rapid economic, industrial and cultural growth of any country a good system transportation is very essential. Transportation system compries of good network of roads, railways, well developed waterways and airways. Airways and waterways although help to some extent in transportation within the country, but they are the modes of transport mainly with foreign countries. Railways and highways, also some extent to help in transport with foreign countries. but their main concerns is within the country itself.

An industrialist has to transport the new materials and then market his finished products. He can do so ~~diff~~ efficiently only through a good system of transportation. In big metropolitan cities, reaching the working places requires a good system of transportation, which may be in the form of urban railway, system or bus system. A farmer can ~~market~~ carry his agricultural produce to the nearby market economically only through a good system of roads. So, development of any country could not be possible without a good system of transportion.

Therefore we say that "As blood circulation through body arteries is essential for well being of a human being, similarly a good system of transportation is essential for well being of a nation".

Question: Discuss the Advantages and Disadvantages of different Modes of Transport.

Answer: The advantages and disadvantages of differents Modes of transport are given below:-

Road Transport:

Advantages	Disadvantages
(I) It has less capital outlay.	(I) It follows seasonal nature.
(II) It provides door to door services.	(II) In here Accidents and Breakdowns occur.
(III) It services in Rural areas.	(III) It is unsuitable for long distance and Bulky Traffic.
(IV) It is a Flexible service.	(IV) It has lack of organization.
(V) It is suitable for short distance.	
(VI) It has less risk of Damage in Transit.	
(VII) It is saving in packing cost.	
(VIII) It provide rapid speed.	
(IX) It's required less cost.	
(X) It is helpful for private owned vehicles.	
(XI) It is feeder to other Modes of Transport.	

Railway Transport:

Advantages	Disadvantages
(I) It is dependable.	(I) It has huge capital outlay.
(II) It is better organized.	(II) It has lack of flexibility.
(III) It provides high speed over long distance	(III) It has lack of Door to Door service.

(IV) It is suitable for Bulky and heavy goods.

(V) It is a cheaper transport.

(VI) It provides more safety.

(VII) It ~~requires~~ provides/has larger capacity.

(VIII) It is a public welfare.

(IX) It gives Adminstrative Facilities of Government.

(X) It creates employment opportunities.

(IV) It is a monopoly

(V) It is unsuitable for short distance and small loads.

(VI) It provides Booking facilities.

(VII) It can not give rural service.

(VIII) Sometiemes it shows under-utilized capacity.

(IX) It has a centralized Adminstation

Air transport:-

Advantages	Disadvantages.
(I) It provides high speed.	(I) It is very costly.
(II) It is comfortable and quick service.	(II) It has small carrying capacity.
(III) It does not require investment in construction of Track.	(III) It is uncertain and unreliable.
(IV) It has no physical barriers.	(IV) It breakdowns and Accidents occurs.
(V) It is easy Access.	(V) It requires large investment.
(VI) It is an emergency services	(VI) It is required specialized skill.
(VII) It gives quick clearence	(VII) It is unsuitable for cheap and Bulky goods.
(VIII) It has national defence.	(VIII) It has a legal Restrictions.
(IX) It is most suitable for carrying light goods of high value.	

Q. Describe about the elements of Transport.

Answer: Elements of Transport:-

Movement of goods or passenger traffic, through rail, sea, air or road transport requires adequate infracture facilities for free flow from place of origin to place of destination.

Irrespective of modes every transport system has some common elements.

(I) Vehicle: Vehicle or carrier is needed to carry passenger or goods.

(II) Routes or path for movement of carriers:-

(a) Routes play an important role.

(b) It may be surface roads, navigable, airway etc.

(c) Availability of well designed and planned routes.

(III) Terminal facilities for loading and unloading of goods and passengers from carriers:-

(a) Objectives of transportation can't be fullfilled unless proper facilities.

(IV) Prime Mover:-

(a) Power utilized for moving of vehicles for transportation.

(V) Transit time and cost:-

(a) Transportation involve time and cost.

(b) Time element is a valid factor for determining effectiveness of a particular mode of transport.

(c) Transit time of available system of Transportation largely determines production and consumption patterns

Perishable goods in an economy.

(VI) Cargo :-

(a) Nature and size of cargo constitute basis of any goods transport system.

These elements influence effectiveness of different moder of a Transport and their utility to uses.

Q. Write down the major disciplines of Transportation.

Answer: Major Disciplines of Transportation :-

Transportation engineering can be broadly consisting of four major parts :-

(a) Transportation planning.

(b) Geometric design.

(c) Pavement design.

(d) Traffic engineering.

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রোল নং: ১৬০১১০

HIGHWAY DEVELOPMENT AND PLANNING

Q. What do you know about historical development of road construction?

Answer: Historical development of Road Construction:-

History of Highway Engineering gives us an idea about roads of ancient times. Roads in Rome were constructed in a large scale and it radiated in many directions helping them in military operation. Thus they are considered to be pioneers in road construction.

Ancient Road:-

(a) In this time most primitive mode of transport was by foot.

(b) These human pathways would have been developed for specific purposes leading to camp sides, food, streams for drinking water etc.

(c) Invention of wheel in Mesopotamian civilization lead to development of animal drawn vehicles.

(d) To provide adequate strength to carry wheels, new wass tended to follow sunny drier side of a path.

(e) After invention of wheel, animal drawn vehicles were developed and need for hard surface road emerged

(f) Traces of such hard roads were obtained from various ancient civilization dated as old as 3500 BC.

(g) Earliest authentic record of road was found from Assyrian empire constructed about 1900 BC.

Roman Roads:

(I) The earliest large scale road construction is attributed to Romans who constructed an extensive system of roads radiating in many directions from Rome.

(II) Romans recognized that fundamentals of good road construction were to provide good drainage, good material and good workmanship.

(III) Their roads were very durable, and some still exist.

(IV) The roads were bordered on both sides by longitudinal drains.

(V) The next step was construction of agger.

→ This was a raised formation up to a 1 meter high and 15 m wide and was constructed with materials excavated during side drain construction.

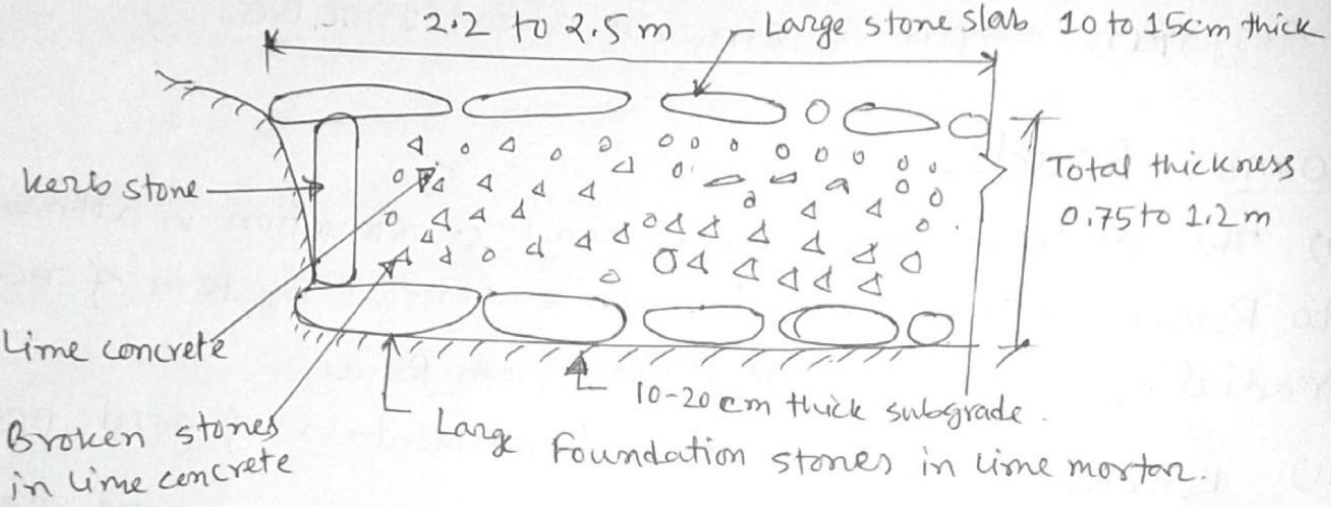
→ this was then topped with a sand levelling course.

→ In case of heavy traffic, a surface course of large 250 mm thick hexagonal flag stones were provided.

→ Main features of Roman Roads are that they were built straight regardless of gradient and used heavy foundation stones at bottom.

→ they mixed lime and volcanic puzzolana to make mortar and they added gravel to this mortar to make concrete.

→ Thus concrete was a major Roman Road making innovation.



French Road:

→ The Major development in road construction occured during regime of Napoleon.

→ Significant contributions were given by Tresaguet in 1764.

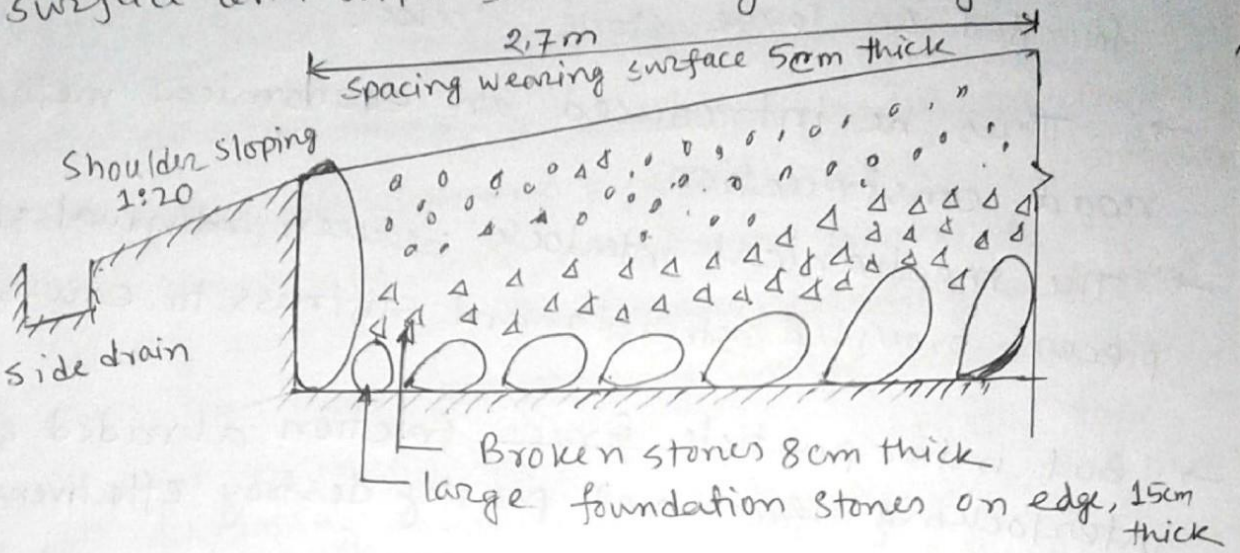
→ He developed a cheaper method of construction than lavish and locally unsuccessful revival of Roman practice.

→ Pavement used 200 mm pieces of quarried stone of a more compact from and shaped such that they had at least one at side which was placed on a compact formation.

→ Smaller pieces of broken stones were then compacted into spaces between larger stones to provide a level surface.

→ Finally, running layer was made with a layer of 25 mm sized broken stone.

→ All this structure was placed in a trench in order to keep running surface level with surrounding country side.



→ This created a major drainage problem which were counteracted by making surface as impervious as possible cambering surface and providing deep side ditches.

→ He gave much importance for drainage.

→ He also enunciated necessity for continuous organized maintenence, instead of intermittent repairs if roads were to be kept unusable all times.

→ For this he divided roads between villagers into section of such length that an entire road could be covered by maintenence men living nearby.

British roads:

(I) British government also gave importance to road construction.

(II) British engineer John Macadam introduced what can be considered as first scientific road construction method.

(III) Stone size was an important element of Macadam recipe

(IV) By empirical observation of many roads, he came to relize that 250 mm layers of well compacted broken angular stone would provide same strength and stiffness.

→ A better running surface than an expensive pavement founded on large stone blocks.

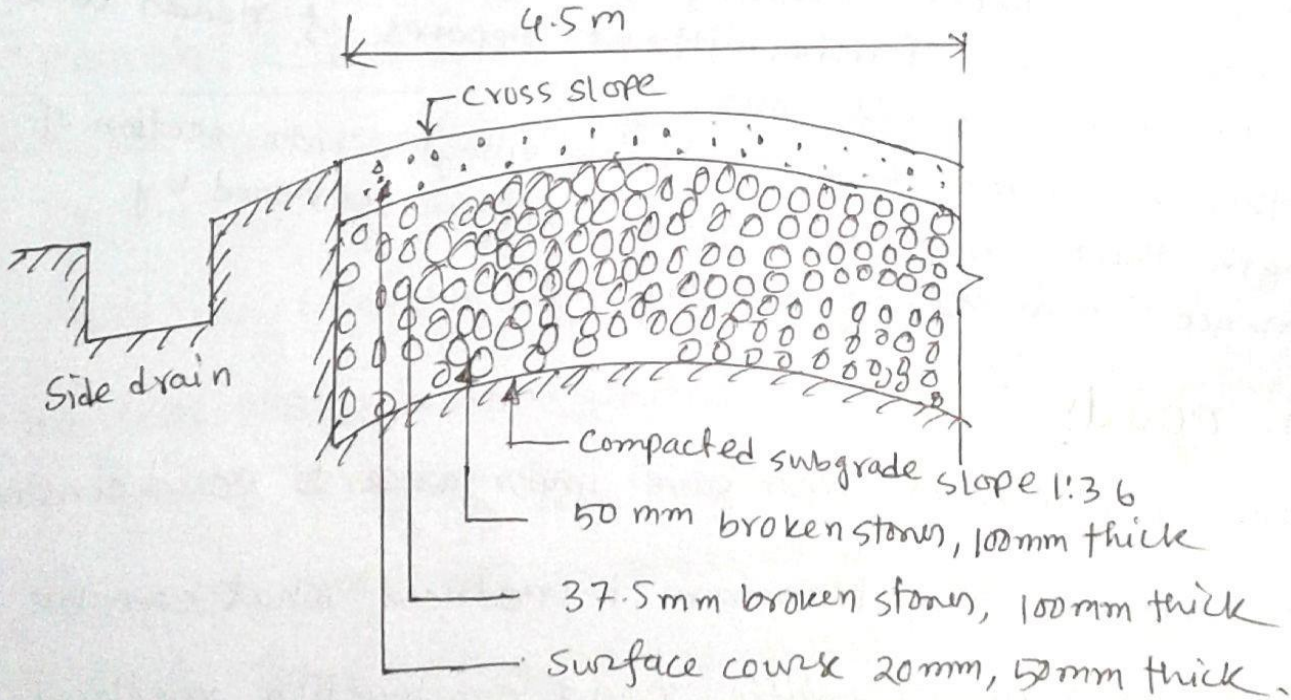
→ Thus he introduced an economical method of road construction.

→ The mechanical interlock between individual stone pieces provided strength and stiffness to course.

→ But inter particle ~~forces~~ friction abraded sharp interlocking faces and partly destroy effectiveness of course.

→ This effect was overcome by introducing good quality interstitial finer material to produce a well-graded mix.

→ Such mixes also proved less permeable and easier to compact.



Q. Describe the Necessity of Highway planning. 2015, 14, 13, 11, 10, 09 08, 07

Answer: Necessity of Highway Planning:-

In The present era planning is considered as a pre-requisite before attempting any development programme. This is particularly true for any engineering work, as planning is also a basic need for highway development. Particularly planning is of great importance when the funds available are limited whereas the total requirement is much higher. This is actually the problem in all developing countries like Bangladesh as the best utilisation of available funds has to be made in a systematic and planned way.

Q. Describe the Objects of Highway planning. 2015, 14, 13, 11, 10, 09, 08, 07

Answer: The objects of Highway planning are briefly given below:-

(I) To plan a road network for efficient and safe traffic operation, but at minimum cost.

(II) To arrive at the road system and the lengths of different categories of roads which could provide maximum utility and could be constructed within the available resources during the plan period under consideration.

(III) To fix up date wise priorities for development of each road link based on utility as the main criterion for phasing the road development programme.

(IV) To plan for future requirements and improvements of roads in view of anticipated developments.

(V) To work out financing system.

* Explain the different methods for the classification of roads.

CLASSIFICATION OF ROADS: 2070

The different types of roads are classified into ~~two~~ three categories Based on usage, carriage way, pavement surfacing.

(I) Based on usage:- According to based on usage roads are two types.

(a) All weather roads: All weather roads are those which are negotiable during all weather, except at major river crossings where interruption to traffic is permissible upto a certain extent.

(b) Fair weather roads: Roads which are negotiable only during fair weather is known as fair weather roads.

(II) Based on carriage way:- According to based on carriage way roads are two types.

(a) Paved roads: Roads provided with a hard pavement course ~~are called unpaved~~ such as water bound Macadam (WBM) layer are known as Paved roads.

(b) Unpaved roads: Roads not provided with a hard pavement course are called unpaved roads.

(III) Based on pavement surfacing: According to based on pavement surfacing roads are also two types.

(a) Surfaced roads: Roads which are provided with cement or bituminous surfacing are called surfaced roads. Road with bituminous surfacing are also

called black topped roads.

(b) Unsurfaced roads: Roads which are not provided with cement or bituminous surfacing are called unsurfaced roads

Modern Roads:

(a) Modern roads by and large follow Macadam construction method.

(b) Use of bituminous concrete and cement concrete are most important development.

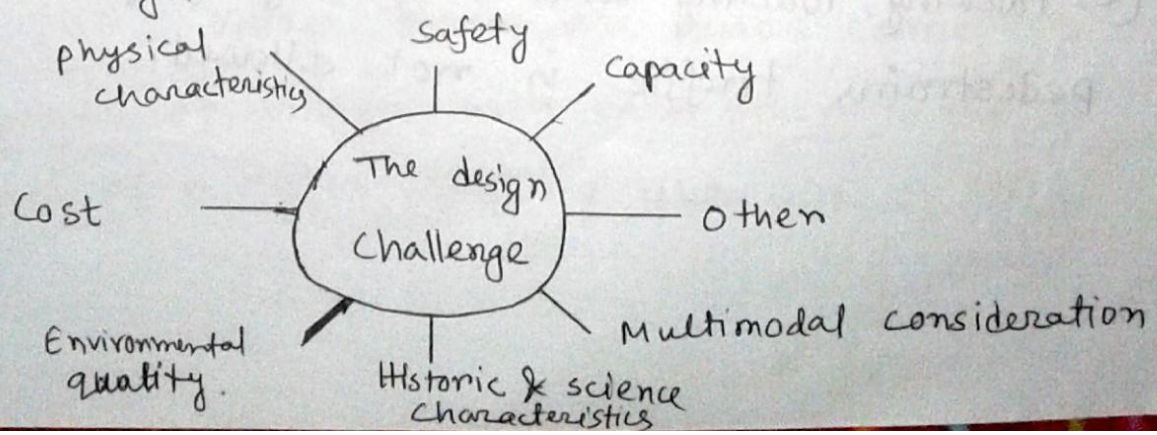
(c) Development of new equipment helps in faster construction of roads.

(d) Many easily and locally available materials are tested in laboratories and then implemented on roads for making economical and durable pavements.

Factors to Considered During Planning:-

(i) It is important to look ahead during planning stage and consider potential impact that a proposed facility or improvement may have while project are started.

(ii) During planning, key decession are made that will affect the design action.



2015 * Write the classification of road based on location and function.

Classification of Roads based on Location and function:

Roads are classified based on location and function are follows:—

MOVENS

(I) Expressways.
(II) National highways (NH)
(III) State highways (SH)
(IV) Major district Roads (MDR)
(V) Other District Roads (ODR)
(VI) Village road. (VR)

Expressways:

(a) It is a the separate class of highways with superior facilities, design standards and high speed (120km/hr)

(b) It are meant at through routes having very high volume of traffic.

(c) It is provided with divided carriageways, controlled access, grade separation at cross roads and fencing.

(d) These expressways should permit only fast moving vehicles.

(e) Parking, loading and unloading of goods and pedestrains traffic is not allowed.

~~This is a~~

National Highways: Main highways running through a country connecting major ports, foreign highways, capitals of large states and large industrial and tourists centres including roads required for strategic movements.

State Highway: State highways (SH) are arterial roads of a state, connecting up with the national highways of adjacent states, district head quarters and important cities within the state and serving as the main arteries for traffic to and from district roads.

Major Districts Roads (MDR): Major districts roads are important roads within a district serving areas of production and markets and connecting those with each other or with major highways of a district. The MDR has lower speed and geometric design specification than NH/SH.

Other Districts Roads (ODR): Other districts roads are roads serving rural areas of production and providing them with outlet to market centres or other important roads like MDR or SH. These are of lower design specifications than MDR.

Village Roads (VR): Village Roads are roads connecting villages or groups of villages with each other to the nearest road of a higher category like ODR or MDR.

Classification based on traffic volume:-

Three types of road.

(I) Light traffic.

(II) Medium traffic.

(III) Heavy traffic.

Light traffic:- In light traffic equivalent axle load (EAL) is less than 10^4 or commercial vehicle per day (CVPD) is ~~equal~~ to less than 50.

Medium traffic: In Medium traffic equivalent axle load (EAL) is equal to 10^4 to 10^6 or commercial vehicle per day (CVPD) is equal to 50 to 300.

Heavy traffic: In Heavy traffic equivalent axle load (EAL) is more than 10^6 or commercial vehicle per day (CVPD) is more than 300.

Classification of Urban Roads :-

Arterial Roads:-

(a) Most city roads which are meant for through traffic usually on a continuous route.

(b) It is generally spaced at less than 15 km in developed business centres whereas in less important areas may be 8 km apart.

(c) It is also a divided highways with fully or partially controlled access, parking, loading and unloading activities are carefully regulated.

(d) Pedestrians are permitted to cross them at intersection only.

Sub-arterial Roads:

(i) City roads which are provide lower level of travel mobility than arterial streets.

(ii) Their spacing may vary from 0.5 km in central business district to 3 to 5 km in sub-urban areas

(iii) Loading and unloading are usually restricted.

(iv) Pedestrains are allowed to cross these highways at intersections.

Collector streets:

(a) City roads which are constructed for collecting and distributing traffic to and from local street and also to provide an access to arterial and sub-arterial streets.

(b) It is located in residential, business and industrial areas.

(c) Accessible from building along them.

(d) There are few parking restictions except during peak hours.

Local Streets:

(a) City roads which provide an access to residence business and other buildings.

(b) Traffic carried either originates or terminates along local streets.

(c) Depending upon importance of adjoining areas, a local street may be residential, commercial or industrial.

(d) Pedestrians may move freely and parking may be permitted without any restriction.

Highways:

(a) Highways is a superior type of roads in a country.

(b) Two types of highways are present.
* Rural highways and urban highways.

(c) Rural highways are those passing through rural areas (villages).

(d) Urban highways are those passing through large cities and towns i.e. urban areas.

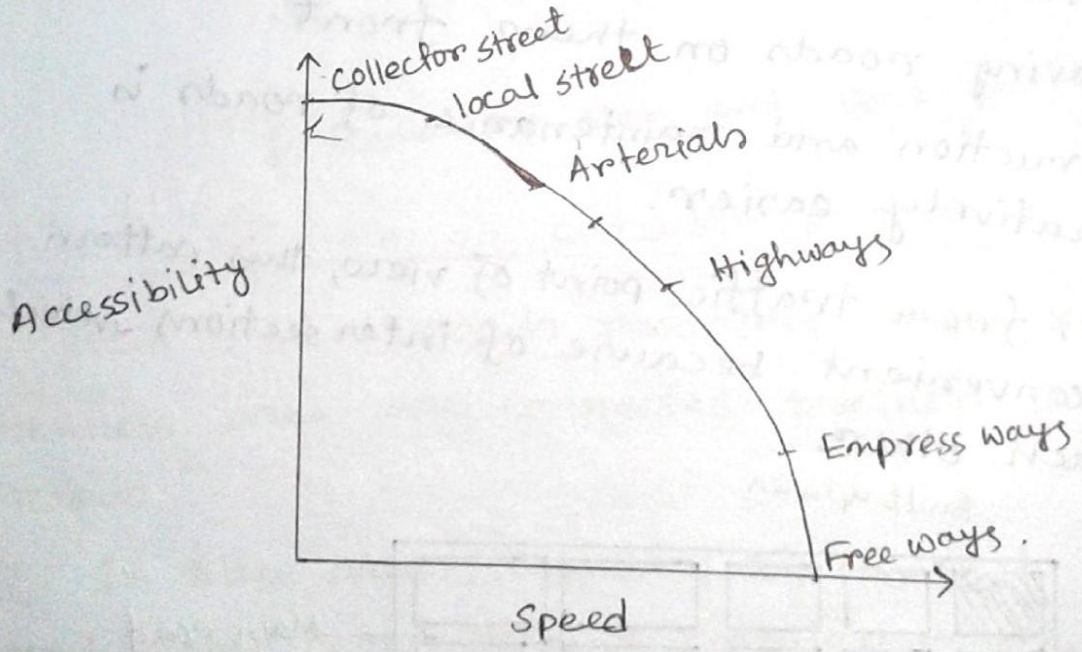
Freeways:

(a) It is a Access-controlled divided highways.

(b) Most freeways are four lanes. Two lanes each direction but many freeways widen to incorporate more lanes as they enter urban-areas.

(c) Access is controlled through use of interchanges and type of interchange depends upon of intersecting roadway (rural roads, another freeway etc).

(d) Heavy speed vehicle can move on it.



Q. Draw the various road patterns commonly use. 2009, 11

Road Patterns:-

⇒ Rectangular or block Pattern :-

(a) Whole area is divided into rectangular blocks of plots, with streets intersecting at right angles.

(b) Main road which passes through centre of area should be sufficiently wide and other branch roads may be comparatively narrow.

(c) Main road is provided a direct approch to outside city.

(d) May be furthered divided into small rectangular block for construction of building placed back to back having roads on their front.

(e) Construction and maintenance of roads is comperatively easier.

(f) But, from traffic point of view, this pattern is not convenient because of intersections, vehicle face each other.

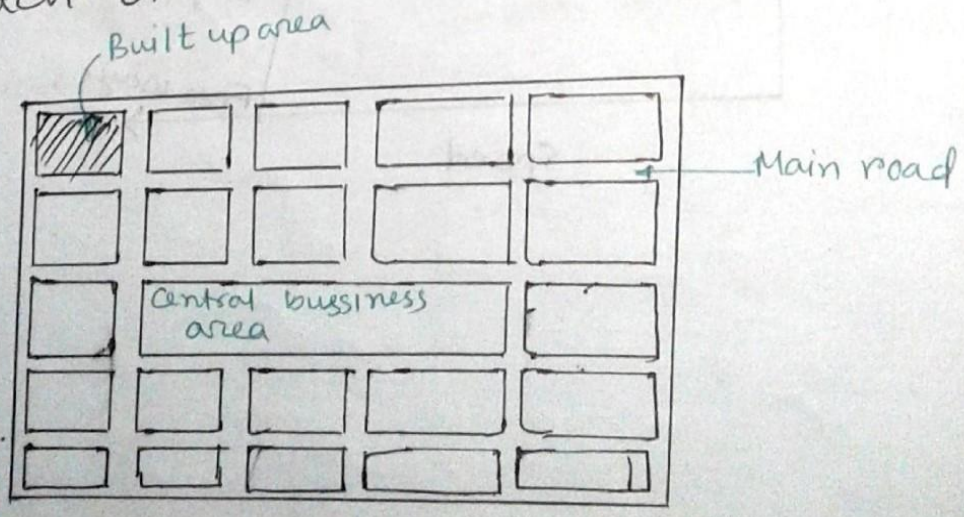


Fig. Rectangular or block pattern.

Radial or star block Pattern :-

(a) Entire area is divided into a network of roads radiating from business area outwardly.

(b) In between radiating main roads, built up area may be planned with rectangular blocks.

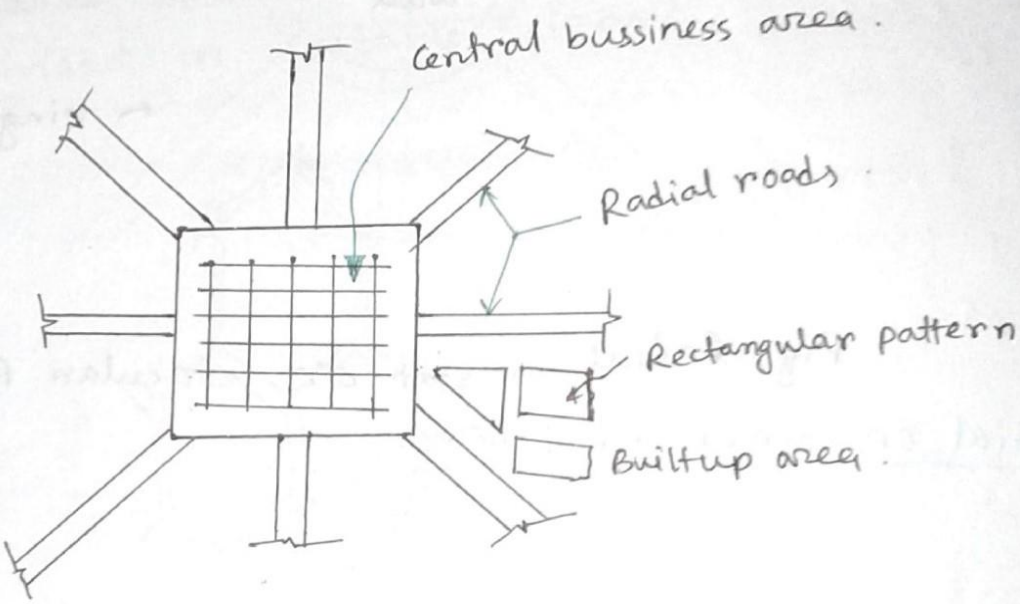


Fig. Radial or star and block pattern.

Radial or star or circular pattern :-

(a) Main radial roads radiating from central business area are connected together with concentric roads.

(b) In these areas, boundary by adjacent radial roads and corresponding circular roads, built up area is planned with a curved block system.

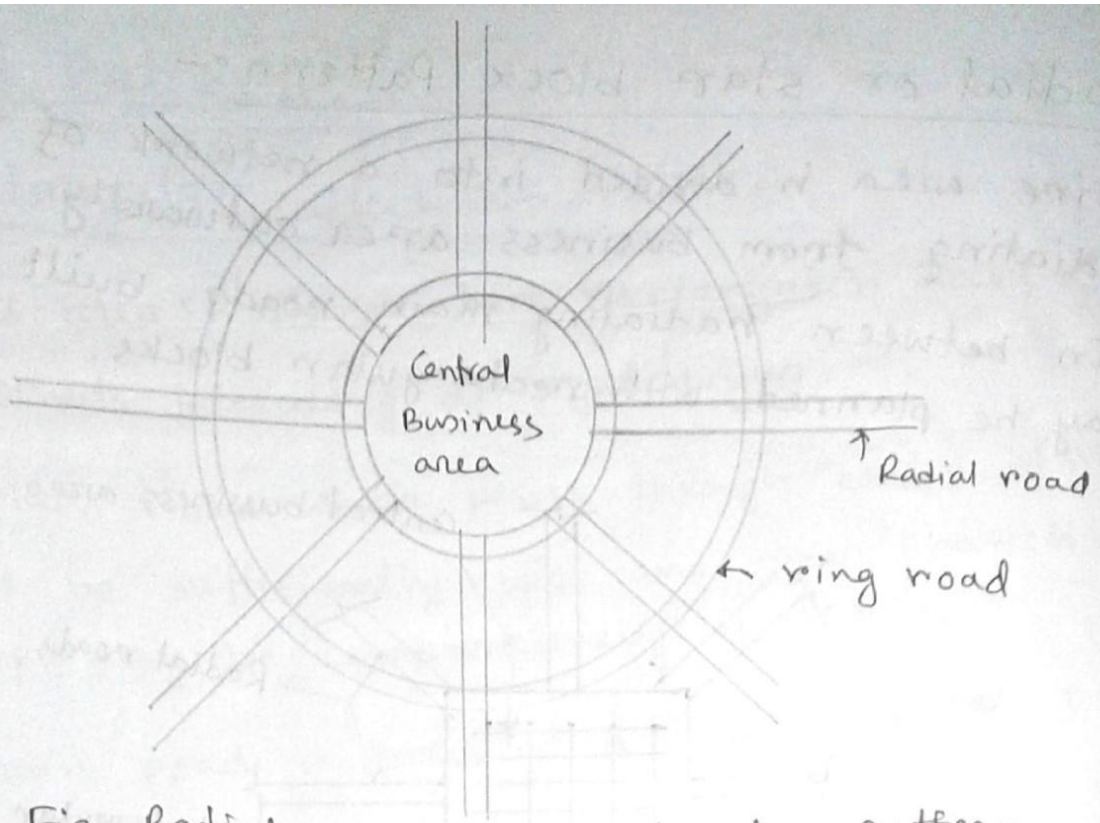


Fig. Radial or star or circular pattern

Radial or star or grid pattern:-

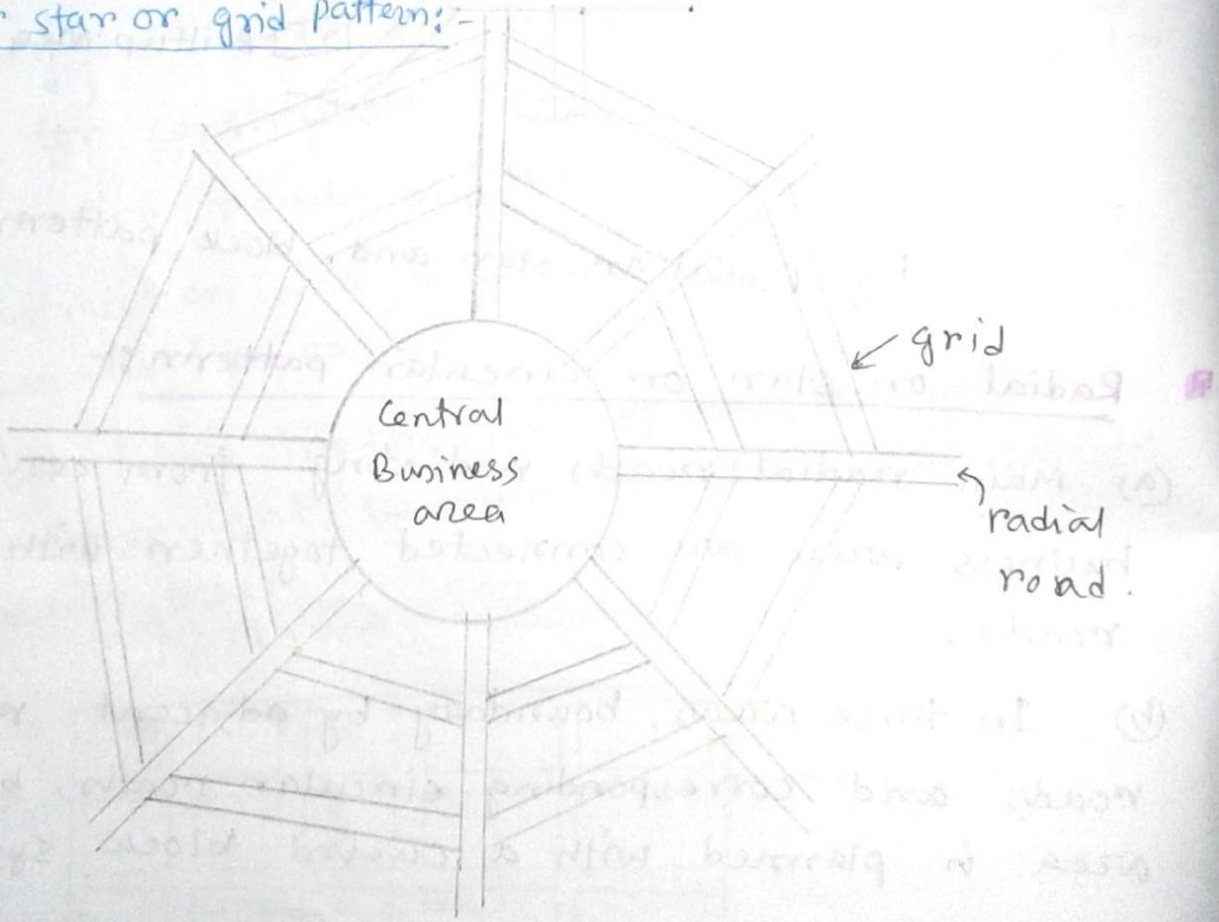


Fig. Radial or star or grid pattern.

Hexagonal pattern:-

(a) In this pattern centre area is provided with a network of roads forming hexagonal figures.

(b) At each corner of hexagon three roads meet.

(c) Built up area bounded by sides of hexagons is further divided in suitable sizes.

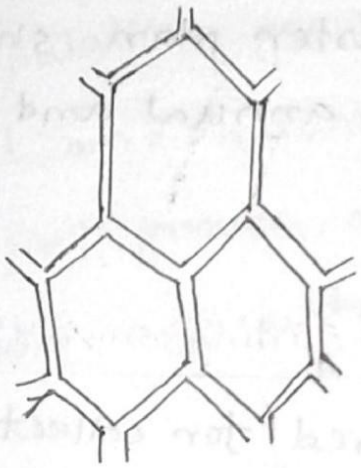


Fig. Hexagonal pattern.

Minimum travel pattern:

In this pattern, city (City centre) is connected by sector centres suburban centres and neighbourhood centres by road which require minimum travel to connect city centre.

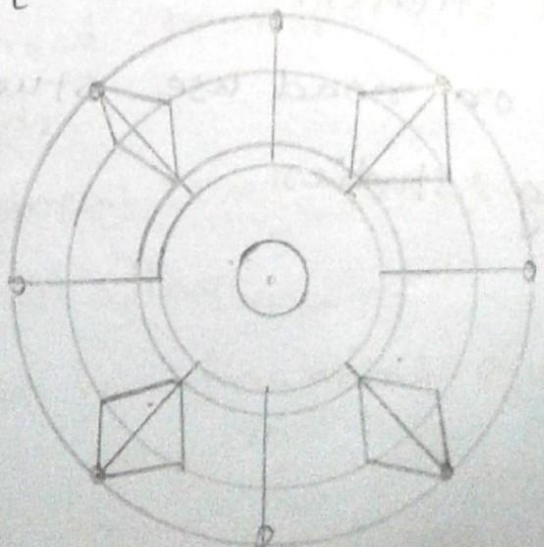


Fig. Minimum travel pattern.

Planning surveys :-

Q. What does include in highway planning phase.

Answer: Highway planning phase includes :-

(a) Assessment of road length requirement for an area (It may be a district, state or the whole country)

(b) Preparation of master plan showing the phasing of plan in annual and or five year plans.

Planning surveys or fact finding surveys: The field surveys which is required for collecting the factual data may be called as planning surveys or fact finding surveys.

⇒ The planning surveys consists of the following studies.

(a) Economic studies.
(b) Financial studies.
(c) Traffic or road use studies.
(d) Engineering studies.

Q. Describe details of planning surveys.

Answer: The planning surveys consists of following studies:-

Economic studies:- The details to be collected include the following :-

(a) Population and its distribution in each village, town or other locality with the area classified in groups.

(b) Trend of population growth.

(c) Agricultural and industrial products and their listing in classified groups, area wise.

(d) Industrial and agricultural development and future trends.

(e) Existing facilities with regard to communication, recreation and education etc.

(f) Per capita income.

Financial studies: The details to be collected include:-

(a) Sources of income and estimated revenue from taxation on road transport.

(b) Living standards.

(c) Resources at local level, toll taxes, vehicle registration and fines.

(d) Future trends in financial aspects.

Traffic or road user studies: Traffic surveys should be carried out in the whole area an on selected routes and locations in order to collect the following particulars:-

(a) Traffic volume in vehicles per day, annual average daily traffic, peak and design hourly traffic volume.

(b) Origin and destination studies.

(c) Traffic flow patterns.

(d) Mass transportation facilities.

(e) Accidents, their cost analysis and causes.

(f) Future trend and growth in traffic volume and goods traffic; trend in traffic pattern.

(g) Growth of passenger trips and the trend in the choice of modes.

Engineering studies:- The studies include:-

(a) Topographic surveys.

(b) Soil surveys.

(c) Location and classification of existing roads.

(d) Estimation of possible developments in all aspects due to the proposed highway development.

(e) Road life studies.

(f) Traffic - studies - Origin and Destination studies.

(g) Special problems in drainage, construction and maintenance of roads.

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রোল নং: ১৬০২২০.

HIGHWAY ALIGNMENT AND SURVEYS

Q. What do you know about highway Alignment? what are the disadvatages of improper allignment?

Answer: Highway Alignment: The marking position or the layout of central line of the highway on the ground, ~~is called~~ and giving direction to highway is called Alignment.

It has two components.

(I) Horizontal alignment – includes straight and curve path.
(II) Vertical alignment – includes level and gradient.

Disadvantages of improper allignment;-

Allignment decesion is important because a bad alignment will ~~enhance~~,

CMVA

(I) Increase in concstruction cost.
(II) Increase in maintenance cost.
(III) Increase in vehicle operating cost.
(IV) Increase in accident rate.

⇒ Once an alignment is fixed and constructed, it is not easy to change it due to increase in cost of adjoining land and construction of costly structures by the roadsides.

Q. Discuss briefly the basic requirements of an ideal alignment. 2015, 11, 09

Answer: Basic requirements of ideal alignment:-

The basic requirements of an ideal alignment betn two terminal stations are that it should be :-

(I) short, (II) Easy, (III) safe & (IV) economical.

Short: (a) Alignment between two terminal stations should be short and as far as possible be straight.

(b) But due to some practical consideration deviations may be needed.

Easy: (a) The alignment should be easy to construct and maintain.

(b) It should be easy for operation of vehicles.

(c) Maximum extend easy gradients and curves should be provided.

Safe: (a) It should be safe both from construction and operating point of view especially at slopes, embankments and cutting.

(b) It should have safe geometric features.

Economical: (a) The alignment should be economical.

(b) It can be considered so only when initial cost, maintenance cost and operating cost is minimum.

Q. Explain the various factors controlling the alignment of roads. 2014, 12, 11, 09

Factors controlling Alignment :-

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The followings are the factors which control the alignment of roads as respectively with explanation.

(1) Obligatory points: → 07, 08, 10, 13 These are control points governing highway alignment of highways. These control panel may be divided into two categories.

(a) Points through which the alignment is to pass - such may cause the alignment to often deviate from the shortest path. Examples, bridge site, mountain, intermediate town etc.

Bridge site;

(i) Bridge can be located only where river has straight and permanent path and also where abutment and pier can be strongly founded.

(ii) Road approach to bridge should not be curved and skew. crossing should be avoided as possible.

(iii) Thus to locate a bridge highway alignment may be changed.

Mountain:

(i) While alignment passes through a mountain, various alternatives are to either construct a tunnel or to go round hills.

(ii) Suitability of alternative depends on factors like topography, site conditions and construction and operating cost.

Intermediate town: Alignment may be slightly deviated to connect an intermediate town or village nearby.

(b) Points through which the alignment it should not pass - Such may cause that it necessary to deviate from the proposed shortest alignment. The obligatory points which should be avoided while aligning a road include religious places, very costly structures, lake, ponds etc.

Religious places: These have been protected by law from being acquired for any purpose. Therefore, these points should be avoided while alignment.

Very costly structures: Acquiring such structures means heavy compensation which would results in an increase in initial cost. So alignment may be deviated not to pass through that points.

Lakes/ponds: Presence of a lake or a pond on alignment path would also necessitable deviation of alignment.

(2) Traffic:

(I) The alignment should suitable traffic requirements.

(II) Origin and Destination study should be carried out in the area and the desire lines be drawn.

(III) The new road to be aligned should kept in view desire lines, traffic flow patterns, etc.

(3) Geometric design:

(I) Geometric design factors such as gradient, radius of curve, sight distance etc. also governs alignment of highway.

(II) To keep radius of curve minimum, it may be required to change alignment of highway.

(III) Alignments should be finalized such that obstructions to visibility do not restrict minimum requirements of sight distance

(IV) Design standards vary with class of road and terrain and accordingly highway should be aligned.

(4) Economics:

(I) Alignment finalized based on above factors should also be economical.

(II) Initial cost, maintenance cost and vehicle operating cost should be taken into account.

(III) Need to avoid high embankment and deep cutting to decrease initial cost.

(IV) Alignment is chosen in a manner to balance cutting or filling

(5) Other consideration :

(I) Drainage considerations, hydrological factors, political considerations and monotony govern alignment.

(II) subsurface water level, seepage flow and high flood level are factors to be kept in view.

⇒ Describe the special consideration of Alignment in hilly Areas.

Answer: Special considerations on hilly areas :-

(1) Stability :-

(I) While aligning hill roads, special care should be taken to align road along side of hill ~~within~~ which is stable.

(II) A common problem in hill roads is that of land slides.

(III) The Cutting and filling of earth to construct roads on hill-side cause steepening of existing slopes and affect its stability.

(2) Drainage :

(I) Numerous hill-side drains should be provided for adequate drainage facility across road.

(II) The Cross drainage structure being costly, attempts should be made to align road in such a way where number of cross drainage structures are minimum.

(3) Geometric standard of hill roads :-

(I) Different sets of geometric standards are followed in hill roads with refference to gradient, curves and speed, ~~and~~.

(II) They consequently influence the sight distance, radius of curve and other related features.

(III) The route should enable the ~~building~~ ruling gradient to be attained in most of the length, minimizing steep gradients, hair pin bands and needless rise and fall.

(4) Resisting length :-

(I) The resisting length of a road may be calculated from the total work done against resistance

(I) The Resisting length of a road is its effective length taking into consideration for total work done against resistances.

(II) The resisting length of a road may be calculated from total work done to moves loads along route taking horizontal length, actual difference in levels between two stations and sum of ineffective rise and fall in excess of floating gradient.

(III) Resisting length of the alignment should be kept as low as possible.

(IV) The ineffective rise and executive fall should be kept minimum.

Q. Briefly explain the engineering surveys needed for locating new highway. 2008, 11, 13

Answer: The stages of engineering surveys are :-

(I) Map study.
(II) Reconnaissance.
(III) Preliminary surveys.
(IV) Final location and detailed surveys.

These are described below :-

Map study: The probable alignment can be located on the map from the following details available on the map.

(a) Alignment avoiding valleys, ponds or lakes.
(b) Possibility of crossing through a mountain pass.
(c) Approximate location of a bridge site for crossing rivers, avoiding bend of the river, if any.

Reconnaissance survey: Some of the details to be collected during reconnaissance are given below:-

(I) Valleys, ponds, lakes, marshy land, bridge, and other obstructions along the route.
(II) Approximate values of gradient, length of gradients and radius of curves of alternate alignments.
(III) Number and type of cross drainage structures.
(IV) Soil type along the routes.
(V) Sources of construction materials.

Preliminary survey: The main objectives of the preliminary survey are :-

(I) To survey the various alternate alignments proposed after the reconnaissance.

(II) To compare the different proposals.

(III) To estimate quantity of earth work materials.

(IV) To finalise the best alignment from all considerations.

Final location and detailed survey: In this survey, two operations are involved.

(I) To layout the final centre line of the road by means of continuous transit survey.

(II) Detailed levelling.

Q. Give the name of drawings to be prepared in highway project.

Answer: The following drawings are usually prepared in a highway project:

(I) Key map.

(II) Index map.

(III) Preliminary survey plans.

(IV) Detailed plan and longitudinal section.

(V) Detailed cross-section.

(VI) Land acquisition plans.

(VII) Drawings of cross drainage and other retaining structures.

(VIII) Drawings of road intersections.

(IX) Land plans showing quarries etc.

Q. What are the $ information that should contain in a project report of highway project.

Answer: Project report: It should contain following information :-

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(I) General details of the project and its importance.
(II) Feature of the road including selection of the route.
(III) Road design and specifications.
(IV) Drainage facilities and cross drainage structures.
(V) Materials, labour and equipment.
(VI) Rates.
(VI) Construction programming and
(VII) other miscellaneous items like diversion roads, traffic control, road side amenities, rest houses etc.

Q. Describe the steps which taken in a new project work.

Answer: Stages in a new project work :-

(I) Map study: With the help of available topographic map of the area.

(II) Reconnaissance survey: A general idea of a topography and other features by an on-the spot inspection of the site.

(III) Preliminary survey: Topographic details and soil survey along alternate alignments, considering of geometric design and other requirements of alignment. Preparation of plans and economic analysis and selection of final alignments.

Location of Final Alignment: Transfer of the alignment from the drawings to the ground by driving pegs along the centre line of finally chosen alignment.

Detailed survey:

(I) survey of ~~co~~ highway construction work.

(II) Computation of earthwork quantities.

(III) Checking of geometric design elements.

Material survey: Survey of construction materials, their collection and testing.

Design: Design details of embankment and cut slopes.

Earth work: Excavations for highway cutting and drainage system. construction of embankments.

Pavement construction: Preparation of subgrade, construction of sub-base and surface courses.

Construction controls:-

Quality control tests during different stages of constructions and check for finished road surface.

Q. Write down the necessity of re-alignment ?

Answer: Necessity of re-alignment :-

(I) Improvement of horizontal alignment design elements.

(II) Improvement of vertical alignment design elements.

(III) Raising the level of a portion of a road.

(IV) Re-construction of over-bridges or under bridges.

(V) Re-alignment required due to a portion of the road being submerged under water.

(VI) Construction of a bypass to avoid the road running through a town or city.

(VII) Defence requirements.

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রোল নং: ১৬০১১০

HIGHWAY GEOMETRIC DESIGN:

Q. Write down the importance of geometric design.

Answer: Importance of geometric design;-

(I) The geometric design of a highway deals with the dimension and layout of visible features of the highway.

(II) Proper geometric design will help in reduction of accidents and their severity.

objectives:

(III) To provide optimum efficiency in traffic operation and maximum safety at reasonable cost.

(IV) Planning cannot be done stage wise like that of a pavement, but has to be done well in advance.

(V) To reach distination in shortest possible time with least inconvenience.

(VI) To achieve maximum ~~saf.~~ speed safety.

Q. what elements are deals Geometric design of highways.

Answer: Elements of geometric design: CSHIV

(I) Cross section elements - It includes cross slope, various width of roads and features in road margin.

(II) Sight distance consideration - It includes cross slope, various width and features in the road margin.

(III) Horizontal alignment details - It includes features like super elevation, transition curve, extra widening and set back distance.

(IV) Vertical alignment details - It includes gradients sight distance and design of length of the curves.

(V) Intersection features - It includes layout, capacity etc.

Q. Describe the factors affecting geometric design.

Answer: Factors affecting geometric design: 2014,11

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(I) Design speed:-

(a) It is defined as the highest continuous speed at which individual vehicles can travel with safety on the highway when weather conditions are conducive.

(b) Different from legal speed limit which is speed limit imposed to curb a common tendency of drivers to travel beyond an accepted safe speed.

(c) Also different from desired speed which is maximum speed at which a driver would travel when ~~unconstrained~~ unconstrained by either traffic or local geometry.

(d) ~~Single~~ Speed is the most important factor that affects geometric design.

(e) Directly affects sight distance, horizontal curve and length of vertical curves.

(f) Since speed of vehicles vary with driver, terrain etc, a design speed is adopted for all geometric design.

(II) Topography:-

(a) It is easier to construct roads with required standards for a plain terrain.

(b) However, for a given design speed, construction cost increases multiform with gradient and terrain.

(c) Therefore, geometric design standards are different for different terrain to keep cost of construction and time of construction under control.

(d) This is characterized by sharper curves and steeper gradients.

(III) Traffic factors:

(a) It is of crucial importance in highway design, is traffic data both current and future estimates.

(b) Traffic volume indicates level of services (LOS) for which highway is being planned and directly affects geometric features such as width, alignment, grades etc.

(c) without traffic data it is very difficult to design any highway.

(IV) Vehicle:

(a) Dimensions, weight of axle and operating characteristics of a vehicle influence design aspects such as width of pavement radii of curve, clearences, parking-geometrices etc.

(b) A design vehicle which has standard weight, dimensions and operating characteristics are used to establish highway design controls to accommodate vehicles of a designated type.

(V) Human: Important human factors that influence geometric design are physical, mental and psychological characteristics of driver and pedestrians like reaction time.

(VI) Design hourly volume and capacity:

(a) General unit for measuring traffic on highway is Annual Average Daily traffic volume. abbreviated as AADT.

(b) Traffic flow or volume keeps fluctuating with time, from a low value during off peak hours to highest value during peak hour.

(c) It will be uneconomical to design roadway facilities for peak traffic flow.

(VII) Environmental factors:-

Environmental factors like air pollution, noise pollution, landscaping, aesthetics and other global conditions should be given due considerations in geometric design of roads.

(VIII) Economy: Design adopted should be economical as far as possible. It should much with funds allotted for capital cost and maintenance cost.

(IX) Other factors: Geometric design should be such that aesthetics of region is not affected.

Q. Write down short note on cross sectional elements.

Answer: Cross sectional elements:

(a) Features of cross-section of pavement influence life of pavement as well as ridiging comfort and safety.

(b) Of these, pavement surface characteristics affect both of these.

(c) Camber, kerbs, and geometry of various cross-sectional elements are important aspects to be considered in this regard.

Q. What are the importance of pavement surface characteristics?

Answer: Pavement surface characteristics:-

For a safe and comfortable driving four aspects of pavements surface are important.

(I) Friction between wheels and pavement surface.

(II) Smoothness of road surface.

(III) Light reflection characteristics of top of pavement surface.

(IV) Drainage of water.

Q. What do you know by Friction in road?

Answer: Friction: Friction between wheels and pavement surface is a crucial factor in design of horizontal curves and safe operating speed. Further, it also affect acceleration and deceleration ability of vehicles. Lack of adequate friction can cause skidding or slipping of vehicles. Frictional force that develops between wheel and pavement is load acting multiplied by a factor called co-efficient of friction and denoted as f. Choice of the value of f is a very complicated issue since it depends on many variables.

Co-efficient of longitudinal friction is 0.35 - 0.4 depending on speed and co-efficient of lateral friction is 0.15.

Former is useful in sight distane calculation and later in horizontal curve design.

Q: Define skid and classify it. 2067, 68

Answer: Skid: when the path travelled along the road surface is more than the circumferential movement of wheels due to their rotation, it is called skid.

Classification of skid: Two types.

(I) Longitudinal skid

(II) Lateral skid.

Longitudinal skid:

(I) It occurs when wheels slide without revolving or when wheels partially revolves.

(II) Skidding happens when path traveled along road surface is more than circumferential movement of wheels due to their rotation.

(III) When brakes are applied, wheels are locked partially or fully and if vehicle moves forward, Longitudinal skid takes place.

(IV) May vary from 0 to 100 percent.

Lateral skid:

(I) It takes place while a vehicle negotiate a horizontal curve, if centrifugal force is greater than counteracting forces (lateral friction and component of gravity due to superelevation)

(II) Considered dangerous as vehicle goes out of control leading to an accident.

Q. Define slip, when it is happen? 2007, 08

Answer: SLIP: when the path travelled along the road surface is less than the circumferential movement of wheels due to their rotation, it is called slip.

→ It occurs when wheel revolves more than corresponding longitudinal movement along road.

→ Usually occurs in driving wheel of a vehicle when vehicle rapidly accelerate from stationary position or from slow speed on pavement surface which is slippery and wet.

→ when road surface is loose with mud.

Q. Write down the Factors affecting friction or skid resistance.

Answer: Factors Affecting Friction or Skid resistance:

(I) Type of pavement surface (cement concrete, bituminus WBM, earth surface etc.).

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

(III) Condition of pavement (wet or dry, smooth or rough, oil spilled, mud or dry sand on pavement).

(IV) Type and condition of tyre (new with good treads or smothered and worn out)

(V) Speed of vehicle.

(VI) Extent of brake application or brake efficiency.

(VII) Load and tyre pressure.

(VIII) Temperature of tyre pavement.

(IX) Type of skid, if any.

Q. what do you mean by pavement unevenness? write down the factors that caused unevenness.

Answer: Pavement Unevenness:-

Always desirable to have an even surface, but it is seldom possible to have such one. Even if a road is constructed with high quality pavers, it is possible to develop unevenness due to pavement failures.

Unevenness affet vehicle operating cost, speed, riding, compact, safety, fuel consumption and wear and tear of tyres.

Unevenness index: → 2007, 08 Unevenness index is a measure of unevenness which is cumulative measure of vertical undulation of pavement surface recorded per unit horizontal length of road.

An unevenness index value less than 1500 mm/km is considered as good.

A value less than 2500 mm/km is satisfactory up to speed of 100 kmph.

A value greater than 3200 mm/km is considered as uncomfortable even for 55 kmph.

The unevenness or undulations on pavement surface may be caused by various factors such as;-

(a) Inadequate compaction
(b) Unscientific construction.
(c) Use of inferior pavement materials.
(d) Improper surface and subsurface drainage.
(e) Use of improper construction machinery.
(f) Poor maintenance ~~paatic~~ practices.
(g) Localized failures due to combination of causes.

Q. Write short note on Light reflecting characteristics & Drainage of water.

Answer: Light reflecting characteristics:-

Night visibility very much depends upon the light reflecting characteristics of the pavement surface. The glare caused by the reflection of head lights is considerably high on wet pavement surface than on the dry pavement. Light colored or white pavement surface ~~cp~~ give good visibility at night particularly during rains, and they produces glare and eye strain during bright sunlight. Black top pavement surface on the other hand provides very poor visibility at nights, especially when the surface is wet.

Drainage of water: Pavement surface should be absolutely impermeable to prevent seepage of water into pavement layer. Further both geometry and texture of pavement surface should help in draining out water from surface in less time.

2014,13,11,07

Q. Define camber ? Why it is provided on road surface?

Answer: **Camber or Cross Slope:** Cross slope or camber is the slope provided to the road surface in the transverse direction to drain off the rain water from the road surface.

It is prepared on the basis of (I) type of pavement surface.
(II) The amount of rainfall.

Providing reasons / Importance of cross slope/camber:

(I) To prevent the entry of surface water into subgrade soil through pavement [The stability, surface condition and the life of the pavement get adversely affected if the water enters in the subgrade and soil gets soaked].

(II) To prevent the entry of water into the bituminous pavement layers [As continued contact with water causes stripping of bitumen from the aggregates and results in deterioration of the pavement layer].

(III) To remove the rain water from the pavement surface as quickly as possible and to allow the pavement to get dry soon after the rain [The skid resistance of the pavement gets considerably decreased under wet condition rendering it slippery and unsafe for vehicle operation at high speed].

⇨ Usually camber is provided on the straight roads by raising the center of the carriageway with respect to edges, forming a crown or highest point on center line. The rate of camber or cross slope is usually designated by 1 in n, which means that transverse slop is in ratio 1 vertical to n horizontal. Camber is also expressed as a percentage. If camber is x%, cross slope is x in 100.

The required camber of a pavement depends on :-

(i) the type of pavement surface.

(ii) the amount of rainfall.

A flat camber of 1.7 to 2.0% is sufficient on relatively impervious pavement surface like cement concrete or bituminous concrete. In pervious surface like water bound macadam or eatch road which may allow surface water to get into the subgrade oil, steeper cross slope is required. Steeper camber are also provided in areas of heavy rainfall.

** Why steep cross slope is not desirable?

Answer: Effect of Too steep cross slope:

Too steep cross slope is not desirable because of the following reasons;-

(i) Transverse tilt of vehicles causes uncomfortable side thrust and a drag on the steering of automobiles. unequal wear of tyres and road surface.

(ii) Discomfort causing throw of vehicle when crossing the crown during overtaking operations.

(iii) Problems of toppling over of highly laden bullock carts and trucks.

(iv) Formation of cross ruts due to rapid flow of water.

(v) Tendency of most of the vehicles to travel along the center line.

* How are the shapes of cross slope?

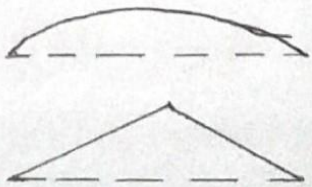
Answer: Types of shapes of cross slope or camber:

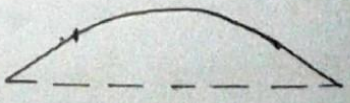
Common types of camber are

(i) parabolic

(ii) Straight.

(iii) Combination of straight and parabolic.





* Write down the recommended values of camber for different types of road surfaces.

Answer: Recommended values of camber for different types of road surfaces. is given below:-

Surface type	Heavy rain	Light rain
Concrete / Bituminous	2%	1.7%
Thin bituminous surface	2.5%	2%
Gravel / WBM	3%	2.5%
Earthen	4%	3%

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V.V.I

* Write short note on carriage-way of road.

Answer: Carriage-way: The metal portion of road which is used for the movement of the vehicles is called the carriage-way.

The carriageway depends on the width of traffic lane and number of traffic lane. The carriage way intended for one line of traffic movement may be called a traffic lane.

~~Ans~~ Width of carriage way / width of pavement:

(I) The width of carriage way or width of pavement depends on width of traffic lane and number of lanes.

(II) The width of a traffic lane depends on width of vehicle and clearance.

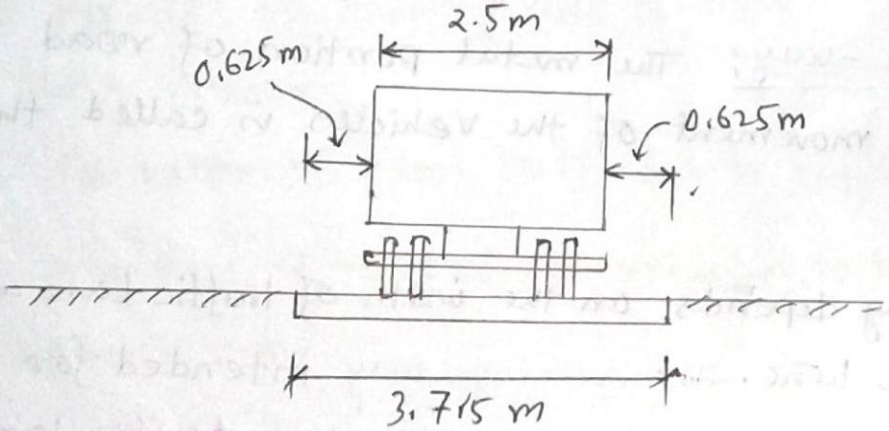
(III) The side clearance improves operating speed and safety.

(IV) Maximum permissible width of a vehicle is 2.44m and desirable side clearance for single lane traffic is 0.68m.

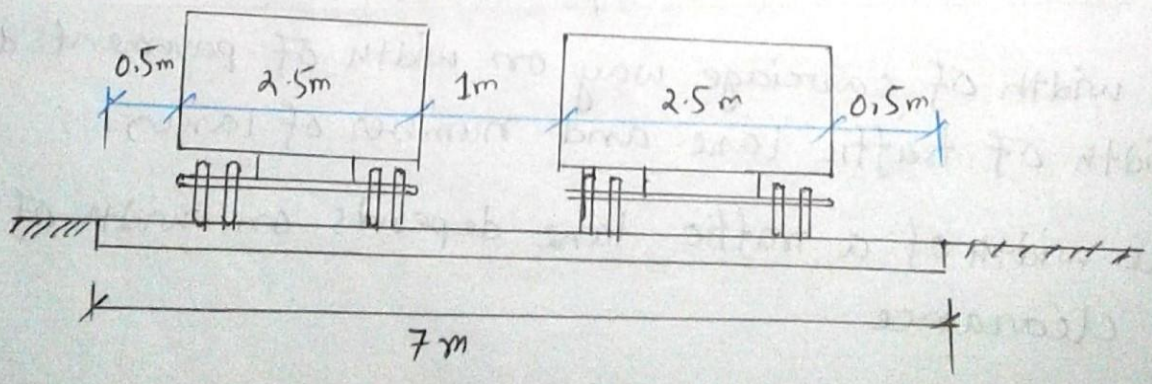
(V) This require minimum of lane width of 3.75m for a single lane road.

(VI) However, side clearance required in about 0.53m, on either side and 1.06 m in centre.

(VII) Therefore, a two lane road require, minimum of 3.5 m for each lane.



(a) Single lane pavement.



(b) Two lane pavement.

Specification for carriage-way width:

Class of road	Width of carriageway (m)
Single lane	3.75
Two lanes, without raised kerbs	7.0
Two lanes, with raised kerbs	7.5
Intermediate carriageway	5.5
Multilane pavements	3.5 for each lane.

* What is traffic separators or Medians? why it is provided in road?

Answer: **Traffic separators or Median:-**

To channelize the roads and for avoiding head to head collision of the vehicles, the barriers should be provided on the road which is called traffic separators or Median.

Here collision occurs when two vehicles are coming from opposite direction.

Reasons:-

The main function of traffic separator is to prevent head-on collision between vehicles moving in opposite directions on adjacent lanes.

The separators may also help to —

(I) channelize traffic into streams at intersections.
(II) shadow the crossing and turning traffic.
(III) segregate slow traffic and to protect pedestrians.

⇒ It may be in form of pavement marking, physical dividers or area separators. Pavement marking is the simplest of all these. The mechanical separator should be designed in such a manner that even if wheels of a vehicle encroach, no part of vehicle body should be damaged.

Area separators may be medians, dividing islands or parkway strips, dividing two direction of traffic flow.

** Define kerbs. Write down its classification briefly.

Answer: Kerbs: Kerb indicates the boundary between the pavement and shoulder, or sometimes islands or footpath or kerb parking space.

Kerbs may be mainly divided into three groups based on their function:-

(1) Low or mountable kerbs: LSBS

(a) It is provided such that encourage traffic to remaining through traffic lanes and also allow driver to enter shoulder area with little difficulty.

(b) The height of this kerb is about 10 cm above pavement edge with a slope which allows vehicle to climb easily.

(c) It is usually provided at medians and channelization schemes and is also helps in longitudinal drainage.

(II) Semi-barrier type kerbs:

(a) When pedestrian traffic is high these type of kerbs are provided.

(b) It has height of 15cm above pavement edge.

(c) This Kerbs prevents encroachment of parking vehicles, but at acute emergency it is posible to drive over this kerb with some difficulty.

(III) Barrier type kerb:

(a) It is designed to discourage vehicles from leaving pavement.

(b) It is provided when there is a considerable amount of pedestrian traffic.

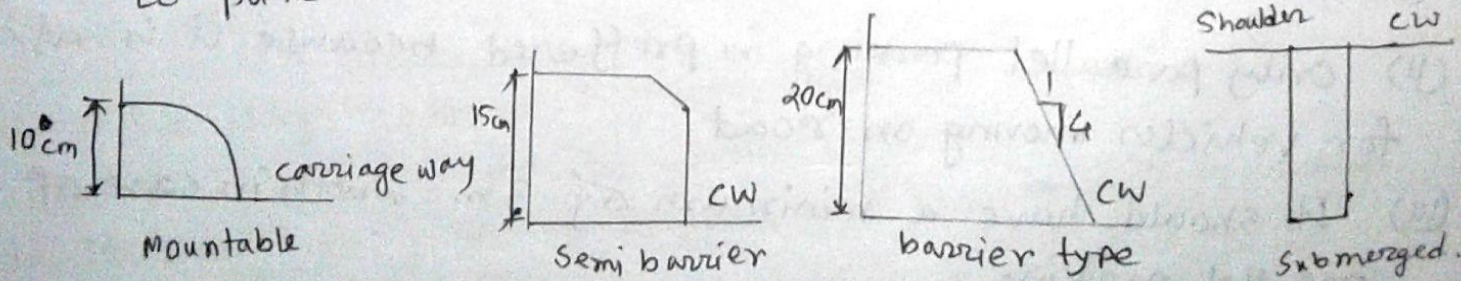
(c) It is placed at a height of 20cm above pavement edge with a steep batter.

(IV) Submerged kerb:

(a) It is used in rural roads.

(b) It is provided at pavement edges between pavement edge and shoulders.

(c) These kerb provide later confinement and stability to pavement.



** What is road margins? Describe its various elements.

Answer: **Road Margin:** The portion of road beyond the carriageway and on roadway is known as road margin.

Various elements that form road margin are given below:-

Shoulders:

(I) These are provided along road edge and are intended for accomodation of stopped vehicles.

(II) These serve as an emergency lane for vehicles.

(III) It is provide lateral support for base and surface course.

(IV) This is should be strong enough to bear weight of a fully loaded truck even in wet conditions

(V) The width of shoulder should be adequate for giving working space around a stopped vehicle.

(VI) It is desirable to have a width of 4.6m for shoulders.

(VII) A minimum width of 2.5m is recommended for 2-lane rural highways.

Parking lanes:

(I) These are provided in urban lanes for side parking.

(II) Only parallel parking is preffered because it is safe for vehicles moving on road.

(III) It should have a minimum of 3m width in case of parallel parking.

Lay-byes:

(I) Lay-byes are provided near public convenience with guide maps to enable drivers to stop clear off the carriageway.

(II) It should normally be of 3.0 m width and atleast 30 m length with 15 m end tapers on both sides.

Bus-byes:

(I) These are provided by recessing kerbs for bus stop.

(II) It is provided so that they do not obstruct movement of vehicles in carriage way.

(III) It should be at least 75 m away from intersection so that traffic near intersections is not difficult.

Frontage roads/service roads: 2014, 2013, 2011

(I) These are provided to give access to properties along an important controlled highways like freeways and expressways.

(II) These may run parallel to highway and will be usually isolated by a separators and access to highway will be provided only at selected points.

(III) These are provided to avoid congestion in expressways and also speed of traffic in those lanes is not reduced.

Drive ways:

(I) Drive ways content highway with commercial establishment like fuel stations, service station etc.

(II) It should be properly designed and located fairly away from an intersection.

(III) The radius of drive way curve should be keeps at large as possible.

(IV) The width of the drive way should be minimized to reduce length of cross walks.

Cycle track:

(I) These are provided in urban areas when volume of cycle traffic or road is very high.

(II) A minimum width of 2m is provided and width may be increased by 1 m for each additional cycle lane.

(III) Layout of the cycle tracks should be carefully decided in large highway intersections and traffic rotaries.

Footpath / side walk:

(I) Exclusive right of way to pedestrian, especially in urban areas.

(II) Provided for safety of pedestrians when both pedestrians traffic and vehicular traffic is high.

(III) Minimum width is 1.5 m and may be increased based on traffic

(IV) It should be either as smooth as pavement or more smoother than that to indue pedestrian to use foot path

Guard rails:

(I) These are provided at edge of shoulder when road is constructed on a fill so that vehicles are prevented from running off embankment, especially when height of fill exceeds 3m.

(II) Various designs of guard rails are in use.

(III) Guard stones are installed at suitable intervals along outer edge of formation of horizontal curves of roads running on embankments.

(IV) Painted with black and white steps so as to provide better right visibility of curves under head light of vehicles.

Embankment slope:

(I) They should be as flat as possible for purpose of safe traffic movement and also for aesthetic reason.

(II) Slope may be kept flat as permitted by economical.

(III) Road side landscaping can improve the aesthetic features of road side.

⇒ Width of Roadway or Formation:

(I) It is sum of widths of pavements or carriageway including separators if any and the shoulders.

(II) It is top width of highway embankment or bottom width of highway cutting excluding side drains.

Right of way:

(I) Right of way (ROW) or land width is width of land acquired for road, along its alignment.

(II) It should be adequate to accommodate all cross-sectional elements of highway and may reasonably provide for future developments.

(III) To prevent ribbon developments along highways, control lines and building lines may be provided.

(IV) Control line is a line which represents nearest limits of future uncontrolled building activity in relation to a road.

(V) Buiding line represents a line on either side of the road, between which and road no building is permitted at all.

Q. Write down the factors govern the lane width of the right of way?

Answer: Right of way width governed by:

(I) Width of formation depending on the category of highway and width of roadway and road margins.

(II) Height of embankment or depth of cutting which is governed by the topography and the vertical alignment.

(III) Side slopes of embankment or cutting which depend on the height of the slope, soil type etc.

(IV) Drainage systems and their size, which depends on the rainfall topography an run off.

(V) Sight distance considerations on horizontal curves, as there is restriction to the visibility on the inner side of the curve due to obstruction such an building structures etc.

(VI) Reserve land for future widening is to be planned in advance based on anticipated future development ant increase in the traffic.

* Define sight distance and classify it.

Sight distance: The safe and efficient operation of vehicle on roads depends among other factor on road length at which an obstruction, if any, becomes visible to the driver in the direction of travel. In other words the feasibility to see ahead, or the visibility is very important for safe vehicle operation on a highway.

⇒ Sight distance is the actual distance along the road surface which a driver from a specified height above the carriage-way has visibility of stationary or moving objects. In other words, sight distance is the length of road visible ahead to driver at any instant.

Restictions to sight distance may be caused at horizontal curves, by objects obstructing vision at the inner side of the road or at vertical summit curves or at intersections.

Sight distance required by drivers applies to both geometric design of highways and for traffic control.

Types of sight distance:

Three sight distance situations are considered in the design:-

(I) Stopping sight distance (SSD), or the absolute minimum sight distance

(II) Overtaking sight distance (OSD), for safe overtaking operation.

(III) Safe sight distance for entering into uncontrolled intersections.

Apart from the three situations mentioned above, the following sight distances are considered by IRC in highway design.

(I) Intermediate sight distance: This is defined as twice the stopping sight distance. When overtaking sight distance can not be provided, intermediate sight distance is provided to give limited overtaking opportunities to fast vehicles.

(II) Head light sight distance: This is the distance visible to a driver during night driving under the illumination of the vehicle head lights. This sight distance is critical at up-gradients and at the ascending stretch of the valley curves.

Q. What are the conditions of the standards for sight distance?

Answer: The standards for sight distance should satisfy the following three conditions:—

(I) Driver travelling at the design speed has sufficient sight distance or length of road visible ahead to stop the vehicle, in case of any obstruction on the road ahead, without collision.

(II) Driver travelling at the design speed should be able to safely overtake, at reasonable intervals, the slower vehicles without causing obstruction or hazard to traffic of opposite direction.

(III) Driver entering an uncontrolled intersection has sufficient visibility to enable him to take control of his vehicle and to avoid collision with another vehicle.

⇒ Write short notes on (SSD).

Stopping sight distance: The minimum sight distance available on a highway at any spot should be of sufficient length to stop a vehicle travelling at design speed, safely without collision with any other obstruction.

The absolute sight distance is therefore equal to the stopping sight distance, which is also some times called non-passing sight distance.

The sight distance available on a road to a driver at any instance depends on :-

(I) **Features of road ahead:** It affects the horizontal alignment, vertical profile of road, traffic condition and position of obstruction.

(II) **Height of drivers eye above road surface:** At summit curves more important factor affecting visibility.

(III) **Height of object above road surface:** Indicates what might be a source of danger to moving vehicle.

The height of drivers eye above road surface → 1.2m
The height of object above road surface → 0.15m.

The distance within which a motor vehicle can be stopped depends upon the factors listed below :-

FESTR

(I) Total reaction time of the driver.
(II) Speed of vehicle.
(III) Efficiency of brakes.
(IV) Frictional resistance between the road and the tyres and.
(V) Gradient of the road, if any.

Total reaction time of driver:

It is the time taken from instant object is visible to driver to instant when brakes are applied. Amount of time gap depends on several factors :-

(a) During this time vehicle travels a certain distance at original speed or design speed.

Thus stopping distance increases with increase in reaction time of driver. Many of the studies show that drivers require about 1.5 to 2 secs under normal conditions. However, taking into consideration, variability of driver characteristics, a higher value is normally used in design for example 2.5 sec.

Total reaction time may be split up into two parts.

Perception time:

(a) It is required for a driver to realize that brakes must be applied.

(b) It is time from instant object comes on line of sight of driver to instant he realizes that vehicle needs to be stopped

(c) It varies from driver to driver and on several other factors such as speed of vehicle, distance of object and environmental conditions.

Brake reaction time:

(i) It is time from instant brake is applied by driver to instant vehicle is deadly stopped.

(ii) It depends on several factors including skill of driver, type of problems and environmental factors.

Q. Write the discussion on PIEV theory.

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

(I) Perception.
(II) Intellection
(III) Emotion and
(IV) Volition.

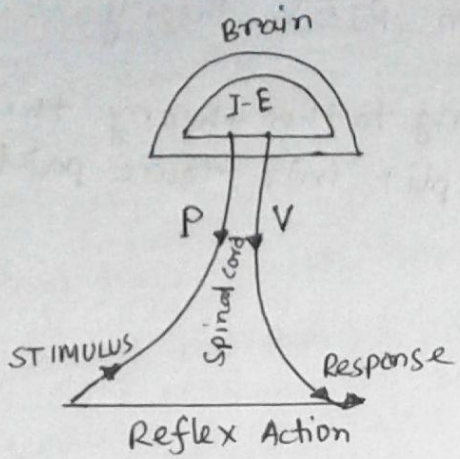
Perception: It is the time required for the sensations received by the eyes or ears to be transmitted to the brain through the nervous system and spinal chord. In other words it is time required to preceive an object or situation.

Intellection time: It is time required for understanding situation. It is also time required for comparing different thoughts, regrouping and registering new sensation.

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. Therefore the emotion time of a driver is likely to vary considerably depending upon the problems involved.

Volition time: It is the time taken for the final action.

Reflex action: It is also possible that driver may apply brakes or take any avoiding action by reflex action.



P = Perception
I = Intellection
E = Emotion
V = volition.

PIEV time of a driver depends on several factors such as:-

(I) physical and psychological characteristics of driver.
(II) Type of problem involved.
(III) Environmental condition.
(IV) Temporary factors (motive of 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.

⇒ Speed of vehicle:

(I) The stopping distance depends very much on the speed of the vehicle.
(II) It is evident that higher the speed, higher will be the stopping distance, more time will be required to stop vehicle.

Efficiency of brakes:

(I) Efficiency of brakes depends ~~or~~ upon age of vehicle, vehicle characteristics.
(II) If brake efficiency is 100%, vehicle will stop at moment brakes are applied.

But practically, it is not possible to achive 100% brake efficiency therefore sight distance required will be more when efficiency of brakes are less. Also for safe geometric design, it is assumed that vehicles have only 50% brake efficiency.

Frictional resistance between tyre and road:

The Frictional resistance between tyre and road plays an important role to bring vehicle to stop. when frictional resistance is more, vehicles stop immediately. Thus sight distance required will be less. No separate provision for brake efficiency is provided while computing sight distance. This is taken into account along with the factor of longitudinal friction. Value of longitudinal friction is between 0.35 to 0.4.

Gradient of road: It is also affects sight distance. while climbing up a gradient, vehicle can stop immediately. Therefore, sight distance required is less. While descending a gradient, gravity also comes into action and more time will be required to stop vehicle. Sight distance required will be more in this case.

Analysis of stopping sight distance:

The stopping distance of a vehicle is the sum of :-

(1) The distance travelled by the vehicle during the total reaction time known as Lag distance.

(11) The distance travelled by the vehicle after the application of the brakes, to a dead stop position which is known as the braking distance.

Lag distance: During the total reaction time or PIEV time the vehicle may be assumed to proceed forward with a uniform speed at which the vehicle has been moving and this speed may be taken as the design speed.

If 'V' in the design speed in m/sec, and 't' is the total reaction time of the driver in seconds, then the lag distance will be Vt meters.

If the design speed is V kmph, then the lag distance works out to,

$$\text{Lag distance} = V \times \frac{1000}{60 \times 60} * t$$

$$= 0.278\ Vt \text{ meters.}$$

The total reaction time of driver depends on a variety of factors and a value of 2.5 seconds is considered reasonable for most situations.

Braking distance: It is the distance travelled by vehicle during braking operation. For a level road this is obtained by equating work done in stopping vehicle and kinetic energy of vehicle.

Q. Derive an expression for SSD at level and slopping. 2015

Derivation: If V is the design speed in m/sec and t is the total reaction time of the driver in seconds. Then

Lag distance = the distance travelled by the vehicle during the total reaction time = Vt.

If F is the maximum frictional force developed and the braking distance is l, then work done against friction forces in stopping the vehicle is,

$$Fl = fWl \quad , W = \text{total weight of vehicle}$$

The kinetic energy at the design speed of V m/sec will be.

$$\frac{1}{2}mv^2 = \frac{Wv^2}{2g}$$

Hence, $fWl = \frac{Wv^2}{2g}$

$$\therefore \quad l = \frac{v^2}{2gf}$$

Here, l = braking distance = the distance travelled by the vehicle after the application of brakes to a dead stop position.

v = speed of vehicle m/sec.

f = design coefficient of friction.

f = 0.4 to 0.35 depending on speed from 30 to 80 kmph.

g = acceleration due to gravity = 9.8 m/sec^2

Stopping distance = lag distance + braking distance.

$$SSD_1 = vt + \frac{v^2}{2gf} \quad \text{in meters.}$$

If speed is V kmph, stopping distance,

$$SD = 0.278\,Vt + \frac{V^2}{254f}$$

which are for level surface.

stopping distance at slopes :-

When there is an ascending gradient of say, +n% the component of gravity adds to the braking action and hence the braking distance is decreased. The component of gravity acting parallel to the surface which adds to the braking force is equal to,

$$W \sin\alpha = W \tan\alpha = \frac{Wn}{100}$$

Equating kinetic energy and work done,

$$\left(fW + \frac{Wn}{100}\right) l = \frac{1}{2} \frac{WV^2}{g}$$

$$l = \frac{V^2}{2g\left(f + \frac{n}{100}\right)}$$

Similarly, in descending gradient of $-n\%$ the braking distance increases, as the component of gravity now oppose the braking force. Hence the equation is given by.

$$\left(fW - \frac{Wn}{100}\right) l = \frac{WV^2}{2g}$$

$$\therefore \quad l = \frac{V^2}{2g\left(f - \frac{n}{100}\right)}$$

Hence general equation for stopping distance may now be modified for n% gradient and may be written as

$$SD = \left[Vt + \frac{V^2}{2g(f \pm 0.01n)}\right]$$ meters

If speed is V kmph. and gradient is n%.

$$SD = 0.278\,Vt + \frac{V^2}{254(f \pm 0.01n)}$$ kmph

These are two required equation.

The minimum stopping sight distance hence should be equal to the stopping distance in one-way traffic lanes and also in two-way traffics roads when there are two or more traffic lanes. On single lane roads when two-way movement of traffic is permitted, the minimum stopping sight distance should be equal to twice the stopping distance. when stopping sight distance for design speed is not available on any section of a road, speed should be restricted by a warning sign and a suitable speed-limit regulation sign.

Overtaking sight Distance (OSD): OSD is the minimum distance open to vision of driver of a vehicle intend in to overtake slow vehicle ahead safely against traffic in the opposite direction. It is also known as safe passing distance.

OSD is the measure at the center of the road which a driver with eye level 1.2 m above the road surface can see the top of an object 1.2m above the road surface.

Factors affecting OSD:-

(I) Speed of (a) Overtaking vehicle (b) overtaken vehicle and (c) the vehicle coming from opposite direction, if any.

(II) Distance between the overtaking and overtaken vehicles. the minimum spacing depends on the speeds.

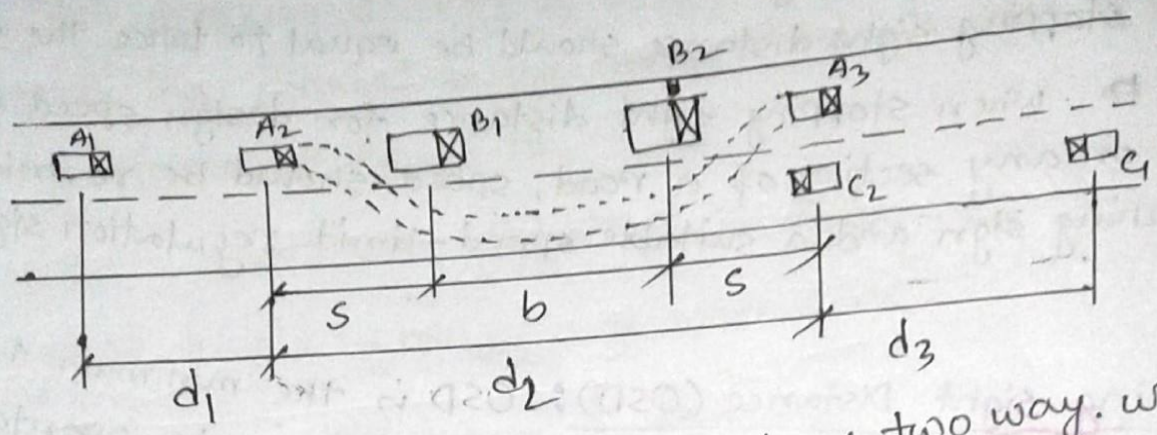
(III) Skill and reaction time of the driver.

(IV) rate of acceleration of overtaking vehicle.

(V) Gradient of the road, if any.

Q. Analyze the overtaking sight distance for measuring it as Overtaking sight Distance (OSD).

Answer:



Consider the above figure of single lane two way. where we get,

A = Overtaking vehicle running at the design speed v as A_1, A_2, A_3.

B = Slow moving vehicle in speed v_b as B_1, B_2

C = Opposite directional vehicle as C_1, C_2.

t = reaction time.

T = total required time for A_2 to A_3.

v = design speed,

v_b = speed of B.

d_1, d_2, d_3, s, b are the spacing or separate distance.

It may be assumed that vehicle A is forced to reduce its speed to speed v_b of slow vehicle B and moves behind it allowing a ~~speed~~ space s, till there is an opportunity for safe overtaking operation.

The distance travelled by vehicle A during this reaction time is d_1 and in between position A_1 and A_2.

This distance will be, $d_1 = v_b t$, m

From position A_2 vehicle A starts accelerating, shifts to adjoining lane, overtaken vehicle B in time T secs. straight distance between A_2 and A_3 is d_2. Minimum distance between A_2 and B_1 is s is given as follows:-

$$s = 0.7 v_b + 6, \text{ m}, \quad (v_b \text{ in m/sec})$$

Distance covered by slow vehicle B travelling at a speed v_b m/sec, $b = v_b T$, m.

Then, $d_2 = b + 2s = v_b T + \frac{aT^2}{2}$

from this, $b = v_b T$, therefore, $2s = \frac{aT^2}{2}$

$$\therefore T = \sqrt{\frac{4s}{a}} \text{ sec.}$$

$d_2 = v_b T + 2s$, where, $s = 0.7 v_b + 6$, m

Distance travelled by c vehicle at speed v m/sec. during time T, is d_3 is given by,

$$d_3 = v \times T$$

$$\therefore \text{So. OSD} = d_1 + d_2 + d_3$$
$$= v_b t + v_b T + 2s + vT \quad (v = \text{m/sec})$$

when V in km/hr.

$$\text{OSD} = 0.28 V_b t + 0.28 V_b T + 2s + 0.28 V T.$$

where, $T = \sqrt{\frac{14.45}{A}}$, A = acceleration in kmph/sec

$s = 0.2 V_b + 6$, (V_b in km/hr)

In case of speed of overtaken vehicle V_b is not given then assume $(V-16)$ Km/hr, where V is design speed in Km/h.

Assume, $V_b = (V-4.5)$, m/sec, where, V is design speed in m/sec.

Q: Write short notes on overtaking zones.

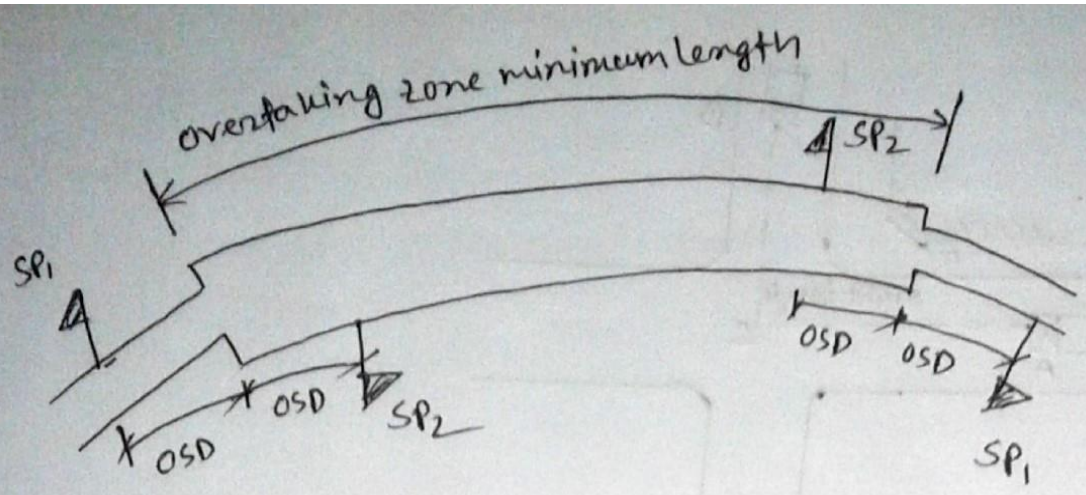
Answer: Overtaking zones: It is desirable to construct highway in such a way that length of road visible ahead at every point is sufficient for safe overtaking. This is seldom practicable. But overtaking opportunity for the vehicles moving at design speed should be given at frequent intervals. These zones which are meant for overtaking are called overtaking zones.

Sign post should be installed at sufficient distance in advance to indicate start of overtaking zones. This distance may be equal to (d_1+d_2) for one-way roads and $(d_1+d_2+d_3)$ for two way roads.

Similarly end of overtaking zones should also be indicated by appropriate sign posts installed ~~zones should be three time safe~~ ahead at distances specified above.

The minimum length of the overtaking zones should be three times safe overtaking distance i.e. $(d_1+d_2)3$ for one way roads and $3(d_1+d_2+d_3)$ for two way roads.

It is desirable that length of overtaking zones is kept five times overtaking sight distance.



OSD = Overtaking sight distance.
= $(d_1 + d_2)$ for one way traffic
= $(d_1 + d_2 + d_3)$ for two way traffic.

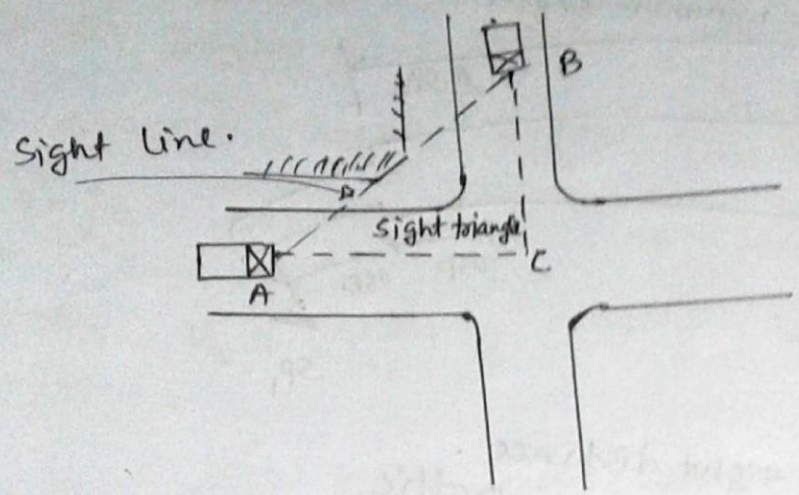
SP_1 = sign post "over taking zone ahead"

SP_2 = sign post, "end of overtaking zone".

Q. Write a short note on sight distance at intersection.

Answer: Sight distance at Intersection:

It is important that on all approaches of intersecting roads, there is a clear ~~tri~~ view across the corners from a sufficient distance so as to avoid collision of vehicle. This is all the more important at uncontrolled intersections. The sight line is obstructed by structures or other objects at the corners of the intersections. The area of unobstructed sight formed by the lines of vision is called the sight triangle.



The design of sight distance at intersections may be based on three possible conditions:—

(I) Enabling the approaching vehicle to change speed.
(II) Enabling approaching vehicle to stop.
(III) Enabling stopped vehicle to cross a main road.

Q. Discuss the importance of sight distance?

Answer. Importance of sight distance:—

(I) Sight distance reduces the possibility of collision.
(II) It helps the driver to run at design speed.
(III) It is a vital factor for safe vehicle operation.
(IV) It helps to reduce traffic jam.
(V) It is essential for fast moving vehicle to overtake or pass slow moving vehicles.

মোঃ রবিউল ইসলাম CE 130110

Transportation Engineering – 1

Problem Solve

Problem: In a district where the rainfall is heavy, major district road of WBM pavement, 3.8 m wide and a state highway of bituminous concrete pavement, 7.0 m wide are to be constructed. What should be the height of the crown with respect to the edges in these two cases?

Soln For WBM.

Provide a camber rate of 1 in 33 as the rainfall is heavy.

Rise of crown with respect to edges.

$$= \frac{3.8}{2} \times \frac{1}{33} = 0.058 \text{ m}.$$

For Bituminous concrete road.

Provide a cross fall of 1 in 50.

Rise of crown with respect to edges $= \frac{7}{2} \times \frac{1}{50}$

$= 0.07 \text{ m}$.

2014 (7 (c))

Problem: Calculate the safe SSD for design speed of 50 kmph for (a) two way traffic on a two lane road (b) two way traffic on a single lane road. Assume $f = 0.37$ and $t = 2.5$ sec.

Soln when V in kmph;

Stopping sight Distance $SSD = 0.278Vt + \frac{V^2}{254f}$

$$SD = 0.278 \times 50 \times 2.5 + \frac{50^2}{254 \times 0.37}$$

$$SD = 61.35 \text{ m Ans.}$$

(a) ∴ Stopping sight distance where there are two lanes

$$SSD = SD = 61.35 \text{ m Ans}$$

(b) Stopping sight distance for two-way traffic with single lane $= 2 \times SD = 2 \times 61.35 = 122.7$ m Ans

Problem: Calculate the min^m SD required to head on-collision of two cars approching from opposite directions at 90 and 60 kmph. Assume $t = 2.5$ sec and $f = 0.7$ and brake efficiency is 50 percent.

Soln Stopping distance for one of the cars,

$$SD \text{ (meters)} = vt + \frac{v^2}{2gf}$$

$V_1 = 90$ kmph

$v = \frac{90}{3.6} = 25$ m/s.

$V_2 = 60$ kmph

$v_2 = \frac{60}{3.6} = 16.67$ m/sec.

As the brake efficiency is 50%, the wheels will skid through 50% of the braking distance and rotate through the remaining distance. Therefore the value of co-efficient of friction developed f may be

taken as 50% of the co-efficient of friction i.e.

$$f = 0.5 \times 0.7 = 0.35$$

The stopping distance for the first car,

$$SD_1 = 25 \times 2.5 + \frac{25^2}{2 \times 9.81 \times 0.35} = 153.51 \text{ m}$$

For 2nd car,

$$SD_2 = 16.67 \times 2.5 + \frac{16.67^2}{2 \times 9.81 \times 0.35} = 82.14 \text{ m}.$$

∴ Sight distance to avoid head-on-collision of the two approaching cars $= SD_1 + SD_2 = 153.51 + 82.14 = 235.65$ m.

Problem: Calculating the stopping sight distance on a highway at a descending gradient of 2% for a design speed of 80 kmph. Assume other data as per IRC recommendation

Soln Total reaction time t may be taken as 2.5 second and design co-efficient of friction as $f = 0.35$.

$$V = 80 \text{ kmph}, \quad n = -2\%, \quad g = 9.8 \text{ m/sec}^2$$

$$v = \frac{80}{3.6} = 22.2 \text{ m/sec}.$$

We know,

$$SSD = vt + \frac{v^2}{2g(f \pm n\%)} = (22.2 \times 2.5) + \frac{(22.2)^2}{2 \times 9.81 (0.35 - 0.02)}$$

∴ SSD = 132 m Ans.

Alternatively,

$$SSD = 0.278 Vt + \frac{V^2}{254(f \pm 0.01 n)} = (0.278 \times 80 \times 2.5) + \frac{80^2}{254(0.35 - 0.01 \times 0.02)}$$

$$= 132 \text{ m Ans}$$

Problem 4.5: Calculate the values of (I) Head light SD (II) Intermediate SD for a highway with design speed of 65 Kmph. Assume suitably all the data required.

Soln

Given: $V = 65$ kmph.

Assume, $f = 0.36$, $t = 2.5$ sec.

(I) Head light sight distance = SD $= 0.278Vt + \frac{V^2}{254f}$

$= 0.278 \times 65 \times 2.5 + \frac{65^2}{254 \times 0.36}$

$= 91.4$ m.

(II) Intermediate sight distance $= 2 \times SD = 2 \times 91.4 = 182.8$ m Ans

2007 2(c)
2015 6(c) Calculate SSD for a design speed of 60 kmph for two-way traffic on a single lane road. Assume $f = 0.35$, $t = 2.5$ sec.

Soln We know sight Distance, (when V in kmph)

$SD = 0.278Vt + \frac{V^2}{254f}$

$= 0.278 \times 60 \times 2.5 + \frac{60^2}{254 \times 0.35}$

$= 82.19$ m.

For two way a single lane traffic SSD $= 2 \times SD$

$= 2 \times 82.19$

$= 164.38$ m Ans

2014 6(c), 2008(4(b)) same
2015 7(b)

An ascending gradient of 1 in 100 meets a descending gradient 1 in 125. A summit curve is to be designed for a speed of 80 kmph so as to have an OSD of 450 m.

Soln

Given,

$$n_1 = +\frac{1}{100}, \quad n_2 = -\frac{1}{125}.$$

$$\therefore N = n_1 - n_2 = \frac{1}{100} - \left(-\frac{1}{125}\right) = \frac{9}{500}$$

If, $L > OSD$ then length of summit curve.

$$L = \frac{NS^2}{9.6} = \frac{9}{500} \times \frac{450^2}{9.6} = 379.687 \text{ m}.$$

As this value is less than OSD of 450 m. Assume L is less than OSD, then length of summit curve,

$$L = 2S - \frac{9.6}{N} = 2 \times 450 - \frac{9.6}{\frac{9}{500}} = 367.67 \text{ m}$$

$\therefore L = 368$ m (say) < 450 m.

$\therefore$ The length of summit curve = 368 m.

2015 8(b) Design the rate of super-elevation for a curve of radius 300 m and speed of 75 kmph.

Soln For mixed traffic conditions, superelevation is given by,

$V = 75$ kmph
$R = 300$ m

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

$$= \frac{75^2}{225 \times 300}$$

$$= 0.083 \text{ m}$$

As the value is greater than the maximum superelevation of 0.07, the actual superelevation to be provided is restricted to 0.07.

2014 8(c) Calculate the extra width of pavement required on a horizontal curve of radius 700 m on a two lane highway. the design speed being 80 kmph. Assume wheel base, $l = 6$m.

Soln

Extra widening required,

$$We = Wm + Wps$$

$$= \frac{nl^2}{2R} + \frac{V}{9.5\sqrt{R}}$$

$$= \frac{2 \times 6^2}{2 \times 700} + \frac{80}{9.5\sqrt{700}}$$

$$= 0.3697 \text{ m}$$ Ans

Here,
$n = 2$
$l = 6$ m
$R = 700$ m
$V = 80$ kmph.

2012 5(b) Find the total width of pavement on a horizontal curve for a new state highway with a ruling maximum radius. Design speed is 80 Kmph, width of road 7.0 m and wheel base is 6.1 m.

Soln

Given, $V = 80$ Kmph, $l = 6.1$ m, $W_b = 7$ m.

Assume, $e = 0.07$, $f = 0.15$. $n = 2$.

$$\therefore \text{Ruling, } R = \frac{V^2}{127(e+f)} = \frac{80^2}{127(0.07+0.15)} = 229 \text{ m}.$$

$$\therefore We = \frac{nl^2}{2R} + \frac{V}{9.5\sqrt{R}} = \frac{2 \times 6.1^2}{2 \times 229} + \frac{80}{9.5\sqrt{229}}$$

$$= 0.72 \text{ m}.$$

$$\therefore \text{Total width, } W = W_b + We = 7 + 0.72 = 7.72 \text{ m}$$

Ans

2012 7(c) An ascending gradient of 1 in 50 m a descending gradient of 1 in 80. Determine the length of summit curve to provide (i) SSD and (ii) OSD for design speed 80 kmph. Assume all other data.

Soln Here, $n_1 = +\frac{1}{50}$, $n_2 = -\frac{1}{80}$.

$\therefore N = n_1 - n_2 = \frac{1}{50} - (-\frac{1}{80}) = \frac{13}{400}$

Assume, $t = 2$ sec, $f = 0.35$,

$V = 80$ kmph.

(i) For SSD, $SSD = 0.278Vt + \frac{V^2}{254f}$

$= 0.278 \times 80 \times 2 + \frac{80^2}{254 \times 0.35}$

$= 116.47$ m. ~ 116.5 m

If, $L > SSD$. $\therefore L = \frac{NS^2}{4.4} = \frac{13}{400} \times \frac{116.5^2}{4.4} = 100.25 < 116.5$ m (not ok)

$\therefore L < SSD$; $\therefore L = 2S - \frac{4.4}{N} = (2 \times 116.5) - \frac{4.4}{\frac{13}{400}} = 97.6 < 116.5$ (ok)

$\therefore L = 98$ m. Ans.

(ii) For OSD, $v = \frac{80}{3.6} = 22.2$ m/s, $v_b = \frac{80-16}{3.6} = 17.78$ m/sec.

Assume, $t = 2$ sec, $a = 0.99$ m/sec^2,

$\therefore S = 0.7 v_b + 6 = 0.7 \times 17.78 + 6 = 18.45$ m

$\therefore T = \sqrt{\frac{4S}{a}} = \sqrt{\frac{4 \times 18.45}{0.99}} = 8.63$ sec.

$d_1 = v_b t = 17.78 \times 2 = 35.56$; $d_2 = v_b T + 2S = (17.78 \times 8.63) + (2 \times 18.45) = 190.4$

$d_3 = VT = 22.2 \times 8.63 = 191.76$ m.

For two way traffic, $OSD = d_1 + d_2 + d_3 = 35.56 + 190.4 + 191.76 \simeq 417.72 \sim 418$ m

If, $L > OSD$. $\therefore L = \frac{NS^2}{9.6} = \frac{13}{400} \times \frac{418^2}{9.6} = 590.7$ m > 418 m (ok)

$\therefore$ Length $L = 591$ m (Ans)

2015 8(b) 1 page max. (using comp. mistake.

Check for co-efficient of lateral friction developed for full speed,

$$f = \frac{V^2}{127R} - 0.07 = \frac{75^2}{127 \times 300} - 0.07 = 0.078$$

As the value is less than 0.15, the design is safe with a superelevation of 0.07. Ans

CT-12 series 2013 7(c), 2008(3(c))

Problem : The speed of overtaking and overtaken vehicles are 70 kmph and 40 kmph, respectively on a two way traffic road. If the acceleration of overtaking vehicle is 0.99 m/sec^2. (a) Calculate safe OSD (b) mention the minimum and desirable length of overtaking zones and (c) draw a neat sketch of the overtaking zone and show the position of the sign posts.

Soln we know,

Overtaking sight distance for two way traffic.

$= d_1 + d_2 + d_3$

Given, $V = 70$ kmph

$v = \frac{70}{3.6} = 19.4$ m/sec.

$v_b = \frac{40}{3.6} = 11.1$ m/sec.

$a = 0.99$ m/sec^2

Assume, $t = 2$ sec.

$\therefore d_1 = v_b t = 11.1 \times 2 = 22.2$ m.

$d_2 = v_b T + 2s$

$S = 0.7 v_b + 6 = 0.7 \times 111.1 + 6 = 13.6\ m$.

$T = \sqrt{\frac{4S}{a}} = \sqrt{\frac{4 \times 13.6}{0.99}} = 7.47\ sec$.

$\therefore d_2 = (111.1 \times 7.47) + (2 \times 13.8) = 110.5\ m$.

$d_3 = v.T = 19.4 \times 7.47 = 144.9\ m$.

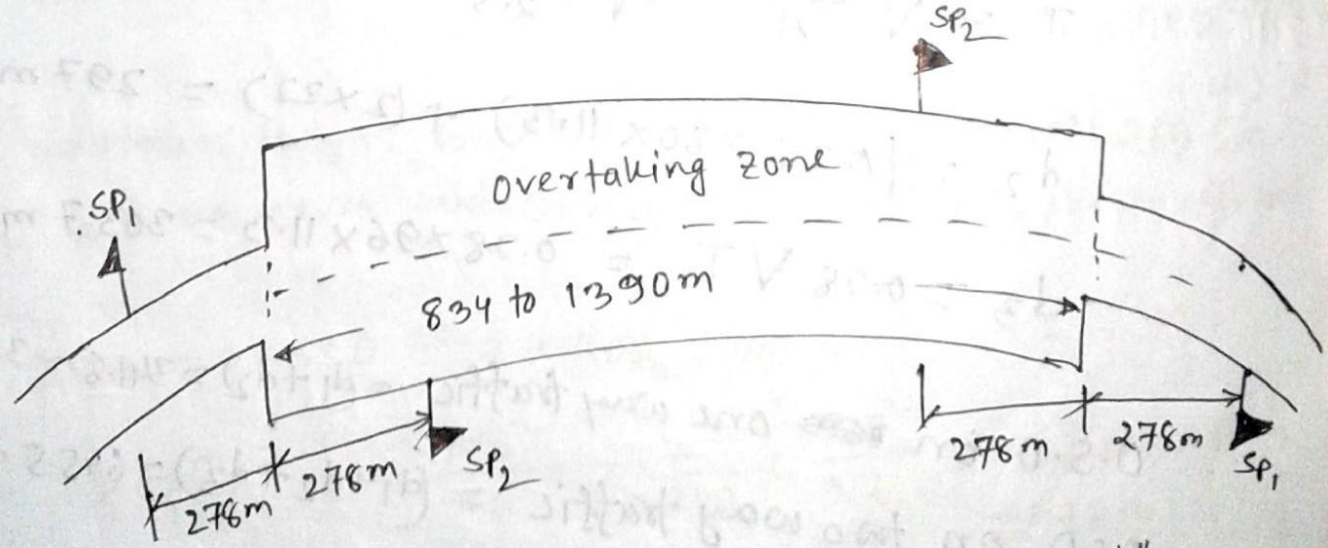
$\therefore O.S.D = d_1 + d_2 + d_3 = 22.2 + 110.5 + 144.9 = 277.6 \sim 278\ m$. Ans.

(b) Minimum length of overtaking zone $= 3 \times OSD$.

for two way traffic overtaking zone (minimum) $= 3 \times 278$
$= 834\ m$. Ans

Desirable length of overtaking zone $= 5 \times OSD$
$= 5 \times 278$
$= 1390\ m$. Ans

(c) The details of the overtaking zone are shown below:-



SP_1 = Sign Post "Overtaking zone ahead"

SP_2 = Sign Post "End of overtaking zone".

Problem: Calculate the safe OSD for a design speed of 96 kmph. Assume all other data suitably.

Soln

$O.S.D = (d_1 + d_2)$ for one-way traffic

$= (d_1 + d_2 + d_3)$ for two-way traffic

$V = 96$ kmph.

$V_b = V - 16 = 80$ kmph.

Let, $A = 2.5$ kmph/sec, $t = 2$ sec.

$\therefore d_1 = 0.28\, V_b t = 0.28 \times 80 \times 2 = 44.8$ m.

$d_2 = 0.28\, V_b T + 2s$,

$s = (0.2\, V_b + 6) = 0.2 \times 80 + 6 = 22$ m.

$T = \sqrt{\frac{14.4\,s}{A}} = \sqrt{\frac{14.4 \times 22}{2.5}} = 11.3$ sec.

$d_2 = (0.28 \times 80 \times 11.3) + (2 \times 22) = 297$ m.

$d_3 = 0.28\, VT = 0.28 \times 96 \times 11.3 = 303.7$ m.

$\therefore$ O.S.D on one way traffic $= (d_1 + d_2) = 341.8 \sim 342$ m.

OSD on two way traffic $= (d_1 + d_2 + d_3) = 645.5 \sim 646$ m

2009 5(c) A vertical summit curve is to be designed when two grades $+\frac{1}{60}$ and $-\frac{1}{80}$ meet on a highway. The SSD and OSD required are 200 m and 700 m respectively. But due to restricted site conditions the length of vertical curve has to be restricted to a maximum valum of 500m. If possible Calculate the length of summit curve needed to fulfill the requirements of (i) SSD and (ii) OSD or at least ISD.

Soln Here, $n_1 = +\frac{1}{60}$, $n_2 = -\frac{1}{80}$

$$N = n_1 - n_2 = \frac{1}{60} - \left(-\frac{1}{80}\right) = \frac{7}{240}$$

SSD = 200 m, OSD = 700 m.

Let, $L > SSD$, $L = \frac{NS^2}{4.4} = \frac{7}{240} \times \frac{200^2}{4.4} = 265.15 > 200$

$= 265.5$ m (Ok)

$\therefore$ Length = 265.5m

Again, let. $L > OSD$, $\therefore L = \frac{NS^2}{9.6} = \frac{7}{240} \times \frac{700^2}{9.6} = 1488.72 > 700$

$= 1489 > 700$ m (Ok).

But maximum length is 500 m. where SSD length 265.5m. which will be cover but OSD length 1489 m which will not cover.

So, OSD $= 2 \times SSD = 2 \times 200 = 400$ m.

$\therefore L > OSD$, $L = \frac{NS^2}{9.6} = \frac{7}{240} \times \frac{400^2}{9.6} = 486.11 > 400$ m

~ 487 m.

Now this length will be covered.

So (Ok)

2007 4(b) Calculate the max^m allowable speed on horizontal curve of radius 200 m. for the following data;

$V = 80$ kmph, $e_{max} = 0.07$, $f_{max} = 0.15$.

Soln

Here, $V = 80$ kmph, $e = 0.07$, $f = 0.15$. $R = 200$ m.

we know, $e + f = \frac{V_{all}^2}{127R}$.

$0.07 + 0.15 = \frac{V_{all}^2}{127 \times 200}$

$\therefore V_{all} = 74.75$ kmph.

Here, $V_{all} < V_d = 80$ kmph.

So, $V_{all} = 74.75$ kmph Ans

2010 3(e) Calculate SSD one lane two way road when $V = 70$ kmph. $f = 0.4$, $t = 2.5$. Brake efficiency 50%.

Soln since brake efficienty 50%.

$\therefore f = 0.4 \times 0.5 = 0.2$

$t = 2.5$ sec.

$V = 70$ kmph.

we know, $SD = 0.278 Vt + \frac{V^2}{254f}$

$= 0.278 \times 70 \times 2.5 + \frac{70^2}{254 \times 0.2}$

$= 145.10 \sim 145.5$ m.

$\therefore$ SSD to avoid collision of the two approching vehicle $= 2 \times SD$

$= 2 \times 145.50$

$= 291$ m

Ans

Formula:

Metalled Road:

$$\text{Total length} = \left[\frac{A}{8} + \frac{B}{32} + 1.6N + 8T\right] + D - R$$

where,

A = Agricultural area, km^2

B = Non agricultural area, km^2

N = no of towns and villages with population range 2001 – 5000.

T = no of towns and villages with population over 5000

D = 15% during the next 20 years.

R = Existing length of railway track, km.

Unmetalled Road:

$$\text{Total length} = (0.32V + 0.8Q + 1.6P + 3.2S) + D$$

where,

V = No of villages with population 500 or less.

Q = no of villages with population 501 – 1000.

P = no of villages with population 1001 – 2000

S = no of villages with population 2001 – 5000

D = Development allowance of 15% for next 20 years.

2010 1(c) Find Additional metalled and unmetalled road length.

(I) Total area = 25000 km²

(II) Agriculture and developed area = 7200 km²

(III) Existing metalled road = 700 km.

(IV) " unmetalled " = 1100 km.

(V) Length of railway = 200 km.

Population range	>5000	2000-5000	1000-2000	500-1000	<500
No of town & villages	14	85	250	500	1300

Soln Given,

A = 7200 km², B = 25000 − 7200 = 17800 km²

R = 200 km, D = 15% of Road length.

N = 85, T = 14

∴ Metalled road $= \left(\frac{A}{8} + \frac{B}{32} + 1.6N + 8T\right) + D - R$

$= \left\{\frac{7200}{8} + \frac{17800}{32} + (1.6 \times 85) + (8 \times 14)\right\} + 15\% \text{ of } RL - 200$

$= 1704.25 + 15\% \text{ of } 1704.25 - 200$

$= 1704.25 + 255.64 - 200$

$= 1759.89$ km.

∴ Additional metalled road length = 1759.89 − 700

= 1059.89 km Ans

Unmetalled road length,

$$= (0.32V + 0.8Q + 1.6P + 3.2S) + D$$

Here, $V = 1300$, $Q = 500$, $P = 250$, $S = 85$

$\therefore$ road length $= \{(0.32 \times 1300) + (0.8 \times 500) + (1.6 \times 250) + (3.2 \times 85)\}$ + 15% of RL

$= 1488 + 15\%$ of 1488

$= 1488 + 223.2$

$= 1711.2$ Km.

$\therefore$ Additional unmetalled road length $= 1711.2 - 1100$

$= 611.2$ Km Ans

same → 2006 1(c)

Problem: 2008 1(c) Calculate the additional length of metalled road for the following data:-

(I) Total area $= 9000$ km^2 (II) Agriculture area $= 3000$ km^2 (III) existing railway $= 100$ km (IV) Existing metal road $= 300$ km.

Population	>5000	2000-5000	1000-2000	501-1000	<500
No. of towns and villages	8	40	130	240	590

Soln Given, $A = 3000$ km^2, $B = 9000 - 3000 = 6000$ km^2, $T = 8$

$R = 100$ km, $D = 15\%$ of Road length. $N = 40$

$\therefore$ Metalled road length $= \left(\frac{A}{8} + \frac{B}{32} + 1.6N + 8T\right) + D - R$

$= \left\{\frac{3000}{8} + \frac{6000}{32} + \{(1.6 \times 40) + (8 \times 8)\}\right\} + 15\%$ of RL $- 100$

$= 690.5 + 15\% \text{ of } 690.5 - 100$

$= 690.5 + 103.575 - 100$

$= 694.075 \text{ km}$

∴ Additional length of metalled road $= 694.075 - 300$

$= 394.075 \text{ km}$ Ans

মোঃ রবিউল ইসলাম
রাজশাহী প্রকৌশল ও প্রযুক্তি বিশ্ববিদ্যালয়
যুবকৌশল বিভাগ
রেজি নং: ১৬০১১০ (MAH)

Transportation Engineering – I

⇒ Horizontal curve:-

The presence of horizontal curves imparts centrifugal force which is a reactive force acting outward on a vehicle negotiating it. The centrifugal force developed depends on the radius of the horizontal curves and the speed of the vehicle negotiating the curve. This centrifugal force is counteracted by the transverse frictional resistance developed between the tyres and the pavement which enables the vehicle to change the direction along the curve and to maintain the stability of the vehicle.

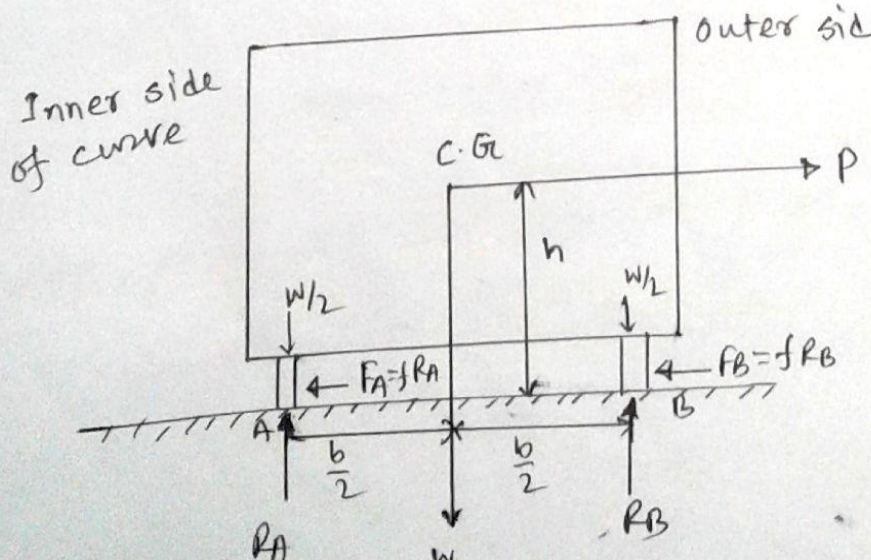


Fig. Effect of horizontal curve.

The centrifugal force (P) acting outward, weight of vehicle 'W' acting downward. Then centrifugal force P is given by, as,

$$P = \frac{Wv^2}{gR}$$

Where, P = centrifugal force, km/m^2

W = weight of the vehicle, kg.

R = radius of the circular curve, m.

v = speed of vehicle, m/sec.

g = acceleration due to gravity = 9.8 m/sec^2

The ratio of the centrifugal force to the weight of vehicle $\frac{P}{W}$ is known as impact factor or centrifugal ratio.

$$\therefore \quad \frac{P}{W} = \frac{v^2}{gR} \qquad \text{——— (I)}$$

The centrifugal force has two effects.

(I) A tendency to overturn vehicle about outer wheels.

(II) A tendency for transverse skidding.

Tendency to overturn vehicle about outer wheel:

Taking moments of overturn vehicle of forces with respect to outer wheel when vehicle is just about to overide.

$$Ph = W * \frac{b}{2} \quad \text{or,} \quad \frac{P}{W} = \frac{b}{2h} \qquad \text{— (I)}$$

At equilibrium overturning is possible when,

$$\frac{b}{2h} = \frac{v^2}{gR} \quad \text{- - -}$$

For safety following condition must satisfy.

$$\frac{b}{2h} > \frac{v^2}{gR}$$

Transverse skiding effect: Second tendency of vehicle is for transverse skidding i.e. when centrifugal force P. is greater than maximum possible transverse skid resistance due to friction between pavement surface and tyre. Transverse skid resistance F is given by,

$$F = F_A + F_B$$

$$= f(R_A + R_B)$$

$$F = fW \qquad [\because R_A + R_B = \text{total weight of vehicle} = W]$$

where, F_A and F_B is the frictional force at tyre A and B. Transverse skid resistance is counteracted by centrifugal force (P) and equating we get,

$$P = fW$$

$$\Rightarrow \frac{P}{W} = f$$

At equilibrium when skidding takes place.

$$\frac{P}{W} = f = \frac{v^2}{gR}$$

For safety following condition must satisfy.

$$f > \frac{v^2}{gR} \qquad \text{——(4)}$$

Equation ③ & ④ gives the stable condition for design

Q. What do you mean by super elevation?

Answer: Super elevation / cant / banking: Super elevation or cant or banking is the transverse slope provide at horizontal curve to counteract centrifugal force, by raising outer edge ~~to counteract centrifugal force~~, of pavement with respect to inner edge, throughout the length of the horizontal curve. When outer edge is raised, a component of curve weight will be complimented in counteracting effect of centrifugal force.

In order to find out how much this raising should be analyze:

Analysis of superelevation:

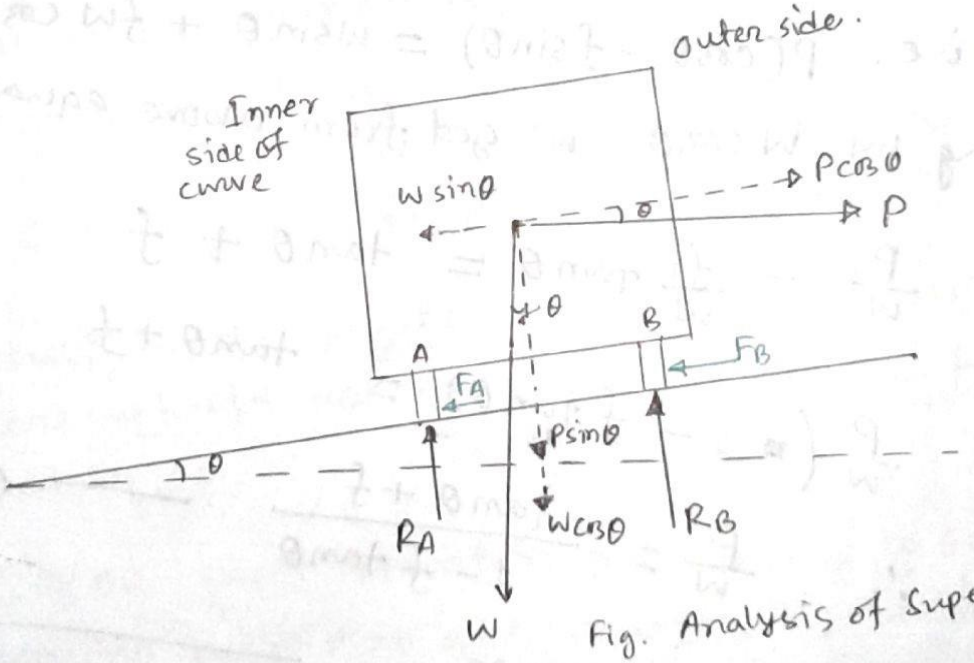


Fig. Analysis of Superelevation.

The forces acting on the vehicle while moving on a circular curve of radius R meters at speed of V m/sec are.

(1) the centrifugal force $P = \frac{WV^2}{gR}$ acting horizontally outwards through the centre of gravity C.G.

(II) The weight W of the vehicle acting vertically downwards through CG.

(III) The frictional force F developed between the wheels and the pavement counteractions transeversely along the pavement surface towards the centre of the curve.

At equilibrium by resolving forces parallel to surface of pavement we get,

$$P\cos\theta = W\sin\theta + F_A + F_B$$

$$P\cos\theta = W\sin\theta + f(R_A + R_B)$$

$$P\cos\theta = W\sin\theta + f(W\cos\theta + P\sin\theta)$$

i.e. $P(\cos\theta - f\sin\theta) = W\sin\theta + fW\cos\theta$ —(a)

Dividing by $W\cos\theta$ we get from above equation.

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

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

$$\therefore \frac{P}{W} = \frac{\tan\theta + f}{1 - f\tan\theta} \quad \text{—(b)}$$

Also we know, $\frac{P}{W} = \frac{v^2}{gR}$ —(c)

from (b) & (c) we get,

$$\frac{v^2}{gR} = \frac{\tan\theta + f}{1 - f\tan\theta} \quad \text{—(d)}$$

But in normally $f = 0.15$, and $\theta < 4°$, so, $1 - f\tan\theta \sim 1$ and for small θ, $\tan\theta \approx \sin\theta = e$, then from equation (d) we get,

$$e + f = \frac{v^2}{gR} \quad \text{—(e)}$$

where, e is the rate of super elevation.

f = coefficient of lateral friction = 0.15.

v = speed of vehicle, m/sec.

R = radius of horizontal curve.

g = acceleration due to gravity.

Three specific cases that can arrise from equation (e'). are as follows: —

(I) If there is no friction due to some practical reasons then $f = 0$ and equation (e) becomes,

$$e = \frac{v^2}{gR} = \frac{V^2}{127R}$$

where, v = m/sec
V = kmph.

This result in the situation where pressure on outer and inner wheels are same, requiring very high super elevation e.

(II) If there is no super-elevation provide due to some practical reasons then $e = 0$ and equation (e) becomes

$$f = \frac{v^2}{gR} = \frac{V^2}{127R}$$

(III) If $e = 0$, $f = 0.15$ and then for state equilibrium and safe travelling speed from equation (e) we can write that,

$$v_b = \sqrt{fgR}, \quad \text{where, } v_b = \text{The restricted speed.}$$

Q. Enumerate the steps for practical design of superelevation.

Answer: Design of superelevation: In designing superelevation following steps should be follow, as practice.

Step (i): The superelevation for 75% of design speed is calculated neglecting the friction.

$$e_1 = \frac{(0.75V)^2}{gR} = \frac{(0.75V)^2}{127R}$$

Step (ii): If the calculated value of $e_1 \leq 7\%$ or 0.07 then the value $e = e_1 = \frac{(0.75V)^2}{gR}$. else if $e_1 > 0.07$ then go to step 3.

Step (iii): Find f_1 for design speed and max e.

i.e. $f_1 = \frac{v^2}{gR} - e = \frac{v^2}{gR} - 0.07$

If this $f_1 < 0.15$, then maximum $e = 0.07$ is safe for design speed else go to step 4.

Step (iv): Find allowable speed v_a for maximum $e = 0.07$ and $f = 0.15$, $v_a = \sqrt{0.22gR}$.

If, $v_a \geq v$, then design is adequate, otherwise use speed adopt control measures or look for speed control measures.

⇒ Maximum and Minimum super-elevation:

Depends on (a) slow moving vehicle (b) heavy loaded truck with high centre of Gravity of load a maximum super-elevation of 7 percent for plain and rolling terrain is recommended. On hilly terrain 10 percent and on urban road it is 4 percent.

Minimum superelevation is 2-4 percent for drainage purpose, especially for large radius of the horizontal curve.

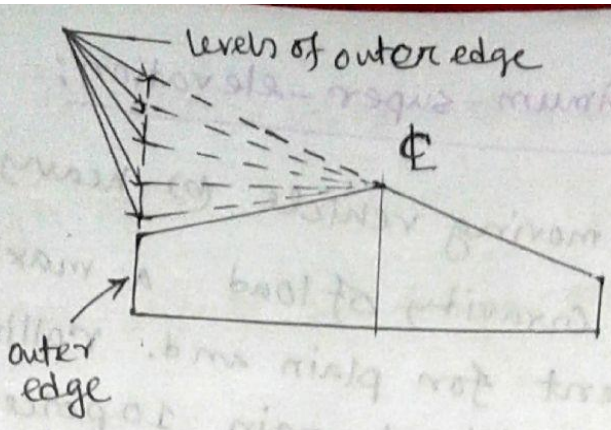
Q. Explain with sketches the method of eliminating camber and introduction of superelevation. 2014, 2015

Answer: The attainment of superelevation may be split into two parts:-

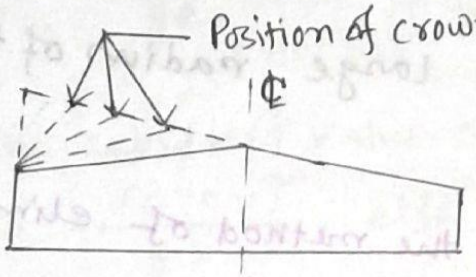
(a) Elimination of crown of the cambered section.
(b) Rotation of pavement to attain full superelevation.

Elimination of crown of the cambered section:-

This may be done by two methods. In the first method, the outer half of the cross slope is rotated about the crown at a desired rate such that the surface falls on the same plane as the inner half and the elevation of the centre line is not altered.



(a) Outer edge rotated about the crown.



(b) Crown shifted outwards (diagonal crown method)

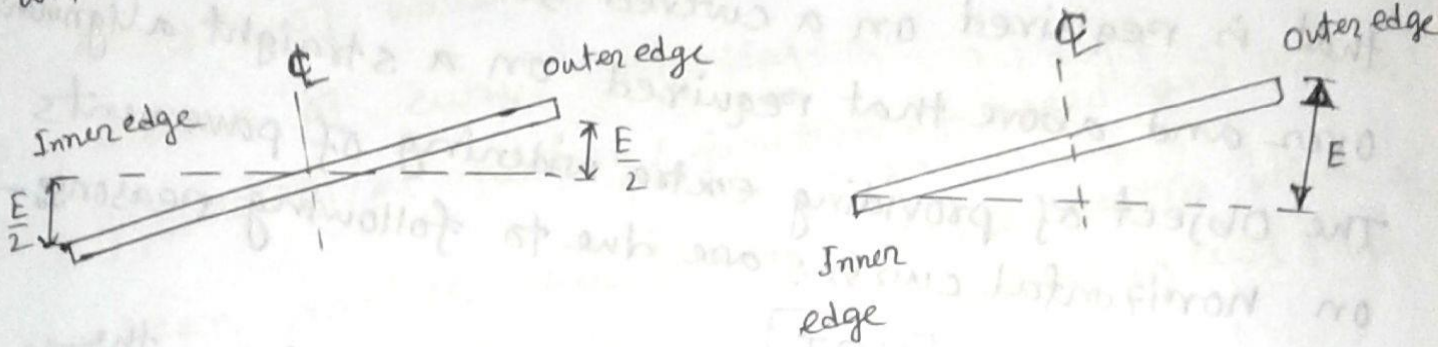
The outer half is further rotated so as to obtain uniform cross slope equal to the camber. The position of crown is progressively shifted outwards, thus increasing width of inner half of cross section progressively.

Rotation of pavement to attain full superelevation:-

There are two methods of rotating the pavement cross section to attain the full superelevation after the elimination of the camber.

(1) By rotating the pavement cross section about the centre line, depressing the inner edge and raising the outer edge each by half the total amount of superelevation i.e. by $\frac{E}{2}$ with respect to the centre.

(II) By rotating the pavement cross section about the inner edge of the pavement section raising both the centre as well as the outer edge of the pavement such that the outer edge is raised by the full amount of superelevation. E with respect to the inner edge.



Describe about radius of horizontal curve:-

Radius of horizontal curve is an important design aspect of geometric design. Maximum comfortable speed on a horizontal curve depends on radius of curve. Although it is possible to design curve with maximum superelevation and co-efficient of friction, it is not desirable because re-alignment would be required if design speed is increased in future. Therefore, a ruling minimum radius R_{ruling} can be derived by assuming maximum superelevation and co-efficient of friction is given as follows:-

$$R_{ruling} = \frac{V^2}{g(e+f)}$$

Ideally radius of curve should be higher than R_{ruling}. Very large curves are not desirable because setting out large curves in field becomes difficult, it is also enhances driving strain.

Q. Why widening of pavement on horizontal curve is done? 2012

Answer: Widening of pavement of horizontal curve:

Extra widening refers to additional width of carriageway that is required on a curved section of a road surface. Over and above that required on a straight alignment. The object of providing extra widening of pavements on horizontal curves are due to following reasons:—

GOT3

(a) Off tracking (the rear wheel does not follow the same path as that of the front wheels, is called off tracking).

(b) Transverse skidding due to excessive speed.

(c) Towing of vehicle.

(d) Tendency of driver to follow outer side of curve.

(e) Greater clearance between crossing or overtaking vehicle.

Q. Write down the factors on which the design of widening depends?

Answer: Required extra widening of pavement at horizontal curves depends on :—

(a) Length of wheel base of vehicle
(b) Radius of curve negotiate
(c) psychological factors (function of speed and radius)

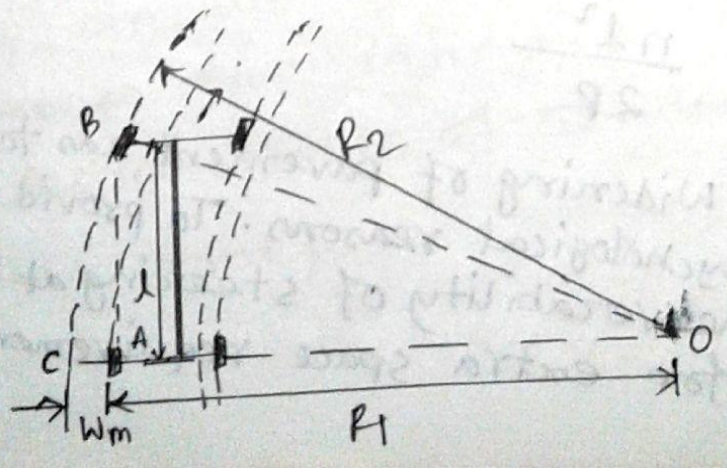
It has been practice therefore to provide extra width of pavement on horizontal curves when radius is less than about 300 m.

Q. Analyse the extra widening on curves?

Answer: Analysis of extra widening on curves :-

The extra widening of pavement on horizontal curves is divided into two parts (i) Mechanical and (ii) psychological widening.

Mechanical widening: The widening required to account for the off-tracking due to the rigidity of wheel based is called mechanical widening (W_m) and may be calculated as follows:-



R_1 = Radius of the path traversed by the outer rear wheel, m.

R_2 = " " " " " the outer front wheel, m.

W_m = off-tracking or the mechanical widening, m.

l = length of wheel base, m.

$W_m = OC - OA = OB - OA = R_2 - R_1$

From, $\triangle OAB$, $OA^2 = OB^2 - BA^2$

$$R_1^2 = R_2^2 - l^2$$

But $\because R_1 = R_2 - W_m$

$$\therefore (R_2 - W_m)^2 = R_2^2 - l^2$$

i.e. $R_2^2 - 2R_2 W_m + W_m^2 = R_2^2 - l^2$

$$\therefore l^2 = W_m(2R_2 - W_m)$$

$$\therefore W_m = \frac{l^2}{2R_2 - W_m}$$

$$\therefore W_m = \frac{l^2}{2R} \quad [\text{Approximately}]$$

In a road having n lanes,

$$W_m = \frac{nl^2}{2R}$$

Physicological widening: Widening of pavement has to be done for some psychological reasons. To provide for greater maneuverability of steering at higher speeds to allow for extra space requirements for

overhangs of vehicle. To provide greater clearance for crossing and overtaking vehicle. An empirical relation for psychological widening, Wps, at horizontal curves is.

$$W_{ps} = \frac{V}{9.5\sqrt{R}}$$

Hence total widening required on a horizontal curve is given by,

$$W_e = W_m + W_{ps}$$

$$\therefore W_e = \frac{n l^2}{2R} + \frac{V}{9.5\sqrt{R}}$$

where, n = no of traffic lanes.
V = design speed
R = radius of horizontal curve,
l = length of wheel base of longest vehicle, m

⇒ Horizontal transition curve: Horizontal transition curve is provided to change horizontal alignment from straight to circular curve gradually. It has a radius which decreases from infinity at straight end (tangent point) to desired radius of circular curve at other end [curve point).

Objectives for providing transition curve:- 2015

There are five objectives for providing transition curve and are given below:—

(I) To introduce gradually centrifugal force between tangent point and begining of circular curve, avoiding sudden jerk on vehicle which increases comfort of passengers.

(II) To enable driver turn steering gradually for his own comfort and security.

(III) To provide gradual introduction of super elevation.

(IV) To provide gradual introduction of extra widening.

(V) To enhance aesthetic appearance of the road.

Types of transition curves:

(I) Spiral (also called clothoid)

(II) Lemniscate

(III) Cubic parabola.

Length of transition curve depends on following factors:-

(I) Rate of change of centrifugal acceleration.

(II) Rate of introduction of superelevation.

(III) By empirical formula.

Vertical Alignment: It consists of gradients (straight lines in a vertical plane) and vertical curves. Usually drawn as a profile, which is a graph with elevation as vertical axis and horizontal distance along center line of road as horizontal axis. Just as a circular curve is used to connect horizontal straight, stretches of road, vertical curves, connect two gradients. When these two curves meet, they form either convex or concave. Former is called a summit curve, while latter is called a valley curve.

Gradient: Gradient is the rate of rise or fall along the length of the road with respect to the horizontal. It is empressed either as rate of rise or fall to the horizontal distance or as percentage rise or fall.

The gradient of a pavement is governed by the following factors:—

1. Characteristics of the traffic.
2. Physical factors of the site such a drainage, safety, appearance, access to adjacent property.
3. Bridge, approach road and railway line - intersection etc.

⇒ While aligning a highway, the gradient is decided for designing the vertical curve. Very steep gradients are avoided. Befor finalising the gradient, construction cost, vehicular operation cost and practical problems in site also has to be considered.

Representation of gradient:

Positive gradient or ascending gradient is denoted as +n and negative gradient descending gradients as -n. Deviation angle N. When two grades meets angle which measures change of direction and is given by algebric difference between two gradient, $N = n_1 - (-n_2) = n_1 + n_2$.

Types of Gradient:

- ✓ Many studies have shown that gradient upto seven percent can have considerable effect on speed of passenger cars.
- ✓ On centrary, speeds of the heavy vehicles are considerably reduced when long gradients as flat as two percent is adopted.
- ✓ Although flatter gradients are desirable. it is evident that cost of construction will also be very high.
- ✓ steeper gradients are desirable, it is evident that cost of construction will also be very high.
- ✓ steeper gradients are permitted for short distance.

Types of gradients:

Gradients are divided into following categories:—

(I) Ruling gradient.
(II) Limiting gradient.
(III) Exceptional gradient.
(IV) Minimum gradient.

Ruling gradient: Ruling gradient or design gradient is maximum gradient with which designer attempts to design vertical profile of road. This gradient depends on terrain, the length of grade, the speed, pulling power of vehicle and presence of horizontal curve.

✓ In flatter terrain, it may be possible to provide flat gradient but in hilly terrain it is not economical and sometime not possible also.

✓ Ruling gradient is adopted by designer by considering a particular speeds as design speed for a design vehicle with standard dimension.

✓ But our country has a hetero geneous traffic and hence it is not possible to lay down precise standards for country as a whole.

✓ Hence, some values for ruling gradient for different types of terrain are recommended.

Limiting gradients:-

This gradient is adopted when ruling gradient results in enormous increase in cost of construction. On rolling terrain and on hill roads, it may be frequently necessary to exceed ruling gradient and adopt limiting gradient, but care should be taken to separate such stretches of steep gradient by providing either a level road or a road with easier grade.

Exceptional gradients:

Exceptional gradient are very steeper gradient given at unavoidable situation. They should be limitted for short stretches not exceeding about 100 meters at a stretch. In mountain and steep terrain, successive exceptional gradients must be separated by a minimum 100 meter length gentler gradient. At ~~least~~ hairpin bends, gradient is restricted 2.5%.

Minimum gradient:

This is important only at location where surface drainage is important. Camber will take care of lateral drainage. But longitudinal drainage along side drains require some slope for smooth flow of water.

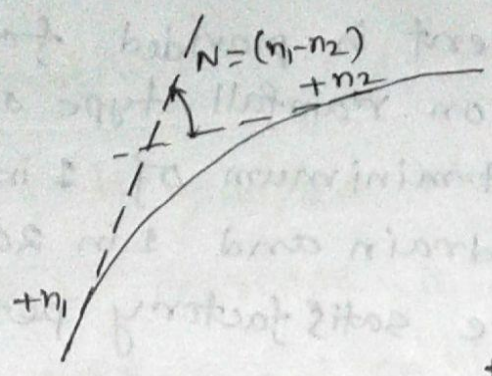
Therefore, minimum gradient is provided for drainage purpose and it depends on rainfall, type of soil and other site condition. A minimum of 1 in 500 may be sufficient for concrete drain and 1 in 200 for open soil drains are found to give satisfactory performance.

Critical length of grade:

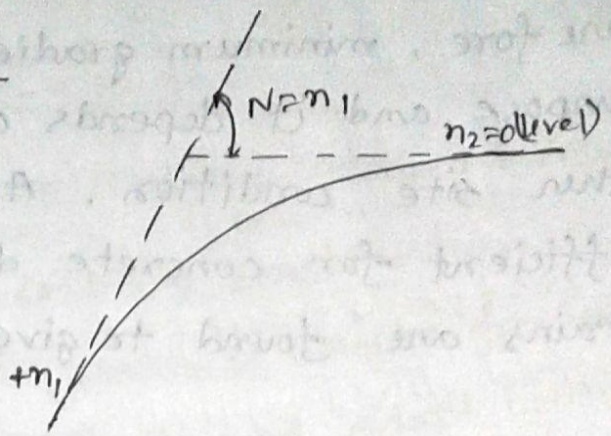
Maximum length of ascending gradient in which a loaded truck can operate without undue reduction in speed is called critical length of grade. A reduction in speed of about 25 kmph is a reasonable value. The critical length for design depends on size, power, load, grad-ability of truck initial speed, final desirable minimum speed.

Summit curve: Summit curve are vertical curves with gradients upward. They are formed when two gradients meet in any of following four ways:—

(I) when a positive gradients meets another positive gradients.
(II) when a positive gradient meets a flat gradients.
(III) when an ascending gradient meets a descending gradients.
(IV) when a descending gradients meets another descending gradients.



(a)



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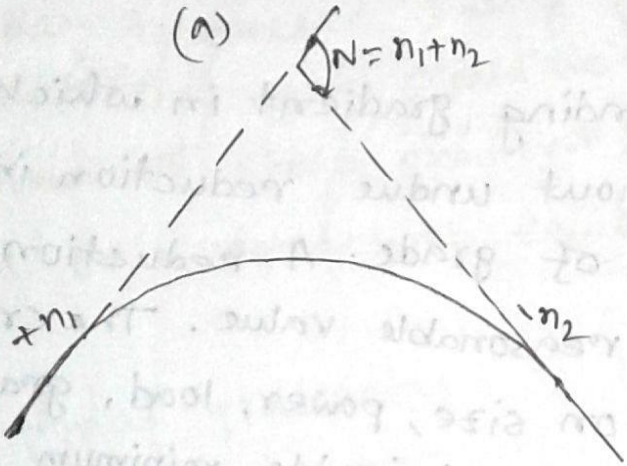

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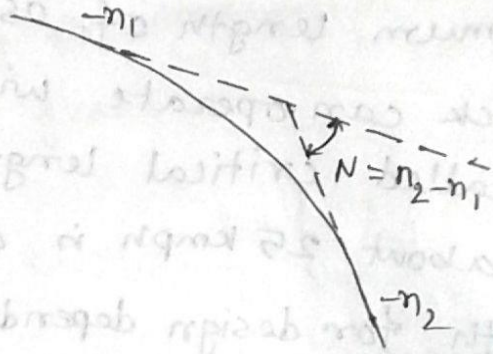
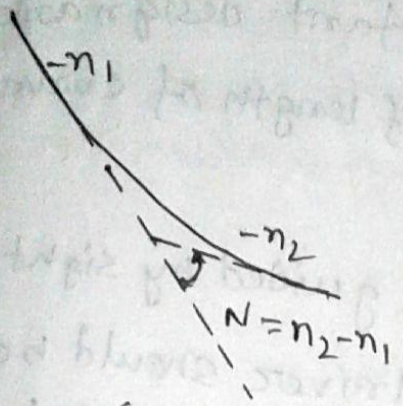


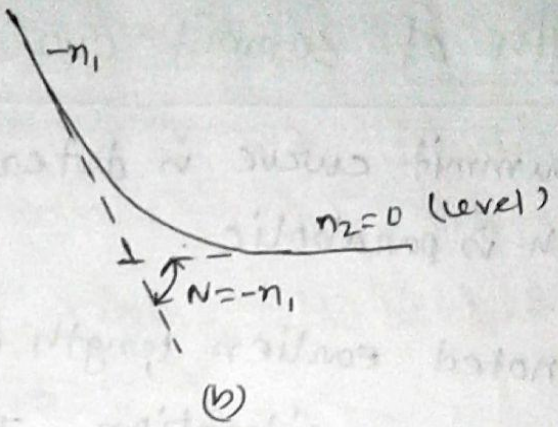
(d)

Valley curve: Valley curve or sag curves are vertical curves with convexity downwards. They are formed when two gradients meets in any ~~way of~~ the following four ways:-

(a) when a descending gradient meets another descending gradient.
(b) when a descending gradient meets a flat gradient.
(c) when a descending gradient meets an ascending gradient.
(d) when an ascending gradient meets another ascending gradients.



(a)



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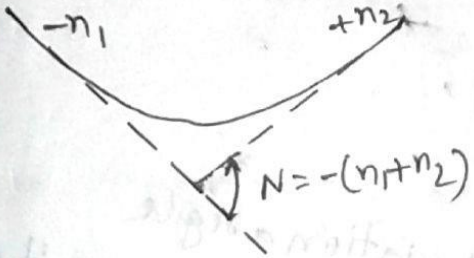

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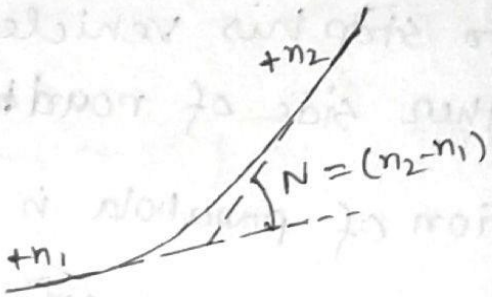


(d)

Length of summit curve: Important design aspect of summit curve is determination of length of curve which is parabolic.

As noted earlier length of summit curve is guided by sight distance consideration. That is, a driver should be able to stop his vehicle safely if there is an obstruction on other side of road.

Equation of parabola is given by,

$$y = ax^2$$

where, $a = \frac{N}{2L}$, where, N = deviation angle and L = length of summit curve.

In deriving length of summit curve, two situation can be arising depending on uphill and downhill gradients when the length of the curve is greater than sight distance and length of curve is less than sight distance.

Let assume, L is the length of the summit curve.

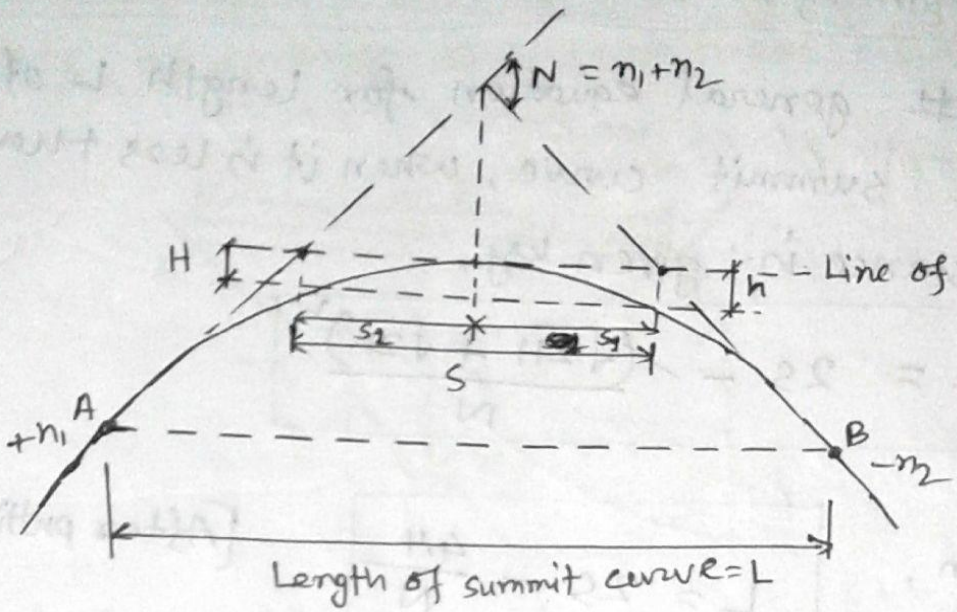
S is SSD / ISD / OSD.

N is devation angle.

H is drivers eye height (1.2m)

and h is height of obstruction (0.15m)

Case I: Length of summit curve is greater than SSD (L>S)



From figure, $y = ax^2$, $a = \frac{N}{2L}$

$H = as_1^2$, $h = as_2^2$

$s_1 = \sqrt{\frac{H}{a}}$, $s_2 = \sqrt{\frac{h}{a}}$

Now, $s_1 + s_2 = \sqrt{\frac{H}{a}} + \sqrt{\frac{h}{a}}$

$s^2 = \left(\frac{1}{\sqrt{a}}\right)^2 (\sqrt{H} + \sqrt{h})^2$

$\therefore s^2 = \frac{1}{a} (\sqrt{H} + \sqrt{h})^2$

$s^2 = \frac{2L}{N} (\sqrt{H} + \sqrt{h})^2$

$\therefore$ $$\boxed{L = \frac{Ns^2}{2(\sqrt{H} + \sqrt{h})^2}}$$

$\therefore$ $$\boxed{L = \frac{Ns^2}{4.4}}$$

[After putting $H = 1.2m$ and $h = 0.15 m$]

Case II: Length of the summit curve is less than SSD (L < SSD)

The ~~lenght~~ general equation for length L of the parabolic summit curve, when it is less than the sight distance is given by,

$$L = 2S - \frac{(\sqrt{2H} + \sqrt{2h})^2}{N}$$

again, $$L = 2S - \frac{4.4}{N}$$ [After putting H = 1.2 m, h = 0.15 m]

Length of summit curve for safe OSD or ISD:

Case I: Length of summit curve greater than OSD or ISD. (L > S).

Then, Length of summit curve is given by,

$$L = \frac{NS^2}{8H}$$

$$L = \frac{NS^2}{9.6}$$ [H = 1.2 m]

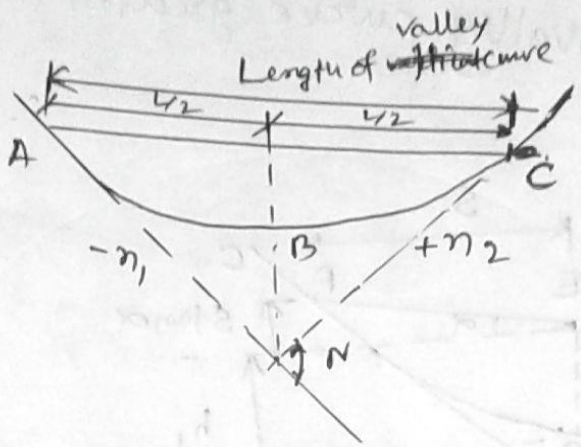
Case II: Length of summit curve less than OSD or ISD (L < S)

Then, Length of summit curve is given by:

$$L = 2S - \frac{8H}{N}$$

$$\therefore \quad L = 2S - \frac{9.6}{N}$$ [H = 1.2 m]

Length of valley curve for comfort condition / with allowable rate of change of centrifugal acceleration :—



For comfort condition,

$$L = 2\left(\frac{NV^3}{C}\right)^{1/2}$$

$$\therefore L = 0.38(NV^3)^{1/2}$$

[$C = 0.06$ m/sec^3]

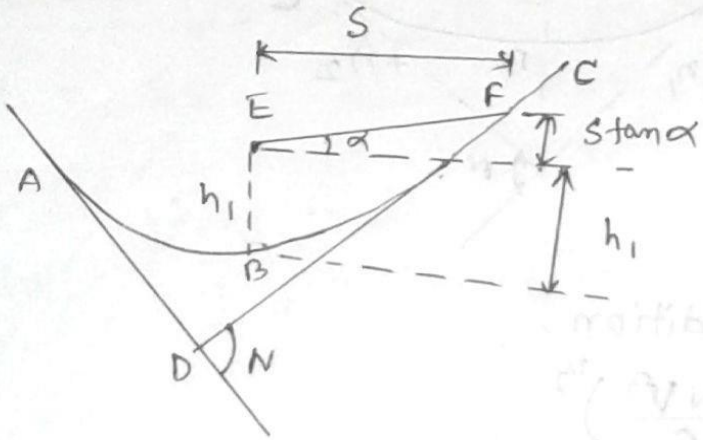
where, L is total length of valley curve, N is deviation angle in radians or tangent of deviation angle or algebric difference in grades. V is dsign speed in kmph. and C is rate of change of centrifugal acceleration in m/sec^3 ($= 0.06$ m/sec^3)

The minimum radius of the valley curve for cubic parabola is given by,

$$R = \frac{L}{2N}$$

Length of valley curve for head light sight distance:-

Case I: Length of valley curve greater than SSD (L>S)



The length of valley curve,

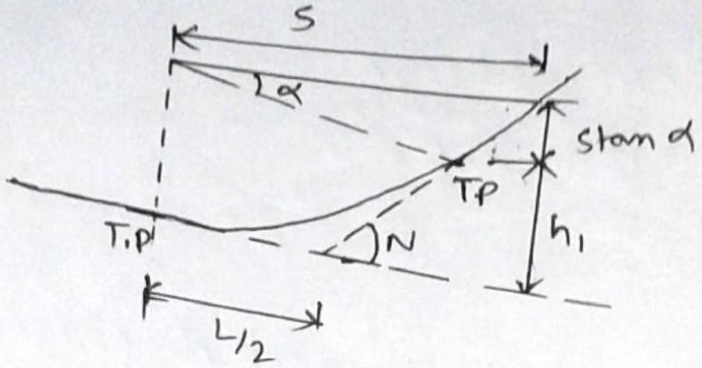
$$L = \frac{NS^2}{2h_1 + 2S\tan\alpha}$$

where L is length of valley curve in meter,
N is deviation angle in radians.
h_1 is height of head sight beam inclination in degrees.
and, S is stopping sight distance.

If average sight of head ~~light~~ light is taken as $h_1 = 0.75\,m$ and beam angle inclination is $\alpha = 1°$, then,

$$L = \frac{NS^2}{1.5 + 0.035S}$$

Case II: Length of valley curve less than SSD (L < S)



The Length of valley curve :

$$L = 2S - \frac{2h_1 + 2S\tan\alpha}{N}$$

If average height of head light is taken as $h_1 = 0.75m$ and beam angle inclination is $\alpha = 1°$, then.

$$L = 2S - \frac{(1.5 + 0.035S)}{N}$$

Maximum length of valley curve obtained between above two condition will be adopted.

মোঃ রবিউল ইসলাম
রাজশাহী প্রকৌশল ও প্রযুক্তি বিশ্ববিদ্যালয়
দুর্যোগপ্রকৌশল বিভাগ
রোল নং: ১৬০২০০.

More you read
More you forget.
So, less read
less u forget.

রবিউল
২৫/০৪/১৭

মো: রবিউল ইসলাম
রাজশাহী প্রকৌশল ও প্রযুক্তি বিশ্ববিদ্যালয়
পুরকৌশল বিভাগ
রোল নং: ১৬০১১০

Traffic : Traffic means movement of persons (only human being) and vehicles on road.

Transport: Transport means movement of persons (only human being) & goods from one place to another place.

Transportation: Transportation means the entire activity involving traffic and transport.

Transportation system: A transportation system may be defined as consisting of the fixed facilities, the flow entities and the control system that permit people and goods to move from one place to another place efficiently in order to partipate in a timely manner in some desired activity.

Transportation Demand: Transportation systems are built to serve people in undertaking their economic, social and cultural activities. People do not normally travel or move their possessions for the sake of movement but to fulfil

certain needs, such as going to school, to work, to shop, or to visit with friends. Transportation engineers accommodate these social activities by providing efficient ways to satisfy the population's need for mobility. Transportation engineers often cooperate with other professionals for efficient ways from the consideration of safety, speed convenience, economic, protection of environmental quality and protection of individual rights.

Role Played by Transportation Are: PTB DEPIGR ~~RTBEIDGP~~

(I) It gives "place utility" to goods.

(II) It gives "time utility" to goods and people.

(III) It bridges the space gap betn the consumer and producer.

(IV) It gives facilities for the exploitation of natural resources.

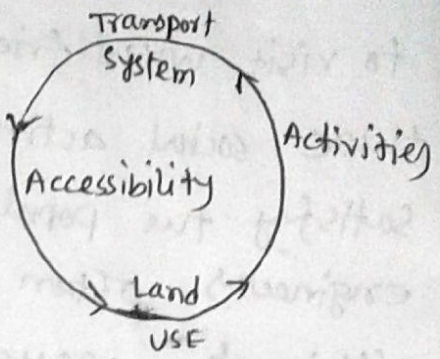
(V) It gives facilities for the international trade and commerce.

(VI) It is important for the defense of a country.

(VII) It determines the pattern of growth of towns and cities.

(VIII) It is a promoter of tourism.

The land use and transport system feedback cycle:



The distribution of land use (residential, industrial or commercial) determines the location of human activities (living, working, shopping, education or leisure).

The distribution of human activities requires trips in the transport system to overcome the distance.

Distribution of infrastructure in the transport system create opportunities that can be measured as accessibility

Distribution of ~~ass~~ accessibility co-determines location decision and so results in change of the land use - system.

Traffic Engineering: Transportation Engineering is that phase of engineering which deals with planning, geometric design and traffic operations of roads and highways, their networks with other modes of transportation for the achievement of safe, convenient and efficient transportation of persons and goods.

Scope: The basic object of traffic engineering is to achive efficient and free flow of traffic with least number of traffic accidents.

Traffic characteristics

Q: Briefly explain the physical characteristics of road users. ~~and static char~~

Answer: Road user characteristics: Road user is only human being includes the driver, pedestrian, cyclist and all other who use the road. The behaviour of the road user, including his physical, mental and psychological characteristics influences the design elements of road and road safety immensely (greately)

(a) Physical characteristics:-

Permanent: (i) Vision, Hearing power, strength, general reaction to traffic situation.

Temporary: Fatigue, Alcohol or drugs, illness.

(b) Mental: Knowledge, skill, intelligence, Experience, literacy.

(c) Psychological: Impatience, Inattentiveness, Fear, Anger, Maturity, Home worries mind etc.

(d) Environmental factors: Atmospheric condition. Facilities to traffic.

Static characteristics of vehicles that affect the traffic performance is given below:—

Static characteristics of vehicles affecting traffic performance are the dimensions, weight and maximum turning angle.

(a) Dimensions:

(i) Width: vehicle Width affects the width of shoulders and the width of parking space.

(ii) Length: Length of vehicle affects the extra widening minimum turning radius, passing sight distance and road capacity.

(iii) Height: Height of vehicle affects the clearance to be provided under-structure, bridge, tunnel, electric service line

Dimension	Particulars	Max^{m} Dimensions (m)
Width	All vehicle	2.50
Height	Single decked vehicle	3.80
	Double " "	4.75
Length	single-unit truck with two or more axles (SU)	11.00
	single-unit bus with two or more axles (BUS)	12.00
	Semi-trailer tractor combinations (WB-40)	16
	Tractor and trailer combination (WB-50)	18.

(b) Weight: Weight of vehicle Affects, the design of pavement thickness, design of bridges, ruling and limiting gradient. etc.

(c) Speed: It Affects, the design of horizontal and vertical curves, super-elevation, design of intersection etc.

(d) Power: It Affects, the total resistance to traction consisting of inertia, rolling and grade resistance.

(e) Braking system: It Affects the stopping distance, overtaking distance and traffic capacity.

(f) Lighting system: Affects the safe turning, effective night operation, number of accidents at night.

→ FLWS

Road characteristics: Road characteristics such as geometric design, surface condition, illumination, access control, road side development etc. have a profound effect on road safety.

(a) **Friction (skid or slip):** Affects the safe speed, distance, super-elevation.

(b) **Light reflection characteristics:** Affects the night visibility of road. Dark surfaces give poor visibility.

(c) **Unevenness:** Affects the cost of vehicle operation, comfort of driver & passengers and driver's safety.

(d) **Surface slope:** The camber required will depend on the ability of the surface to drain off water.

⇒ **Traffic Surveys are carried out To :-**

(I) Estimate the type of traffic at present and for future.
(II) Determine the facilities provided on the roads.
(III) Design the geometric features and pavement thickness of the roads
(IV) Design the drainage system, bridges, culverts etc.
(V) Surveys relating to accidents help in redesigning the road width, curves, traffic signals etc.

Traffic Volume Study

Q. Define traffic volume and discuss the presentation system of traffic volume data.

Traffic volume: Traffic volume is the number of vehicles that pass a given line of road per unit time at any selected period. It is also termed as traffic flow. It is expressed as vehicles per hour or vehicles per day.

Most of the cities in Bangladesh carry mixed traffic flow. For mixed traffic, it is the normal practice to convert the flow into equivalent passenger car unit (PCU) and then flow is expressed as PCUs per hour or PCUs per day.

The number of cars a vehicle can substitute is known as PCU of that vehicle. This PCU value can change at any junctions and straight roads. It is not an absolute but relative value.

Time headway: Time headway is the time interval between the passes of successive vehicles moving in one way stream and measured from head to head as they pass a point on the road.

Space headway: Space headway is the time interval between the ~~pas~~ successive vehicles moving in one way stream and measured from head at any instance.

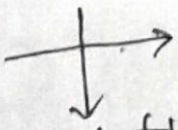
** Maximum flow is attained at the speed when the time headway is minimum.

Traffic flow characteristics: At road intersections traffic maneuvers are,

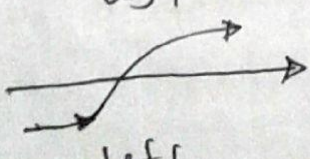
(I) Diverging

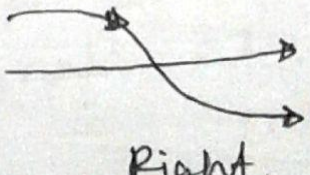
(II) Merging

(III) Crossing



(IV) Weaving





Traffic flow study is essential at large intersection for :— GRCC

(I) The proper geometric design.
(II) The decision of traffic regulary measures.
(III) The design of traffic control system.
(IV) Identification of conflict points.

Purposes of Traffic Volume study:

(I) It establishes the importance of any road.
(II) It helps in designing new routes and new facilities.
(III) The data are used of road pavements, bridges and culverts.
(IV) The data are used for designing, planning and regulation phase of traffic engineering.
(V) It is used for studying economic use of roads and tax collection levy.

Traffic volume gives following information:—

(a) Hourly, daily, yearly and seasonal traffic volume variation. (b) Volume and direction of traffic.
(c) Variation of vehicle flow on different parts of a road system. (d) Proportion of cars, heavy vehicles, slow vehicles etc.

Average daily traffic (ADT): ADT is the average flow of traffic only for a few days like 7 days, 15 days etc

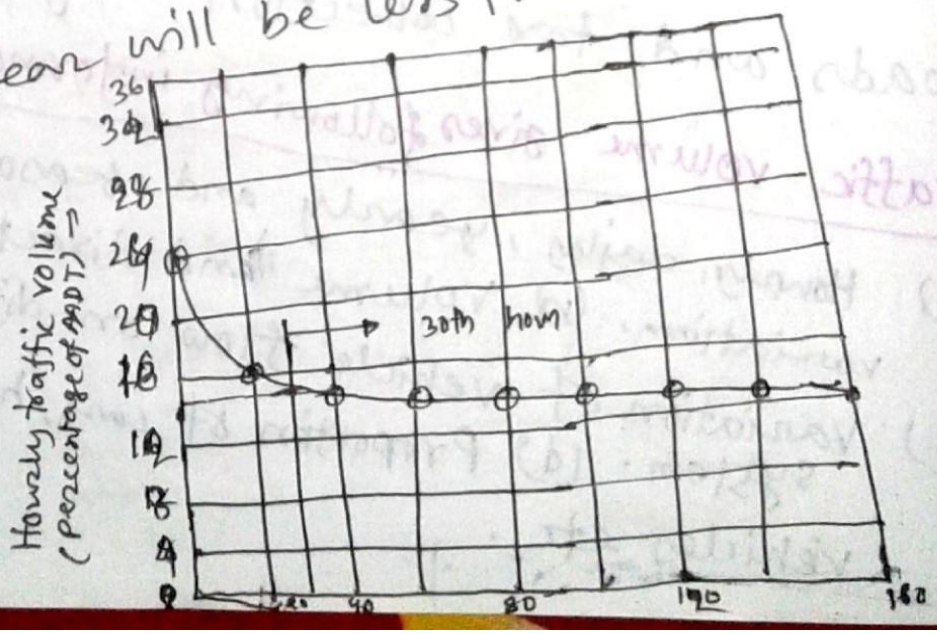
Annal Average daily traffic (AADT): AADT is the average flow of traffic for one year i.e. $1/365^{th}$ of annual flow.

Peak hourly volume: Peak hourly volume is the maximum number of vehicles moving at particular period of time.

Question: what is DHV? why 30th highest hourly volume is considered as DHV? Explain with an example (2013).

Answer: **Design Hourly Volume: (DHV),**

Design hourly volume (DHV) is the hourly volume that will be exceeded only 29 times in a year and all other hourly volumes of the year will be less than this value.



The 30th highest hourly volume of the year is taken as the design volume. This value represents the point of change in the shape of the curve.

for example,

Let, peak hourly volume = 1000 vehicle per hour.

AADT = 4200 vehicle per day.

From graph.

Traffic congestion (Hour)	Hourly traffic volume (vehicle per hour)
0	$0.24 \times 4200 = 1008$
29	$0.15 \times 4200 = 630$
160	$0.12 \times 4200 = 504$

So, road facilities provided considering peak hourly volume will be uneconomical and those are considering AADT will be inadequate for most of the time in the year but those are considering DHV is found to be satisfactory for both economic and adequacy points of view. This volume on a percentage basis varies very little from year to year. Traffic congestion on such road is expected for 29 hours out of 8760 hour.

Thus, 30th highest hourly volume is generally taken as design hourly volume.

Traffic projection factor (TPF): TPF is the factor that gives the ultimate volume at the end of design period in terms of current traffic. It is given as,

$A = P(1+r)^{n+x}$, where, A = No. of vehicles/day for design.

P = No. of vehicle/day at last census

r = Annual rate of increase in traffic.

n = construction period in years.

x = Design period in years.

Speed Study:

Speed: Speed is the rate of movement of traffic & expressed in m/s or km/hr.

Travel time: The total time required for travel from one place to another is known as travel time.

Spot Speed: Spot speed is the instantaneous speed of a vehicle at a specified location.

Average speed: the average spot speed of all vehicles passing through a particular section or spot is known as Average speed.

TMS: Time mean speed (TMS) is the average of instantaneous speed of observed vehicle at the spot. ~~is called time mean speed.~~ It is calculated as follows.

$$\text{Time mean speed, } V_t = \frac{\sum_{i=1}^{n} V_i}{n}$$

V_i = observed instantaneous speed of ith vehicle

n = no. of vehicles observed.

SMS: Space mean speed (SMS) is the average speed of vehicles in a certain road length at any time. It is expressed as V_s and calculated,

$$V_s = \frac{d n}{\sum_{i=1}^{n} t_i}$$

d = length of the road consideration

n = no of observed vehicle.

t_i = observed travel time for ith vehicle to travel distance d.

Running speed: It is obtained by dividing the distance covered by the time during which the vehicle was actually in motion. That is,

$$\text{Running speed} = \frac{\text{Distance}}{\text{Time during which the vehicle in motion}}$$

The time for actually in motion.

Overall or Travel speed: The ratio between the distance covered by the vehicle with the total time including all delays, stoppage and travel time etc.

$$\text{Travel speed} = \frac{\text{The distance covered}}{\text{The total time including all delays, stoppage and travel time etc.}}$$

Spot speed study: It is useful for.

(I) To decide the speed trends.
(II) To study the traffic capacity.
(III) Planning traffic control & regulation measures.
(IV) Accident studies.
(V) To compare different drivers and vehicles under specified conditions.

Uses of Speed and Delay Study: On the basis of this study,

(I) Spots of traffic congestion, their cause and remedies can be easily suggested.
(II) Travel time can be determined that reflects the efficiency of road.

Fixed delay: The delay between two specific points which is caused by traffic signal, stop signal and level crossing is known as Fixed delay.

operational delay: The delay between two specific points which is caused by interference by turning & parking vehicles, pedestrians and accidents is known as operational delay.

Traffic Capacity Study

Traffic capacity: Traffic capacity of a lane is the ability of the lane to accommodate traffic during a given time period under operating conditions.

Traffic density: Traffic density is the number of vehiles occupying a unit length of lane at a given instant. expressed as (v/km).

Basic capacity: Basic capacity is the number of passenger cars that can pass a point on a lane or a roadway during one hour under the most nearly ideal roadways and traffic condition.

Possible capacity: Possible capacity is the maximum no of vehicles that can pass a lane or a roadway during one hour under prevailing roadway and traffic condition.

Practical capacity (Design capacity): Practical capacity is the maximum no of vehicles that can pass a point on a roadway during one hour under prevailing roadway and traffic conditions, without unreasonable delay or hazard.

Importance of traffic capacity study:

(i) It governs the no of lanes, width of lanes, intersections and weaving sections.

(ii) It assessed the adequacy or defficiency of a highway networks by comparing with the present volume.

(iii) It helps to make plan for improvements in the geometric features, junctions, control devices and TMM.

Level of service (LOS):

LOS denote the level of facility one can derive from a road under different operating characteristics and traffic volumes.

Factors considered in evaluating the level of service are

DEFST

(a) speed & travel time.
(b) Traffic interruptions.
(c) Freedom to maneuver.
(d) Driver comfort.
(e) Economy.

Factors affecting capacity and level of service:

GRLLASS

(I) Lane width.
(II) Lateral clearance.
(III) Shoulders.
(IV) Surface condition.
(V) Alignment.
(VI) Grade etc.

Origin and destination (O&D) study:

Origin: Origin is defined as the place where the trip begins.

destination: Destination is defined as the place where the trip ends.

Specific uses of O&D study:

(I) To determine the no-of by-passable traffic that enters a town and thus establish the need for a bypass.

(II) To determine the extent to which the present highway system is adequate and to plan for new facilities.

(III) To plan public transportation system in the cities.

(IV) To establish over or under bridge sights according to the traffic demand.

(V) To provide wide roads along the maximum desire liners of travel

Parking study:

Objectives of Parking study:- To investigated,

(I) parking demand
(II) Parking space inventory
(III) Parking practices
(IV) Parking characteristics → present practice of parking
parking pattern
accident involved during parking.

~~Parking system~~:

Objectives of parking study: DPFAR

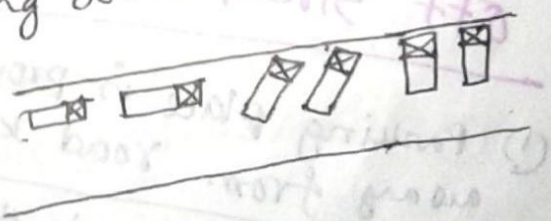
(I) To satisfy parking demand of vehicles.
(II) To minimize parking problems.
(III) To improve existing parking facilities.
(IV) To minimize accident rate due to parking and unparking operation.

Parking system: There are two types of parking facilities designed for traffic need as.

(I) On-street (curb/kerb) parking.
(II) Off-street parking.

On street parking: Parked along the kerb which is very convenient for peoples but causes of traffic jams.

Common methods of on-street parking are



(I) Parallel parking
(II) Angle parking
(III) Right angle parking.

Prohibitations:

To ensure safety and convenience, it is desirable to prohibit parking at following locations,

(I) Near intersections (II) Near level crossings.
(III) Pedestrian crossing (IV) Narrow streets.
(IV) Structures etc.

Off street parking: when parking places are provided away from the road curb. such as.

(I) Surface car parks. (II) ~~Near by~~ Multi-storey car parks.
(III) Roof parks (IV) Mechanical car parks (V) Underground car parks.

peripheral parking schems: Parking facilities are provided at the periphery of the town. They are :-

(a) Park and walk (b) Park and ride (c) Good-bye(kiss) and ride.

Off street parking	On street parking
(I) Parking place is provided away from road kerb.	(I) Road kerb acts as parking place.
(II) It does not lead to traffic congestion(~~for~~) and accident.	(II) It may lead to traffic congestion and accident
(III) Parking cost is less	(III) This system is comperatively costly.
(IV) It ~~for~~ is not harmful to the capacity of the road.	(IV) It is harmful to the capacity of the road.

Road Accident :=

Road accident: An accident which occured or originated on a road open to public traffic resulting in either injury or loss of life, or damage property, in which at least one moving vehicle was involved.

Causes of road accidents: The causes of road accidents are given below:— RVREO ROVER

(I) **Road factors and its effect on road accident:**

(a) Design speed, control of access, pavemen width, pavement surface, shoulders, horizontal curve, vertical alignment, Median width, sight distance, intersections etc.

(II) **Vehicle Factors and its effect on road accident:**

It is said that vehicles are the biggest culprits that cause serious accidents. Factors are,

vehicle body and its features, Braking system, Lighting system, steering system, mixed traffic, overloading, tyres.

Road users and its effect on road accident:

Driver, Rider, cyclist, passengers, pedestrian all are the only human being they uses road and there factors are,

Environmental Factors: Elements of weather that involved in road accidents are.

(a) Factors that make the road slippery like, snow-ice.
(b) Factors that restrict the normal visibility of road users like, - fog, smoke etc.

Other factors: Ribbon developments, advertisement boards, trees, attractive views, material on road etc.

⇒ Road users and its effect on road accident.

Driver: The driver characteristics that influence road safety are,

(I) Driver judgement, skill and emotional make-up.
(II) Age of drivers. (III) Gender of drivers
(IV) Marital status (V) Training of drivers (VI) Fatigue
(VII) Alcohol and drugs the driver.
(VIII) Use of crash helmets (IX) Use of safety belts.

Motor cycle and scooter Riders: Compulsory regulatory measures for safety to these riders are :—

(I) Provision of rear view mirrors.
(II) Provision to cover the rear wheel.
(III) Driver and one pillion rider.
(IV) No pillion rider during learning.
(V) carefully merging, crossing & diverging.
(VI) No talk with pillion rider.
(VII) No competition with car or other motor-cycle.

Cyclist: Cyclist are popular because (I) consumes no energy (II) occupies less space (III) free of noise & pollutant.

Usual causes for cycle accidents are,
(a) Improper turns, (b) Violation of traffic laws.
(c) Double riding (d) More than two cycle remaing abreast.
(e) Defective brakes (f) Lake of night lamp.

Passenger: Bad characteristics of passanger are
(I) Alighting from or getting into moving vehicles.
(II) Mounting of roof and hanging of side of the vehicle.
(III) Pushing or walking on roof.
(IV) keeping hand & head outside.
(V) Talking with drivers.

V.V.I ★RPTD

Pedestrian: Factors that affect the pedestrian safety are

(a) **Personal factors:** Carelessness, illiteracy, violation of rules and regulations, play on road etc.

(b) **Road Factors:** Geometric features, intersections, crossing facilities, footways facilities, road light.

(c) **Time factors:** Dark period and dry in a week when traffic is heavy, special rush days in a year.

(d) **Other factors:** Age, gender, social conditions, drunken pedestrians. familiarity with the locality etc.

ACCIDENT STUDIES

Accident studies:

① **Collection of accident data:-**

(a) General (date, time, persons involved in the accident)
(b) Location of accident, (c) Details of vehicles involved.
(d) Nature of accident (e) Road & traffic condition
(f) primary causes of accident (g) Accident costs.
(h) Driver conditions.

(2) Accident report: The accident should be reported to the police authorities who would take legal actions especially in more serious accidents involving injuries or damage to properties.

(3) Accident records: The accident records are maintained giving all particulars of the accidents location and other details by means of (i) Location file (ii) spot maps & (iii) collision diagrams.

Accident Investigations: RDVPC Following investigation may be carried out to analysis the accident properly.

(a) Recording general observation: skid length of pavement, relative position of vehicles & objects.

(b) Driver test: Analysis of breath and spinal fluid for alcohol ~~test~~. content, tests on driver characteristics.

(c) Vehicle test: Test on the (i) condition of brakes & steering (ii) essential accessories (iii) details of dents.

(d) Probable cause of accident: Accident types side condition position of vehicles & objects involved.

(e) Cost analysis: Injuries and fatalities of persons involved, damage of vehicles & properties, traffic delay.

Measures for the Reduction in Accident Rates:

3 E → EEE

Engineering measures:-

(a) Road design (b) Preventive maintenance of vehicles
(c) Accident records "before and after" the introduction of preventive measures to study the efficiency.
(d) Road lighting ~~effic~~ at intersections.

Enforcement measures:

(a) Speed control (b) traffic control devices.
(c) Training and supervision (d) Medical check.
(e) Special precautions for commercial vehicles.
(f) observance of law and regulation

Educational measures:

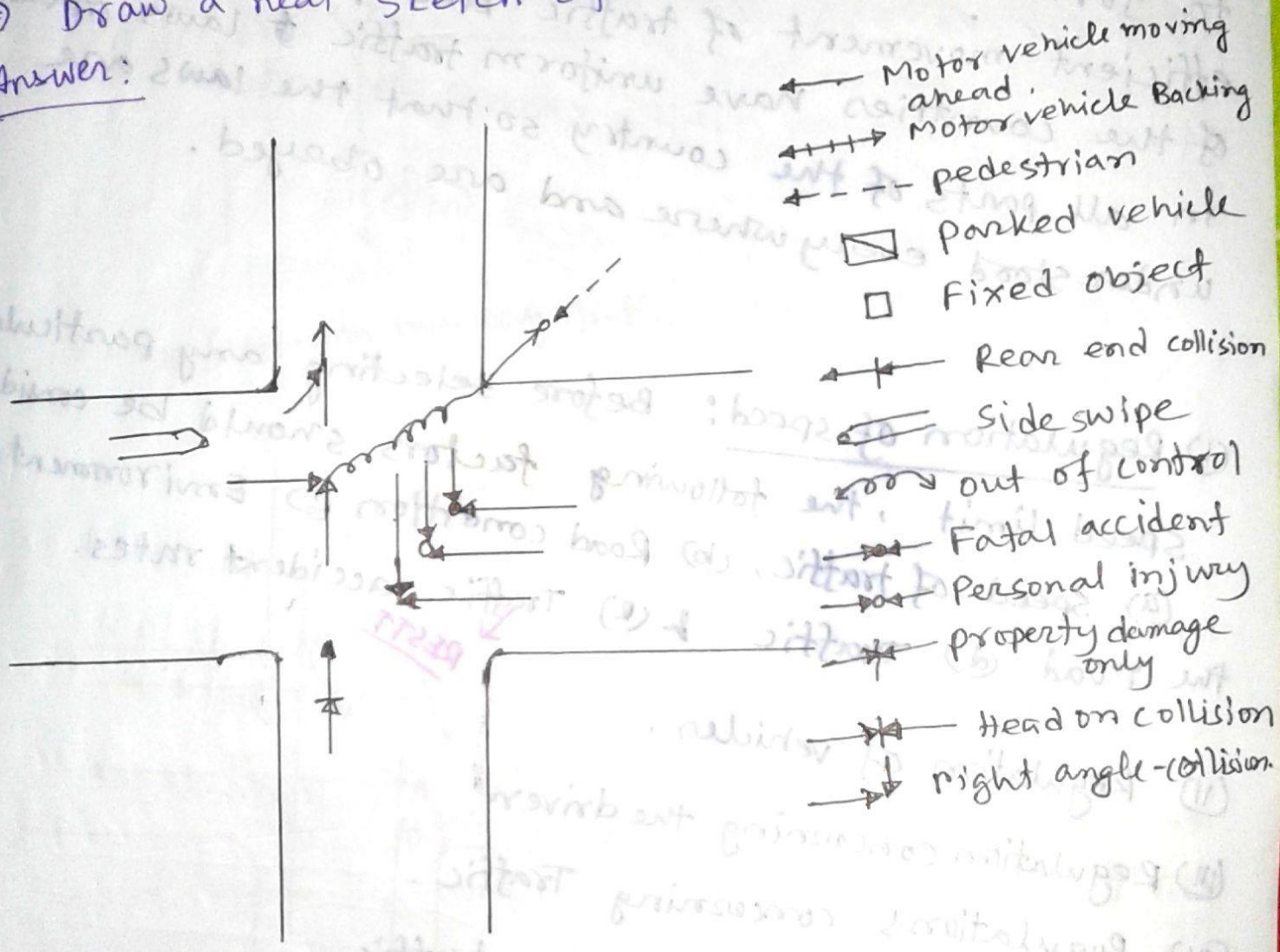
(a) Education of road users: The passenger and pedestrian should be taught the rules of the road, correct manner of crossing etc, by introducing necessary instruction in the schools.

(b) Propaganda and Exhortation: By proper adult education & training, related advice by religious leaders, teachers and society leaders. Related programs in the electronic media, news paper and magazine. Make poster of the serious accidents and use of imaginative and catching slogans.

e) Safety drive: Imposing traffic safety week, special provisions should be made for giving knowledge of traffic rules to the common man by the help of traffic police.

⇒ Draw a neat sketch of collision diagram.

Answer:



Collision diagrams and symbols.

Traffic Operation

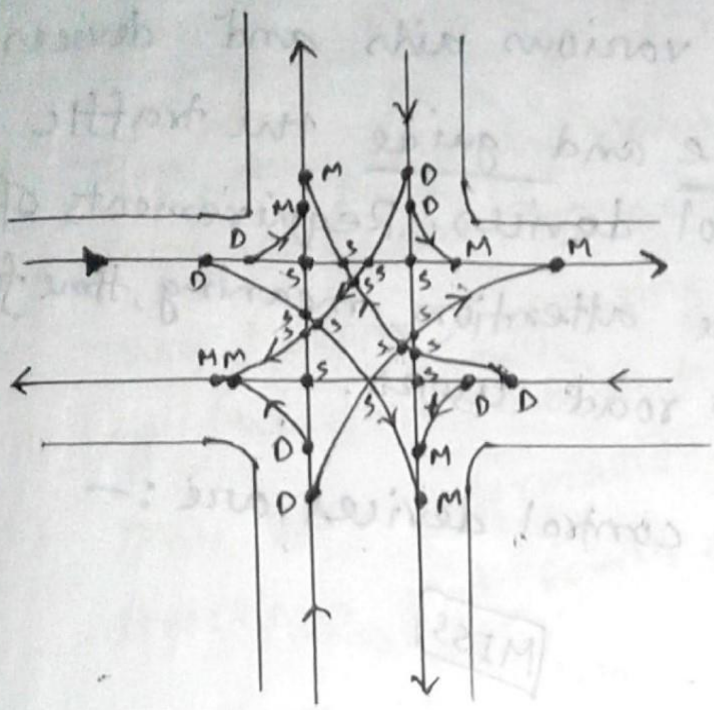
2015

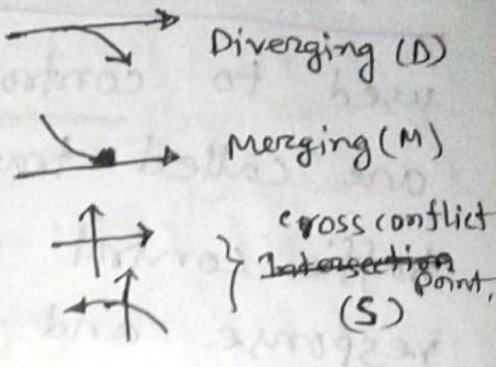
Traffic regulation; (Need): The motor vehicle is a machine in charge of a human being. It is necessary to formulate the suitable regulations for safe and efficient movement of traffic and pedestrians. Most of the countries have uniform traffic laws operating in all parts of the country so that the laws are understood everywhere and are obeyed.

(I) Regulation of speed: Before selecting any particular speed limit, the following factors should be considered. (a) speed of traffic, (b) Road condition (c) Environment of the road (d) Traffic & (e) Traffic accident rates.

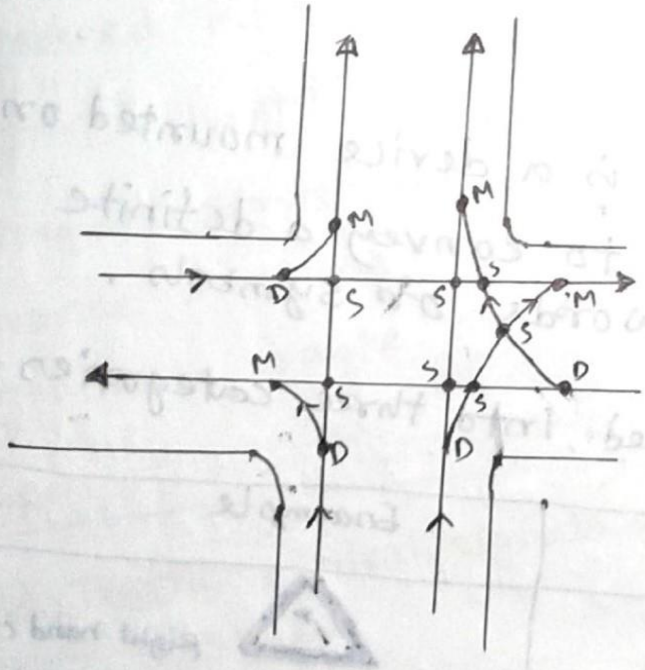
REST

(II) Regulation of vehicles.
(III) Regulation concerning the driver.
(IV) Regulations concerning Traffic.
(V) General rules concerning traffic.
(VI) Parking Regulations.
(VII) Enforcement of Regulations.
(VIII) Regulations concerning Traffic flow.

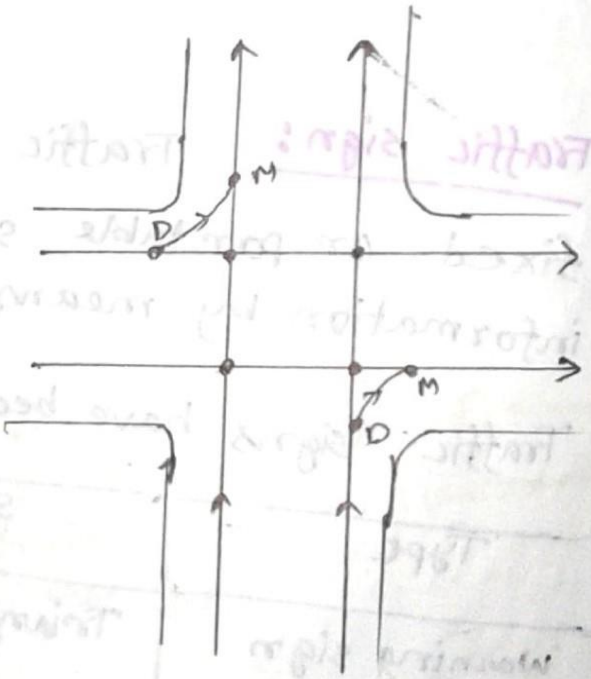




32 conflict with two-way traffic



15 point conflict with one-way regulation on one road.



8 conflict with one-way regulation on Both roads.

Traffic control device: The various aids and devices used to control, regulate and guide the traffic are called traffic control devices. Requirements of traffic control devices are attention, meaning, time for response and respect to road users.

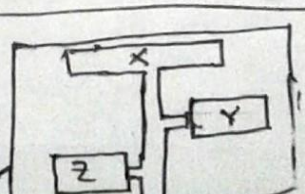
The most common traffic control devices are :-

MISS

(a) Traffic signs.
(b) Traffic signals.
(c) Traffic markings.
(d) Traffic Islands.

Traffic sign: Traffic sign is a device mounted on a fixed or portable support to convey a definite information by means of words or symbols.

Traffic signs have been divided into three categories.

Type	Shape	Example
Warning sign	Triangular	 Right hand curve
Regulatory signs	circular	 Left turn prohibited
Informatory sign	Rectangular	 Advanced direction signs.

Importance / functions of Traffic Signs:

(i) They give timely warning of hazardous situation where they are not self evident.

(ii) They help in regulating traffic by imparting massage to the drivers about the need to stop or give-way.

(iii) They give information as to highway routes, directions and points of interest.

Traffic signal: Traffic signals are control devices which could alternately direct traffic to stop and proceed at level intersection using red and green traffic light signals automatically. The main requirements of traffic signals are to (i) draw attention (ii) provide meaning and time to respond and (iii) to have minimum waste of time.

Types of Traffic signals:

(a) Traffic control signals
- Fixed-time signal
- Manually operated signals
- Traffic actuated (automatic) signal.

(b) Pedestrian signal.

(c) Special traffic signal.

Advantages of traffic signals:

(I) They provide oderly movement of traffic
(II) They reduce certain types of accidents, notably right angle collisions
(III) Pedestrian can cross the road safety at the signalized intersection.
(IV) The signal allow crossing of the heavy traffic flow with safety.
(V) Automatic traffic signal may workout to be economical

Disadvantages of traffic signals:

(I) The rear-end collisions may increase.
(II) Improper design and location of signals may lead to violations of the control system.
(III) Failure of the signal due to electric power failure or any other defect may cause confusion to the road users.

Cycle length: Cycle length is the time required for one complete sequence of signal indications.

Phase: Phase is a part of the cycle length allocated for specific traffic movements.

Road marking: Road or traffic markings are made of lines, patterns, words, symbols or reflectors on the pavement, kerb sides of islands or on the fixed object within or near the roadway.

Function of road marking: It is used for

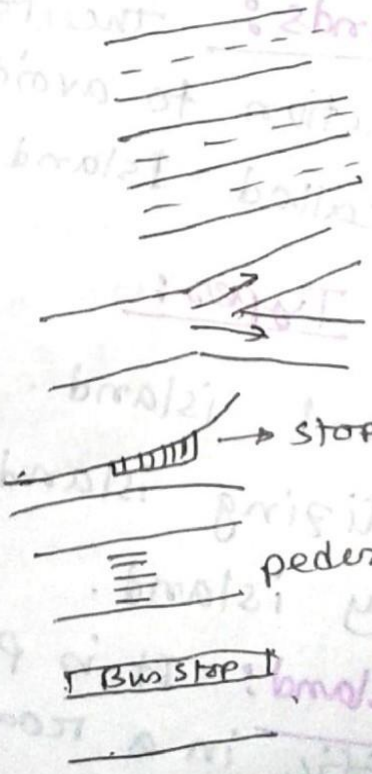
(I) control (II) warn (III) Guide or regulate the traffic.

Types:

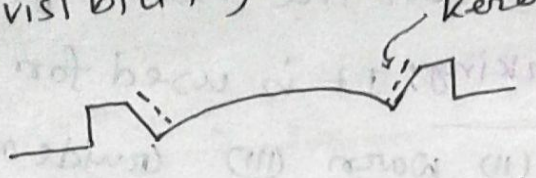
(a) Pavement or carriageway marking.
(b) Kerb markings.
(c) Object marking.
(d) Reflector unit marking.

Pavement marking:

(I) Center lines
(II) Lane lines
(III) Route direction
(IV) Stop Lines
(V) Cross walk lines
(VI) Bus stop



Kerb marking: It indicate certain regulations like parking regulations. Marking on the kerb and edge of islands with alternate black and white line increase the visibility from a long distance.



Object marking: Indicate physical obstruction on or near roadway object markings needs.

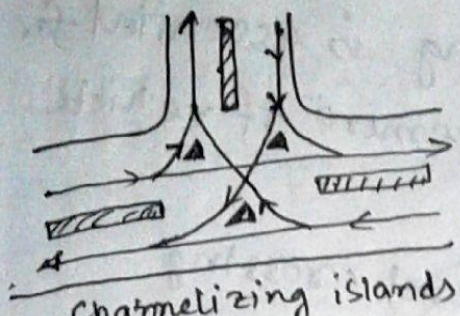
Reflector marking: Indicate hazardous obstruction by reflecting yellow light at night.

Traffic islands: The raised areas provided at level intersection to avoid or minimise conflict area is called Islands.

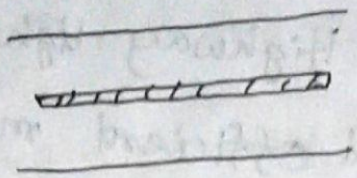
~~Functions~~: **Types:**

(I) Divisional island.
(II) Channelizing island.
(III) Rotary island.

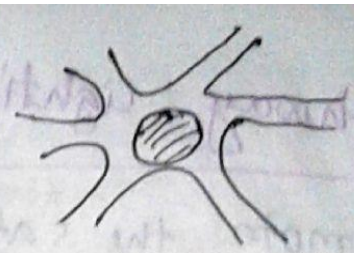
(I) **Divisional island:** It is provided to separated opposing flow of traffic in a road ~~having~~. It reduces the possibilities of head on collisions and other accidents.



Channelizing islands



Divisional Island



Rotary islands.

Channelizing Islands: It is used for

(I) Guide the traffic into proper channel through intersection areas.
(II) very useful as traffic control device for large intersection at grade.
(III) They serve as refuge islands for pedestrian.
(IV) They are useful when the direction of the flow is to be changed.

Rotary Islands: Rotary island (central Island) is an enlarged highway intersection where vehicle are circulate in clockwise direction up to approaching their desired road.

Functions:

(I) Segregate vehicular traffic from pedestrian traffic.
(II) Segregate traffic into specified path.
(III) Increase traffic safety.
(IV) Increase traffic capacity of road.
(V) Reduce conflict area.

Highway Lighting: Highway lighting is essential for

(I) Promote the safe and efficient movement of vehicle
(II) Pedestrian traffic.
(III) at intersection, bridge site & level crossing.

Silhouette: When the brightness of the object is less than that of the background is known as silhouette → $B_o < B_b$

Reverse silhouette: when the brightness of the object is more than that of the background is known as Reverse silhouette → $B_o > B_b$

Surface detail: when the variations in brightness and colour of the object surface without regard to its background.

Factors affecting night visibility are:

BB GRAST

(I) Size of the object.
(II) Brightness of the object.
(III) Brightness of the background.
(IV) Reflecting characteristics of the pavement surface.
(V) Glare on the eyes of the driver.
(VI) Time available to see the object.
(VII) Amount and distribution of light flux from the lamp.

Describe briefly Design factors of Highway lighting?

Answer: Highway lighting design factors are.

(I) Lamps (II) Luminaire distribution of Light.
(III) spacing of Lighting units (IV) Height and over hang mounting
(V) Lateral placement. (VI) Lighting Layout.

Lamps: Road Lighting lamps may be as follows:-

(a) Tungsten filament lamps → Cheap but low light producing efficiency.

(b) Fluorescent lamps → Long life, good visibility but low output per lamp.

(c) Sodium vapour lamp → Yeollow colour, costly but these are preffered at large intersection.

(d) Mercury vapour lamp → Bluish white colour, costly but more pleasing to the eye.

Luminaire distribution of Light: It should be downward and cover the pavement between the kerbs and the adjacent area. The unit of illumination is Lux or Lumen/m² In urban roads carrying fast traffic it should be 20 to 30 lux, mixed traffic 15 lux, 4 to 8 lux on secondary road.

Spacing of lighting units: It influence by electric distribution poles, road layout and type of side features. Spacing should be 3 to 5 times the mounting height on straight road and less than this on sharp curves.

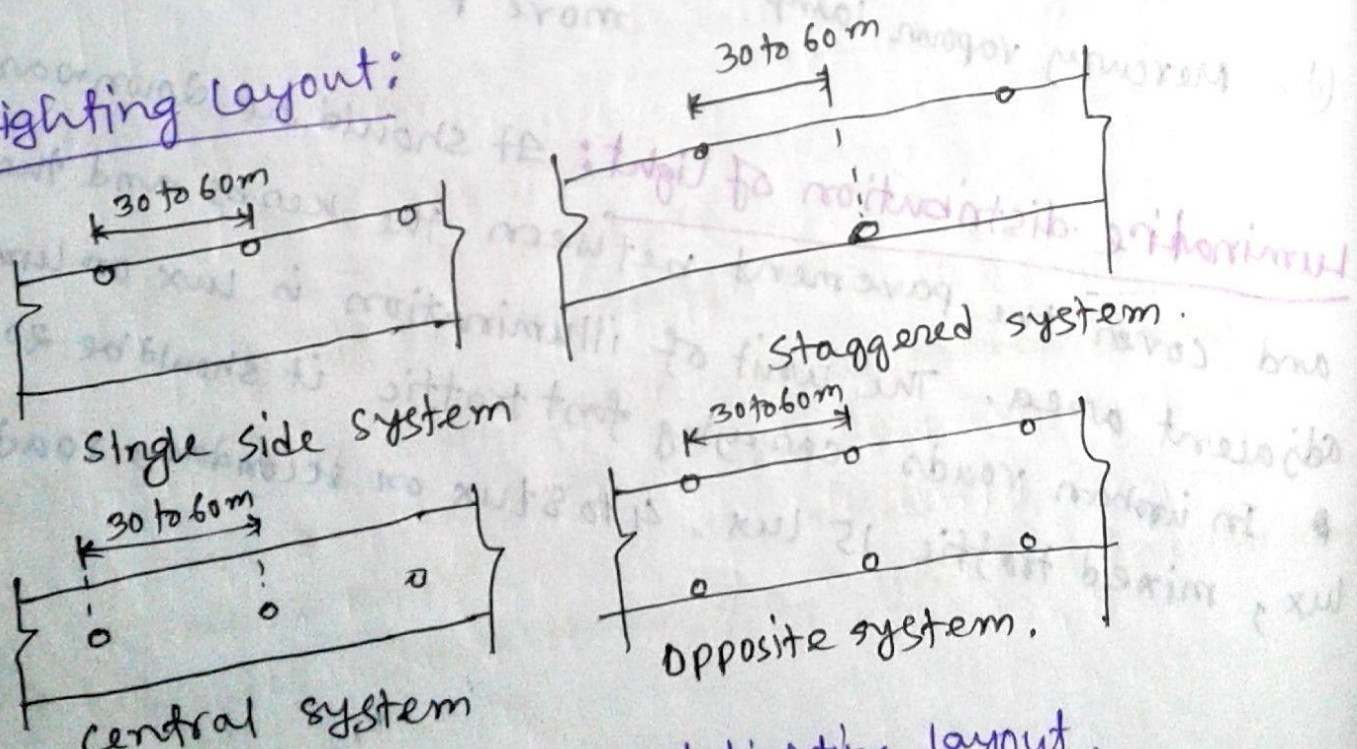
Height and over hang of mounting: Height of mounting varies from 6 to 10 m. over hangs ($\leq 2m$) would keep.

Lateral placement:

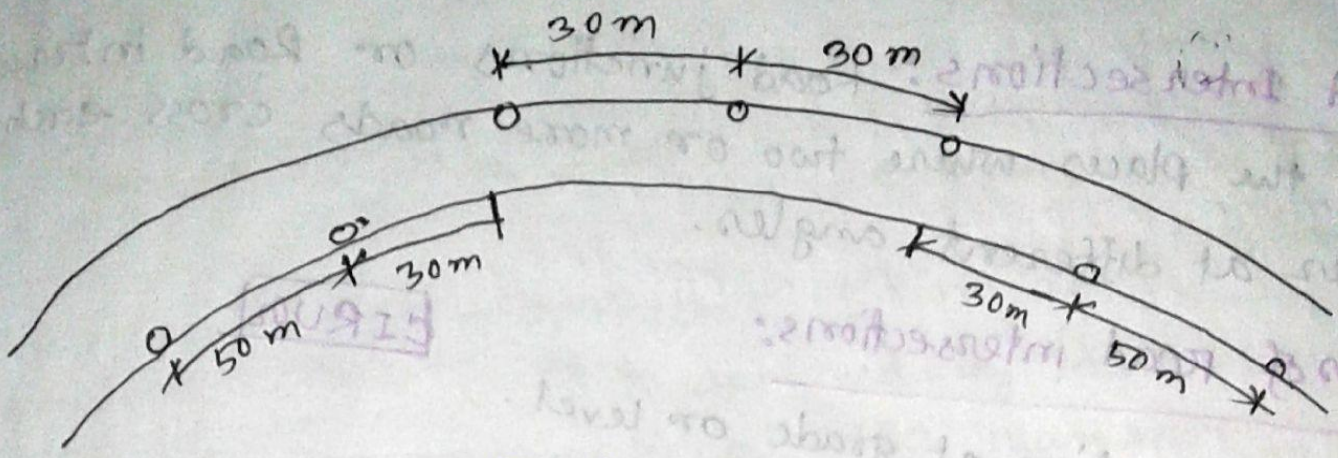
(a) For road with raised kerbs → Minimum 0.3m and desirable 0.6 m from the edge of raised kerbs.

(b) For roads without raised kerbs → Minimum 1.5 m from the edge of carriageway or minimum 5.0 m from the centre line of carriageway.

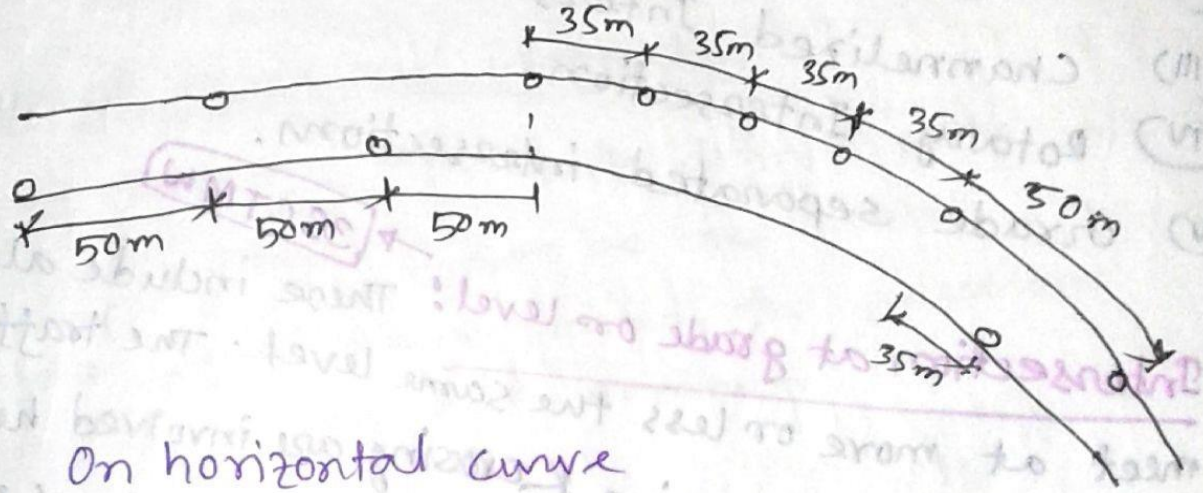
Lighting layout:



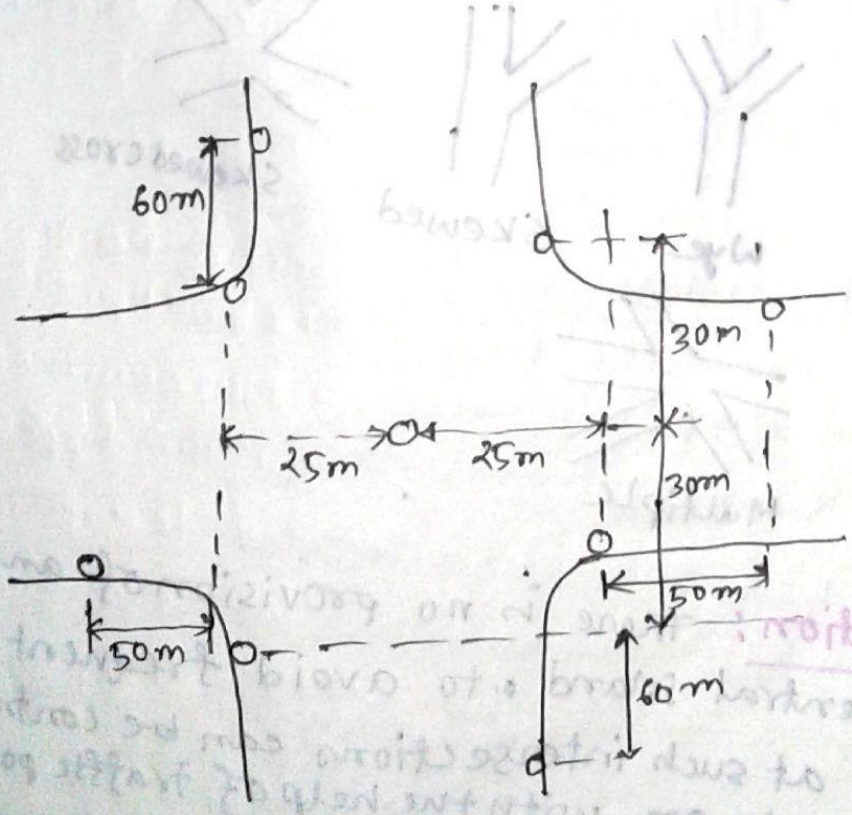
On straight road lighting layout.



On vertical curve



On horizontal curve



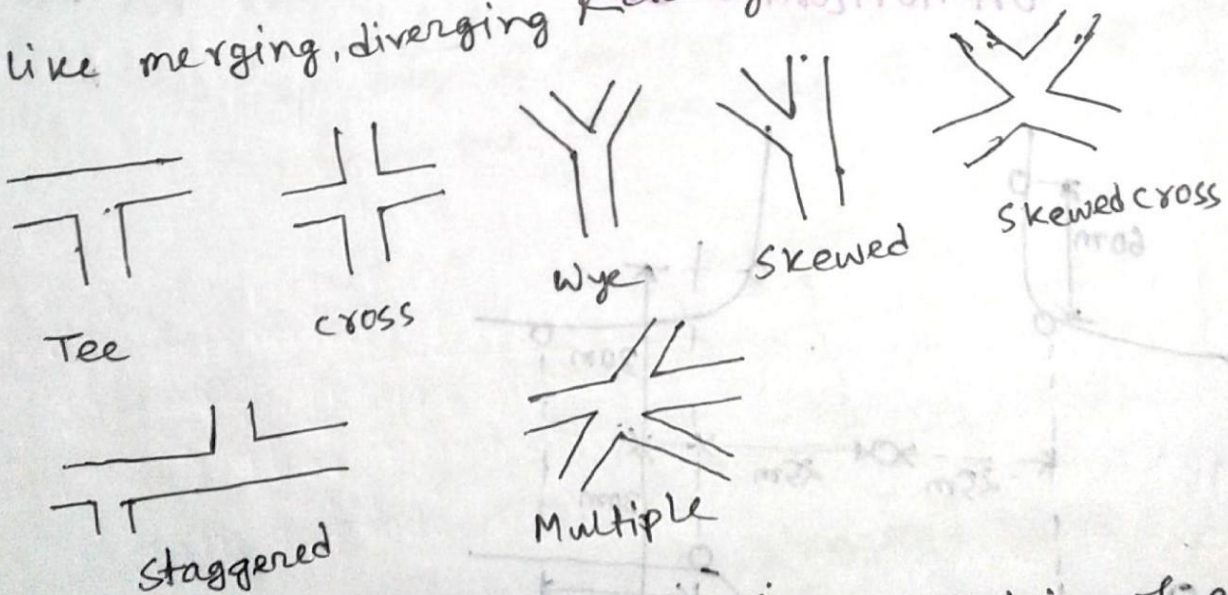
On intersection.

Road Intersections: Road junctions or Road intersections are the places where two or more roads cross each other at different angles.

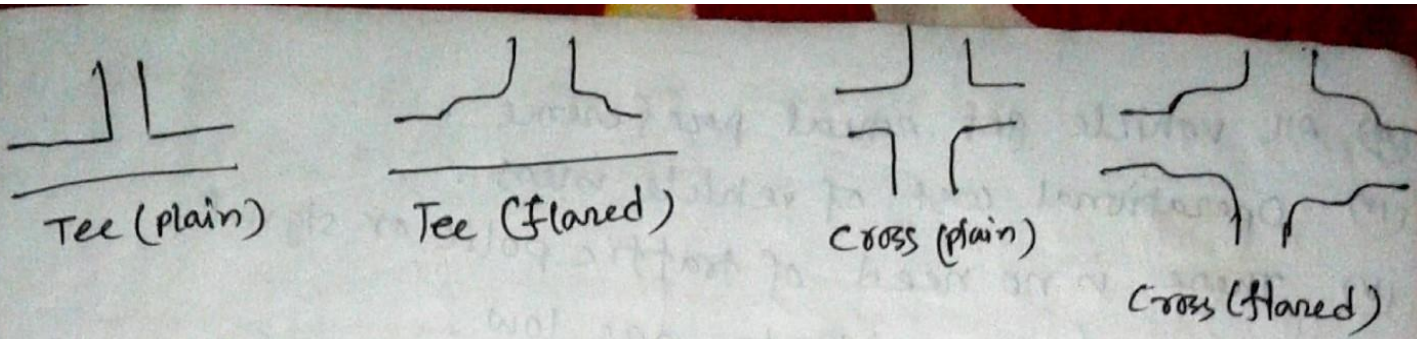
Types of road intersections: EIRUGR

(I) Intersection at grade or level.
(II) Unchannelized Intersections.
(III) Channelized Intersection.
(IV) Rotary Intersection.
(V) Grade separated intersections.

Intersection at grade or level: 3SCTMW
These include all roads which meet at more or less the same level. The traffic manoeuvres like merging, diverging & crossing are involved here.



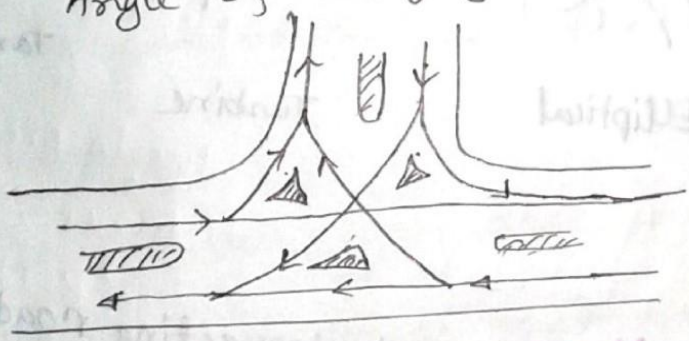
Unchannelized intersection: There is no provision of any direction island or central island, to avoid frequent accidents, heavy traffic at such intersections can be controlled by installing traffic signals or with the help of traffic police. No additional pavement width for turning is called plain intersection and with additional pavement width is called flared intersection.



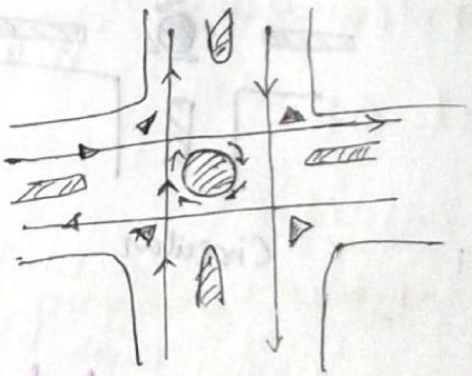
Channelized intersection: It is achieved by introducing islands into the intersectional area, thus reducing the total conflict area available in the unchannelized intersection.

Advantages of channelized intersection:

(i) vehicles can be confined to definite paths.
(ii) Points of conflicts can be separated.
(iii) Refuse islands can be provided for pedestrians.
(iv) Angle of merging kept minimum.



Tee (complete channelization)



Cross (CC)

Rotary intersection: Traffic from all the converging roads keeps on moving round the central island in clockwise direction and adopts its road of desire to move out of rotary without stopping where. On rotary crossing conflicts are completely eliminated.

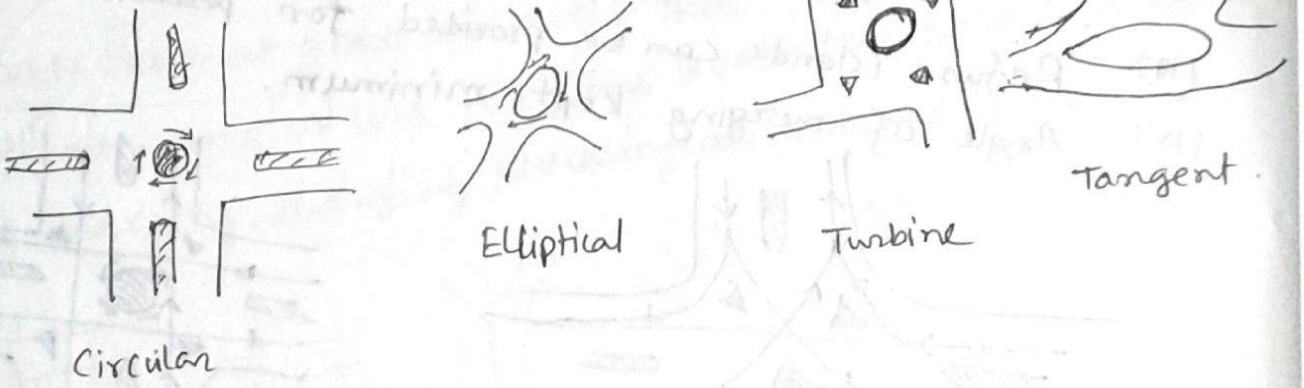
Advantage:-

(i) Traffic handling capacity is the highest.
(ii) It is more safe.

(III) All vehicle get equal preference.
(IV) Operational cost of vehicle is less.
(V) There is no need of traffic polic or signal.
(VI) Number of accidents are low.

Disadvantages:-

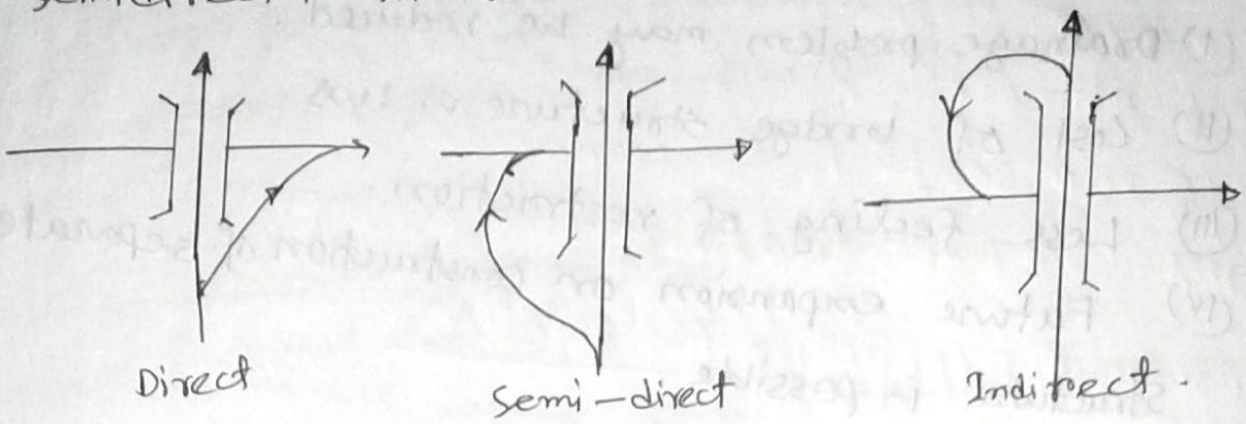
(I) Requires a large area of land and hence it is costly in build up area.
(II) Pedestrican cross the road. rotary is defected.
(III) More than seven intersecting road, it is unsuitable.



Grade Separated Intersection: The intersecting roads are separated by parsing one road over or below the other road and thus eliminating the crossing manoeuvres, this is called grade separated intersection. This type of intersection causes least delay and hazard to crossing the traffic and much superior to insections at grade from the point of view of traffic safety and efficient operation.

Transfer of route at the grade separation is provided by interchange facilities consisting of ramps.

Interchange ramps may be classified as:-
direct, semidirect, indirect.



Advantages:

(I) There is no crossing conflicts.
(II) Increased safety for turning traffic.
(III) provide comfort and convenience for driver.
(IV) saves travel time & operation cost.
(V) It can be designed for any angle of intersection.

Disadvantages:

(I) It involves very large area.
(II) It involves lot of expenditure in providing bridges under passes and interchange ramps.
(III) Unnecessary rising grades and sags are introduced in vertical alignment.

Over pass: when the major highway is taken above by raising its profile above the general ground level by embankment and an over-bridge across another highway.

Advantages:

(I) Drainage problem may be reduced.
(II) Cost of bridge structure is less.
(III) Less feeling of restriction.
(IV) Future expansion or construction of separate bridge structure is possible.

Disadvantages:

(I) Embankment with steep gradient increase the grade resistance
(II) Long vertical curve required for clear sight distance.

Under pass: when the highway is taken by depressing it below the ground level to cross another road by means of an under-bridge is known as under pass.

Advantages:-

There is warning to traffic in advance due to presence of an under pass which can be seen from distance.

Disadvantages:

There may be trouble some drainage problems at underpass during moonsoon.

By-pass: By-pass is an arrangement for diverting a traffic flow to avoid unnecessary hazards.

Fly-over: Fly-over is a bridge over a large road intersection for safe traffic flow avoiding conflict.

Detrimental effects of traffic:-

(I) Road safety (II) Noise (III) Air pollution (IV) Vibration
(V) Visual instrusion and Degrading the Aesthetics.
(VI) Severance.

Road safety: Movement on road is free from accident when it is known as road safety.

Noise: Noise is an unwanted sound intruding upon the quiet life and privacy of the urban dwellers.

Bad effect of Noise: SBP

(a) Subjective effect: Such as discomfort, disturbance and noisenes.
(b) Behaviour effects: Such as interference in speech, T.V. programs. studies, student mind in class room.
(c) physicological effects: The startle phenomena that can results in harmful effect on body.

The generation of Noise By traffic:-

(I) Noise generated by various parts of the vehicle.
(II) Noise contributed by the interaction betn vehicle and road surface
(III) Noise depend on speed, flow & traffic density.

control of traffic noise: (I) Change in design of vehicles and tyres.
(II) Elimination of noiser vehicle etc.

Air pollution: Pollution of atmosphere by fumes and smell emitted by the motor vehicles makes the urban streets extremely unpleasant. The source of pollutant:-
(I) The major source is the exhaust gass emitted by the internal combustion engine.
(II) Evaporative losses from the fuel tank & the carburetor.
(III) Losses from the crank case.

Bad effects: Small doses of CO_2, NO_2, PbO_2 does not appear to be a danger to health but the increase in the concentration may ultimately affect the well-being of the residents. Smog is a result of the combination of smoke & fog can cause hazards to driving and irritation to the eyes.

Measures for controlling Air pollution:

(I) Reducing the pollutants at the source.

(II) Use of small cars instead of bigger ones.

(III) Use of alternative fuels, bypasses and ring roads.

(IV) staggering work hours

Transportation System Management: (TSM)

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

Some of the well known traffic management measures are:- (ROTECT)

(I) Restriction on right turning movement.

(II) One-way streets.

(III) Tidal-flow operations.

(IV) Exclusive Bus-lanes.

(V) Closing side-streets (frontage road)

(VI) Traffic aids.

Traffic Aids:-

(I) Roadway Delineators: It is intended at turning point to provide visual aids to drivers at night.

(II) Hazard Markers: It is intended to define obstructions like guard rails & abutments at road sides.

(III) Object Markers: It is used to indicate hazards and obstruction within channelising islands.

(IV) Speed Breaker: Humps painted with white paint are used to control speed near crowded area.

(V) Rumble strip: It producing noise and driver get alerts.

(VI) Guard rails: It is needed for guiding pedestrians to subways, footbridges, and surface crossing.

(VII) Safety barriers: It is intended to prevent vehicles accidentally leaving the highway.

(VIII) Barricades and channelisers: It is required for controlling and diverting traffic on construction zones and temporary diversions.

(IX) Traffic Attenuators: It is required for absorbing the energy of impact of vehicles that go out of control.