Model Set Questions with Answers

MODEL – 1

[CET - 502]

Full Marks – 70 **Time – 3 Hours**

*Answer any **five** questions.*

Figures in the right-hand margin indicate marks.

1. (a) Name important transportation organisations. [2
   (b) Describe with neat diagram explain the different types of flexible pavements. [5
   (c) What do you mean by stopping sight distance ? Also give detailed analysis. [7
2. (a) Name common binders. [2
   (b) Calculate the passing sight distance for a two-way traffic highway for which the design speed of 60 kmph. The rate of acceleration of the fast moving vehicle may be assumed as 3.6 kmph/second and the difference in speed between the overtaking vehicle and overtaken vehicle as 20 kmph. What will be the passing sight distance if only one-way traffic is allowed ? [5
   (c) Compare between Bitumen and Tar. [7
3. (a) What do you mean by soundness test ? [2
   (b) Design the rate of superelevation for a horizontal highway curve radius 750 m and speed 110 kmph. [5
   (c) Explain the design of vertical curves. [7
4. (a) Define cement stabilization. [2
   (b) Explain in detail lime stabilization. [5
   (c) Explain briefly sub-surface and surface drainage system is highways with skethes. [7
5. (a) Why retaining walls are provided in will roads ? [2
   (b) State the causes of Flexible pavements with neat sketches. [5
   (c) Explain briefly with neat sketch of CBR Test. [7
6. (a) Name the different traffic characteristics. [2
   (b) Classify and explain traffic signals. [5
   (c) With neat sketch discuss the different traffic signs. [7
7. (a) Define Texturing and separation membrane. [2
   (b) Explain briefly "How the sub-grade will prepared for a Nation Highways" with the steps of construction. [5
   (c) What are the factors considered for road side development and what are the purposes of planting trees on the road side ? [7

ANSWERS TO MODEL – 1

1. (a) Name important transportation organisations.

Ans. Important Transportation organistions are :

(i) IRS (Indian Road Congress)

(ii) Ministry of surface transport

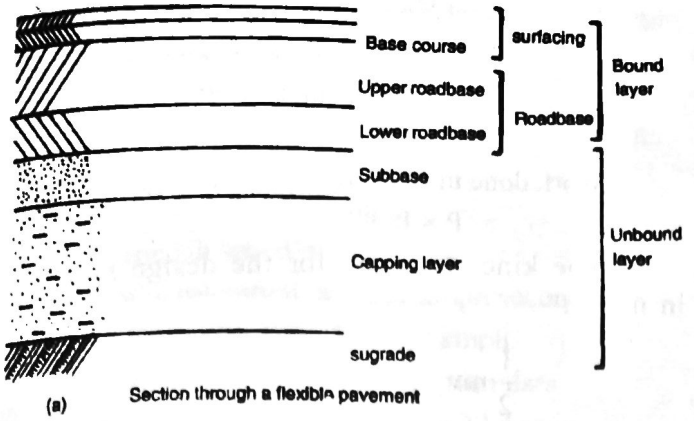
(iii) CRRI (Central Road Research Institute)

(b) Describe with neat diagram explain the different types of flexible pavements.

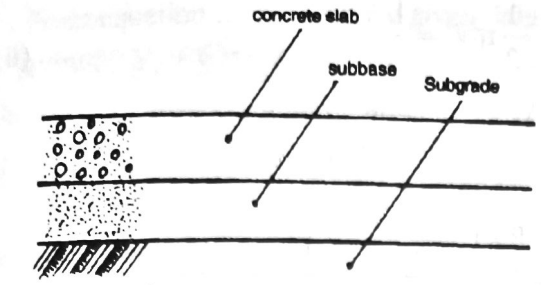
Ans. Flexible pavement is a pavement structure that maintains intimate contact with and distributes loads to the subgrade and depends on aggregate interlock, particle friction, and cohesion for stability. In contrast rigid pavement is a paveme nt structure that distributes loads to the subgrade having as one course a Portland cement concrete slab of relatively high bending resistance. Thus a flexible pavement is generally considered to be any pavement other than a concrete one. Flexible pavement can be of three types : (i) Layered, (ii) Deep strength and (iii) Composite.

Layered Flexible Pavements : These are comprised of several layers of granular materials over subgrade with thin asphaltic layer.

Deep Strength Flexible Pavements : These types of pavements have whole thickness of asphaltic construction over subgrade.

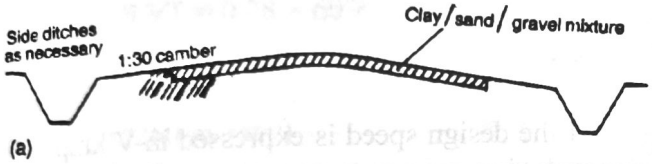


(a) Section through a flexible pavement

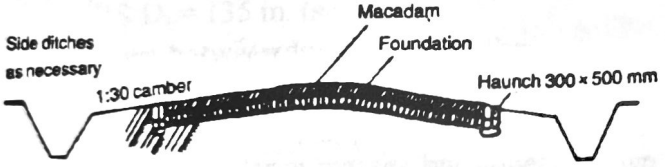


(b) rigid pavement

Secation through a concrete pavement



(a)



(b) Light duty roads

(c) Earth road

(d) Waterrbound macadam road

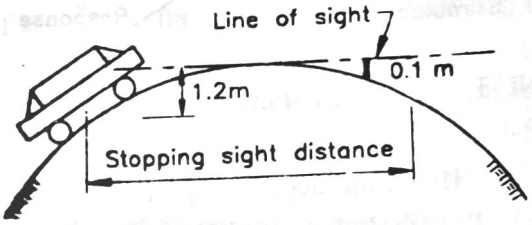
Composite Flexible Pavements : These pavements make use of stabilized layer with asphaltic surfacing.

The essential difference betwen flexible and rigid type of pavement is the manner in which they distribute the load over the subgrade. Flexible pavement has self-healing power. It reflects the deformation of subgrade and of subsequent layers on the surface. On the other hand the rigid pavement because of its rigidity and high modulus of elasticity tends to distribute the load over a reletively wide area of subgrade soil. Thus a major portion of the structural capacity is supplied by the pavement slab itself by beam action. Therefore, in the design of rigid pavements the flexural strength of concrete is the major factor in the design and not the subgrade strength. It is because of this fact that when the subgrade deflects, beneath a rigid pavement, the concrete slab is also to bridge over localized failures and areas of the inadequate support because of slab action.

The flexible pavement consists of a series of layers with the highest quality materials at or near the surface. Since it functions mainly by way of load distribution through the component layers which gradually reduces the stresses reaching the subgrade so as to be within the limit of safe bearing capacity, therefore, thickness design requirements in case of flexible pavements is greatly influenced by the subgrade strength.

(c) What do you mean by stopping sight distance ? Also give detailed analysis.

Ans. Stopping or Non-overtaking or Non-passing Sight Distance : It is the distance needed by a driver travelling at design speed to stop before before reaching an obstruction ahead. In case of summit curve stopping sight distance is the distance measured along the road surface so that an object of height 0.10 m. can be seen by a driver whose eye is at a height of 1.20 m above the road (see figure below).



Analysis of Stopping Distance : The stopping sight distance of a vehicle is a sum of reaction distance and the breaking distance.

Reaction Distance : It is the distance travelled by the vehicle during total reaction time. If V be the design speed in kmph and t is the total reaction time of the driver in seconds, then

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

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

I.R.C. has recommended the following values of reaction time :

TABLE - 1

Speed in kmph.	50	65	80
Reaction times in seconds	3.00	2.75	2.50

The total reaction time is the total period between the hazard coming into view and the instant the brakes take effect. It is dependent on driver's behaviour and design speed. Based on "PIEV theory" the total reaction time is comprised of :

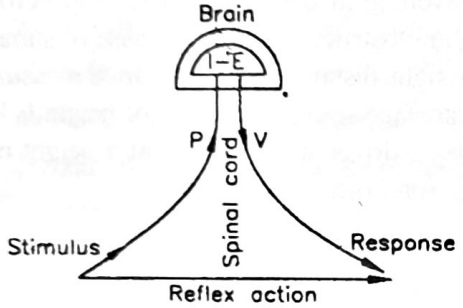
(i) *Preception time* i.e., the time required to perceive an object or situation.

(ii) *Intellection time* i.e., the time required for comparing the different throughts, regrouping and registering new sensations.

(iii) *Emotion time* i.e., the time elapsed during emotional sensation and disturbances.

(iv) *Volition time* i.e., the time required for the final action.

The PIEV process can be depicted as in figure below.



NOTATIONS : P-Perception, I-Intellection, E-Emotion, V - Volition.

The PIEV time depends upon :

(i) Physical characteristics of driver.

(ii) Psychological factors.

(iii) Environmental conditions.

(iv) Purpose of trip.

(v) Speed of vehicle.

The total reaction time of an average driver may be as low as 0.5 seconds for simple situations to as high as 3 to 4 seconds for complex problems.

Braking Distance : It is the distance travelled by the vehicle after the application of the brakes.

(a) Braking Distance of a Level Raod : It may be obtained by equating the work done in stopping the vehicle and the kinetic energy. Let P be the maximum frictional force developed, and

L = The braking distance

f = Co-efficient of friction = 0.4

W = Weight of the vehicle

Then, $P = f \times W$

Work done in stopping the vehicle against friction

$= P \times L$ .....(i)

The kinetic energy for the design speed '$_V$' in m/sec.

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

$$\text{or, } \frac{1}{2} mv^2 = \frac{1}{2} \frac{Wv^2}{g} \quad \text{.....(ii)}$$

$\therefore$ Work done in stopping the vehicle

= Kinetic energy

$$\text{or, } P \times L = \frac{1}{2} \frac{Wv^2}{g}$$

$$\text{or, } f W \times L = \frac{1}{2} \frac{Wv^2}{g}$$

$$\text{or, } L = \frac{v^2}{2gf}$$

If the design speed is expressed in V kmph.

Then, $L = (0.278\ V)^2/2gf$

Stopping distance = Reaction distance + braking distance.

$$= 0.278\ Vt + \frac{(0.278V)^2}{2gf}$$

$$= 0.278\ Vt + \frac{(0.278V)^2}{2 \times 9.8 \times 04}$$

$$= 0.278\ Vt + \frac{(0.278V)^2}{7.84} = 0.278Vt + 0.01V^2$$

$\therefore$ S.D. = $0.28\ Vt + 0.01\ V^2$ (say).

2. (a) Name common binders.

Ans. (i) Cement (ii) Bitumen (iii) Tar

(b) Calculate the passing sight distance for a two-way traffic highway for which the design speed of 60 kmph. The rate of acceleration of the fast moving vehicle may be assumed as 3.6 kmph/second and the difference in speed between the

overtaking vehicle and overtaken vehicle as 20 kmph. What will be the passing sight distance if only one-way traffic is allowed ?

Ans. Case - 1 : Determination of passing sight distance for two-way traffic.

Design speed, V = 60 kmph.

Difference in speed, m = 20 kmph.

Rate of acceleration, a = 3.6 kmph/second.

$\therefore$ $V - m = V_b = 60 - 20 = 40$ kmph.

From equation ..... using the given data :

$d_1 = 0.56\ (V - m) = 0.59 \times 40 = 22.4$ m.

From equation ..... using the given data :

$s = 0.20\ V_b + 6 = 0.20 \times 40 + 6 = 14$ m.

From equation ..... using the given data :

$$T = \sqrt{\frac{14.4s}{a}} = \sqrt{\frac{14.4 \times 14}{3.6}} = 7.4 \text{ seconds}$$

From equation ..... using the given data :

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

$= 0.28 \times 40 \times 7.4 + 2 \times 14.0 = 110.5$ m.

From equation ..... using the given data :

$d_3 = 0.28\ VT = 0.28 \times 60 \times 7.4 = 124.3$ m.

$\therefore$ $d_1 + d_2 + d_3 = 22.4 + 110.5 + 124.3$ m.

or, $= 257.2$ m.

P.S.D. = 260 m. (say)

Case - 2 : Determination of passign sight distance fow one-way traffic.

P.S.D. $= d_1 + d_2 = 22.4 + 110.5 = 132.9$ m.

or, P.S.D. = 135 m. (say).

(c) Compare between Bitumen and Tar.

Ans. Comparision of Bitumen and Tar :

- Both bitumen and tar appear blackish in colour when viewed in large masses but appear brown in colour when viewed in thin films.
- Tar coated aggregates exhibit lower stripping action as compare to bitumen coated aggregates.
- Tar is more temperature susceptible i.e., it becomes liquid at lower temperature and solidify at comparatively higher ones.
- Tar takes mre time to set, therefore, central mixing plant can be used for efficient road construction work.
- Tar is not susceptible to dissolving actionof petroleum solvents. Hence inparking areas where petrol and oil are likely to drip from vehicles, a tar surfacing may have a longer life than a bitumen one.
- Tar contains a higher percentage of free carbon. Therefore, it is more brittle at low temperature.
- Tars may be overheated and spoiled more easily than bitumen.
- Tar makes more time to set. Therefore, tar roads take more time before they are opened to traffic.
- Tar contains more phenolic content, therefore, they get oxidised easily.
- Tar gets crystallised and forms an internal structure.

3.(a) What do you mean by soundness test ?

Ans. Soundness Test : These are accelerated laboratory tests to evaluate the resistance of aggreagates to weathering action due to alternate wet dry and or freeze thaw cycles.

(b) Design the rate of superelevation for a horizontal highway curve radius 750 m and speed 110 kmph.

Ans. For mixed traffic, super-elevation is given by, $e = \dfrac{v^2}{225\,r}$

Here, V = 110 kmph, R = 750 m, e = 0.08

As the value is greater than the maximum super-elevation 0.07, the actual super-elevation to be provided is restricted to 0.07.

$$\therefore\ f = \frac{v^2}{127\,R} - 0.07 = \frac{(110)^2}{127 \times 750} - 0.07 = 0.057$$

As this value is less than 0.15, the design is safe with a super-elevation of 0.07.

(c) Explain the design of vertical curves.

Ans. Design of Vertical Curves : Vertical curves are provided in elevation at change of gradients. These curves are convex when two grades meet at a 'summit' and concave when they meet at a 'sag'. Generally vertical curves are not considered necessary when the total grade change from one tangent to the other does not exceed 0.5%. The vertical curves are usually parabolic primarily because of the ease with which it can be laid out as well as enabling the comfortable transition from one grade to another.

Summit curves are required to be introduced at situations where,

(i) A positive grade meets a negative grade.

(ii) A positive grade meets another milder positive grade.

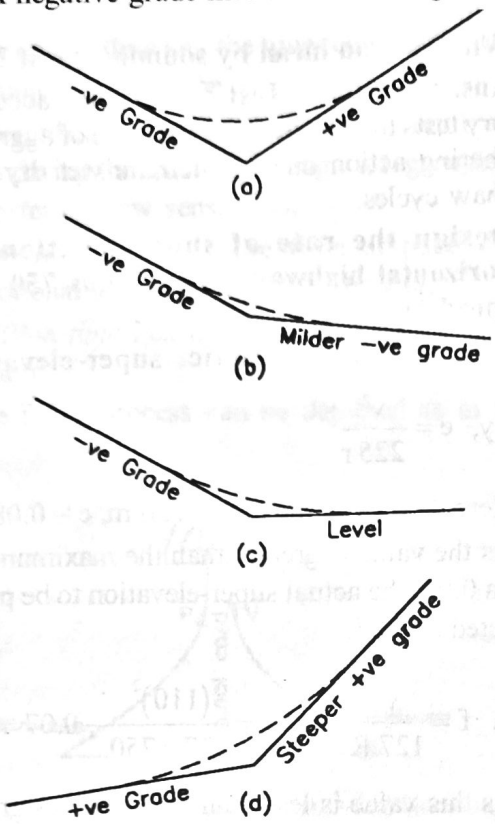
(iii) A positive grade meets a level stretch.

(iv) A negative grade meets a steeper negative grade.

The centrifugal force generated by the movement of a vehicle along a summit curve acts in a direction opposite to the direction in which its weight acts (see figure). Valley curves are required to be introduced at the situations where,

(i) A negative grade meets a positive grade.

(ii) A negative grade meets a milder negative grade.



(iii) A negative grade meets a level stretch.

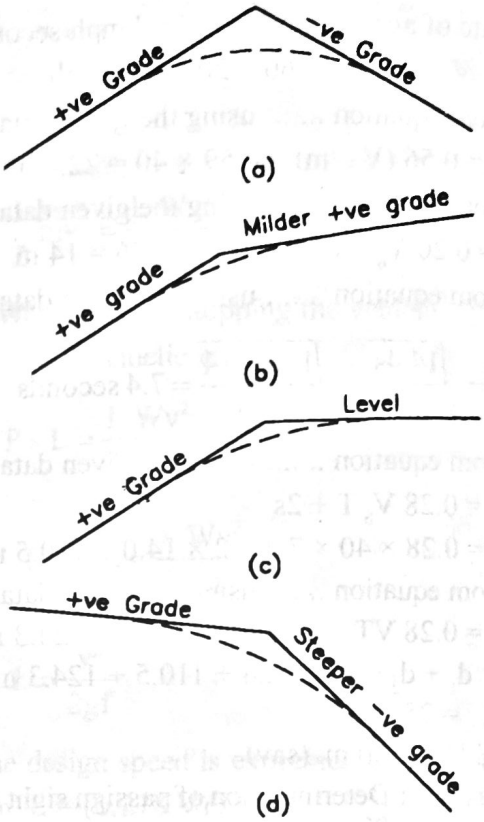
(iv) A negative grade meets a steeper positive grade.

The centrifugal force generated by the vehicle moving on a valley curve acts in the same direction as the weight of vehicle (see figure). The length of the vertical curve depends upon the algebraic difference in grade and determined by the rate of change at which it is decided to change the gradient of the line.

In order to design the vertical curves the following assumptions are made :

- The curve is so flat that the length of curve is equal to the length of the chord.
- The portions of the curve along the two tangents on either side of the point of intersection are equal.
- The angles subtended by the tangents with the horizontal are so small that the tangetns of these angles are equal to the angles in radians

themselves. Profile views presented in above figures have referencing points which correspond to all highway points even if a horizontal curve occurs concurrently with a vertical curve. Thus each highway point is uinquely defined, vertically by stationing (which is measured along a horizontal plane for vertical referencing).



4. (a) Define cement stabilization.

Ans. Cement Stabilization : It is the improvement of a soil or pavement material usually through the addition of a binder or additive. The use of stabilization means that a wider range of soils can be improved for bulk fill applications and for construction purposes. The most common method of stabilization involves the incorporation of small quantities of binders. Such as cement, to the aggregate.

(b) Explain in detail lime stabilization.

Ans. Lime Stabilization : Lime stabilized soils are generally used as sub-bases for high type of pavements and bases for low and intermediate types of pavements. When lime is added in clayey soils it lowers the liquid limit of soil, raises the platic and shrinkage limit and reduces theplasticity index. This renders clayey soil friable, easy to be pulverized, reduces swelling; decreases the O.M.C. required for compaction and lowers the maximum unit weight obtainable with a given compactive effort. This is due to various reactions like base exchange, floccultion, cementing action and carbonation.

The various factors affecting soil lime properties are (i) type and nature of soil, (i) amount and type of lime, (iii) compaction (iv) curing and (v) chemical additives.

Lime for lime-stabilization work should be commercial dry lime slaked at site or pre-slaked The quantity of lime to be added should be on the basis of the available calcium-oxide content of lime as determined in accordance with IS : 1514.

So far there is no standard method for design of soil lime mix. Generally the amount of lime required is based on the unconfined compressive strength or the CBR test criteria. Normally 2 to 8% of lime may be required for coarse grained soils and 5 to 10% for plastic soils. Lime when used mainly as a modifier for a highly plastic clay, then lime content may be higher than design values to reduce the plasticity index and swelling values up to desired limits.

It has been found that strength of soil lime mix increases with addition of materials like cement, flyash and surkhi, these materials are an intermediate between flexible materials and rigid construction. These materials can be used as base courses under flexible bituminous layers and classified as composite construction. The important examples are :

- Lime flyash concrete.
- Lime pozzolana concrete.
- Lean cement concrete and.
- Cement bound granular material.
- Lean cement concrete.

(c) Explain briefly sub-surface and surface drainage system is highways with skethes.

Ans. Refer to 2015(W) Q. No. 5.(c)

5. (a) Why retaining walls are provided in will roads ?

Ans. These walls provide adeqaute stability to the roadway and to the slope. They are generally constructed on the valley-side of the roadway. In order to permit easy drainage the retaining walls should be built in dry stone masonary. The top width of the wall should not be less than 0.6 m while the bottom width should not be less than 0.4 times the height of the wall. A front batter of 1 in 4 with rear side vertical should be provided.

(b) State the causes of Flexible pavements with neat sketches.

Ans. Refer to 2015(W) Q. No. 5.(b)

(c) Explain briefly with neat sketch of CBR Test.

Ans. Refer to 2017(W) Q. No. 4.(b)

6. (a) Name the different traffic characteristics.

Ans. Traffic characteristics affect highway design and traffic performance. They include :

(i) Vehicular characteristics

(ii) Road user characteristics

(iii) Road characteristics.

(b) Classify and explain traffic signals.

Ans. Classification of Signals : Generally a traffic signals is composed of three lanterns arranged vertically with a red lens on top, yellow in the middle and a green lens at the bottom. These lenses are illuminated from behind by an independent light source. The normal sequence of traffic signals is red, red-yellow, green and yellow. The red period indicates that the vehile on the road towards which it is facing must stop and the green period indicates that the vehicle on the streets towards which it is facing can proceed. The function of red-yellow period is to indicate stopped vehicles and pedestrians, that the lights are about to change to green. This will prepare them to enter the intersection as soon as the lights change. The yellow period warns approaching vehicle of a coming change in the signal indication. This also acts as clearance interval for vehicles or pedestrians within the intersection. Generally Red/Yellow period is 2 seconds and yellow perio as 3 seconds. The Red, Yellow and Green Traffic lights were first introduced in America and were first installed in Europe in the city of London in 1932.

Generally signal heads installed on 2.5 m high posts are located on the adjacent left-hand side of the road and also on the right hand side of the road on the far side of the intersection. In case of very wide roads it is desirable to install the signal post on the pedestrian refuge or on the central reservation. A brief discussion of different types of signals is given below :

Traffic signals can be classified into the following groups :

(i) Fixed time signals.

(ii) Traffic actuated signals.

(iii) Pedestrian signals.

(iv) Flashing signals.

(v) Linked signal system.

(i) Fixed time signals : This type of signals are most efficient at intersections where traffic patterns are relatively stable over long periods of time. Since thery are set to repeat regularly a cycle of red, yellow and green lights, therefore, their consistent starting time and

duration of cycle length facilititates linking of adjacent traffic signals. This linkage permits speed control through many intersections. These signals are designed for peak time traffic requirements, therefore, excessive and frustrating delays to vehicles will occur during off-peak times. These signals are quite popular in many countries except U.K. They are cheap, easy to maintain and adaptable to network signalling. Different fixed sequences can, however, be brough into operation by automatic, clock controlled or manual switching. Major disadvantages are that of inflexibility and inability to use junction to capacity at off-peak hours.

(ii) Traffic actuated signals : These signals are automatically adjusted to meet the needs to the traffic. They provide maximum efficiency of movement even at intersections subjected to variatioin in volume. The minimise vehicle delay, increase intersection capacity and reduce the number of rearend collisions.

This type of signal consists of a detector-pad placed in the carriageway at some distance back before each stop line. This actuates the appropriate detector, thereby, enabling to registeraion of every vehicle approaching the intersection. Since these signals are quite expensive, thereofre, in developoing country like India the traffic police is assigned the duty to watch the traffic demand and to vary the timings of the cycles according to the actual traffic demand. If detector pads are placed on all the legs of an intersection, the control is known as full traffic actuated, and if the detector pads are used on some of the legs at an intersection, it is known as semi-traffic actuated.

(iii) Pedestrian signals : Generally during the red period the pedestrains can cross the roads because vehicles are in a stop position. When the pedestrain traffic is heavy a scramble phase is added to two stop-and-go phase which allows pedestrains to move on all the four cross-walks and diagonally too. During this invertal the vehicles remain at a standstill on all legs.

(iv) Flashing signals : Sometimes a yellow flashing is installed on main road and red flashing on cross road to caution the drivers on the main road to slow down and warrants the drivers on the cross road to stop and then proceed. Flashing yellow signals are also used to warn in advance of situations like physical obstruction ahead on the roadway or sharp curve ahear. In case of fixed time signal operation during off-peak hours, it is beneficial to change from stop-and-go to a flashing signal

Capacity of a signalized intersection depends on roadway width, number of lanes, geometric design of intersection, operational and central factors such as number of turning movements, number and size of commercial vehicles, pedestrian traffiac, peak hour demands, parking regulations, turn controls, traffic signal characteristics and abutting land use.

There are generally three apparatuses used to determine the performance at intersections with permitted signals. The first is based on field observations from which average performance characteristics are determined. The second is based on theoretical considerations and derived formulae. The third general appraoch is a combination of the above whereby theoretical techiques are tested against field observations and are modified accordingly. In developing countries like India, due to complexity of the mixed flow, it is extremely difficult to formulate and analytically solve for the performance characteristics.

The main objective of designing a signalized intesection is to provide sufficient capacity for the volume of traffic approaching the intersection. The design should be such which minimizes total delay, builds short queues, and provides a high probability of passing through the intersection on the first green period for most users. In other words the signal timing should be in accordance with traffic flow on intersection.

(v) Linked signal system : In order to have more efficiency movement of traffic volume it is desirable that the actions of the individual signals should be co-ordinated where possible. This will result in less delay to vehicles at intersection and an increase in the capacity of the linked route. The linked signal system can be classified into the following main system :

- Simultaneous systems.
- Alternate systems.
- Simple progressive systems..
- Flexible progressive systems..
- Computer systems.

(c) With neat sketch discuss the different traffic signs.

Ans. (i) Traffic Signs : The traffic signs should be backed by law in order to make them useful and effective. Traffic signs have been divided into three categories according to Indian Motor Vehicles Act. These are (i) Regulatory signs (ii) Warning signs and (iii) Informatory signs.

The signs should be placed such that they could be seen and recognized by the road users easily and in

time. The transverse location of the signs may be such that in the case of roads with kerbs, the edge of the sign adjacent to the road is not less than 0.6 m away from the edge of the kerb, on roads without kerbs (as on rural highways with shoulders) the nearest edge may be 2.0 m to 3.0 m from the edge of the carriageway. The signs should be mounted on sign posts painted alternately with 25 cm black and white bands. The size, shape, colour code and the symbols used and the location of the signs should be as specified under each category. The reverse side of all the sign plates should be painted gray.

Regulatory Signs : Regulatory or mandatory signs are meant to inform the road users of certain laws, regulations and prohibitions, the violation of these signs is a legal offence. The regulatory signs are classified under the following sub-heads :

(i) Stop and Give-way signs.
(ii) Prohibitory signs.
(iii) No Parking and No Stopping signs.
(iv) Speed Limit and Vehicle Control signs.
(v) Restriction Ends sign.
(vi) Compulsory Direction Control and other signs.

The stop sign is intended to stop the vehicles on a roadway, it is octogonal in shape and red in colour with a white border. This sign may be used in combination with a rectangular definition plate with the word 'STOP' written in English and other languages as necessary. The give way sign is used to control the vehicles on a road so as to assign right of way to traffic on other roadways. This sign is triangular in shape with the apex downwards and white in colour with a red border; this sign may also be used in combination with a definition plate. These signs are shown in figure below.

Prohibitory signs are meant to prohibit certain traffic movements, use of horns or entry of certain vehicle class. These signs are circular in shape and white in colour with a red border. The common prohibitory signs are, Straight Prohibited, No Entry, One-way, Vehicles Prohibited in Both Directions, All Motor Vehicles Prohibited, Truck Prohibited, Hand Cart Prohibited, Cycle Prohibited, Pedestrian Prohibited, Right/Left Turn Prohibited, U-Turn Prohibited, Overtaking Prohibited and Horn Prohibited.

No parking sign is meant to probibit parking of vehicles at that place, the definition plate may indicate the parking restriction with respect to days, distance, etc. The No Parking sign is circular in shape with a blue back ground, a red border and an oblique red bar at an angle of 45 degrees. No Stopping/Standing sign is meant to prohibit stopping of vehicles at that place, the scope of the prohibition may be indicated on a definition plate. The No Stopping/Standing sign is circular in shape with blue back ground, red border and two oblique red bars at 45 degrees and right angle to each other. The sketches of the Prohibitory Signs, No Parking and No Stopping signs are shown in figure below.

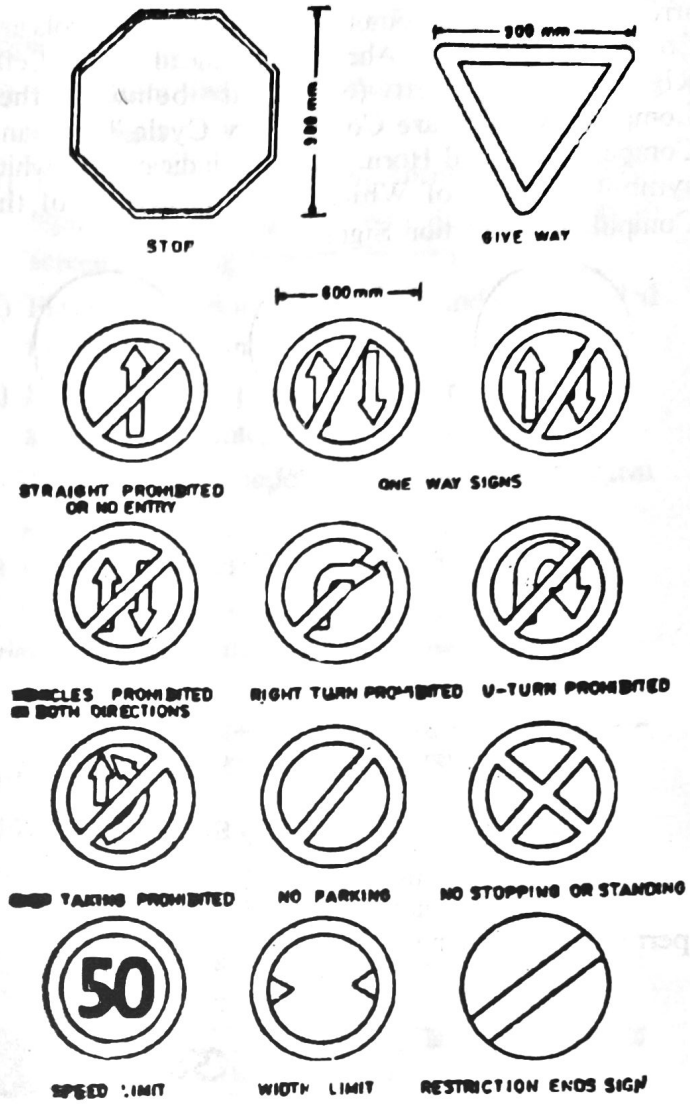
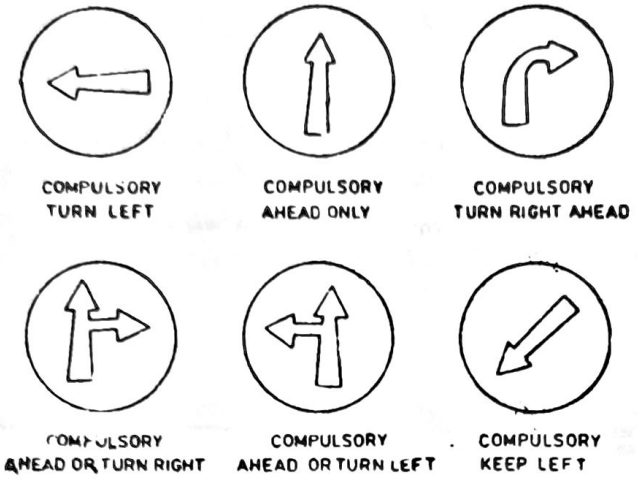


Fig. Regulatory Signs

Speed Limit signs are meant to restrict the speed of all or certain classes of vehicles on a particular stretch of a road. These signs are circular in shape and have white back ground, red border and black numerals indicating the speed limit. The Vehicle Control Signs are also similar to Speed Limit signs with black symbols instead of the numerals. The common controls are Width Limit, Height Limit, Length Limit, Load Limit and Axle Load Limit. The definition plate may be used in combination to give more details, symbolically or by words.

Restriction Ends sign indicates the point at which all prohibitions notified by Prohibitory signs for moving vehicles case to apply. These signs are also circular with a white back ground and a broad diagonal black band at 45 degrees.

Compulsory Direction Control signs indicate by arrows, the appropriate directions in which the vehicles are obliged to proceed, or the only directions in which they are permitted to proceed. These signs are circular in shape with a blue back ground and white direction arrows. Some of the Compulsory Direction Controls are Compulsory Turn Left, Ahead Only, Ahead or Turn Left/ Right and keep Left. (See figure below). Other Compulsory signs are Compulsory Cycle Track and Compulsory Sound Horn; these are indicated by white symbols instead of White direction arrows of the Compulsory Direction Signs.



(Compulsory Direction Control Signs)

Fig. Regulatory Signs

The dimensions shown in figures above, are for normal size signs; however smaller size signs may be permitted on minor roads.

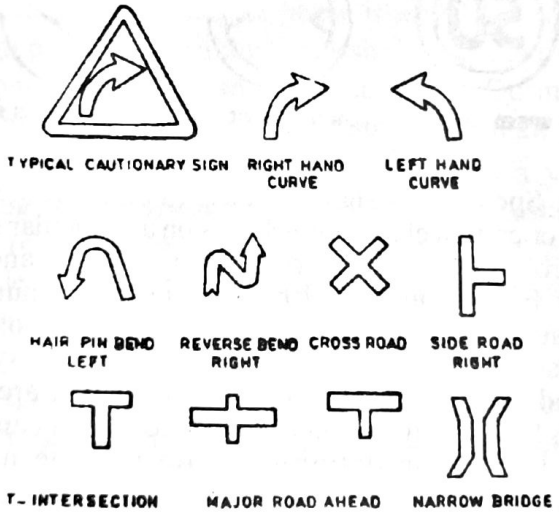


Fig. 5.26 Warning Signs

Warning Signs : Warning or Cautionary signs are used to warn the road users of certain hazardous conditions that exist on or adjacent to the roadway. The Warning signs are in the shape of equilateral traingle with its apex pointing upwards. They have a white back ground, red border and black symbols. The warning signs are to be located at sufficient distance in advance of the hazard warned against; these distances are 120, 90, 60, and 40 metre respectively on National/State Highways, Major District Roads, Other District Roads and Village Roads, on urban roads this distance is 50 metre.

The commonly used Warning signs are, Right Hand/Left Hand Curve, Right/Left Hair Pin Bend, Right/ Left Reverse Bend, Steep Ascent/Descent, Narrow Bridge/Road Ahead, Gap in Median, Slippery Road, Cycle Crossing, Pedestrian Crossing, School Zone, Men at Work, Ferry, Cross Road, Side Road, T-Intersection, Y-Intersection, Major Road Ahead, Round About, Dangerous Dip, Hump or Rough Road, Barrier Ahead, Unguarded Railway Crossing, Guarded Railway Crossing and Falling Rock. Some of the Warning Signs are as shown in above figure.

Informatory Signs ; These signs are used to guide the road users along routes, inform them of destination and distance and provide with information to make travel easier, safe ad pleasant. The information signs are grouped under the following sub-heads :

(i) Direction and Place Identification signs.

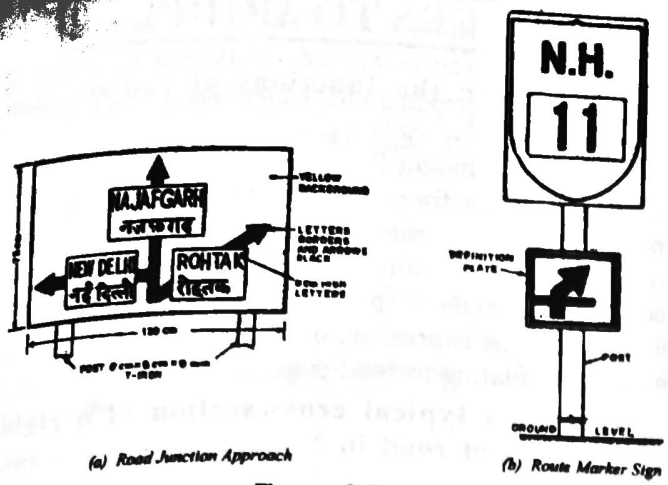
(ii) Facility Information signs.

(iii) Other useful Information signs.

(iv) Parking signs

(v) Flood gauge

The Direction and Place Identification signs are rectangular with white back ground, black border and black arrows and letters. The inscriptions should be in English and other languages as necessary. The signs of this group include Destination signs, Direction signs, Re-assurance signs, Route Marker and Place Identification signs. Figure below shows some of the Informatory signs.



(a) Road Junction Approach (b) Route Marker Sign

Fig. Informatory Signs

7. (a) Define Texturing and separation membrane.

Ans. Texturing : Road surface textures are deviations from a plan and smooth surface, affecting the vehicle/tyre interaction.

Separation membrane : A layer of separation membrane is normally placed between sub-base and concrete slab. It prevents the loss of water from cement paste which affects the strength of concrete slab.

(b) Explain briefly "How the sub-grade will prepared for a Nation Highways" with the steps of construction.

Ans. Preparation of the Sub-grade : Following steps are necessary for the preparation of the sub-grade.

(i) Clearing site

(ii) Excavation and construction of fills.

(iii) Shaping of sub-grade.

(i) Clearing site : The site clearance may be done manually using appliances like spade, pick and hand shovel or using the mechanical equipment like bulldozer and scarper etc.

(ii) Excavation and construction of fills : It may also be done manually or using the excavation, hawling and compaction equipment.

Dozers are considered very useful for haulage of short distances. If the compaction is done manually it will not be sufficient and proper, it should be left to get consolidated under atmospheric conditions. Various equipment used by manual labour or shovel, spade, pick-axe, baskets, rammers and hand rollers. The sub-grade

(c) What are the factors considered for road side development and what are the purposes of planting trees on the road side ?

Ans. Road Side Development and Arboriculture : Road side development deals with the development of aesthetic and other amentities of road and the abutting land or the right of way. Proper planning is needed for road side development right from the stages of preliminary surveys for highway alignment and during construction.

The following are some of the points to be considered for this :

(i) Consistent and smooth horizontal and vertical alignments.

(ii) Wide right of way and shoulders in rural hgihways. Wide right of way in urban areas to screen adjoining property by plantation.

(iii) Flat side slopes in embankment and cut, rounded to blend to original surface.

(iv) Suitable planting of road side stress and shrubs and proper maintenance.

(v) Turfing on side slopes and on shoulders or rural road.

(vi) Developing pleasant views and parking places.

Planting of trees on the road side, or the road arboriculture is one of the important aspects in road side development. Trees provided on both sides of urban and rural road serve the following purposes :

(i) to provide attractive landscape of road sides.

(ii) to provide shade to the road users.

(iii) to protect against moving sand in desert areas.

(iv) to provide fruit bearing trees and timber.

(v) to incercept the annoying sound waves and fumes from road vehicles.

MODEL – 2

[CET - 502]

Full Marks – 70 **Time – 3 Hours**

*Answer any **five** questions.*

Figures in the right-hand margin indicate marks.

1. (a) What are the functions of Indian road congress ?[2

(b) Draw a typical cross-section of a rigid pavement road in National Highways and mention the layers of rod from the base. [5

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Power shovel.

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ain briefly sub-surface and surface drainage m is highways with skethes. [7

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to provide a forum for regular pooling up of information, knowledge and experience for all matters affecting the construction and maintenance of roads in India, to recommend standard specifications and to provide a platform for the expression of professional opinion and on matters relating to road engineering.

(b) Draw a typical cross-section of a rigid pavement road in National Highways and mention the layers of rod from the base.

Ans. Rigid Pavements : It is constructed from cement concrete or reinforced concrete slabs. Grouted concrete roads are in the category of semi-rigid pavements.

The design of rigid pavement is based on providing a structural cement concrete slab of sufficient strength to resists the load from traffic. The rigid pavement has rigidity and high modulus of elasticity to distribute the load over a relatively wide area of soil.

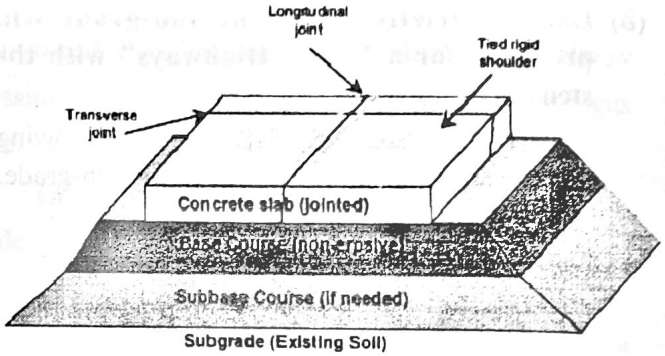


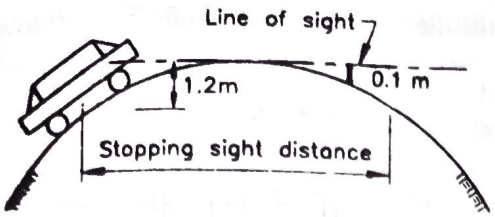
Fig. Rigid Pavement Cross-section

Minor variations in sub-grade strength have little influence on the structural capacity of rigid pavement. In the design of a rigid pavement, the flexural strength of concrete is the major factor and not the strength of sub-grade. Due to this property of pavement, when the sub-grade deflects beneath the rigid pavement, the concrete slab is able to bridge over the localized failures and areas of inadequate support from sub-grade because of slab action.

(c) What do you mean by passing sight distance ? Also give a detaled analysis.

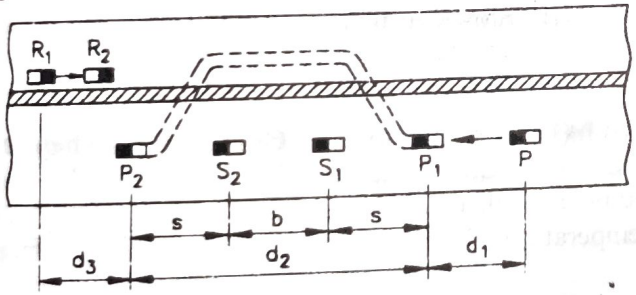
Ans. Passing or Overtaking or Non-stopping Sight Distance : It is the minimum distance open to the view of the driver of a vehicle intending to overtake a slow vehicle ahead with safety against the traffic of opposite direction.

Passing sight distance at a summit curve is the distance measured along the centre line of the road which a driver with his eye level 1.20 m, above the road surface can see the top of an object 1.20 m. above the road surface (see figure below).



Thus, overtaking sight distance is the distance needed by a driver on two-lane road travelling at the same speed as the vehicle to be overtaken to accelerate move into the opposing traffic lane, overtake the vehicle travelling at 16 km per hour less than the design speed and return to his own lane of travel before meeting an opposing vehile travelling at the design speed. The time ddduring which overtaking manoeuvre takes place increases with increasing speeds from about 5 secs. at 30 km/hr to 12 secs. at 100 km/hr. due to overtaking acceleration rate decreasinglinearly with increasing speeds. Overtaking sight distance is approximately twice the distance travelled at design speed during the time of overtaking manueuvre i.e., the sum of the distance travelled during this time by the overtaking and the opposing vehicles. Every attempt should be made to provide overtaking sight distance of the road as long as possible.

In case of road stretches where the safe passing distance cannot be provided overtaking opportunity for vehicles moving at design speed should be given at frequent intervals. The zones having enough pavement width for the safe overtaking operations are called as overtaking zones. Sign posts should be installed at sufficient distance in advance to indicate the st art of overtaking zones. Similarly, sign posts should be installed to indicate the end of overtaking zones. It is always desirable to keep the lengt of overtaking zones as equal to five times the overtaking sight distance (see figure below).



Analysis of Passing Sight Distance : In figure below, vehicles P and R are moving at design speed in opposite directions in two different lanes. Vehicle S is a slow moving vehicle moving in the direction of P vehicle.

The corredponding relative position of the three vehicles is shown by suffixes, so that when vehicle P is a at P_1, it is just going to overtake vehicle S at S_1. At this time vehicle R is at R_1. At this stage, vehicle P accelerates and crosses vehicle S by entering the opposite lane and comes back to orignal lane at position P_2. At that time vehicle S would have moved to position S_2 and R will be at position R_2 just opposite P_2. Therefore, the minimum sight distance should be the sum of the distances d_1, d_2 and d_3.

where,

d_1 = Distance travelled by the vehicle P from its position P_1 during the time in which vehicle P decides whether or not, he should take over the slow moving vehicle S, i.e., perception time.

d_2 = Distance travelled by the vehicle P_1 from its position P_2.

d_3 = Distance travelled by the vehicle R from position R_1 to R_2.

V = Design speed of the road in kmph.

m = Difference in speed of fast and slow moving vehicles i.e., P and S.

a = Rate of acceleration in m/sec^2 of vehicle P.

t = Time required to complete the actual overtaking manoeuvre.

s = Headway i.e. speed of the vehicles just before and just after the overtaking operation.

2. (a) What is superelevation ?

Ans. Superelevation : In order to resist the acting centrifugal force on a curved section of a highway, it is customary to rise the outer edge of the road above the inner edge. The transverse slope expressed as the ratio of the height of the outer edge with respect to the horizontal width along a curve is known as superelevation.

(b) Describe the following Tests on aggregates.

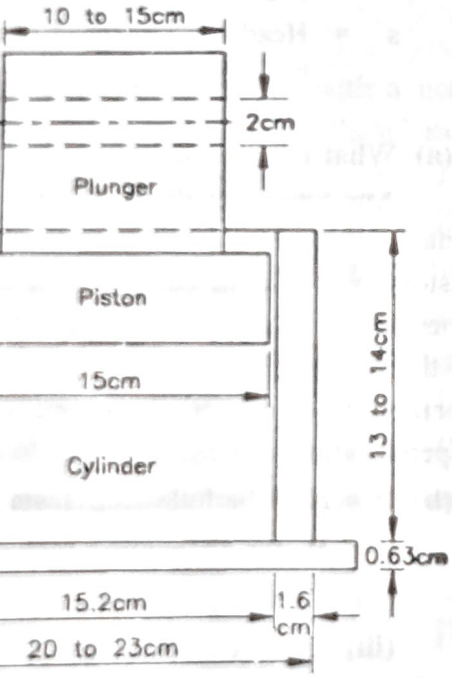
(i) Water absorption test.

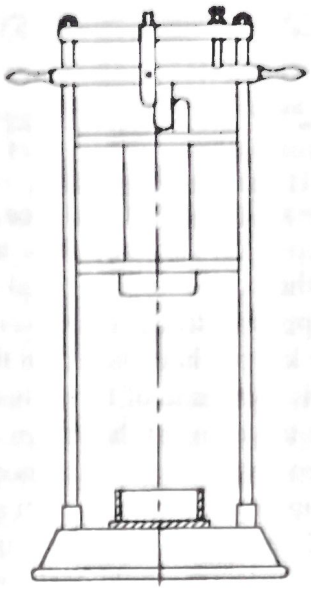
(ii) Crushing strength test.

(iii) Impact test.

water absorption values of aggregates
struction range from less than 0.1% to
naterials used in road surfacing, while
4% may be accepted in base course

hing Strength test : This is a measure
e of an aggregate to crushing under a
d compressive load. The test is normally
aterial dried at 100-110°C for a period
ng a 12.5 mm IS sieve and retained on a
The aggregate is placed in three equal
being tamped 25 times by the tamper
el cylinder 15 cm diameter with a base
nger (see figure below). A load of 40
lly applied to the material over a period
The load is then released and the amount
ng 2.36 mm IS sieve or No. 7 BS-sieve
The mean of the two results to nearest
expressed as a percentage of the total
mple is termed as the aggregate crushing
ality aggregate to be used in base course
ourse should not have crushing value
d 30 respectively.





The test is carried out on the whole of aggregates which passes a 12.5 mm IS sieve and is retained on a 10 mm IS sieve after drying it in an oven for a period of 4 hrs, at a temperature of 100 to 100°C. The test sample is placed in the cup and compacted by a single tamping of 25 strokes of the taping rod, the hammer is so raised that its lower face is 380 mm above the upper surface of the aggregate in the cup. The hammer is allowed to fall freely over the aggregate for a total of 15 blows. Each being delivered at an interval of not less than one second. After impact the mean of the two materials passing 2.36 mm IS sieve is calculated to the nearest whole number and is expressed as percentage of the total weight of the original sample. A good quality aggregate to be used in base course and surcacing course should not have impact value more than 45 and 30 respectively.

(c) Describe the different types of cutback bitumens.

Ans. The Cutback Bitumens can be divided into following three types :

(i) Slow Curing (S.C.)

(ii) Medium Curing (M.C.)

(iii) Rapid Curing (R.C.)

(i) Slow Curing Cutback : They are manufactured by either blending bitumen with boiling point gas oil, or by controlling the rate of flow and temperature of crude during the first cycle of refining.

Since the slow curing cutbacks contain volatile oils, therefore, they are liable to remain liquid inor on the raodway, for a relatively long time after being applied. Thus, the binding strength developes at a comparatively slow rate. It is because of this reason that the slow curing cutbacks are best used with dense graded aggregate which provide a strong interlocking framework and do not require immediate, strong, cementing action from the binder. They should never beused as a binder for open graded road surfacings. They are also used on the surface of soil aggregate road in warm climates to prevent dust nuisance.

Slow curing cutbacks are available in six grades viz. 0 to 5 depending upon their consistency. They are designated as S.C-0, S.C-1, S.C-2, S.C.-3, S.C.-4, and S.C--5. Recently in United States these grade have been revised on the basis of Kinematic Viscosities of the mixture.

(ii) Medium Curing Cutback : These are manufactured by fluxing 100/300 penetration grade bitumen with a petroleum distilate e.g. kerosene or with a cold tar cresote oil or Antheracene oil, or with a mixture of these. They are generally considered the most practical for use in bituminous stabilisation of soil. It is possible to effectively coat the fine graded aggregate and sandy sooils with medium curing cutback.

(iii) Rapid Curing Cutback : They are prepared by diluting a suitable penetration grade bitumen with a very volatile petroleum distillate e.g. Gasoline or Naptha. They are used when a quick change back to the residual semi-solid binding agent is desired.

They have relatively low flash points which render their use hazardous, particularly when the very viscous grades which may have to be heated before admixing are used in road construction.

3. (a) Define W.B.M.

Ans. W.B.M. : The Water Bound Macadam roads were considered to be one of the superior methods of construction until the fast moving vehicles started using these road. Dust is formed on the road surface during dry weather due to the crushing and abroading action of steel-tyred animal drawn vehicles. Under the combined action of the mixed traffic and under adverse weather conditions and WBM roads could not last long.

(b) Determine the absolute minimum radius and ruling minimum radius for minimum value of super-elevation of horizontal curve for a design speed of 50 kmph.

Ans. The fundamental equation of the horizontal curve is $e + f = V^2 / 126\ Rm$.

where, absolute minimum radius 'Rm' can be determined by taking the maximum value of superelevation 'e' as 1 in 15 or 0.067 and co-efficient of lateral friction 'f' as 8.15.

$$\therefore\ 0.067 + 0.15 = \frac{50^2}{126\ Rm} = 0.217$$

or, $Rm = 2500/126 \times 0.217 = 90.75$ m.

For designing a new highway horizontal curve the ruling minimum radius is calculated by increasing the design speed by 16 kmph.

Therefore, fundamental equation for the horizontal curve becomes, $e + f = (V + 16)^2 / 126\ Rr$.

$$\text{or, } 0.067 + 0.15 = \frac{(50+16)^2}{126\ Rr} = 0.217$$

or $0.217\ Rr = 66 \times 66 / 126$

or $Rr = 66 \times 66 / 126 \times 0.217 = 158.42$ m.

(c) Write short notes on :

(i) Mechanical Stabilization.

(ii) Lime Stabilization.

(iii) Cement Stabilization.

(iv) Fly ash Stabilization.

Ans. (i) Mechanical Stabilization : The mechanical stabilization means the improvement of the stability or bearing power of the soil by the use of controlled compaction, proportioning and the addition of suitable admixture or stabilizer.

(ii) Lime Stabilization : Lime stabilization is a widely used means of chemically transforming unstable soils into structurally sound construction foundations. Lime stabilization is particularly important is road construction for modifying subgrade soils, sub-base materials and base materials. The improved engineering characteristics of lime-treated materials provide important benefits to both portland cement concrete and asphalt pavements.

(iii) Cement Stabilization : It is the improvement of a soil or pavement material usually through the addition of a binder or additive. The use of stabilization means that a wider range of soils can be improved for bulk fill applications and for construction purposes. The most common method of stabilization involves the incorporation of small quantities of binders. Such as cement, to the aggregate.

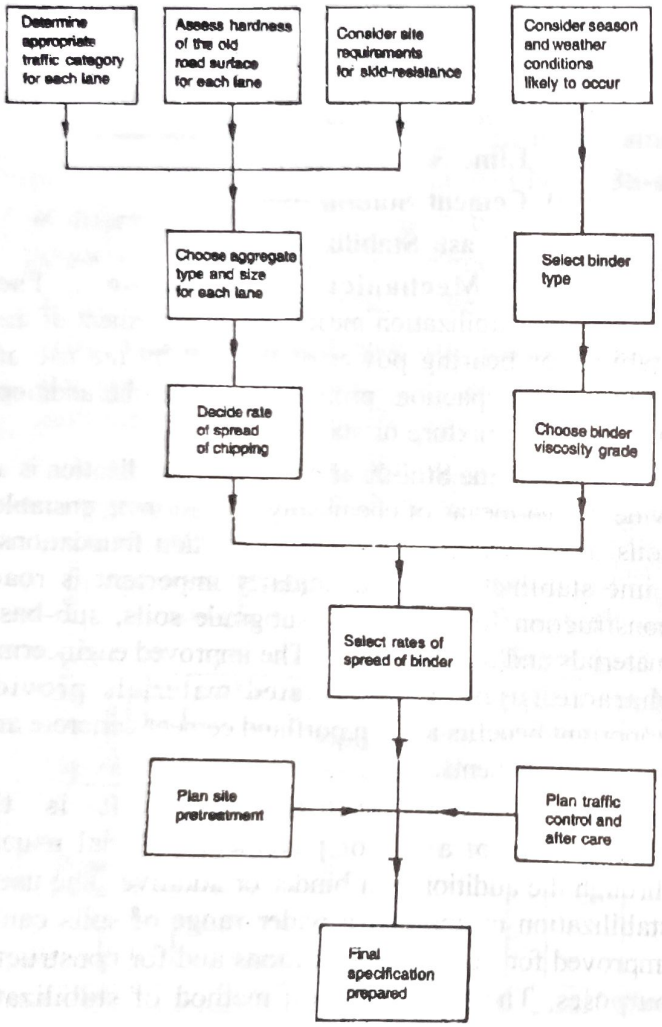
(iv) Fly ash Stabilization : Stabilization of soil and pavement bases with soil fly ash is an increasingly popular option for design engineers. Fly ash stabilization is used to modify the engineering properties of locally available materials and produce a structurally sound construction base. Both nos self-cementing and self-cementing coal ash can be used in stabilization application.

4. (a) Define Fly ash Stabilization.

Ans. Fly ash Stabilization : Stabilization of soil and pavement bases with soil fly ash is an increasingly popular option for design engineers. Fly ash stabilization is used to modify the engineering properties of locally available materials and produce a structurally sound construction base. Both nos self-cementing and self-cementing coal ash can be used in stabilization application.

(b) Draw the flow diagram for the planning and surface specification dressing.

Ans.



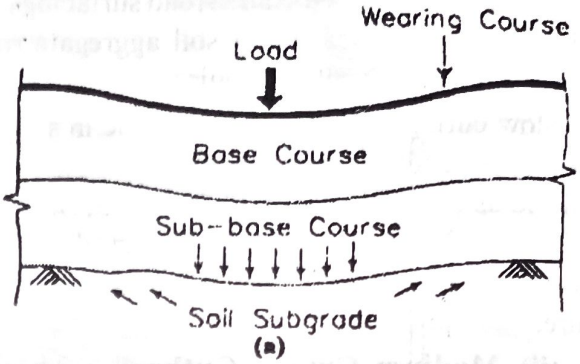
(c) State the causes of Flexible pavements with neat sketches.

Ans. Causes of Failure of Flexible Pavement :

The failure of flexible pavements is defined as the localized depression and heaving up in its vicinity.

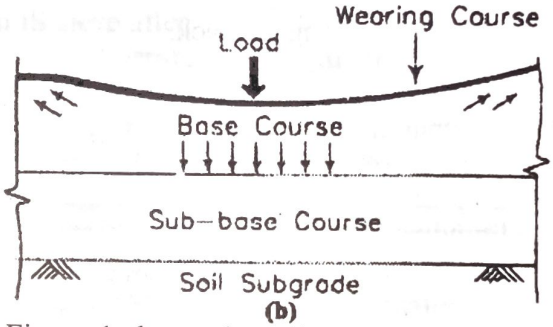
The sequence of depression and heaving up develops a wavy surface of the pavement.

The settlement of any of the component layer of the flexible pavement develops waves and corrugations or longitudinal ruts and shoving on the pavement surface.



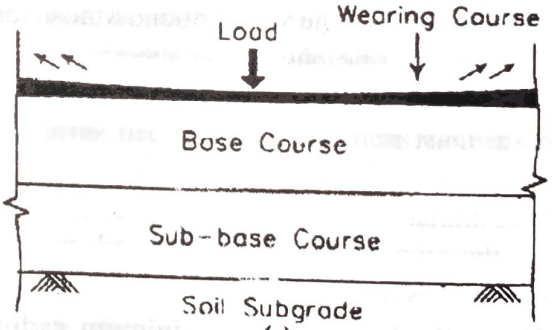
(a)

The excessive unevenness of the pavement surface may itself be considered as a failure. Thus to make a pavement durable and maintain its stability, each layer should be stable. Figure below illustrates the above concept of failure in flexible pavement.



(b)

Figure-1 shows the failure due to subgrade soil, figure-2 shows failure due to base course and figure-3 shows failure due to wearing course. The failure of sub-grade may be attributed due to the following causes.



(c)

1. Inadequate stability :

The inadequate stability of the sub-grade may be attributed due to the following factors.

(i) Inherent weakness of the soil itself.

(ii) Excessive moisture in the sub-grade.

(iii) Inadequate compaction of the sub-grade.

2. Excessive stress application :

The excessive stress application is due to the application of more load than designed or provision of inadequate thickness of pavement. The deformation of sub-grade soil increases with increase in number of load repetitions.

5. (a) Define Landscaping and arboriculture.

Ans. Landscaping

Arboriculture : The highly engg. with his inherent ingenuity and patience can achieve wonderful results with only small cost to beautify the road.

Road arboriculture is one of the architectural effect, which adds to the general or overall appearance of the road. Arboriculture means free culture, that is care and planting of trees.

(b) Write short notes on :

(i) Power shovel.

(ii) Dredgers.

Ans. (i) Power Shovel : It is used to excavate earth of all classes except rock and load it into wagons. They are mounted on crawler tracks. It consists of a mounting, cab, boom, dipper stick, dipper and hoist line. It can effectively excavate earth from a lower level to where it stands and when the depth of the face to be excavated is not too shallow.

(ii) Dreadgers : These are the equipments used for the excavation of the bed of a river, lake or sea for the purpose of deeping. They are of following three types : (i) Dipper (ii) Ladder, and (iii) Suction.

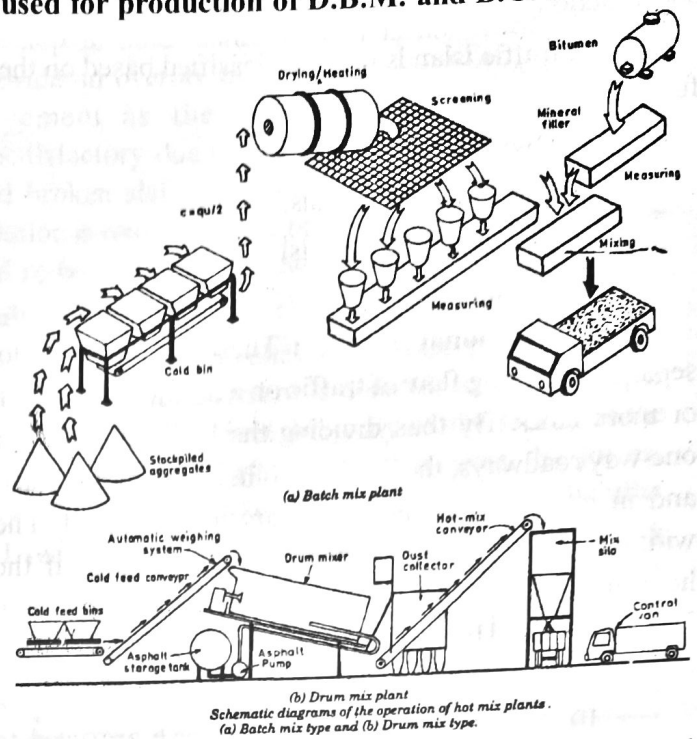
Dipper dredgers excavate all types of underwater soil and discharge the loaded bucket either on the bank or on a floating vessel. These dredgers can excavate up to 50 cu.m/hr. They can operate up to 20 m depth and has a range up to 35 m.

Ladder dredger is comprised of a bucket elevator mounted one vessel. The bucket when dipped into the soil is lifted with the help of belting. The bucket in the lifted position discharges into the hopper at the top of the elevator from which another system of belt conveyor discharges the material into standing vessel.

Suction dredger is a heavy duty pump mounted on a vessel. The suction line is supported by means of a ladder up to the river bed. The pumped material is conveyed with the help of discharge up to a distance of 3 m and heights of 30 m.

(c) Explain the working procedure with a neat sketchmetic plan view of a "Hot Mix Plant" used for production of D.B.M. and B.C.

Ans. Working procedure of a 'Hot mix plant' used for production of D.B.M. and B.C. :



Schematic diagrams of the operation of hot mix plants. (a) Batch mix type and (b) Drum mix type.

A schematic diagram of the working of a typical drum mix plant is shown in figure. Recently, there have been a number of modifications in the conventional design of a Drum Mixer, making its use more popular in comparison to a batch mixing plant, the main advantages being savings in energy and reduced pollution.

Hot-mix plants of various capacities are covered by an Indian Standard. The capacities are :

20 – 30 T/hour

30 – 45 T/hour

40 – 60 T/hour

60 – 90 T/hour

80 – 120 T/hour

6. (a) Define Texturing and separation membrane.

Ans. Texturing : Road surface textures are deviations from a plan and smooth surface, affecting the vehicle/tyre interaction.

Separation membrane : A layer of separation membrane is normally placed between sub-base and concrete slab. It prevents the loss of water from cement paste which affects the strength of concrete slab.

(b) What do you mean by Traffic Islands and classify it ?

Ans. Traffic Islands : Traffic Islands are raised areas constructed within the roadway to establish physical channels through which the vehicular traffic may be guided. Traffic islands often serve more than one function.

The traffic islands may be classified based on the function as :

(i) Divisional islands.

(ii) Channelizing islands.

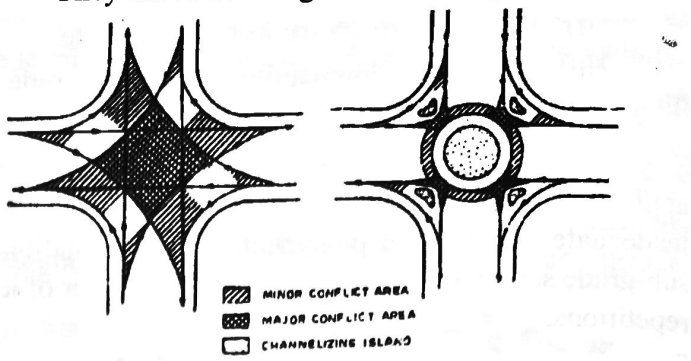
(iii) Pedestrian loading islands.

(iv) Rotary islands.

(i) Divisional islands : These are intended to separate opposing flow of traffic on a highway with four or more lanes. By thus dividing the highway into two one-way roadways, the head-on collisions are eliminated and in general other accidents are also reduced. The width of the divisional islands should be large if the head light glare is to be reduced during night driving. The kerb should be high enough to prevent vehicles from entering into the islands.

(ii) Channelizing islands : These are used to guide the traffic into proper channel through the intersection area. Channelizing islands are very useful as traffic control devices for intersection at grade, particularly when the area is large. The size and shape of the channelizing islands will very much depend upon the layout and dimensions of the intersections. Considerable professional experience and skill is required for the successful design of channelizing islands. If the islands are not properly designed and place, there is a possibility of violation of rules be the traffic resulting in greater hazards. The various uses of properly designed channelizing islands are listed below.

- The area of possible conflicts between traffic stream is reduced. This is illustrated in figure below. By introducing channelizing islands both the major and minor conflict areas are reduced.
- They establish the desired angles of crossing and merging of traffic streams.
- They are useful when the direction of the flow is to be changed.
- They serve as convenient locations for other traffic control devices.
- They serve as refuge islands for pedestrains.



(a) Area of conflict without channelizing island *(b) Area of conflict with channelizing islands*

Fig. Conflict Areas

The design and functions of rotary islands, has been discussed in detail in under traffic rotary.

(iii) Pedestrian loading islands : These are provided at regular bus stops and similar places for the protection of passengers. A pedestraian island at or near a cross walk to aid and protect pedestrian crossing the carriageway may be termed as pedestrian refuge islands. For crossing multilane highways, pedestrian refuge island after two or three lanes would be desirable. The area in the roadway adjacent to the kerb which is kept reserved for use by stopped bus may be called a bus kerb loading zone.

(iv) Rotary islands : It is the large central island of a rotary intersection, this island is much larger than the central island of channelized intersection. The crossing manoeuvre is converted to weaving by providing sufficient weaving length.

(c) Explain briefly sub-surface and surface drainage system is highways with skethes.

Ans. Refer to Model - 1, Q. No. 5.(c)

7. (a) Define right of way.

Ans. Right of way is the area of land acquired for the road along its alignment. It depends on the importance of the load and possible future development.

(b) Discuss the maintenance procedures of cement concrete roads.

Ans. Maintenance Procedures of Cement Concrete Roads : It may be stated here that very little maintenance such as maintenance of joints only is needed for cement concrete roads, if they are well designed and constructed. Main defect in this type of road is formation of cracks. It is therefore necessary to examine the cracks and causes are ascertained before any remedial measure is adopted. Various types of cracking have been explained in earlier.

Treatment of Cracks :

The cracks developed in cement concrete (CC) may be classified into two groups :

(i) *Temperature cracks,* which are initially fine cracks or hair-cracks formed across the slab, in between a pair of transverse or longitudinal joints, dividing the slab length into two or more approximately equal parts due to the temperature stresses like the shrinkage stress, warping stress, etc. in the slab.

(ii) *Structural cracks* formed near the edge and corner regions of the slabs, due to combined wheel load and warping stresses in the slab.

The presence of fine cracks only as such are not harmful and do not call for immediate maintenance. As the cracks due to the shrinkage in the CC pavement start from the bottom of the slab, by the time fine cracks are visible onthe top of the slab, the cracks at the bottom portion would have got widened. Due to repeated application of heavy wheel loads and the variations in temperature and moisture conditions, the cracks get widened and further deterioration becomes rapid. Once the surface water starts getting into the pavement and the subgrade through the widened cracks, progressive failure or the pavement is imminent. Therefore before these cracks get wide enough to permit infiltration of water, they should be sealed of to prevent rapid deteriorations.

The dirt, sand and other loose particles at the cracks are thoroughly cleaned using a sharp tool, stiff brush and pressure blower. Kerosene oil is applied on the cleaned cracks to facilitate proper bonding of the sealing material. The cracks are then filled by suitable grade bituminous sealing compound, heated to liquid consistency. The sealer is placed upto about 3 mm above the level of the slab along the cracks and a layer of sand is spread over it to protect the sealer temporarily.

The formation of structural cracks in CC slabs should be viewed seriously and needs immediate attention, as these indicate possible beginning of pavement failure. First the cause of the failure should be investigated. If the failure is confined to one or a few slab only at a particular location, and in general there are no structural cracks in other slabs, the failure may be localized one due to some weak spot in the subgrade or due to localized settlement of embankment or underground drainage problem. The maintenace work in such a case involves first remedy of the basic cause of the failure and then re-casting the failed slabs. In the case of general pavement distress indicating the start of structural failure of the pavement, immediate steps are to be taken to strengthen the CC pavement by a flexible or rigid overlay experitiously before the structural cracks develop in other slabs also. It is not worth while to provide an overlay over a badly cracked or failed CC pavement as the riding surface becomes very unsatisfactory due to uneven settlement of the cracked and broken slabs. In such a case the only permanent solution is removal of the broken-up CC pavement slabs and re-construction of new flexible or rigid pavement.

Maintenance of Joints :

Joints are the weakest parts in CC pavements. The efficiency of the pavement is determined by the proper functioning of the joints. Majority of the failure in the CC pavements are observes at or near the joints. Therefore, utmost care is to be taken to see that the filler and sealer materials are intact at the joints. During summer the joint sealer material is squeezed out of the expansion joints due to the expansion of the slabs; subsequently as the slabs contract during winter, the joint gap opens out and cracks are formed in the old sealer material. Therefore, periodic maintenance of the joint sealer is essential both at expansion and contraction joints as a part of routine maintenance work of the CC pavement. The opened-up joints are cleaned with brush and refilled with suitable joint sealer material before the start of the rains.

The joint filler material at the expansion joints may get damage or deteriorated after several years of pavement life. The repair consist of removal of the sealer and deteriorrated riller and sealer materials from the expansion joints cleaning up, replacement with new filler board (provided with suitable grooves cut on the bottom half at the positions of the dowel bars) and sealing the top of the joints with suitable sealer material. It will be convenient to insert the new filler board at the expansion joints during winter season when the joint opening is widest.

(c) Explain the construction procedures of embankment.

Ans. Construction of Embankment : The embankment may be constructed either by rolling in relatively thin layers or by hydraulic fills. The former is called rolled-earth method and is preferred in highway embankments. Each layer is compacted by rolling to a satisfactory degree or to a desired density before the

next layer is placed. Compaction is carried out at optimum moisture content so as to take advantages of maximum dry density using a specified compacting effort and equipment. The thickness of the layers may vary between 10 and 30 cm depending on various factors such as soils type, equipment, specifications etc.

The practice of dumping the earth without compacting properly and allowing the fill to get consolidated under weather during few subsequent season should be avoided as the settlement will continue for a very long period. If pavement is constructed before the settlement of the fill is almost complete, the pavement is likely to become uneven and also fail later-on.

Preparation of Subgrade : The preparation of subgrade includes all operations before the pavement structure could be laid over it and compacted. Thus the preparation of subgrade would include site clearance, grading (embankment or cut section) and compaction.

The subgrade may be suited on embankment or excavation or at the existing ground surface. In all the cases, site should be cleared off and the top soil consisting of grass, roots rubbish and other organic matter are to be removed. Next, the grading operation is started so as to bring the vertical profile of the subgrade to designed grade and camber. Bull dozers, scrapers and blade graders are useful equipment to speed up this work. It is most essential to compact the top of subgrade, upto a depth of about adequately before placing the pavement layer.

Soil Compaction : By compaction of soil, the particles are mechanically constrained to be packed more closely, by expelling part of the air voids. Compaction increases the density and stability, reduces settlement and lowers the adverse effects of moistuer. Hence proper compaction of fills, subgrade, sub-base and base course are considered essential for proper highway construction.

The various factors influencing soil compaction include the moisture content, amount and type of compaction, soil type and stone content. It is a well known fact that there is an optimum moisture content (OMC) for a soil which would give maximum dry density for a particular type and amount of compaction. Hence it is always desirable to compact the soil at the OMC after deciding the compacting equipment.

MODEL – 3

[CET - 502]

Full Marks – 70 **Time – 3 Hours**

*Answer any **five** questions.*

Figures in the right-hand margin indicate marks.

1. (a) Mention two functions of CRRI (Central Road Research Institute). [2
   (b) Mention differences between Flexible Pavement and Rigid Pavement. [5
   (c) With a neat sketch, describe methods of providing super-elevation. [7
2. (a) What do you mean by CBR Test ? [2
   (b) Discuss about the different bituminous emulsions and its uses. [5
   (c) Describe Bituminous macadam. [7
3. (a) What is D.L.C. ? [2
   (b) Define gradients. Describe different types of gradients. [5
   (c) Describe water bound macadam. [7
4. (a) Differentiate premix carpet and semidense carpet. [2
   (b) How to prepare bituminous concrete ? [5
   (c) Discuss the different rigid pavement deficiencies. [7
5. (a) What is MART ? [2
   (b) Explain briefly sub-surface and surface drainage system is highways with skethes. [5
   (c) Write short notes on : [7
      (i) Mechanical Stabilization.
      (ii) Lime Stabilization.
      (iii) Cement Stabilization.
      (iv) Fly ash Stabilization.
6. (a) Define Landscaping and arboriculture. [2
   (b) Describe the different types of Traffic signal system. [5
   (c) What is the necessity of Embankment ? Discuss the different characteristics. [7

7. (a) Define P.Q.C. [2

(b) Explain briefly different road characteristics. [5

(c) With neat sketch explain the different equipments used for subgrade preparation. [7

ANSWERS TO MODEL – 3

1. (a) Mention two functions of CRRI (Central Road Research Institute).

Ans. Two functions of CRRI are :

- To develop labour intensive methods and manual aids for construction of low-cost all weather roads.
- To develop appropriate machinery, tools, equipments and instruments for adopting technologies as related to highway engineering and as relevant to the country to achieve indigenous self-sufficiency.

(b) Mention differences between Flexible Pavement and Rigid Pavement.

Ans. The major differences between the type f pavements can be tabulated below :

Flexible Pavement	Rigid Pavement
1. It consists of a series of layers with the highest quality materials at or near the surface.	1. It consists of one course portland cement concrete slab of relatively high bending resistance.
2. It reflects the deformations of subgrade and subsequent layers on the surface.	2. It is able to bridge over localized failures and areas of inadequate support.
3. Its stability depends upon aggreage interlock particle friction and cohesion.	3. Its structural capcity is supplied by the pavement slab itself by beam action.
4. Pavement design is greatly influenced by the subgrade strength.	4. Flexural strength of concrete is major factor for design.
5. It functions by way of load distribution through the component layers.	5. It distributes load over a wide area of subgrade because of its rigidity and high modulus of elasticity.

(c) With a neat sketch, describe methods of providing super-elevation.

Ans. Methods for Providing Superelevation :

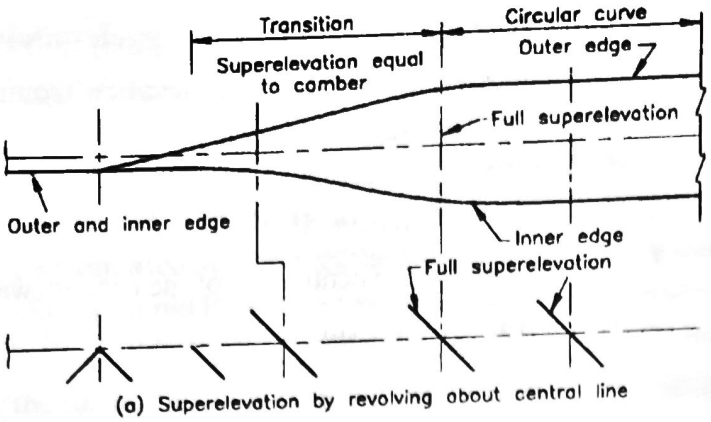
The actual attainment of superelevation requires the carraigeway cross-section be tilted. This tilting of the carriageway can be carried out by one of the following three methods :

1. Rotation about the centre line of the carriageway.
2. Rotation about the outside edge of the carriageway.
3. Rotation about the inner edge of the carriageway.

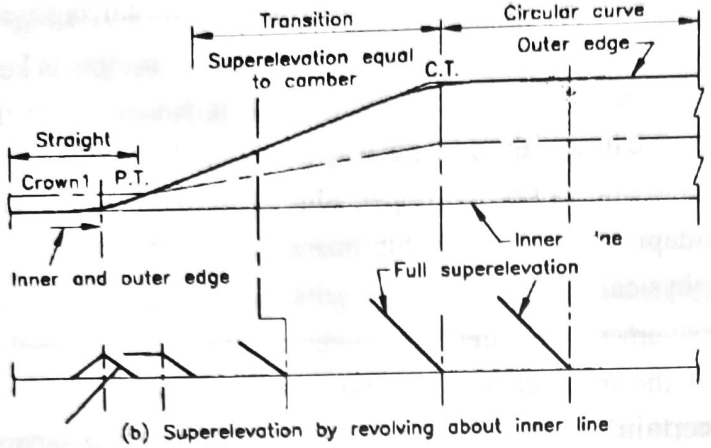
In first method, the level of the centre line is kept constant. The road surface which is rotated abut the centre line of the carriageway gradually lowers the inner edge and raises the upper edge. This method is easily adaptable and applicable in most cases if there are no physical controls. It also results in least distortion of the pavement. This method, however, may result in a valley at the inner edge which might be difficult to drain in certain site conditions. In such sitautions the second method is preferable. In this method the surface of road is rotated about the inner edge. The raises the centre and the other edge. This method is also suitable to avoid encroachment on clearance requirements. The third method in which the surface of the road is rotated about the outer edge depresses the centre and the outer edge. This method should be adopted where overall appearance is the criterion.

The superelevation should be unifomrly attained from the beginning of the transition curve to the end of the transition curve where the circular curve starts so that the full designed value of the superelevation exists at the beginning of the circular curve. Figures show the method of attaining superelevation in each case. Curves of flat radii may not need a transition curve. But such curves might require superelevation greater than the normal camber, if their radii is less than those indicated in table below. In such cases, two-third of the required superelevation should be attained before the start of the circular curve keeping the rate of superelevation run-off 1 in 150 for plain and rolling terrain and 1 in 60 for mountainous and steep terrain.

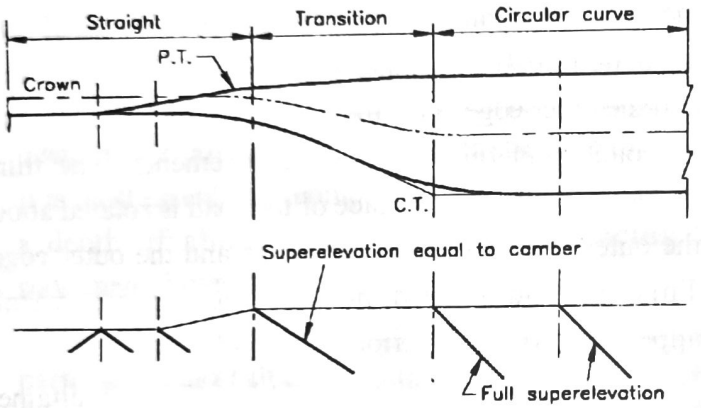
When providing superelevation, no abrupt changes in grade are introduced in longitudinal profile.



(a) Superelevation by revolving about central line



(b) Superelevation by revolving about inner line



(c) Superelevation by revolving about outer line

These shoule be rounded off for smooth riding and to avoid unsightly appearance, by short vertical curves. Such vertical curves should be at least 15 metres in length.

In case of divided carriageways the superelevation can be achieved in the following ways :

- The two carriageways and the median are superelevated as a plane section.
- The median is kept level and the two carriageways are rotated about the edge of the median.
- The two carriageways are separately super-elevated, resulting in the median having its edges at different levels.

2. (a) What do you mean by CBR Test ?

Ans. CBR Test : The most well known California Bearing Ratio method of flexible pavement design is based on an arbitrary soil strength test which is a penetration test known as CBR test.

(b) Discuss about the different bituminous emulsions and its uses.

Ans. Bitumen Emulsion : An emulsion is a mixture of two immiscible liquids. The liquid which is dispersed is often called the internal phase while the surrounding liquid is known as the external phase. The mixing is done in the presence of an emulsifying agent such as resion or soap which help in mixing the two liquids. Generally bitumen emulsions are of two types. In the first type minute globules of bitumen are dispersed in water. The second type consists of a bitumen water mixture in which up to about 10% water forms the dispersed phase and cutback bitumen is the continuous phase. This type is also known as inverted emulsion.

Emulsifiers used in the preparation of bitumen emulsions can be either anionic or cationic emulsifiers. Emulsions are manufactured by mixing water, bitumen and the emulsifying agent in either colloid mill or a high speed mixer. Anionic road emulsionscan be classified as :

(i) Labile emulsions.

(ii) Semi-stable emulsions.

(iii) Fully stable emulsions.

(i) Labile emulsions : These emulsions contain only a minimum amount of emulsifiers, therefore, they break down rapidly on application. They are not suitable for mixing with aggregates but are used for surface dressing, tack coating, grouting and concrete curing purposes. These emulsions cannot be stored in cold weather because they break on freezing and do not redisperse on thawing.

(ii) Semi-stable emulsions : This type of emulsions contain sufficient amount of emulsifiers to permit mixing with certain grades of aggregate before breakdown occurs. They are used for retreading of old road surfaces.

(iii) Fully stable emulsions : These types of emulsions have sufficient mechanical and chemical stability for all purposes involving mixing with aggregates. They are particularly useful for winter road works because they can be frozen and thawed without any appreciable breakdown.

Cationic emulsions are used in the following instances :

(i) Tack coating purposes.

(ii) Coating we aggregates.

(iii) To seal gravel surfaces before applying surface dressing.

The following factors influence the breakdown in case of bitumen emulsions.

(i) Rate of evaporation of water.

(ii) The physico-chemical reaction between the aggregate and the emulsion.

(iii) The absorption qualities of the surface being covered.

(iv) The amount of mechanical disturbance applied during compaction.

(c) Describe Bituminous macadam.

Ans. Bituminous Macadam : This consists of a single construction 5 cm or 7.5 cm thick compacted crushed aggregates premixed with a bituminous binder. This type of construction utilizes quite flexible gradation control and provides an economical and strong base course.

It has been established that a thinner section of bitumen bound macadam is equivalent to a thicker section of WBM or gravel base course section. This is because of the fact that the load distribution through the bitumen bound macadam is comparatively on a wider area and the surface is more resistant to deformation.

Bitumen bound macadam can be used advantageously in snow bound hilly terrain, regions of high ground water table and in areas where medium type of aggregates are available.

Construction Procedure : Bitumen bound macadam should be laid during dry weather only. Before actual construction, the base should be prepared, shaped and conditioned to a specified grade and cross-section. The prepared surface should be thoroughly cleaned and made free from dust.

Materials : The various binders used are : straight run bitumen, road tar, cut back or emulsion.

The straight-run bitumen grade 30/40 or 60/70 or 80/100 is chosen depending upon the climatic conditions. The quantity off the bitumen needed depends upon the grading adopted in the design.

The crushed store aggregates to be used should be clean, strong, durable, cubical in shape, hydrophobic, low porosity and free from organic and other deleterious matters. The various physical requirements of aggregates should be as shown below :

Los Angeles Value	less than 35%
Aggregates impact value	less than 30%
Flakiness index value	less than 25%
Stripping	less than 25%
Water absorption	less than 1%

The aggregate gradings both for 7.5 cm and 5 cm thick bituminous macadam should conform to the followings.

The binder content for premixing generally varies from 3 to 4.5% for grading I and grading II and 3.5 to 6% for grading III. As per Asphalt Institute classification 5 cm and 7.5 cm bitumen bound macadam falls under open mix type category. Marshall and Hubbard field methods of mix design are considered unsuitable for such type of mixes. Even though the Hveem's method is listed as doubtful by the Asphalt Institute for this type of mixture. This method of mix design is adopted for determination of optimum bitumen content to obtain the laboratory mix design.

It is essential to lay a tack coat over the base before laying bitumen bound macadam construction. The quantity of binder for tack coat should be 5.0 to 7.5 kg per 10 m^2 for bituminous base and 7.5 to 10 kg per 10 m^2 for untreated WBM layer.

Preparation of Mix : In a hot mix plant the bitumen and aggregates are separately heated to a temperature in the range of 155-163°C and 150 - 177°C respectively. At no time the difference in temperature between the aggregates and bitumen shuld exceed 14°C.

The mixture is so thorough that a homogeneus mixture is obtained in which all particles of the aggregates are coated uniformly. The mixture is carried to the site through vehicle or a wheel borrow figure shows a typical layout of batch plant which is used for manufacture of bituminous mixed. This can be erected and put into operation within a few days and are capable of easy change from manufacturing one bituminous mix to another. For small work and in places where mixing plant is not available hand-operated drum mixer should be used.

3. (a) What is D.L.C. ?

Ans. D.L.C. : Dry clean concrete is the concrete with high water content is considered lean because it has a lower concentration of cement compared to other kinds of paving and building materials of that class. It is often used as a plaster between bricks or other pieces of infrastructure to create a light seal. Lean concrete cracks over time when it is not applied properly or mixed to the right specifications. Lean concrete is commonly used in road construction as the lowest level under the pavement on which vehicles travel.

(b) Define gradients. Describe different types of gradients.

Ans. Gradients : It may be defined as the rate of rise or fall along the length of highway. It depends upon the nature of traffic, nature of country and the type of surfacing material. It can be classified into following three categories :

(i) Ruling Gradient : It is a gradient which in the normal course must never be exceeded in any part of a road. In other words it is the permissible design gradient such that the tractive effort of vehicles can counteract the tractive resistance without much fatigue in case of animal drawn vehicle and without uneconomic consumption of petrol in case of power driven vehicles.

(ii) Limiting Gradient : It is a gradient sleeper than the ruling gradient which may be used in restricted length where keeping within the ruling gradient is not feasible.

(iii) Exceptional Gradient : It is a gradient steeper than the limiting gradient which may be used in short stretches only in extra-ordinary situations.

The Indian Roads Congress has recommended the followoing values of maximum gradients.

(c) Describe water bound macadam.

Ans. Water Bound Macadam Roads : In India water bound macadam has been the most popular base course material. Macadam construction means the base course made of crushed or broken aggregates bound together by the action of rolling water bound macadam construction. It should consist of clean, crushed or broken aggregate mechanically interlocked by rolling, and bonded together with screenings binding material, where necessary and water, laid on a prepared subgrade, sub-base, base or existing pavement as the case may be. Generally, WBM is constructed in thickness ranging between 8 cm to 30 cm. The camber provided for WBM surface ranges between 1 in 36 to 1 in 45.

Materials : Aggregates used in water bound macadam have the following major characteristics viz. strength, shape, surface texture, size and grading. These aggregates should be either crushed or broken stone, crushed slag, overburnt brick aggregates, naturally occuring aggregates such as kankar or laterite.

Crushed or broken stones should be hard, durable and free from excess of flat, elongated, soft and dis-integrated particles, dirt and other objectionable matters. Crushed slag should be of angular shape, uniform inquality and density and free from thin elongated and soft pieces, dirt or other objectionable matters. Crushed slag should have unit weight of more than 1120 kg/m^3. Brick aggregates should be of overburnt brick bats and be free from dust and other foreign matter. Kankar should be tough and should not contain any clay in the cavities between nodules.

In order to fill the voids in the coarse aggregate generally screenings of the same materials as that of the coarse aggregate are used. In case of soft aggregates such as brick metal, kankar and laterite screenings may not be necessary. In certain cases moorum or gravel having liquid limit and plasticity index below 20 and 6 respectively may be used in place of screenings.

The 12.5 mm and 10 mm screenings size gradation are suitable for coarse aggregate grading 2 and coarse aggregate grading 3 respectively.

Construction : Before starting the actual construction, it is necessary to stack the aggregate in the form of stockpiles along the side of the roadway. Generally 20% extra broken stone on volume basis are

stacked. Therefore, quantity of aggregate required for one kilometre length per metrre width and for one centrimetric thickness.

$= 1.2 \times 1000 \times 1 / 100 = 12$ cubic metres.

Generally, 30 m^3 screenings are also required per 100 m^2 area.

The subgrade or sub-base or base on which the WBM is to be constructed should be prepared to the specified grade and camber. The prepared base must be free of dust and ruts, if any.

The coarse aggregates are spread uniformly upon the prepared base from the stock piles, such that the thickness of compacted layer does not exceed 7.5 cm. Quantifies for 7.5 cm compacted thickness and 10 m^2 surface area of WBM road.

4.(a) Differentiate premix carpet and semidense carpet.

Ans. The differences are :

Premix Carpet	Semidence carpet
• The premix carpet (PMC) is not at all suitable for roads especially streets in towns. This is used in developed countries primarily for road safety, the bitumemn content, which provides thick bitumen film around the aggregate particles.	• A dense asphaltic conc. is very costly specifications for mix-design, aggregates gradation, binder, content and stability. While this specification undoubtedly yields returns for the investment. At the same time, the aurhorites may feel that an open-textured surface such as a 20mm chipping carpet may not be meeting the requirements of traffic & climte.

(b) How to prepare bituminous concrete ?

Ans. Construction Proceduce of Bitumious Concrete : It should be laid during dry weather conditions only.

Materials :

(i) Binder : The straight-run bitumen grade 30/40 or 60/70 or 80/100 is chosen depending upon the climatic conditions. The quantity of bitumen needed varies from 5.0 to 7.5% by weight of mix.

(ii) Coarse Aggregates : The crushed coarse aggregates to be used should be clean, strong, durable, cubical in shape, hydrophobia, of low porosity and free of organic or other deleterious matters. The physical requirements of the aggregates should conform to the one described for bitumen bound macadam.

(iii) Fine Aggregates : The aggregates (Passing 2.36 mm sieve and retained on 0.75 mm sieve) should be clean, hard, durable, uncoated, dry, and free from soft, or flaky pieces and organic or deleterious matters.

(iv) Filler. The filler (passings 600 micron sieve) should be an inert material e.g., stone dust, cement, hydrated lime, flyash or other non-plastic matter.

(v) Gradation of Aggregates : The combined grading of mineral aggregates and filler should conform to any of the two gradings given below :

Sieve Size	Percent by Weight Passing the Sieve	
	Grading I	Grading II
20mm	–	100
12.5 mm	100	80 – 100
10 mm	80 – 100	70 – 90
4.75 mm	55 – 75	50 – 70
2.36 mm	32 – 50	35 – 50
600 micron	18 – 29	18 – 29
300 micron	13 – 23	13 – 23
150 micron	8 – 16	8 – 16
75 micron	4 – 10	4 – 10

Generally, for compacted layer thickness of 25-40 mm any of the two gradings could be used but for layer thickness of 40-50 mm only grading No. 2 should be used. While the laboratory mix design gives the proportion of mineral aggregates and binder, the blending of the materials at the plant to produce the required gradation is achieved by the 'Job Mix Formula'. There are two job mix formulae that will be needed in the operation of a hot mix plant, viz. (1) for the cold aggregates feed and (2) for the hot bins. The gradation of the aggregates from the stockpiles is the mix in the laboratory. The gradation of the aggregates from the hot bins after they are sized into various fractions is found out and again another job mix formula is worked out to

blend the materials from the hot bins and the mineral filler. This enables the accurate weighting of material from each bin that should be discharged into the weighing hopper by opening the gates. The permissible variations from the job mix formula should conform to the following limits.

(c) Discuss the different rigid pavement deficiencies.

Ans. Rigid Pavement Deficiencies : The know-how regarding the following different types of rigid pavement deficiencies help in thorough understanding of theoretical principles in the design of rigid pavements.

(i) Buckling Blow up or Tenting : It is localized upward buckling of the slab occurring usually at a transverse crack or joint. It is due to excessive expansion of the slab with insufficient joint from serving its purpose.

(ii) Shattering Blow up : It is localized shattering of the slab occurring usually at a tranverse crack or joint. It is due to excessive expansion of the slab with insufficient joint width, joints fouled with incompressible material preventing the joint from serving its purpose.

(iii) Corner Cracking or Corner Break : It is a break in a pavement at the corner of the slab near the juncture of the transverse joint and longitudinal joint or slab edge. It is due to overloading the pavement slabs at or near the corners, an unstable foundation or voids formed because of loss of foundation material under the slab.

(iv) D Craking : These are series of fine, hairline cresent-shaped cracks in the concrete surface usually paralleling a joint or major crack and usually curving across slab corners. Its causes are still under study but generally attributed to freeze - thaw cycles and peculiar aggregate pore structure.

(v) Longitudinal Cracking : It is a crack or break approximately parallel to the pavement centreline. It is due to lateral contraction, lateral movement and settlement of the roadbed, possibly lateral bending or curling.

(vi) Random Cracking : It is unrestrained or uncontrolled, irregular break or separation of the slab. It is due to overloading of unreinforced concrete slab and, inadequate roadbed support.

(vii) Transverse Cracking : It is a crack or break approximately at right angles to the pavement centreline. It is due to insufficient contraction joints are weakened plane joints and or overloading an upward curled slab having inadequate roadbed support.

(viii) Crazing : These are fine, hairline cracks apparently extending only through the surface layer and tending to intersect at an angle of approximately 120 degrees forming a chicken-wire pattern. It is due to the weak surface of the slab caused by excessive finishing, possible rich mortar in surfacing.

(ix) Curling or Bending or Warping : It is a slab bending. It is due to uneven expansion or contraction of the top and bottom slab surfaces caused by differences in temperature above and below the slab or differences in moisture conditions between these surfaces.

(x) Faulting or Step Off or Step : It is a different vertical displacement of abutting slabs at joints or cracks creating a "step" deformation in the pavement surface. It is due to one slab setting more than the adjacent slab, uneven roadbed support under the slabs, heaving of one of the slabs. Faulting often occurs at the junction of a rigid and a flexible pavement.

(xi) Joint Blast Damage : It consists of joint material softened and blown out of the joint. It is due to heat and blast from jet aircraft moving slowly or standing near a joint.

(xii) Joint Failure : It consists of broken or crushed slab edges. It is due to joints fouled by incompressible materials tending to prohibit slab expansion.

(xiii) Joint Filler Extrusion : It is joint filler protruding above joint edges. It is due to poor adhesion between joint filler and slab edges, too much material in the joint, joint too narrow to take care of slab expansion, improper application of joint filler.

(xiv) Joint Stripping : It is joint filler coming out of the joint. It is due to lack of adhesion to the joint edges, incompatible joints material, contaminated joint edges from previously used joint filler.

(xv) Pumping : It is the ejection of mixtures of water, clay or silt along or through transverse or

longitudinal joints, cracks, or pavement edges. It is due to insufficient support from water saturated bases or roadbeds. When a load is imposed on the slabs, it is depressed on to the satraed material underneath, squeezing the water and fines out through the joints anf cracks or from under the slab.

(xvi) Scaling : It is progressive disintegration and loss of the concrete wearing surface. It is due to eroding of the surface by reaction from de-icing materials, repititive freezing and thawing cycles or weakened surface caused by over-finishing. (See figure)

(xvii) Spalling : It is breakdown or disintegration of slab edges at joints or cracks or directly over reinforcing steel, usally resulting in the removal of sound concrete. It is due to breakdown of pavement joint edges from traffic action and progressive destruction of the surface adjacent to this damage, possibly weakening of this surface caused by over-finishing of the slab at the joint.

5. (a) What is MART ?

Ans. This is the basic requirements of traffic control devices. Such that –

M – Meaning A – Attention

R – Respect T – Time

(b) Explain briefly sub-surface and surface drainage system is highways with skethes.

Ans. Refer to Model - 1, Q. No. 4.(c)

(c) Write short notes on :

(i) Mechanical Stabilization.

(ii) Lime Stabilization.

(iii) Cement Stabilization.

(iv) Fly ash Stabilization.

Ans. (i) Mechanical Stabilization : The mechanical stabilization means the improvement of the stability or bearing power of the soil by the use of controlled compaction, proportioning and the addition of suitable admixture or stabilizer.

(ii) Lime Stabilization : Lime stabilization is a widely used means of chemically transforming unstable soils into structurally sound construction foundations. Lime stabilization is particularly important is road construction for modifying subgrade soils, sub-base materials and base materials. The improved engineering characteristics of lime-treated materials provide important benefits to both portland cement concrete and asphalt pavements.

(iii) Cement Stabilization : It is the improvement of a soil or pavement material usually through the addition of a binder or additive. The use of stabilization means that a wider range of soils can be improved for bulk fill applications and for construction purposes. The most common method of stabilization involves the incorporation of small quantities of binders. Such as cement, to the aggregate.

(iv) Fly ash Stabilization : Stabilization of soil and pavement bases with soil fly ash is an increasingly popular option for design engineers. Fly ash stabilization is used to modify the engineering properties of locally available materials and produce a structurally sound construction base. Both nos self-cementing and self-cementing coal ash can be used in stabilization application.

6. (a) Define Landscaping and arboriculture.

Ans. Arboriculture : The highly engg. with his inherent ingenuity and patience can achieve wonderful results with only small cost to beautify the road.

Road arboriculture is one of the architectural effect, which adds to the general or overall appearance of the road. Arboriculture means free culture, that is care and planting of trees.

(b) Describe the different types of Traffic signal system.

Ans. Types of Traffic Signal System : There are four general types of co-ordination of signals for road network, as listed below :

(i) Simultaneous system

(ii) Alternate system

(iii) Simple progressive system

(iv) Flexible progressive system.

(i) Simultaneous System : In this system all the signals along a given road always show the same indication (green, red etc) at the same time. As the division of cycle is also the same at all intersections, this system does not work satisfactorily.

(ii) Alternate System : In this system, alternate signals or groups of signals show opposite indications in a route at the same time. This system is also operated by a single controller, but by reversing the red and green indicator connections at successive signal systems. This system generally is considered to be more satisfactory than the simultaneous system.

(iii) Simple Progressive System : A time schedule is made to permit, as nearly as possible, a continuous operation of groups of vehicles along the main road at a reasonable speed. The signal phases controlling "Go" indications along this road is scheduled to work at the pre-determined time schedule. The phases and intervals at each signal installation may be different, but each signal unit works as fixed time signal, with equal signal cycle length.

(iv) Flexible Progressive System : In this system it is possible to automatically vary the length of cycle, cycle division and the time schedule at each signalized intersection with the help of a computer. This is the most efficient system of all the four types described above.

Pedestrian signal are meant to give the right of way to pedestrians to cross a road during the 'walk period' when the vehicular traffic shall be stopped by red or stop signal on the traffic signals of the road.

Flashing beacons are meant to warn the traffic. At flashing red signals, the drivers of vehicles shall stop before entering the nearest cross walk at an intersection or at a stop line, when marked Flashing yellow signals are caution signals meant to signify that drivers may proceed with caution.

(c) What is the necessity of Embankment ? Discuss the different characteristics.

Ans. Necessity of Embankment : When it is required to raise the grade line of a highway above the existing ground level it becomes necessary to construct embankments. The grade line may be raised due to any of the following reasons :

(i) To keep the subgrade above the high ground water table.

(ii) To prevent damage to pavement due to surface water and capillary water.

(iii) To maintain the design standards of the highway with respect to the vertical alignment.

The design elements in highway embankments are :

(i) Height (ii) Fill material (iii) Settlement

(iv) Stability of foundation (v) Stability of slopes.

(i) Height : The height of the embankment depends on the desired grade line of the highway and the soil profile or topography. Also the height of the fill is sometimes governed by stability of foundation, particularly when the foundation soil is weak.

(ii) Fill Material : Granular soil is generally preferred as highway embankment material. Silts, and clays are considered less desirable. Organic soils, particularly peat are unsuitable. The best of the soils available locally is often selected with a view to keep the lead and lift as low as possible. At times light-weight fill material like cinder may be used to reduce the weight when foundation soil is weak.

(iii) Settlement : The embankment may settle after the completion of construction either due to consolidation and settlement of the foundation or due to settlement of the fill or due to both. If the embankment foundation consists of compressible soil with high moisture content, the consolidation can occur due to increase in the load. The settlement of the fill is generally due to inadequate compaction during construction and hence by proper compaction this type of settlement may be almost eliminated. Whatever be the type of settlement, it is desirable that the settlement is almost complete before the construction of pavement. To accelerate the

rate of consoliation of saturated foundation clay, vertical sand drains are sometimes constructed. These are vertical columns of sand installed in the compressible foundation like marshy soils in order to decrease drainage path and thus accelerate the rate of consolidation. The vertical sand columns may be of 30 to 60 cm diameter and 2.5 to 6 meter spacing, arranged in a hexagonal pattern. A horizontal sand blanket, 40 to 60 cm thick is placed at the top of the drains extending across the entire width of embankment at its bottom. This helps the water to flow out with ease. Figure below shows typical cross-section of embankment with vertical sand drains.

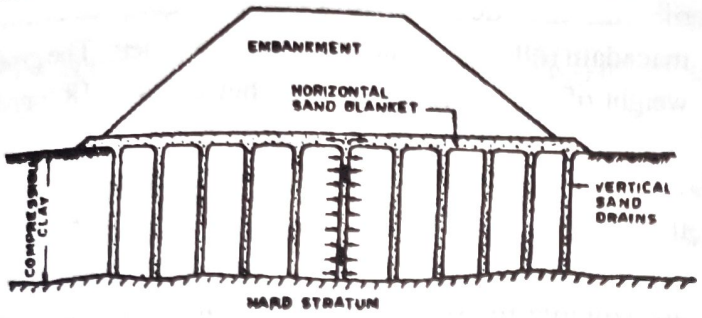


Fig. Embankment with Vertical Sand Drains at Foundation

(iv) Stability of Foundation : When the embankment foundation consists of weak soil just beneath or at a certain depth below in the form of a weak stratum, it is essential to consider the stability of the foundation against a failure. This is all the more essential in the case of high embankments. The foundation stability is evaluatd and the factor of safety is estimated by any of the following approaches :

(i) Assuming a certain failure surface such as a circular arc or any other composite shape and analying it with Swedish circular arc analysis or method of wedges, as the case may be.

(ii) Estimating the average shear stress and strength at the foundation layers by approximate methods and estimating the factor of safety.

(iii) Using theoretical analysis basd on elastic theory.

The factor of safety in the case of compressible soil foundation is likely to be minimum just after the completion of the embankment. Later due to consolidation of foundation and consequent gain in strength there will beincrease in the foundation factor of safty. Thus it is evident that in such compressible foundation soils, the vertical sand drains woule be useful also to increase the rate of gain in strength. By proper design of vertical sand drains, it is possible to limit the decrease in founation factor of safety due to the construction, within the allowable value.

(v) Stability of Slopes : The embankment slopes shouls be stable enough to eliminate the possibility of a failure under adverse moisture and other conditions. Hence the stability of the slope should be checked or the slope should be designed providing minimum factor of safety of 1.5. Often much flatter slopes are preferred in highway embankments due to aesthetic and other reasons.

7. (a) Define P.Q.C.

Ans. P.Q.C. : This is pavement quality concrete that's used for Runway, Expressway, Toll plaza, now and till N.H. for long life about 30 years. It's use where highly temperature variation and vehical tyres take a brake in opposite case Bitumunous pavement in that are may be blud or cracked.

(b) Explain briefly different road characteristics.

Ans. Road Characteristics : They include :

(i) Friction : The friction between tyre and road surface determines :

- Safe speed.
- Stopping distance.
- Starting distance.
- Turning distance.
- Superelevation.
- Skid resistance and slippage.

Skid may be defined as the path travelled along the road surface which is more than the circumferential movement. This happens when the wheels slide without revolving. The skidding is caused due to water, clay, dust, oil and grease on the pavements. Skidding can be of three types :

a. Straight skidding : This occurs in the direction of travel due to sudden application of brakes.

b. Impending skidding : This occurs when the braking is gradual and wheels continue to revolve.

c. Sideway skidding : This occurs on curves where sufficient superelevation is not provided or when the co-efficient of friction is inadequate.

In case of horizontal curves when the centrifugal force is greater than lateral friction, lateral skidding takes place. In order to safeguard against the dangerous lateral skidding, I.R.C. has recommended low value of lateral co-efficient of friction i.e., 0.15. On the other hand, the value of longitudinal friction to be accounted for in the design of horizontal curve is assumed as 0.4.

Slip is known to have occured when the driving wheels of a vehicle revolve more than the longitudinal movement. This occurs on a slippery and wet road surface.

(ii) Hardness and Smoothness. It affects

- The cost of vehicle operation.
- Driver's comfort.
- Driver's safety.

It may be measured by profilographs, unevenness indicator, AASHO profilometer and the CHOLE profilometer. Roughness index is expressed as the cumulative vertical deformation of the surface per unit horizontal length. Its unit is cm/km. based on the roughness index, pavements are classified into following categories :

Pavement Surface Type	Roughness Index cm/km
Good	150
Satisfactory	250
Uncomfortable	> 320

(iii) Light Reflecting Characteristics : The colour of the pavement affects its visibility. Light coloured pavement surface gives better visibility by silhouette and direct vision. The texture of surface determines glare and specular reflection glare by reflection of head light. It is more on the wet pavement surface than compared to dry surface. Dark surfaces provide poor visibility during the nights. Rough textured and well drained surface reduces specular reflection.

(iv) Surface Slope : The ability to drain off the surface determines the camber required.

(c) With neat sketch explain the different equipments used for subgrade preparation.

Ans. Compacting Equipment : Soil compaction is achieved in the field either by rolling, ramming or by vibration. Hence the compacting equipment may also be classified as rollers, rammers and vibrators. Compaction of sands are also achieved by watering ponding and jetting.

Rollers : The principle of rollers is the application of pressure, which is slowly increased and then decreased. The various type of rollers which are used for compaction are smooth wheel, pneumatic tyred and sheepsfoot rollers. Further the construction equipment such as truckes, tractors and bulldozers also help in compaction of the materials to some extent.

Smooth Wheeled Rollers : There are two types of smooth wheeled rollers, one three-wheeled or macadam rollers, and the other tandem rollers. The gross weight of the former type range beween 4 to 18 tonnes whereas that of the latter type with two axles varies between 1 to 14 tonnes. The compacting efficiency of the smooth wheeled roller depends on the weight, width and diameter of each roller. The smooth wheeled rollers are suitable to roll a wide range of soils, preferably granular soils and pavement materials for the various layers. These are particularly found to be useful in compacting soils and other materials where a crushing action is advantageous.

Pneumatic Tyred Rollers : In this type number of pneumatic wheels are mounted on two or more axles, under a loading platform. These rollers are pulled by tractors. The pneumatic tyred rollers are considered to be most suitable to compact non-plastic silts and fine sands. In addition to the direct pressure due to rolling, there is also a slight kneading action. The mechanics of compaction by pneumatic tyred rollers is illustrated in figure below.

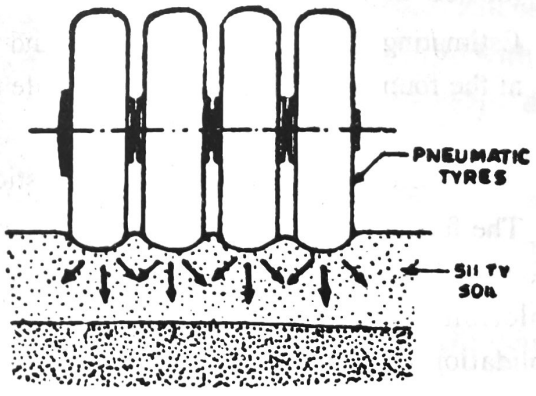


Fig. Compaction by Pneumatic Tyred Roller

Sheepsfoot Roller : This types of roller consists of hollow steel cylinder with projecting feet. The weight of the roller can be increased by filling the drum with wet soil. The weight, diameter and width of the roller may be varied and also the shape and size of the feet. These may be pulled by tractors. The efficiency of the sheepsfoot rollers depends on the weight of the roller and the number of feet in contact with the ground at a time. Sheepsfoot rollers are considered more suited to compact clayey soils. During rolling operations the soil under the projecting feet get compacted and also there is a considerable kneading action to the soil. The thickness of compacting layer is kept about 5 cm more than the length of each foot. Figure below illustrated the mechanics of compaction under a sheepsfoot roller. About 24 or more number of passes of the roller may be necessary to obtain adequate compaction. However the top layer of the subgrade or fill may be compacted using smooth wheeled roller so as to get a properly finished surface.

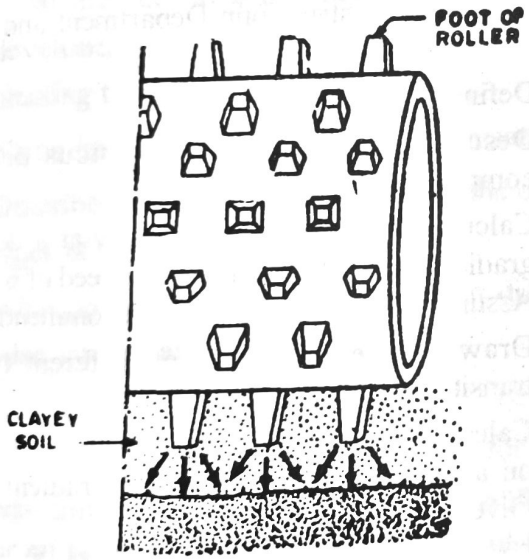


Fig. Compaction by Sheepsfoot Roller

Rammers are useful to compact relatively small areas and where the rollers cannot operate such as compaction of trenches, foundation and slopes. The output rammer is much lower than that of roller.

Vibrators are most suited for compacting dry cohesionless granular material. There are also vibrator mounted roller to give the combined effects of rolling and vibration. Vibratory rollers are advantageously used in compacting a wide range of materials.

Watering (jetting and ponding) is considered to be an efficient method of compacting cohesionless sands. Watering heavily and rolling by smooth wheel of pneumatic tyred roller may also give adequate compaction of cohesionless sands.

Field Control for Compaction :

For adequate quality control in construction, it is essential to have proper field control in compaction. The two field control tests needed are :

(i) Measurement of moisture content

(ii) Measurement of dry density.

The moisture content of the soil may be found before compaction by any one of the rapid methods suitable at the site. If the moisture is controlled at the OMC, then the next control needed is the dry density, the desird value of which may be achieved by increasing the number of passes for the selected equipment and the thickness of each layer. Dry density may be found by any suitable method, the sand replacement method is considered quite satisfactory.

A certain percentage (say 100 or 50 %) of the standard density is generally aimed at in the field compaction. Thus by field checks it is possible to control the construction to achieve adequate compaction. However, statistical quality control methods should be followed for the compaction in construction of high embankments.

PRACTICE SETS

SET – 1

[CET - 502]

Full Marks – 70 **Time – 3 Hours**

*Answer any **five** questions.*

Figures in the right-hand margin indicate marks.

1. (a) Define Landscaping and arboriculture. [2
   (b) Describe the different types of Traffic signal system. [5
   (c) What is the necessity of Embankment ? Discuss the different characteristics. [7
2. (a) Define P.Q.C. [2
   (b) Explain briefly different road characteristics. [5
   (c) With neat sketch explain the different equipments used for subgrade preparation. [7
3. (a) Mention two functions of CRRI (Central Road Research Institute). [2
   (b) Mention differences between Flexible Pavement and Rigid Pavement. [5
   (c) With a neat sketch, describe methods of providing super-elevation. [7
4. (a) What do you mean by CBR Test ? [2
   (b) Discuss about the different bituminous emulsions and its uses. [5
   (c) Describe Bituminous macadam. [7
5. (a) What is D.L.C. ? [2
   (b) Define gradients. Describe different types of gradients. [5
   (c) Describe water bound macadam. [7
6. (a) Differentiate premix carpet and semidense carpet. [2
   (b) How to prepare bituminous concrete ? [5
   (c) Discuss the different rigid pavement deficiencies. [7
7. (a) What is MART ? [2
   (b) Explain briefly sub-surface and surface drainage system is highways with skethes. [5
   (c) Explain briefly sub-surface and surface drainage system is highways with skethes. [7

SET – 2

[CET - 502]

Full Marks – 70 **Time – 3 Hours**

*Answer any **five** questions.*

Figures in the right-hand margin indicate marks.

1. (a) What do you mean by Breast walls ? [2
   (b) Explain briefly sub-surface and surface drainage system is highways with skethes. [5
   (c) Describe the different compact equipments. [7
2. (a) Define load factor. [2
   (b) Discuss briefly the advantages and dis-advantages of traffic signals. [5
   (c) Explain the working procedure with a neat sketchmetic plan view of a "Hot Mix Plant" used for production of D.B.M. and B.C. [7
3. (a) Define surface sub-surface drainage. [2
   (b) Discuss surface drainage system with neat sketch. [5
   (c) Draw a flow chart of organisation of State Highway Constructionn Department and specify their duties and responsibilities. [7
4. (a) Define right of way. [2
   (b) Describe the functions of various pavement components. [5
   (c) Calculate the SSD on a highway at a desecding gradient of 2.35% for a design speed of 65 kmph. Assume other data as per IRC recommendation. [7
5. (a) Draw a generral shapes of different types of transition curves. [2
   (b) Calculate the minimum non-passing sight distance on a highway at a descending gradient of 6%. Given the following data :
      (i) Design speed = 80 kmph.
      (ii) Reaction time of driver = 2.5 seconds.
      (iii) Co-efficient of friction between tyre and road surface = 0.4. [5
   (c) Describe the different abrasion tests. [7,,
6. (a) Explain water absortpion test. [2

(b) Calculate the superelevation required for a concrete road 7.5 m wide on a curve of 800 m radius of a design speed of 50 kmph. [5

(c) Describe the different types of transition curves. [7

7. (a) Define lime stabilization. [2

(b) Describe cement stabilization in detail with factors affecting soil cement properties. [5

(c) Explain briefly sub-surface and surface drainage system is highways with skethes. [7

SET – 3

[CET - 502]

Full Marks – 70 **Time – 3 Hours**

*Answer any **five** questions.*

Figures in the right-hand margin indicate marks.

1. (a) Name the different traffic characteristics. [2

(b) Classify and explain traffic signals. [5

(c) With neat sketch discuss the different traffic signs. [7

2. (a) Define Texturing and separation membrane. [2

(b) Explain briefly "How the sub-grade will prepared for a Nation Highways" with the steps of construction. [5

(c) What are the factors considered for road side development and what are the purposes of planting trees on the road side ? [7

3. (a) Name important transportation organisations. [2

(b) Describe with neat diagram explain the different types of flexible pavements. [5

(c) What do you mean by stopping sight distance ? Also give detailed analysis. [7

4. (a) Name common binders. [2

(b) Calculate the passing sight distance for a two-way traffic highway for which the design speed of 60 kmph. The rate of acceleration of the fast moving vehicle may be assumed as 3.6 kmph/ second and the difference in speed between the overtaking vehicle and overtaken vehicle as 20 kmph. What will be the passing sight distance if only one-way traffic is allowed ? [5

(c) Compare between Bitumen and Tar. [7

5. (a) What do you mean by soundness test ? [2

(b) Design the rate of superelevation for a horizontal highway curve radius 750 m and speed 110 kmph. [5

(c) Explain the design of vertical curves. [7

6. (a) Define cement stabilization. [2

(b) Explain in detail lime stabilization. [5

(c) Explain briefly sub-surface and surface drainage system is highways with skethes. [7

7. (a) Why retaining walls are provided in will roads ? [2

(b) State the causes of Flexible pavements with neat sketches. [5

(c) Explain briefly sub-surface and surface drainage system is highways with skethes. [7

SET – 4

[CET - 502]

Full Marks – 70 **Time – 3 Hours**

*Answer any **five** questions.*

Figures in the right-hand margin indicate marks.

1. (a) Define Fly ash Stabilization. [2

(b) Draw the flow diagram for the planning and surface specification dressing. [5

(c) State the causes of Flexible pavements with neat sketches. [7

2. (a) Define Landscaping and arboriculture. [2

(b) Write short notes on : [5

(i) Power shovel., (ii) Dredgers.

(c) Explain the working procedure with a neat sketchmetic plan view of a "Hot Mix Plant" used for production of D.B.M. and B.C. [7

3. (a) Define Texturing and separation membrane. [2

(b) What do you mean by Traffic Islands and classify it ? [5

(c) Explain briefly sub-surface and surface drainage system is highways with skethes. [7

4. (a) Define right of way. [2

(b) Discuss the maintenance procedures of cement concrete roads. [5

(c) Explain the construction procedures of embankment. [7

5. (a) What are the functions of Indian road congress ?[2

(b) Draw a typical cross-section of a rigid pavement road in National Highways and mention the layers of rod from the base. [5

(c) What do you mean by passing sight distance ? Also give a detaled analysis. [7

6. (a) What is superelevation ? [2

(b) Describe the following Tests on aggregates. [5

(i) Water absorption test.

(ii) Crushing strength test.

(iii) Impact test.

(c) Describe the different types of cutback bitumens. [7

7. (a) Define W.B.M. [2

(b) Determine the absolute minimum radius and ruling minimum radius for minimum value of super-elevation of horizontal curve for a design speed of 50 kmph. [5

(c) Write short notes on : [7

(i) Mechanical Stabilization.

(ii) Lime Stabilization. (iii)Cement Stabilization.

(iv) Fly ash Stabilization.