



Malabar Polytechnic College Kottakkal
Maravattam, Kadampuzha, Malappuram Dist. Kerala

Approved by AICTE, New Delhi, Govt. of India - Affiliated to State Board of Technical Education, Govt. of Kerala

DEPARTMENT OF CIVIL ENGINEERING

SEMESTER 5-2021 REVISION

5013-TRANSPORTATION ENGINEERING

QUESTION BANK

MODULE 2

Part A (1 mark)

1. List the four typical component layers of a flexible pavement.

Answer:

Sub grade, Sub base, Base course and Wearing course or Surface course

2. Define right of way.

Answer:

The right of way is the total land area acquired for the construction and the development of the roadway. The width of acquired land is known as Land width.

3. Define simple curve.

Answer:

Simple curve is designated as the degree of curve which is the angle in degrees subtended by a chord of 30m length.

4. List the types of horizontal curves on roads.

Answer:

- 1.Simple Curve
- 2.Compound Curve
- 3.Reverse Curve

5. List the types of camber.

Answer:

- Straight line camber
- Parabolic Camber
- Composite camber

Part B (3 mark)

1. What is meant by gradient of a road? Describe various types of gradients.

Answer:

Gradient of a road is the rate of rise or fall along the length of x or n%.

Types of gradient:

1. Ruling gradient — it is the maximum gradient within which designer designs the vertical profile of a road.
2. Limiting gradient — it is the gradient used at places where topography compels adopting steeper gradients due to enormous increase in construction cost with gentler slope.
3. Exceptional gradient — in extra ordinary situation, it may be unavoidable to provide still steeper gradients at least for shorter duration. But length of stretch should not exceed 100 m at a stretch.
4. Minimum gradient — minimum gradient is required to provide for drainage purpose.

2. Explain the construction of Water Bound Macadam roads. Or

Explain the construction procedure of new WBM road starting with sub grade preparation.

Answer:

Construction of Water Bound Maccadam road

- WBM is the base course of crushed or broken aggregate mechanically interlocked by rolling. Voids are filled by screening material along with water. It can be applied as based course, sub base or surface course.
- Preparation of subgrade – The subgrade is prepared to the required grade and camber. On existing pavement depressions or pot holes are filled and undulations are removed. On existing bituminous road, 45- degree furrows are made to 5 cm depth and width.
- Provision of lateral confinement — lateral confinement is provided by constructing the shoulders to advance ahead of carriageway and by terminating the inner sides vertically.
- Spreading of course aggregates — coarse aggregates are spread uniformly to proper profile and even thickness and is often checked by templates.
- Rolling - compaction is done by three wheeled roller of 6 to 10 tones capacity. Rolling is done from edge to the centerline by forward and backward rolling There should be uniform overlap between each run.
- Application of screening — after rolling, dry screening is done to fill up the voids.
- Sprinkling and grouting — surface is then sprinkled with water, swept and rolled. Wet screenings are swept into the voids using hand brooms. Rolling is continued till coarse aggregates are well bonded.
- Application of binding material — binding material is then applied at uniform and slow rate at two or more successive thin layers. Water is sprinkled over the surface; wet slurry fills the voids. This is followed by rolling.
- Setting and drying — After final compaction, WBM course is allowed to set over night. On the next day, damaged spots are located and filled with screening or binding material. Traffic is not permitted till the WBM is completely dried.

3. State the necessity of super elevation.

Or

State super elevation and explain the need for super elevation.

Answer:

Super elevation is necessary to counteract the effects of centrifugal force.

It is the amount by which the outer edge of a curve on a road is raised above the inner edge to counteract the imbalance caused by outward thrust.

When a vehicle travels in a circular path or curved path, it is subjected to an outward force which makes a vehicle to overturn and skid due to Centrifugal force. To overcome this force and for safe travel of a vehicle, the outer edge of the road is raised above the inner edge. This is known as superelevation or banking of roads.

4. Write short notes on camber. Or

Describe the needs of camber.

Answer:

CAMBER: The cross slope in the transverse direction of road is called Camber.

- It is generally provided for the purpose of draining the rain water from the road surface towards the edges, to protect the subgrade, and for safety, as wet pavement conditions are quite undesirable from safe driving point of view.
- The central part of the road which is raised is called the crown.
- The cross slopes can be expressed as 1 in n or in percentages as n%. Steep cambers are effective in quick removal of surface water but are undesirable as they will erode the surface.

Types of camber:

There are generally three types of cambers provided along the road surface namely straight line, parabolic and composite cambers.

- Straight line camber: These are provided with two equal uniform straight line slopes at both sides of the crown and are also known as Plane cross slopes.
- Parabolic Camber: In parabolic camber, the cross slope is in the shape of simple quadratic parabola.
- Composite camber: Composite camber may be composed of partly parabola and partly straight line or two straight lines having different slopes.

5. Describe the importance of highway transportation.

Answer:

- They facilitate conveyance of people goods raw materials manufactured articles speedily and easily in the different parts of the country.
- They act as the only source of communication in regions of high altitude and mountainous region.
- They help in growth of trade and other economic activities by establishing @, contact between towns and villages.
- They help in promoting cultural and social ties among people and thus strength the national unity.
- They provide more employment opportunity.
- They enhance land value and thus bring better revenue.
- They serve as feeders for airways waterways and railways.

6. Explain different phases of bituminous road construction.

Answer:

Steps in Bituminous Road Construction

- Preparation of the existing base course layer. The existing surface is prepared to the proper profile and by removing the potholes or rust if any.
- Application of Tack Coat: Using a mechanical sprayer or pouring can. bituminous binder is sprayed evenly at the specified rate.
- Preparation and placing of Premix. The premixed bituminous concrete is laid to the required thickness.
- Rolling: The rolling is done with tandem roller of 6 to 8 tonnes weight. The rolling is started from the edges proceeding towards the centre longitudinally over lapping not less than one third of roller tread.
- Finishing and opening to traffic: The surface is checked for camber and opened for traffic after 24 hours.

7. Differentiate between camber and gradient.

Answer:

Camber	Gradient
It is the slope provided to the road surface in the transverse direction to drain off the rainwater from the road surface.	It is the slope provided to the surface of the road in the longitudinal direction for the vertical alignment of the road.
Camber is often referred to as a <u>cross slope</u> or a crown.	Gradient is also known as a <u>grade</u> .

Camber is expressed as a percentage or ratio.	Gradient is expressed as a percentage or a ratio.
The major goal of road camber is to promote effective drainage of rainfall or other liquids from the road surface and to minimize water stagnation.	The major goal of providing gradient in roadways is to promote smooth and safe vehicle movement by gradually changing height.

8. Write note on highway curves.

Answer:

(i) Horizontal curves:

It is a curve in plan to provide a change in the direction of the central line of a road. It is a circular curve with or without transition ends. Different types of circular curves are:

(1) Simple curve

This is a curve of single arc of uniform radius connecting two tangents. This curve is designated as degree of the curve which is the angle in degree subtended at the centre by a chord of 30 metres length. This curve is suitable for slow moving traffic and large radius. Such a curve may lie within two tangent lengths or two transition curves.

(2) Compound Curve:

This is formed by joining two or more simple curves of same or different radii which turn in the same direction. In this curve the adjacent simple curves have a common tangent. This type of curve is used in order to avoid cutting in hard rock or heavy lifting.

(3) Reverse Curve:

Reverse Curve which is also called as serpentine curve consists of two simple curves of same or different radii and turn in the opposite direction. In this curve the adjacent simple curves have a common tangent and their centres lie on opposite sides of the curves.

(ii) Vertical Curve:

It is a curve in the longitudinal section of a roadway for easy change of gradient. Vertical curves are provided where change of gradient is more than 0.5%. They are of two types:

- 1) Summit curves
- 2) Valley/sag curves

Objectives:

- To provide gradual change in gradient
- To provide sufficient visibility
- To provide Comfort to passengers.

(iii) Transition Curve: A curve whose radii gradually varies from infinity to finite value of equal to the radius of circular curve to be connected is known as a transition curve or easement curve. It is introduced between a straight and a curved path.

Objectives:

- To provide gradual change in the radius of curvature
- To avoid discomfort of road users
- To enable gradual introduction of super elevation.

Different types of transition curves are:

1. Spiral
2. Cubic parabola
3. Lemniscate.

9. Differentiate between stopping sight distance and overtaking sight distance. Or

**Explain the types of sight distance and objectives of each type. Or
State the importance of various types of sight distances.**

Answer:

Sight distance: It is the length of a road visible to a driver ahead of him. It is the next important element on a road from safety point of view.

Stopping sight distance: it is the distance needed by a drive travelling at design speed to stop his vehicle before colliding with an obstruction ahead. As per the IRC guideline, driver's eye level must be at 1.2m and obstruction height at 0.15m. It consists of two parts - reaction distance and braking distance,

$$SSD = 0.278Vt + \frac{v^2}{254f}$$

V - speed in km/h.

t - reaction time in sec.

f - Coefficient of friction.

Overtaking sight distance: It is the minimum distance that needs to be visible to a driver moving at design speed and intending to overtake a slow-moving vehicle ahead, with safety against the traffic in the opposite direction. IRC guideline - overtaking and overtaken driver's eye levels at 1.2m. It consists of three components - d1, d2 and d3.

d1- distance between overtaking and overtaken vehicle at the start of overtaking process.

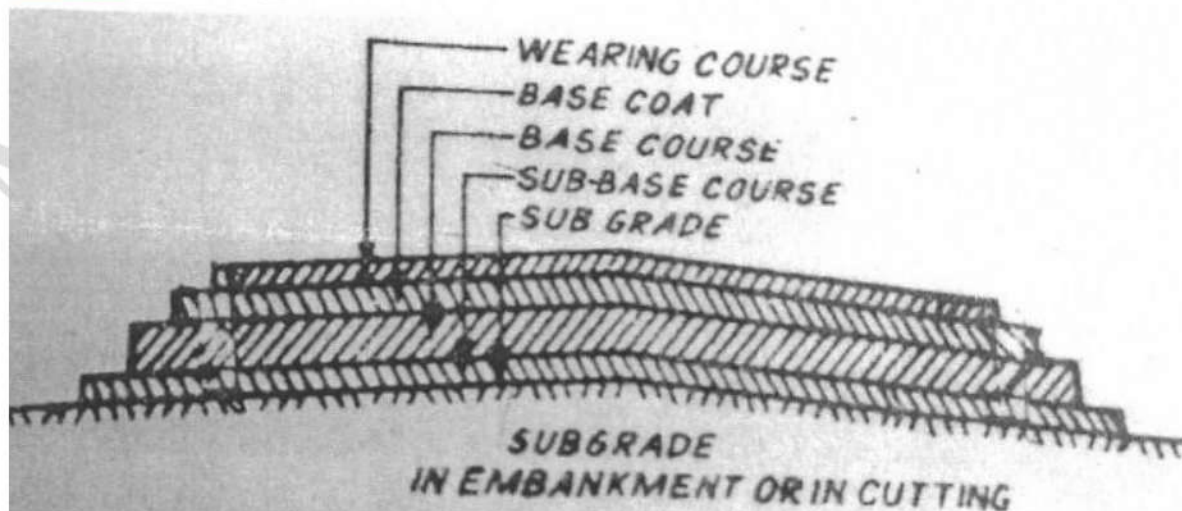
d2- distance covered during actual overtaking process.

d3 - the clear distance required between overtaking vehicle and the vehicle coming in the opposite direction.

$$OSD = d1 + d2 + d3$$

10. Draw the typical cross-section of highway in embankment and label its parts.

Answer:



11. Explain different types of vertical curves.

Answer:

It is a curve in the longitudinal section of a roadway for easy change of gradient. Vertical curves are provided where change of gradient is more than 0.5%. They are of two types:

- 1) Summit curves
- 2) Valley/saga curves
 - To provide gradual change in gradient
 - To provide sufficient visibility
 - To provide Comfort to passengers.

12. Explain the functions of Subgrade and Base Course in road structure.

Answer:

Base course: The base course is the layer of material immediately beneath the surface of binder course.

The functions and requirements of this layer are:

- It provides additional load distribution and contributes to the sub-surface drainage.
- It may be composed of crushed stone, crushed slag, and other untreated or stabilized materials.

Sub-grade: The topsoil or sub-grade is a layer of natural soil prepared to receive the stresses from the layers above. The functions and requirements of this layer are:

- It is essential that at no time soil sub-grade is overstressed.
- It should be compacted to the desirable density.

Part C (7 mark)

1. Differentiate:

(a) Spoil bank and borrow pit

(b) Super elevation and extra widening

(c) Cutback bitumen and bitumen emulsion

Answer:

a) Difference between spoil bank and borrow pit

Spoil bank: is a pile of refuse material or waste earth material created by excavation of earth from a site or excess soil excavated from a site.

Borrow pit: is a pit resulted from excavation of material for use in embankment construction.

b) Super elevation and extra widening:

Superelevation is the raising of the outer edge of the pavement at curve compared to inner edge in order to counteract centrifugal force.

Extra widening: Width of pavement is widened especially for horizontal curve of smaller radii

- i) to account for mechanical off tracking of vehicles wheels and
- ii) to account for psychological clearance between vehicles.

c) Cutback bitumen and bitumen emulsion

Cutback bitumen: is the liquid bitumen by dissolving bitumen in a solvent like naphtha, gasoline, kerosene or any petroleum distillates. After laying the solvent will evaporate and bitumen will bind with aggregates.

Bitumen emulsion: it is a mixture of water and bitumen. Bitumen is broken down to tiny droplets and is suspended in water.

2. What is meant by sight distance? Briefly explain stopping sight distance and overtaking sight distance used for road design.

Answer:

Sight distance: It is the length of a road visible to a driver ahead of him. It is the next important element on a road from safety point of view.

Stopping sight distance: it is the distance needed by a driver travelling at design speed to stop his vehicle before colliding with an obstruction ahead. As per the IRC guideline, driver's eye level must be at 1.2m and obstruction height at 0.15m. It consists of two parts - reaction distance and braking distance,

$$SSD = 0.278Vt + \frac{v^2}{254f}$$

V - speed in km/h.

t - reaction time in sec.

f - Coefficient of friction.

Overtaking sight distance: It is the minimum distance that needs to be visible to a driver moving at design speed and intending to overtake a slow-moving vehicle ahead, with safety against the traffic in the opposite direction. IRC guideline - overtaking and overtaken driver's eye levels at 1.2m. It consists of three components - d1, d2 and d3.

d1- distance between overtaking and overtaken vehicle at the start of overtaking process.

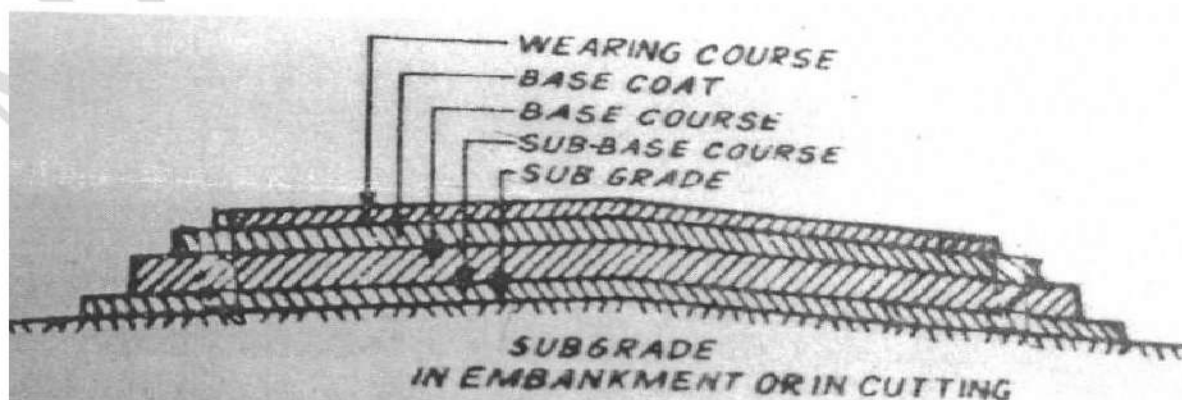
d2- distance covered during actual overtaking process.

d3 - the clear distance required between overtaking vehicle and the vehicle coming in the opposite direction.

$$OSD = d1 + d2 + d3$$

3. Sketch the cross section of a road and explain the functions of each layers.

Answer:



or

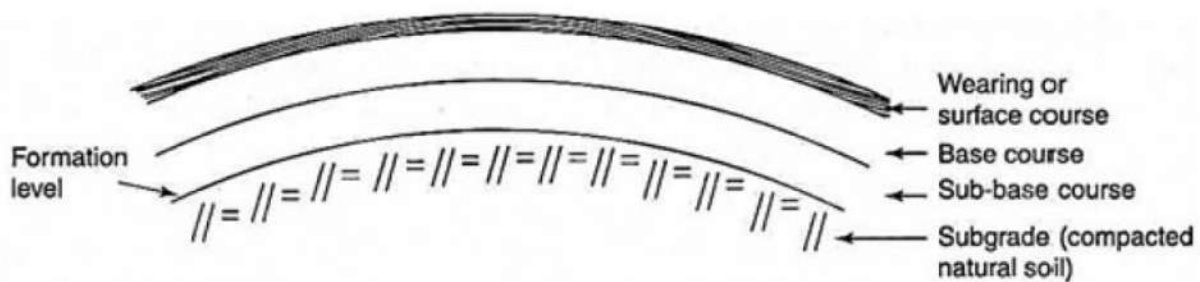


FIG. 7.1 Courses (layers) of a pavement

Wearing course: Wearing course is the layer directly in contact with traffic loads and generally contains superior quality materials. .

The functions and requirements of this layer are:

- It provides characteristics such as friction, smoothness, drainage, etc.
- It will prevent the entrance of excessive quantities of surface water into the underlying base, sub-base and sub-grade.
- It gives strength to the road structure. It act as a cushion between wheel and base.

Base course: The base course is the layer of material immediately beneath the surface of binder course.

The functions and requirements of this layer are:

- It provides additional load distribution and contributes to the sub-surface drainage.
- It may be composed of crushed stone, crushed slag, and other untreated or stabilized materials.

Sub-Base course: The sub-base course is the layer of material beneath the base course. The functions and requirements of this layer are:

- It provides structural support, improve drainage, and reduce the intrusion of fines from the sub-grade in the pavement structure.
- If the base course is open graded, then the sub-base course with more fines can serve as a filler between sub-grade and the base course.

Sub-grade: The topsoil or sub-grade is a layer of natural soil prepared to receive the stresses from the layers above. The functions and requirements of this layer are:

- It is essential that at no time soil sub-grade is overstressed.
- It should be compacted to the desirable density.

4. State the necessity and requirements of road drainages.

Answer:

The importance of drainage is one of the most important aspects for location and design of highway because of following reasons:

- To prevent subgrade failure: Soil subgrade excess moisture reducing the stability of pavement which leads to subgrade failure.
- To prevent reduction in strength of pavement material: The strength of pavement material like stabilized soil and WBM (water bound macadam) is reduced.
- To prevent frost action: In flexible pavement the formation of waves and corrugation take place due to poor drainage.
- Decrease volume changes: Volume of subgrade is change especially in clayey soils due to variation in moisture content. This sometimes leads to pavement failure.
- Prevent mud pumping failure: Mud pumping is due to presence of water in subgrade soil especially in rigid pavement. Prevent erosion of soil: Due to surface water, erosion of soil from top of road and slope of embankment.

5. Give the importance of gradients for roads with their types.

Answer:

Gradient of a road is the rate of rise or fall along the length of x or n%.

Types of gradient:

1. Ruling gradient — it is the maximum gradient within which designer designs the vertical profile of a road. Desirable upper limit of gradient 1 in 20 to 30
2. Limiting gradient — it is the gradient used at places where topography compels adopting steeper gradients due to enormous increase in construction cost with gentler slope. The limit: 1 in 15 to 20
3. Exceptional gradient — in extra ordinary situation, it may be unavoidable to provide still steeper gradients at least for shorter duration. But length of stretch should not exceed 100 m at a stretch. The Limit : 1 in 12 to 15
4. Minimum gradient — minimum gradient is required to provide for drainage purpose.

Limit is 1 in 100 to 200

Terrain	Ruling	Limitings	Exceptional
Plain/Rolling	3.3	5.0	6.7
Hilly	5.0	6.0	7.0
Steep	6.0	7.0	8.0

6. Compare rigid and flexible pavements.

Answer:

Flexible Pavement	Rigid Pavement
1. It undergoes elastic deformation and adjust itself to normal loading	1. It acts as a beam and resists deformation under normal loading.
2. Under heavy loads it yields forming local depression.	2. Under very heavy loading it ruptures forming cracks.
3. It is not subjected to temperature stress	3. It is subjected to heavy temperature stresses.
4. After undergoing deformation, it gets back to its original shape	4. Any damage caused due to heavy loading remains permanently.

7. Explain with the help of a sketch how surface drainage and sub-surface drainage is provided on roads.

Answer:

Surface drainage:

Under the surface drainage, water is to be collected in longitudinal drains and then disposed of at the nearest stream, valley or water course. Surface water is removed from surface of road by providing camber or cross slope to the road surface. The road surface is also made impervious to prevent the water entering the subgrade.

- Road on embankment: When the road is on embankment, the surface water to flow across the shoulders and down the side slope to the side drains. Side slopes are properly protected by grass so that erosion of side slope does not take place. The flow of water from the road surface is well distributed to give a uniform flow of water. If slopes are not properly protected and uniform flow is not possible than pavement and shoulders irregularities concentrate the flow into small streams, side slope are badly damaged and washed away. In

such saturation the longitudinal V shaped drains are provided to protect side slopes to retain water at outer edge of the shoulders and then disposed of at natural ground by means of paved drains. Sloping drains provided by pitching and aprons are provided at the foot of the slope. Drains are provided on both sides. The minimum distance of the drains from the formation should not be less than 2 meters. Surface drainage system arrangement in embankment is shown in Fig-1. On low embankments about 1.8 to 2.0 m high, side slope is 1:4 and protected by vegetation. The velocity of flow can be reduced by giving flat slope to the shoulders.

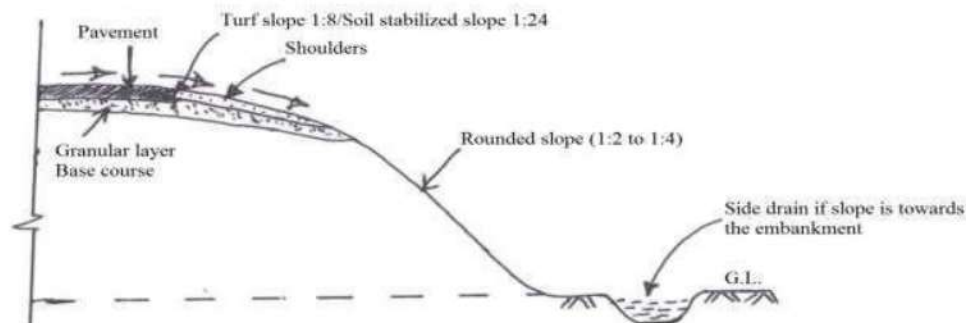


Fig-1 Surface drainage in Road embankment

- Road in cutting

When the road is in cutting the drains are provided on either side of formation in Fig-2. In these case the drains just after the edge of formation. In places where there is a restriction of spacing. Construction of deep open drains may be undesirable. Road formation in cutting covered drains filled with layers of coarse sand and gravel may be used. See Fig-3.

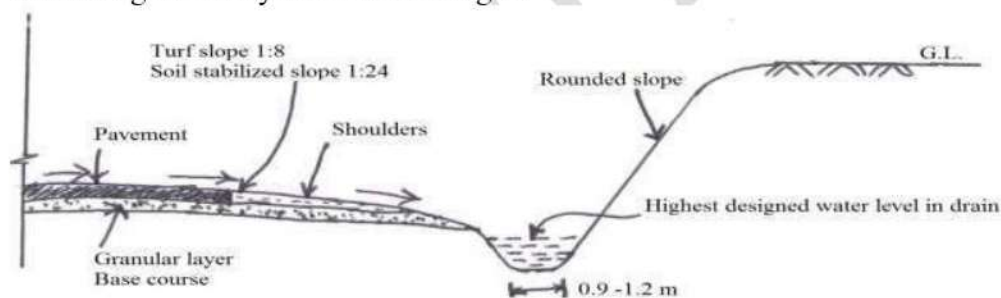


Fig-2 Surface drainage in cutting

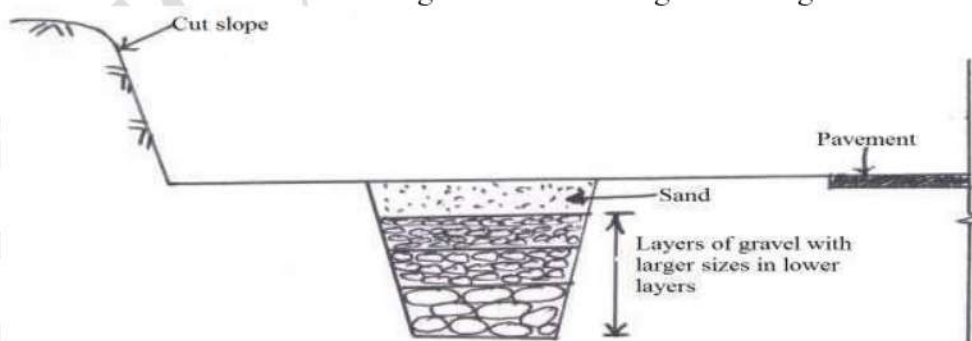
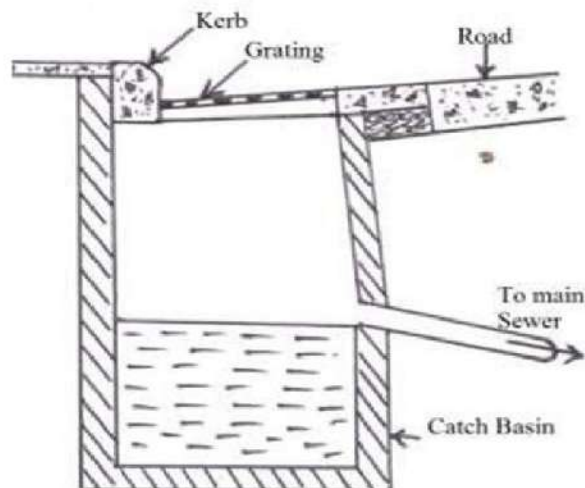


Fig-2 Covered drainage trenches

- Surface drainage system in urban roads:

Because of limitation of land and due to the presence of foot path, dividing island, it is necessary to provide underground longitudinal drainage. Water drained from pavement surface can be carried forward in longitudinal direction. This water may be collected in catch basin at suitable interval and lead through underground drainage pipes. Section of catch pit with grating to prevent the entry of rubbish into the drainage system is shown in Fig



- **Cross drainage**

Whenever highway crosses a river or stream, cross drainage works have to be provided. Sometimes water from side drains also is diverted away from the road through cross drains to divert water from the road to a water course. On highways usually culverts and bridges are used as cross water way of about 6 m, and then the cross-drainage structure is known as culvert. For higher discharge and greater linear way, the structure is known as bridge.

Sub surface water drainage

The change in moisture content of soil affects its bearing capacity of soil. The increase in moisture content of soil reduces its bearing capacity. Thus, keeping moisture content of the subgrade of the road. The change in moisture content of the subgrade is due to fluctuations in the ground water table, seepage flow, percolation of rain water and capillary water. Thus, the aim of the sub soil drainage is to prevent changes in the moisture content of the subgrade.

- **Control of sub soil flow**

If the seepage zone exists with one-meter depth from surface then it is essential to intercept the seepage flow by means of deep side drains or sub drains under the pavement. This should release the excessive hydrostatic pressure and lower the water table. Installation of intercepting drains as shown in Fig 6

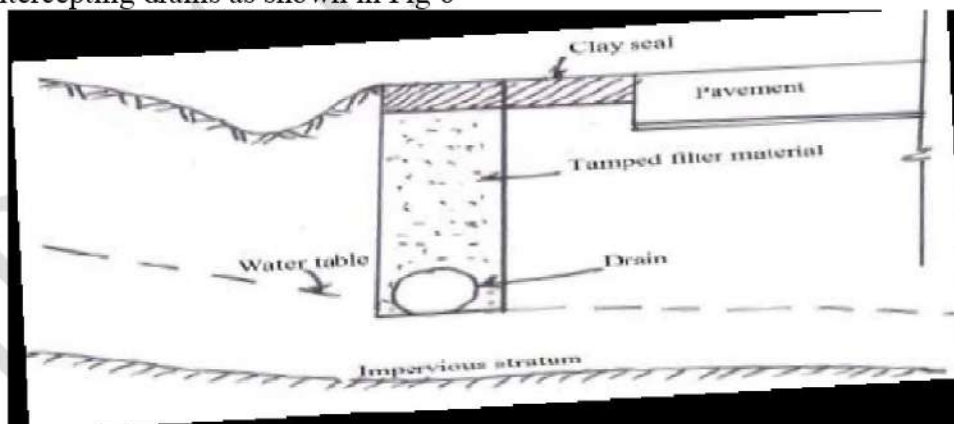


Fig – 6 – Intercepting Drains

- **Control of high water table:**

In order to avoid excessive pressure on subgrade and pavement it is essential that water table should be fairly below level of subgrade. It has been found that water table should be kept at least 1.2 m below the subgrade. In place where the formation level is to be kept at or below the ground level, it necessary to lower the water table. It is possible to lower the water table in relatively permeable soil by construction of longitudinal drainage trenches with drainpipe and filter sand. See fig.

