LECTURE NOTES ON

HIGHWAY ENGINEERING

4th SEMESTER DIPLOMA

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Highway Planning and alignment

The main objectives of highway planning are

i) To assist the general planner for serving adequately.

ii) To create awareness of unforeseen events.

iii) To indicate the analysis for the establishment of financial and management policies.

iv) To make optimum use of the existing conditions.

v) To prepare a plan in such a way that traffic operation are carried out efficiently.

vi) To provide factual analyses leading to the determination of required physical development.

Classification of Highways

The highways are classified

a) According to location and function

b) Build, operate and transfer projects

c) According to traffic

d) According to transported tonnage.

According to location and function the road system in India are classified as.

1) National highways (NH)
2) State highways (SH)
3) Major district roads (MDR)
4) Other district roads (ODR)
5) Village roads (VR)

According to traffic roads are classified as follows,

a) Character of traffic

b) Designed speed

c) Traffic density

Character of traffic is determined by the type of vehicles which use the road. If the traffic vehicles include fast moving trucks, cycles, bullock carts etc it is known as mixed traffic and it is designated by letters M.

For designated speed it is indicated by a figure. For instant the figure 60 would mean that the road has designed speed of 60 kmph.

The number of vehicles using the road per hour or per day is known as traffic density. If the traffic density is 1200 it indicates that 1200 vehicles per day use the road.

Length of NH + SH + MDR = L =

$$\frac{A}{8} + \frac{B}{32} + 1.6N + 8T + D - R$$

Length of ODR + VR = L_1

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

Highway alignment

The route or position of centre line of the highway on ground is called highway alignment. The importance of proper selection of highway alignment at the beginning of the project can easily be understood.

Following are the four guiding principles to be applied for the ideal highway alignment.

a) Easiness
b) Economics
c) Safety
d) Shortness

Factors affecting highway alignment

Following are the factors which affect the highway alignment.

1) Availability of road building materials
2) Crossings
3) Geological features
4) Land acquisition
5) Easy grades and curves.
6) Obligatory points
7) Proper drainage
8) Traffic

Planning surveys

The highway planning surveys are conducted for sound decisions regarding the scope policies and financing the highway development programmes.

The planning surveys are also known as fact finding survey and they include the collection of accurate data with respect to the following items of road projects.

1) Economic studies
2) Engineering studies
3) Financial studies
4) Traffic studies

Reconnaissance survey

It is the first engineering survey that is carried out in territory which has not been previously surveyed. The main objects of reconnaissance survey are.

i) to obtain general knowledge of the whole territory.

ii) to obtain information regarding the salient features of the territory.

Location survey

The main objects of location survey is to carry out detailed survey along the route which has been found.

Importance of location survey

The location survey establishes the centre line of the actual highway to be laid. The end of location survey is the beginning of the actual construction of proposed highway.

Work on location survey

The location survey is carried out in two stages

i) paper location
ii) field location

Paper location

The final route which is selected is put up on paper and details such as gradients, curves, contours etc are worked out. All the working drawings are prepared.

Field locations

The field locations transfer paper location on the ground so that it might have as good a profile as it has on paper location.

General principles of re-alignment:

Following general principles may be Observed to have highway re-alignmen

1) Entire alignment - The re-alignmen project should be framed for the whole alignment.

2) Major bridges - The decision of constructing a major bridge should be carefully taken after studying.

3) Other bridges and under-bridges - If the gates of railway crossings are frequently closed and working of highway is disturbed then constructing over-bridges or underbridges be done.

4) Through traffic - If the town or city through which the highway passes has substantially developed and if the traffic terminating at town or city is quite small as compared to traffic then the construction of a bypass road will be justified.

5) Water Logging - The length of highway affected by water logging during monsoon be clearly marked and it should be raised.

Notes On highway drainage

Highway drainage

It is defined as the interception and removal of water from, over and under an area. Hence it is the process of the removal of excess of water from road surface and also from road subgrade.

Highway drainage may be grouped into four main categories

i) Interception of surface water which would flow across the road or along it or would flood it.

ii) Surface drainage of rain water from the road and its margin.

iii) Interception of seepage water.

iv) Under-drainage of the road bed and its crust.

The above group (i) and (ii) are known as surface drainage and the groups (iii) and (iv) are termed as sub-surface drainage.

It should be necessary to provide suitable drainage structures in the form of culverts, bridges and causeways at places where the water courses or streams or rivers cross the highway.

Sources of water entering the road structure

i) Capillary action of water - The water which is existing in the soil rises due to the capillary action and enters the subgrade portion of the road structure

ii) Floods - Due to heavy rains there is overflowing of culverts and bridges along the road and thus the water covers the road surface at the time of such floods

iii) Rain water falling on the road surface - The part of rain water which directly falls on the road surface may percolate through the body of the road structure.

iv) Rain water from surrounding area - The rain water accumulating on the surrounding area finds its way to the subgrade of the road structure

Requirements of good highway drainage system

1) Adjoining land - The surface water from the adjoining land should be prevented from entering the roadway.

2) Camber - The road surface should be provided with suitable camber so as to drain off quickly the water that falls on it.

3) Cross-drainage works - It should be such that the overflowing of water on the road surface does not occur at the time of highest flood.

4) Gradient - For heavy rainfall area it should provided with minimum gradient.

5) Water table - The highest level of ground water table below the level of subgrade should be at least 1.20mt.

6) Water logged areas - It is necessary to take special precautions of water logged areas.

Permeability ratio

The permeability ratio is defined as.

$$\text{permeability ratio} = \frac{\text{15 percent of the filter material}}{\text{15 percent of size of the subgrade material}}$$

The filter material should be such that it is sufficiently permeable and for this purpose the permeability ratio should be greater than 5.

Piping ratio

$$\text{piping ratio} = \frac{\text{15 percent size of the filter material}}{\text{85 percent size of the subgrade material}}$$

The piping ratio should be less than 5.

The particle size distribution curve for the subgrade soil is plotted and by applying the above two criteria, the grain size distribution curve of filter material is obtained.

Road Construction in Waterlogged areas

The methods which may be suggested in such cases are as follows,

1) Control of capillary rise - Suitable method to arrest capillary rise may be adopted:

2) Pavement thickness - Depending upon the subgrade conditions, sufficient thickness of pavement should be provided.

3) Raising the road level - The road level should be raised by constructing an embankment.

4) Sand drains - Provision of vertical sand drains at suitable spacing.

5) Sub surface drainage system - The level of ground water table may be depressed by laying a suitable sub-surface drainage system.

Hydraulic Analysis

It deals with the flow of liquids. It is primarily concerned with how to provide efficient and safe transport of water so as to avoid danger to property. The cross-sectional area of the side drain is obtained by the following formula

$$Q = AV$$

Q = Design run off in m^3/sec

A = cross-sectional area in m^2

V = Allowable velocity of flow in m/se

Defects due to improper highway drainage

i) It allows the washing out of highway portions and causes excessive erosion.

ii) It causes considerable damage to the shoulders and pavement edge due to presence of excess water.

iii) It causes the failure of bituminous pavements due to stripping of bitumen from aggregates.

iv) It is the prime cause of failures in rigid pavements.

v) It leads to the failure of earth slopes because excess moisture causes increase in weight and thus the stress is also increased.

vi) It leads to the formation of waves and corrugations in flexible pavements.

vii) It makes the road surface soft especially constructed of the soil itself.

viii) It softens the subgrade soil and decreases its supporting power or bearing capacity.

Notes on Geometrical design of highway

The three important factors affecting the geometrical design of highway are.

i) classification of roads
ii) topography of the area
iii) traffic characteristics present as well as future.

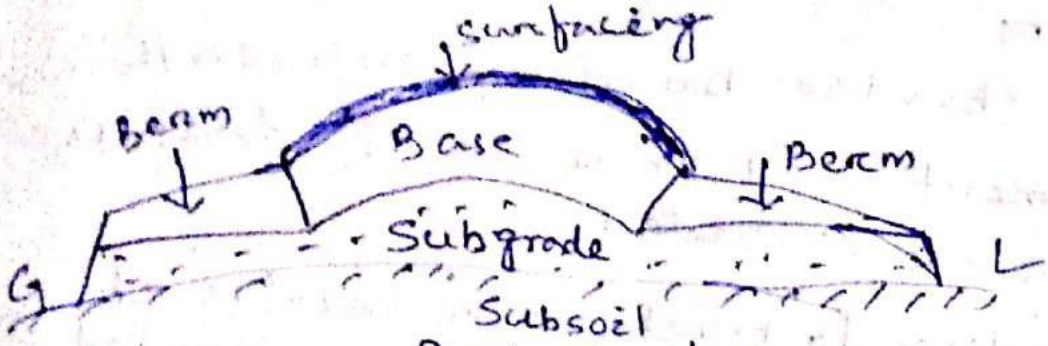
Main considerations of standards for geometrical design of highways

i) adequate right of way.
ii) adequate sight distances along the road.
iii) adequate width of formation.
iv) Providing super-elevation on horizontal curves.
v) reasonable gradients.
vi) sufficient camber or cross slope.

Road structure

For the purpose of design the road structure may be divided into following components.

i) Subsoil
ii) Subgrade
iii) Base
iv) Surfacing



Road structure

Subsoil

This is the natural or prepared soil on which the road has to be formed. It should be stable and strong to carry safely the traffic load and weight of roadway.

Subgrade

The subgrade functions as a support to the road surface and its foundation.

Base

The base or foundation may consist of two layers the bottom layer is known as sub-base. The sub-base should be stable. The function of road base is to transmit the load from the surfacing to subgrade.

Surfacing

The topmost layer on which the traffic directly travels is known as road surfacing. The main function of road surfacing is to provide a smooth and stable running surfacing which is suitable for the type and intensity of traffic.

Kerbs

To show the boundary between the road pavement and shoulder of footpath kerbs are provided.

According to functions or heights at pavement edges kerbs can be divided into following three classes.

i) class I kerbs
ii) class II kerbs
iii) class III kerbs

Right of way

The term right of way is used to indicate the area of land acquired along the road alignment by the highway organisation.

The right of way mainly depends upon importance of road and following components

i) availability of funds
ii) cost of acquisition of lands
iii) drainage systems
iv) height of embankment or depth of cutting
v) side slopes of embankment or cutting.
vi) visibility considerations on curves
vii) width of formation
viii) width of land required for future development.

Camber

The cross-section of road surface shows the convexity upwards and the highest point on the curved road surface is known as crown. Hence camber is the slope of the line joining the crown and the edge of the road surface.

Necessity of camber

It is mainly provided for the following two reasons.

i) It prevents the entry of water or moisture into the subgrade soil and thus the stability of road base and surfacing is increased.

ii) The removal of water from road surface makes it non slippery and safe from driving of vehicles at high speed.

Shapes of camber

i) Parabolic camber
ii) Straight line camber
iii) Combined camber

Stopping sight distance (SSD)

It is defined as the distance travelled by a vehicle to stop safely without any collision with other vehicles. It is measured along the centre-line of road.

Factors affecting SSD

i) Efficiency of brakes
ii) Frictional resistance between roads and tyres.
iii) Slope of the road surface
iv) Speed of vehicle
v) Total reaction time of the driver.

Total reaction time of the driver

The time taken by the driver from the instant the object is seen to the instant when brakes are applied is known as reaction time of the driver. It can be divided into following two categories.

a) Brake reaction time - The time taken by the driver of the vehicle for the application of brake is known as brake reaction time. It depends on the skill of the driver and type of problem etc.

b) Perception time - The time taken by the driver of vehicle to realise that brake is to be applied is known as perception time and it varies from driver to driver. It also depends on several factors such as speed of the vehicle, distance of object, climatic conditions etc.

PIEV theory

According to PIEV theory total reaction time of driver is composed of following elements.

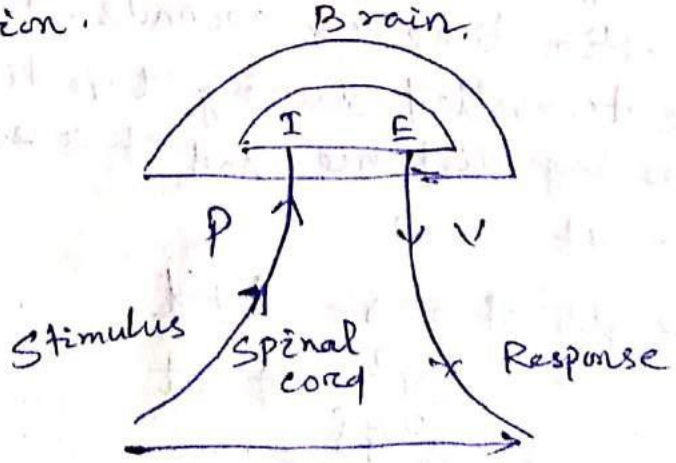
a) perception time
b) Intellection time
c) Emotion time
d) Volition time

a) The perception time 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.

b) The intellection time is the time required for understanding the problem or situation. It also suggests the time required fore comparing the different ideas.

c) The emotion time is the time which is passed during emotional sensations and disturbances such as fear, angere etc.

d) The volition time is the time taken for the final action.



Length of SSD

Length of SSD = Braking distance + Lag distance

Let W = total weight of vehicle

f = coefficient of friction

l = braking distance in mt.

v = speed of vehicle in m/sec.

g = acceleration due to gravity

= 9.8 m/sec^2

Now work done against friction in stopping the vehicle = kinetic energy of the moving vehicle.

$$\Rightarrow f.Wl = \frac{W.v^2}{2g}$$

$$\Rightarrow fl = \frac{v^2}{2g}$$

$$\Rightarrow l = \frac{v^2}{2gf}$$

For finding the lag distance let 't' be the total reaction time in seconds. Then distance travelled during this time is known as lag distance and it is expressed as $d = vt$

Hence length of SSD = $l + d$.

$$= \frac{v^2}{2gf} + vt$$

Crossing sight distance (CSD)

It is usually taken as double the stopping sight distance (SSD).

Thus CSD = 2 x SSD

Overtaking sight distance (OSD)

It is defined as the distance required by a vehicle to overtake safely another vehicle travelling in the same direction where the speed difference between vehicles is assumed to be 16 km p.h. It is also known as passing sight distance.

Mathematically, $OSD = V_2t + V_2t_0 + 2s + Vt_0$

Supere-elevation

It is used to indicate the transverse slope or inclination provided to the pavement surface throughout the length of the horizontal curve.

Advantages of superelevation

i) It ensures smooth and safe movements of passengers and goods on the road.

ii) It introduces the centripetal force to counteract the effect of centrifugal force.

iii) It results in the increase in volume of traffic.

iv) The maintenance cost of road on curve is reduced.

v) There is a decrease in the intensity of stresses on the foundation of road

vi) The water can be drained off easily because there is no necessity of providing drains on the outer edge of the road.

Mathematically

$$e + f = \frac{v^2}{gR}$$

Horizontal curves

The ideal condition for the highways would to have a straight alignment without any curvature or change direction.

Necessity of horizontal curves are,

i) to adjust with the topographical features of the country.

ii) to avoid certain religious, monumental or some other structures of historical and sentimental importance.

iii) to keep the drivers of vehicles alert because very straight long roads make them careless.

iv) to make use of existing right of ways.

v) to provide access to a certain locality.

vi) to solve the problem of acquisition of land.

Notes on highway maintenance

The highway maintenance consists of corresponding correcting deficiencies in the highway which have developed as a result of age, wear, weather and damage and taking steps to prevent or delay the development of other deficiencies.

There are two types of maintenance

i) Preventive
ii) Breakdown

In preventive maintenance an attempt is made to anticipate potential failure.

In breakdown maintenance the failure has already occurred and steps or measures must be taken to determine and correct the cause as well as to repair the damage.

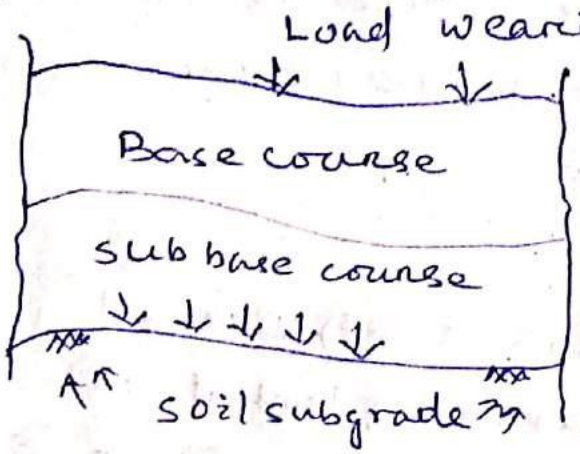
Causes of failure of pavements

The pavements are classified into two categories namely flexible pavement and rigid pavements. Hence the failure in each type of pavement occurs.

i) Failures in flexible pavements
ii) Failures in rigid pavements

The flexible pavement failure is defined by the localized depression zone or settlements.

The localized depression may develop due to the failure of any component layer of the flexible pavement structure. In flexible pavement failure it occurs in failure of subgrade, failure in base, or sub base course and failure in wearing course.



Failure in Subgrade

Failure in rigid pavements

Following are the two factors which are responsible for failure in rigid pavements:

i) Deficiency of pavement materials

The various defects of rigid pavements are due to poor workmanship, use of soft aggregates, poor surface finish, improper curing, poor quality of joint filler etc.

ii) Structural inadequacy

This system is structurally unstable such as inadequate pavement

thickness, inadequate subgrade support, poor subgrade soil, incorrect spacing of joints etc.

Typical flexible pavement failures

Following are the some typical flexible pavement failure.

i) Alligator or map cracking
ii) consolidation of pavement layers
iii) Formation of waves.
iv) Frost heaving
v) Lack of binding with the lower course
vi) Longitudinal cracking
vii) Reflection cracking
viii) Shear failure

Typical rigid pavement failures

Following are the some of typical rigid pavement failures.

i) Mud pumping.
ii) Scaling of cement concrete
iii) Shrinkage cracks
iv) Spalling of joints.
v) Structural cracks
vi) Warping cracks

Maintenance of earth roads

The earth roads will require frequent maintenance. Following are the usual damages take place on earth roads.

i) formation of dust in dry weather.
ii) formation of cross ruts along the surface after the rainy season.
iii) formation of longitudinal ruts along wheel path of slow moving vehicles.

The maintenance of earth roads can be grouped in the following two categories.

i) Normal maintenance
ii) preventive maintenance

Again normal maintenance are as follows.

i) Damaged road surface
ii) Road surface proper
iii) side drains
iv) Stumps and rocks

Similarly the purpose of preventive maintenance of road can take place as follows,

i) Control of moisture content
ii) Restricting traffic after rains

Maintenance of gravel roads

The maintenance of gravel road surface consists in keeping it smooth, free from ruts etc by repairing the holes. It can be classified in the following two ways.

i) Normal repairs
ii) Periodical renewal

Again normal repairs of gravel road consists of following two items.

i) Repair to pot holes and ruts
ii) Upkeep of surface

In periodical renewal if a fairly long stretch of road length having 1km or more is badly damaged it should be renewed.

Benefits of improved highways

There are various benefits which are gained by the improved highways as follows.

i) Cheaper transport
ii) development of commerce, industry and agriculture
iii) development of intellectual and social life
iv) development of natural resources
v) good defence from military point of view.

vi) good transport facilities.

vii) increase in fire protection

viii) increase in land values.

ix) increase in sanitary and medical protection.

Maintenance of W.B.M. roads

The W.B.M road surface deteriorates mainly because of the following reasons.

i) Fast moving vehicles - The first moving vehicles will loosen the interlock between finer particles and the road metal is broken.

ii) Grinding of stones - Due to abrasive action of steel tyres of bullock carts the grinding of stones takes place and it results in bad shape of the road surface.

iii) Hoofs of the animals - The pounding effects of the hoofs of the animals cause the dislocation of stones and soft pieces are formed. These finer particles are then carried away by wind.

The maintenances of W.B.M roads can be grouped into two categories.

1) Normal repairs
2) Surface renewals.

Maintenance of bituminous roads

The maintenance of bituminous roads can be grouped in five categories,

i) patch repairs
ii) preventing skidding of vehicles
iii) Reducing reflection cracking
iv) stripping and ravelling
v) waves and corrugations

In patch repairs following operation can be done.

i) Marking the patches - The affected or damaged surface areas of the road are marked in rectangular shape.

ii) Cutting and digging - The portion is then excavated till the sound materials are encountered.

iii) Filling the holes - In case of premix pavement the excavated portion is filled with premix bituminous concrete of the type used in the original construction.

Waves and corrugations - When waves and corrugations are found on the pavement surface it is absolutely necessary to investigate the basic reason and to suggest the preventive measure.

Maintenance of cement concrete roads

Following are the four main items of maintenance of cement concrete roads.

i) Maintenance of joints
ii) Mud jacking
iii) Patch repairs
iv) Treatement of cracks

Maintenance of joints

The joints are Weakest parts of the cement concrete pavement and hence they should be checked periodically.
The damaged joint sealers should preferably be replaced before the start of monsoon.

Mud jacking

It is used to indicate the raising of a settled cement concrete slab.
A trench is made along the side of the pavement and a pipe is driven under the slab at a sufficient distance to transport the grouting material to the desired location.

Notes on Traffic Engineering

Traffic engineering includes the study of regulations for traffic, characteristics of traffic, controling and guiding measures for traffic, flow of traffic at junctions, parking areas, traffic survey etc.

Objectives of traffic engineering

1) To achieve smooth and easy flow of traffic at intersections.
2) To develop methods for improvement in general and for solving specific problems.
3) To have safe, convenient, rapid and economic transport of persons and goods.
4) To improve the speeds of vehicles.
5) To increase the traffic carrying capacity of roads.
6) To reduce delays in road journeys.
7) To reduce the chances of road accidents to a minimum.
8) To remove traffic congestion.
9) To make the streets safe for the movements of pedestrains and vehicles.

Traffic surveys

The main objectives of traffic studies are as follows,

i) To analyse the road accidents and to find out road elements contributing to their occurrence.
ii) To determine the facilities provided on the road.
iii) To get data for suitable geometrical design of various components of road.
iv) To obtain the knowledge of the nature of traffic at present and to forecast its future trend.
v) To provide suitable parking facilities.
vi) To suggest controlling measures for speed.

The various methods of traffic surveys are

1) Accident survey
2) Origin and destination survey
3) Parking survey
4) Spot speed survey
5) Speed and delay survey
6) Traffic volume survey

Parking survey

Some of the terms used in parking survey are as follow,

i) Parking accumulation - It indicates the number of vehicles which are parked in a specified area at a given instant. During peak hours the parking accumulation is from 70 percent to 90 percent of the traffic accumulated.

ii) Parking duration - The length of the time for which a vehicle remains in the parked position is known as parking duration.

iii) Parking load - The total sum of vehicle hours of parking is the parking load and its magnitude and distribution throughout the day will serve as a measure of overall usage.

iv) Parking turnover - The ratio of the number of vehicles parked during a period to the total parking capacity is known as Parking turnover. If the parking turnover is high it indicates well utilisation of parking space.

v) Parking volume → The actual number of different vehicles which park is termed as the parking volume.

Traffic control

The objects of having effective traffic controlling devices are,

→ To develop free and rapid flow of traffic on roads and streets in towns.

→ To prevent the rapid traffic flow from being in undue danger either to its own units or to the public at large.

Various methods of traffic control adopted are,

i) achieving segregation of traffic.

ii) imposing heavy penalties on the defaulters of traffic rules and regulations.

iii) imposing speed restrictions as in case of road over a bridge.

iv) making the streets one way.

v) providing good visibility, easy curves sufficient widths and parking places.

vi) regulating turning of vehicles at junctions manually by policemen.

vii) making proper design of junctions.

Traffic control devices

In order to control, regulate and guide traffic it is necessary to have suitable traffic devices which are known as traffic control devices.

Following are the requirements of use of traffic control device,

i) It must convey clear and simple meaning.
ii) It must command attention.
iii) It must command respect of road users.
iv) It must give adequate time for proper response.
v) It must justify its necessity.

The selection and use of traffic control devices should be made only after an engineering study so that devices are not indiscriminately placed.

Following are the four basic types of traffic control devices,

i) Road markings
ii) Road signs
iii) Traffic signals
iv) Speed breakers

Road markings

Certain lines, patterns, words, symbols or reflectors on the pavement, kerb, near the roadway are marked on the road surfaces by means of guiding and controlling the traffic. These are known as road markings or traffic markings. Following are the usual forms of road markings.

i) arrow markings
ii) bus stop markings
iii) centre-line markings
iv) guide lines
v) kerb markings
vi) marking demarcating traffic lanes
vii) parking space limits
viii) pedestrian crossings
ix) stop lines

Road signs

The road sign is the most used and least costly of traffic control devices.

Following are the purposes of road signs.

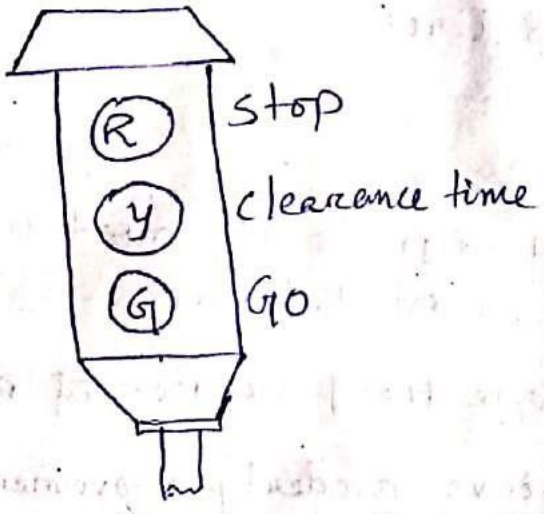
i) to achieve orderly movement of traffic.
ii) to control speeds of vehicles.
iii) to control traffic behaviour such as parking, overtaking etc.
iv) to direct traffic on different routes.
v) to guide road users of hazardous conditions ahead.

vi) to intercept heavy traffic in order to allow other vehicles and pedestrains.
vii) to reduce the chance of accidents etc.

Traffic Signals

To control traffic at important road junctions or intersections, the automatic traffic signals are installed in big towns. There are usually three colours namely red, yellow and green included in the traffic signals.

The red and green lights indicate stoppage and movement respectively. The yellow light indicates change or clearance time.



The traffic signals of various patterns and designs are available. The most commonly adopted traffic signal is the automatic fixed time signal.

Advantages of traffic signals.

Following are the advantages of traffic signals.

i) There is increase in the traffic handling capacity at the road junction.

ii) There is overall improvement in the quality of traffic flow at the road junction.

iii) They allow safe crossing of heavy traffic

iv) They help in reducing certain types of accidents especially those at right angled collisions

v) The permit the pedestrians to cross the roads safely and with confidence.

vi) They prove to be economical as compared to manual control.

vii) They provide for the orderly movement of traffic.

Speed Breakers

A speed breaker is a hump surface across the roadway. It has a rounded shape with width greater than the wheel base of most of the vehicles. A speed breaker acts as a strong stimuli to arouse reaction in the brain.

Low cost Roads

Low cost road is used to mean the road whose initial as well as maintenance costs are low. The low costs roads are meant for low intensity of traffic. Following two precautions should be taken in the initial stage.

i) The geometric standard of low cost roads should be such that no alteration may be required when these roads are upgraded in future.

ii) With the increase in traffic it should be possible to strengthen the pavement in stages.

Classification of low cost roads

These are divided into six categories.

i) Earth roads
ii) kankar roads
iii) Gravel roads
iv) Moorum roads
v) Traffic bound macadam roads
vi) Water bound macadam roads

Advantages of earth roads

a) They can be constructed speedily.
b) They involve the use of locally available earth. It can be arranged such that earth obtained from cutting is equal to earth required for filling. This is known as balancing of earthwork.

c) They prove cheap in construction cost.

d) When traffic increases, they provide good foundation.

Disadvantages of earth roads

a) Most of the earth roads are fair weather roads and they become useless in monsoons.

b) They are useful for light traffic only.

c) They wear out quickly. Hence their repair and maintenance costs are high.

Dust prevention

Following are the various preventive measures taken to bring down the intensity of dust nuisance on low cost roads.

i) Application of road oil.
ii) Sprinkling with water
iii) Tar or asphalt surfacing
iv) Use of hygroscopic material

Application of road oil

The application of a coat of road oil on the surface of earth, gravel or W.B.M road keep down the dust and increase the road carrying capacity.

Sprinkling with water

If water is sprinkled in too much quantity it will create muddy surface and the wet road surfacing will get worn quickly under the traffic.

Tare or asphalt surfacing

A light coating of tare or asphalt is given to the surface of gravel road to lay down dust and to increase its load carrying capacity. A light surfacing of tare or asphalt known as surface dressing is given to the surface of W.B.M. road.

Use of hygroscopic material

The use of materials like calcium chloride (CaCl2) assists in preventing the dust nuisance. The powder of calcium chloride is sprinkled on the surface of W.B.M. road. This powder takes up the moisture from the atmosphere.

Soil stabilized Roads

It is used to indicate any treatment or process on soil to improve its strength or bearing power by reducing its susceptibility.

Objectives of soil stabilization

i) To alter the chemical properties of soil.
ii) To avoid changes in the soil characteristics due to increase or decrease of water or moisture content.
iii) To increase resistance to softening action of water.
iv) To increase the shear strength of soil.
v) To reduce the chances of swelling.

vi) To increase the compressive strength of soil

vii) To increase the flexibility so as to take the wheel load without deformation and cracking.

viii) To prevent the cracks in soil due to reduction of water or moisture content.

ix) To retain the desired minimum strength by water-proofing.

Mechanics of soil stabilization

The general procedure to be adopted for soil stabilization are,

i) The properties of soil to be stabilized are studied and evaluated by carrying out various field and laboratory tests.

ii) The desirable properties in which the soil is lacking are decided.

iii) The most effective and economical method to get the soil of desired quality is decided by considering various factors such as type of soil, requirements of stabilized layer, availability of stabilizers.

iv) The stabilized soil mix is designed to achieve the desired characteristics of soil.

v) The soil stabilized road is constructed by adopting suitable method of construction.

Soil stabilizers

Various types of stabilizers are found out and it can be grouped in the following three categories.

a) Bituminous materials
b) Cementing agents
c) Chemical stabilizers

Bituminous materials

These materials work as water proofing agents and they provide a layer around soil particles to stop or retard the absorption of water.

Cementing agents

The strength of stabilized soil can be considerably improved by addition of cementing agents like cement or lime.

Chemical stabilizers

The addition of certain chemicals either alone or in combination may impart useful changes in some types of soils. They may work either as water retaining agents or water repelling agents.

Methods of soil stabilization

a) Mechanical stabilization
b) Bituminous stabilization
c) Cement stabilization
d) lime stabilization
e) Chemical stabilization

Characteristics of soil

Following are the characteristics of soil,

a) Centrifuge moisture equivalent
b) Colour
c) Field moisture equivalent
d) Grain shape
e) Linear shrinkage and volumetric change
f) Particle sizes and distribution
g) Plasticity
h) Presence of fines
i) specific gravity
j) state of compaction

Plasticity

It is used to mean the ability of soil to undergo changes of shape without rupture. Consistency is used to mean the relative ease with which soil can be deformed.

Following are the four states of consistency in terms of water content.

i) liquid state
ii) plastic state
iii) semi-solid state
iv) solid state.

Textural classification of soil

This type of soil classification is based on the particle size distributions in which soils are classified on a triangular diagram. It shows percentages of sand, silt and clay fractions in the soil. A triangular diagram showing textural classification is divided into areas each of which is given a general name that describes the soil type.

The sizes of particles for sand, silt and clay are respectively 2mm to 0.05mm, 0.05mm to 0.005mm, and less than 0.005mm.

Highway research board classification of soils

The (HRB) Highway Research Board classification system is also known as public Roads Administration (PRA) classification system.

In this classification system the soils are divided into seven groups A-1, A-2, A-3, A-4, A-5, A-6 and A-7 in decreasing order of stability.

The group index is mentioned to describe the performance of the soils when they are to be used for the pavement construction. It depends upon following factors

i) The amount of material passing the 75 micron IS sieve

ii) the liquid limit

iii) the plastic limit

The group index is obtained by the following equation,

$G.I. = 0.2a + 0.005ac + 0.01bd$

where a = that portion of percentage passing 75 micron sieve greater than 35 and not exceeding 75 and expressed as a whole number from 0 to 40.

b = that portion of percentage passing 75 micron sieve greater than 15 and not exceeding 55 and expressed as a whole number from 0 to 40.

c = that portion of the numerical liquid limit greater than 40 and not exceeding 60 and expressed as positive whole numbers from 0 to 20.

d = that portion of the numerical plasticity index greater than 10 and not exceeding 30 and expressed as positive whole number from 0 to 20

If the maximum value of a, b, c and d are taken i.e. a = 40, b = 40, c = 20 and d = 20

then Group index will be,

$G.I. = 0.2a + 0.005ac + 0.01bd$

$= 0.2 \times 40 + 0.005 \times 40 \times 20 + 0.01 \times 40 \times 20$

$= 8 + 4 + 8 = 20$

Hence the value of group index varies from 0 to 20. The greater the G.I number the poorer the soil. The group index number is recorded to the nearest whole numbers.

No	Value of G.I	Soil condition
1	0	Excellent
2	1	Good
3	2 to 4	Fair
4	5 to 9	Poor
5	10 to 20	Very poor

Highway Construction

The type of construction adopted for a particular road depends upon

i) the volume and nature of traffic to use the road.
ii) the nature of the materials available
iii) the topography
iv) foundation conditions
v) type and availability of construction equipment
vi) financing arrangements and timing.

The road construction process

Any road construction job consists of number of basic steps

a) planning, programming and pre-construction activities
b) site clearance
c) setting out
d) earthworks
e) bridge construction
f) drainage structures
g) pavement construction
h) Landscaping.

Construction of various layers

Bituminous pavements are constructed in different layers such as base course, binder course and surface course. These layers are made of different materials and provides different functions to the bituminous pavements.

1) Bituminous base course

Base course layer in a bituminous pavement consists of mineral aggregates such as gravel, stones and sands bonded together with bituminous materials. This layer is used as the foundation on which surface course or binder is plaed.

2) Bituminous binder course

Binder course layer is an intermediate layer between base course and surface layer. It is the first layer in case of two layer bituminous resurfacing. Bituminous binder course is made of bituminous aggregate mixture.

3) Bituminous concrete layer

It is a mixture of aggregates continuously graded from maximum size to minimum sizes. Sufficient bitumen is added to the mix so that the compacted concrete mix effectively impervious.

Stresses in rigid pavements

Various stresses in rigid pavements are,

i) Temperature stresses
ii) friction stresses
iii) wheel load stresses

Due to the temperature differential between the top and bottom of the slab, curling stresses are included at the bottom or top of the slab.

In frictional stresses, due to the contraction of slab due to shrinkage or due to drop in temperature tensile stresses are induced at the middle portion of the slab.

In wheel load stresses the slab is subjected to flexural stresses due to the wheel loads.

Various types of failure in flexible pavement and rigid pavement

The term pavement generally means the surfacing layer only.
The pavements are divided into following two categories.

1) Flexible pavement
2) Rigid pavement

Flexible pavement

The flexible pavements can not take up the tensile stresses caused by load and their load-carrying capacity develops from the load distributing characteristics of the layered system. Such pavements consists of a series of layers with the strongest at or near the surface.
A flexible pavement consists of soil subgrade, sub base course, base course and surface course. The flexible pavements are favoured mainly for the following reasons,

i) It does not require skilled labourers
ii) It is cheap in construction.
iii) It makes use of the locally available materials.
iv) It requires less supervision.

Rigid Pavements

The rigid pavements can take up tensile stresses and they consists of a concrete slab which may serve as surfacing layer. It is to provide a good base or subbase course below the cement concrete slab because it increases the life of pavement. The rigid pavements are made of cement concrete which may either be plain, reinforced or prestressed. The rigid pavement because of its high modulus of elasticity for all ranges of temperature.

Factors affecting the design of pavements

Following are the factors which are to be considered for design of pavements -

1) climate
2) Environment
3) Geometry
4) pavement materials
5) Subgrade soil
6) Traffic

Design of bituminous paving mixes

Following are the factors involved in the design of bituminous paving mixes,

i) durability
ii) fatigue resistance
iii) flexibility
iv) fracture or tensile strength
v) permeability
vi) Skid resistance
vii) stability
viii) Stress - strain characteristics
ix) thermal characteristics.
x) workability characteristics

Different types of failure in flexible pavements are,

i) Alligator cracking or Map cracking (fatigue)
ii) Consolidation of pavement layers
iii) Shear failure cracking
iv) Longitudinal cracking
v) Frost heaving
vi) Lack of binding to the lower course
vii) Reflection cracking
viii) formation of waves and corrugation.

Rigid pavement failure

Following are the types of rigid pavement failures,

1) Mud pumping
2) Scaling of cement concrete
3) Shrinkage cracks
4) Spalling of joints
5) Structural cracks
6) Warping cracks

Faulting in rigid pavement

The difference in elevation between the joints is called faulting. The main cause of failure in rigid pavement due to faulting are,

→ Settlement of the foundation that is caused due to soft foundation.

→ The pumping or the erosion of material under the pavement resulting in voids under the pavement slab causing settlement.

→ The temperature changes and moisture changes that causes curling of the slab edges.

→ The setting and curing processes of the concrete slab results in such cracks.