HIGHWAY ENGINEERING NOTES 4TH SEMESTER

reducing gradient

CH:- 5

HILL roads:-

The term hill road can be explained with reference to the cross slope i.e. the slope approximately perpendicular to the centre-line of the highway alignment. There a road is termed as a hill road if it passes through a terrain with a cross slope of 25 percent or more and it is characterised by widely differing elevation, deep gorges, numbers of water courses and steep slopes. The hill roads are also sometimes referred to as ghat roads.

PROTECTIVE WORKS FOR HILL ROADS:-

In order to give stability and a sence of safety to the hill roads, the following three types of protective work are provides

1) Retaining Walls.
2) Breast Walls.
3) parapet Walls.

Retaining Walls:- The formation of a hill road is generally prepared by the excavation of the hill and

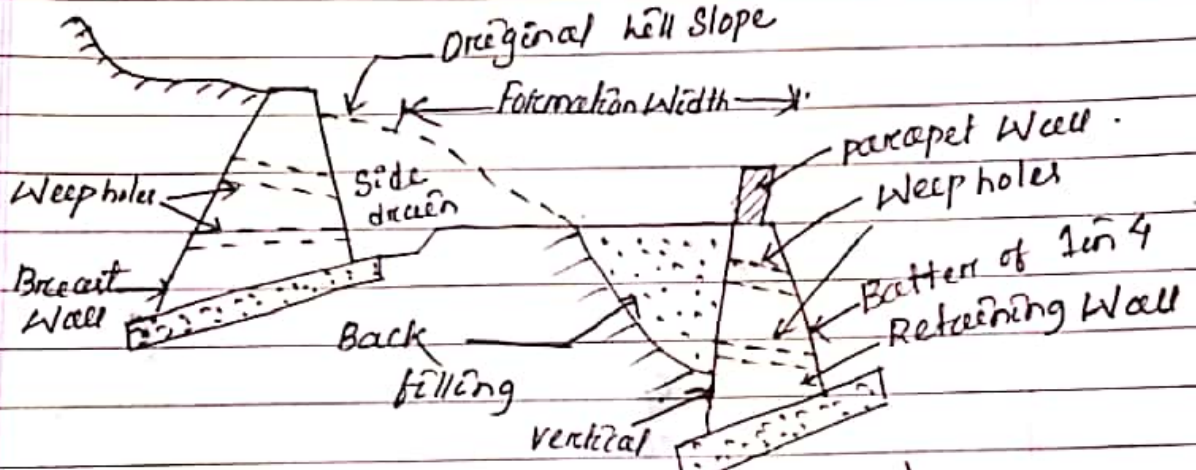
Teacher's Signature .....

the material which is excavated is dumped or stacked along the cut portion. The retaining wall is constructed on the valley side of the roadway to prevent the sliding of back filling.

i) at all re-entrant curves.

ii) at places where the hill section is partly in cutting and partly in embankment; and

iii) at places where the road crosses a drainage.



(PROTECTIVE WORKS FOR HILL ROADS).

Where stones are economically and easily available. It is customary to construct the retaining walls in dry stones masonary as it permits easy drainage of seeping water. The design of retaining walls is based on rules-of-thumb and the performances of similar existing retaining walls. The minimum width of 600mm is kept at the top. The rear side is kept vertical. The front side is provided with a batter of 1 in 4. If the height of retaining wall exceeds 6m or so, the bonds of coursed rubble masonary in cement mortar at vertical and horizontal intervals of about 3m are constructed to grant additional stability to the wall.

To facilitate the drainage of the water behind the retaining wall, suitable weep holes at vertical height of 1m and horizontal spacing of 1.2m are provided with slope outwards.

2) Breast Wall:- The cut portion of hill is to be prevented from sliding and the wall which is constructed for the purpose is known as breast wall. The breast walls are provided with a front batter of 1 in 2 and a back batter of 1 in 3. The back batter may be provided either in one straight batter or in the form of projections. If the height of the wall is less than 2m, the entire section is made in random rubble stone masonary. If the height of wall exceeds 2m, the top portion of 2m height alone is made in random rubble masonary and the remaining portion is constructed in cement mortar of proportion (1:6).

The weep holes, as in case of retaining walls, are provided with slope outwards and sometimes the vertical gutters connecting the weep holes to the side drain are provided.

Hair-pin bends:- As explained in Art 12-13 at sharp horizontal curves it becomes necessary to provide hair-pin bends with increase in radius of the curve, as shown in fig 12.3 Because of precipitous rock, deep valley, steep ascends to obligatory points and presence of innumerable streams, gorges, hair pin bends are unavoidable.

On hill roads. Within limits of the available terning angle, it is often very difficult and sometimes even impossible to lay out curves following normal geometric standards of design. A hair pin bend is located on a hill side having the minimum slope and maximum stability. It must also be safe from view point of land-slides and ground water.

Hair-pin bends with long arms and further spacing should be preferred. This reduce construction problems and expensive protective works.

a) Minimum design speed = 20 km/h.

b) Minimum radius of the inner curve = 14m.

c) Minimum length of transition = 15m.

d) Superelevation in circular portion of the curve = 1 in 10.

e) Minimum width of carriageway at the apex of the curve are 11.5 and 9.0m respectively for two-lane and single lane pavements of National and State Highways. The maximum carriageway width for MDR and ODR is 7.5m and that for village road is 6.5m.

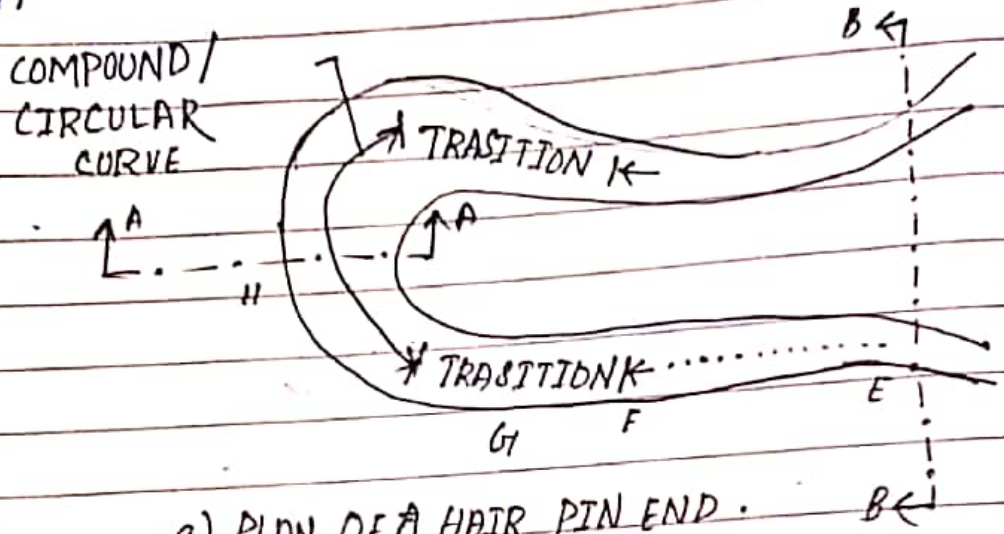
f) The maximum and minimum gradients are 1 in 40 and 1 in 200 respectively at the curve.

g) Approach gradient should not be steeper than 1 in 20 (5.0%) for a length of 40m and not steeper than 1 in 15 (0.067%) beyond this stretch.

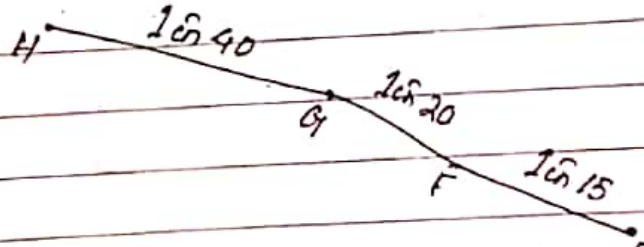
i) For good visibility at the hair-pinbend, the inland portion shall be cleared of all obstructions including tree and shrubs.

It is suggested that the full roadway width is surfaced at the hair-pin bends. Approach gradients should not be steeper than 5% for 40m. The straight length between two successive hair-pin

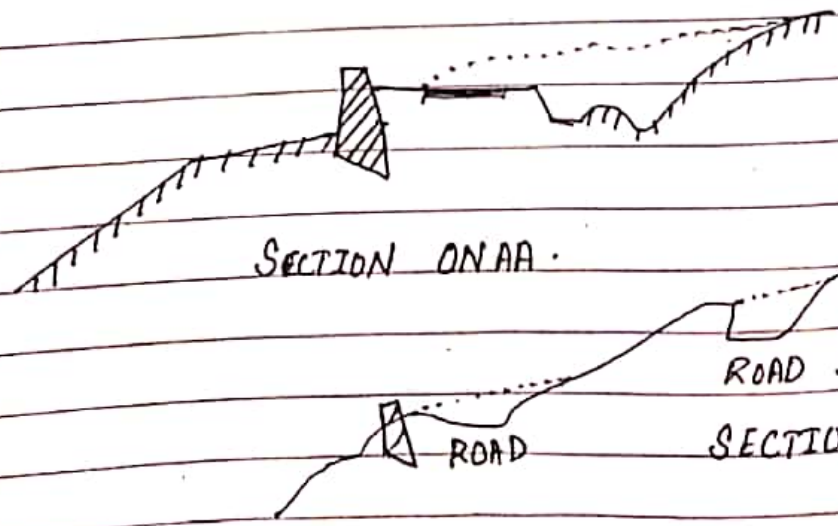
bends should be minimum of 60 m excluding the length of circular and transition curves. This length further depends upon the hill slopes to avoid costly protective measures between the upper and lower arms of the bends.



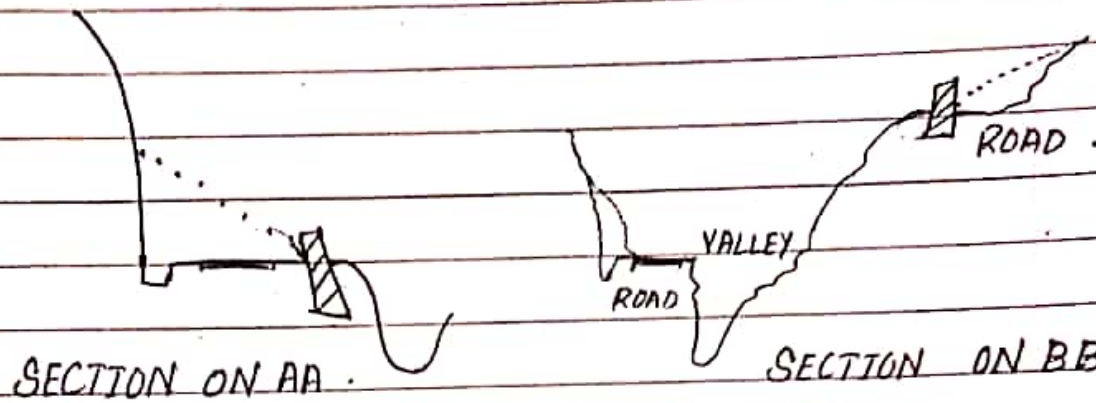
a) PLAN OF A HAIR PIN END.



b) LONGITUDINAL SECTION ALONG EFGH.



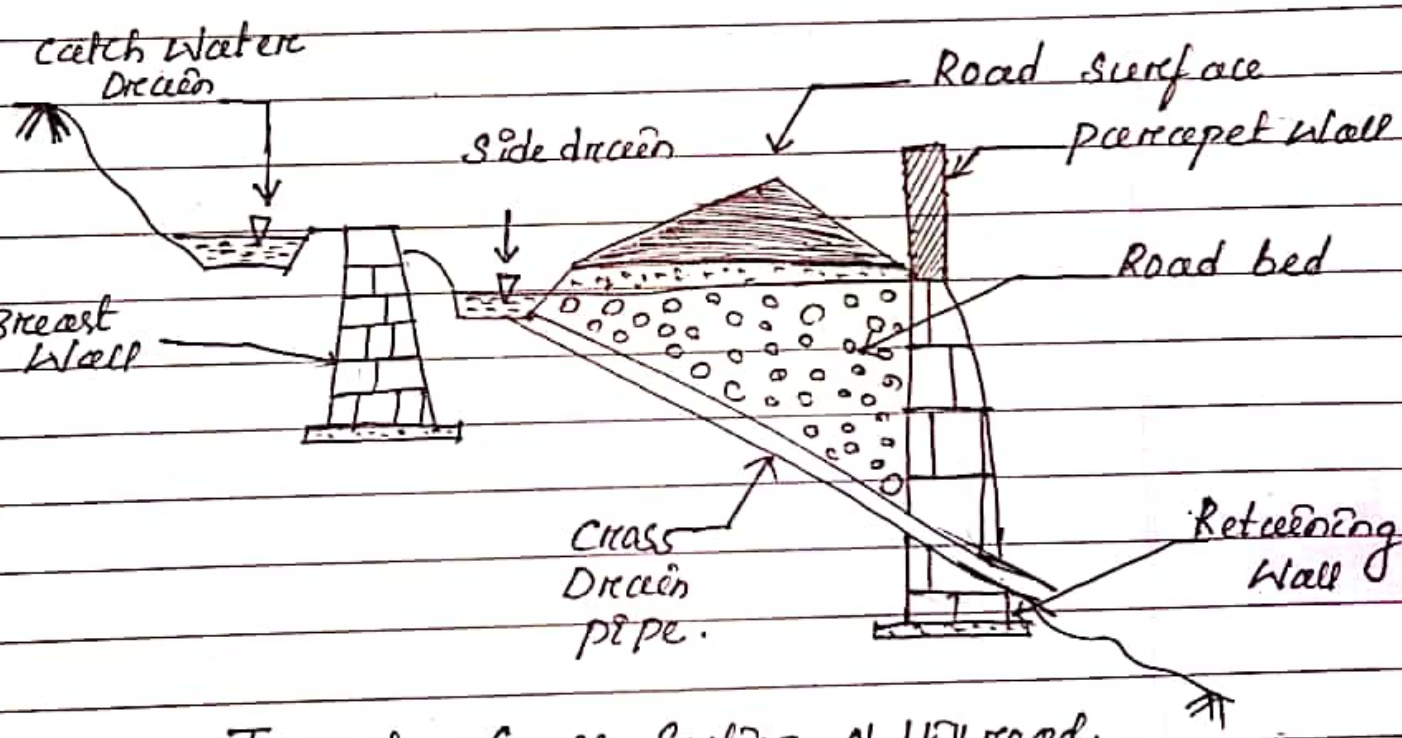
c) HAIR PIN BEND ON SAME SIDE OF THE HILL.



SECTION ON AA.

SECTION ON BB.

d) HAIR PIN BEND AROUND A VALLEY



Typical Cross-Section of Hill road.

CH:- 6.

REQUIREMENTS AND IMPORTANCE OF HIGHWAY DRAINAGE:-

Requirements of Highway Drainage:-

a) The Surface Water from the carriageway and Shoulder should effectively be drained off without allowing allowing it to percolate to subgrade and Weaken the soil.

b) The Surface Water from the adjoining land should be prevented from entering the roadway.

c) The Side drain should have sufficient capacity and longitudinal slope should to carry away all the Surface Water collected from the roadway.

d) Flow of Surface Water across the road and Shoulders and along slopes should not cause erosion or form cross ruts.

e) Seepage and other sources of under-ground Water should be effectively intercepted and drained off by the suitable subsurface drainage system.

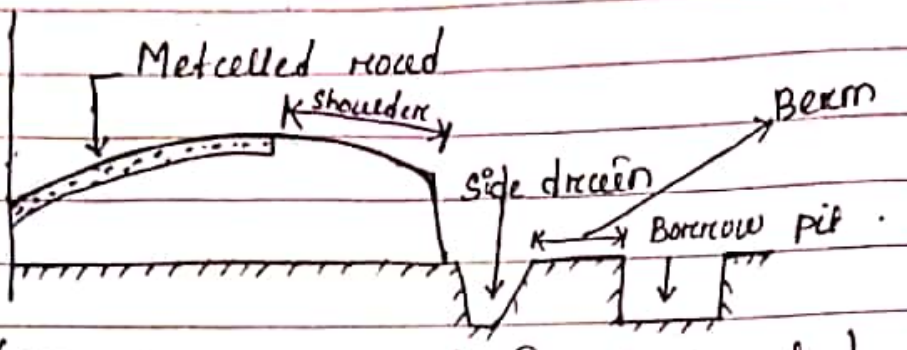
f) Highest level of ground Water-table should kept well below the level of subgrade, preferably by at last 1.2m. If the highest level of ground Water level is closer than 1.2m, it is desirable to lowere the same with a well planned and laid subsurface drainge System.

g) In Water-logged areas special precautions should be taken, especially if determental salts were present or if flooding is likely to occur.

SURFACE DRAINGE:- 1) The main object of surface drainage is to remove rain Water from the carriageway as rapidly as possible so that traffic may move safely and efficiently.

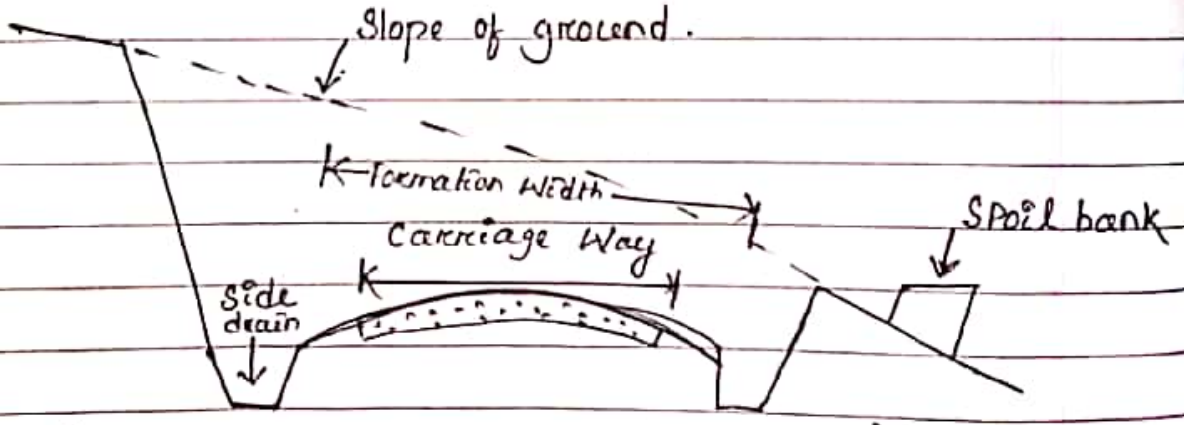
(2) The provision of surface drainage is through of at the initial stage of location or alignment of the highway.
3) In fact, the surface drainage forms one of the essential consideration for the location of a highway and it is seen that all the streams flow away from the highway. Thus the drainage problem is reduced to tackling the water which falls within the roadway boundary only.
4) For the purpose of collecting the surface water, the longitudinal side drains or ditches are laid and the water is then disposed off to the nearest stream, valley or water course.
5) The side drains are usually V-shaped or trapezoidal, the capacity of trapezoidal shape being greater. They should be preferably lined, if possible, with rubble masonary work which may either be laid dry or joints filled with grout.

1) Side drains for road in embackment :- For roads in embackments, the side drains are provided on one or both sides of the road beyond the shoulder, as shown in fig 11-1. The side drains are constructed at a minimum distance of about 2m from the edge of embankment so that the water flowing in the drains does not enter the earthwork.
The drains are also helpful in arresting the rain water falling on the adjacent land parallel to the road and it is thus not allowed to reach the embackment. The water flowing in the side drains can then be suitably disposed off without causing any harm to the road~~way~~ way.



(Side drains for road in embankments)

2) Side drains for road in cutting :— For roads in cutting the side drains are provided on either side of the formation, as shown in fig 11-2. These drains are carefully designed and it is to be seen that they do not overflow under any circumstances and making the roadway submerged in water



(Side drains for road in cutting).

The open deep side drains may prove to be dangerous and unsightly especially in cases where there is restriction of space. In such circumstances the covered drains or pipe drains or ditches filled properly with suitable materials like coarse sand and gravel may be provided.

SUB - SURFACE DRAINAGE :-

The development of Science of soil mechanics has shown that the increase in the moisture content by of the soil beyond a certain limit lends to the decrease in the strength of soil. It is therefore necessary to have an efficient sub-surface drainage system for keeping the road surface in good order. It is natural that if the materials composing the road structure are placed on the wet, retentive or undrained soil will get quickly disintegrated by traffic.

(1) Causes of changes in moisture content :-

The moisture content of subgrade soil changes due to a number of causes and they can be enumerated as follows :-

i) Movement of capillary water
ii) percolation of water into the subgrade through cracks on the road surface.
iii) Rise or fall in the level of the water table
iv) Seepage of water into the subgrade from the heigher ground adjacent to the road.
v) transfer of moisture either from or to the soil to the verges as a result of difference in moisture content.
vi) transfer of moisture from or to lower soil layers by suction
vii) transfer of water vapours through the soil etc.

2) Situations requiring sub-surface drainage :-

Following are the conditions or circumstances which require the provision of a suitable sub-surface

drainage system :-

i) The road is at the foot of a hill and there are chances of the road being damaged by water coming from the top.

ii) The road is in cutting and there are chances of considerable seepage in the slopes.

iii) The road is passing through flat country and the water from the adjacent lands stagnates and makes the road bed soft and unstable.

iv) The soil below the road is subjected to the action of springs passing nearby.

v) The surface of the road has the normal underground water table which is sufficiently below the crust of the road. But there is tendency of the moisture to rise to the surface of the road or subgrade through the capillary action.

3) Methods of sub-surface drainage :- The main object of sub surface drainage is to keep the highest water table level fairly below the level of subgrade so that the subgrade and pavement layers are not subjected to excessive moisture. The methods adopted for sub-surface drainage can be grouped in the following three categories:

i) Methods to control capilary rise.

ii) Methods to control seepage flow.

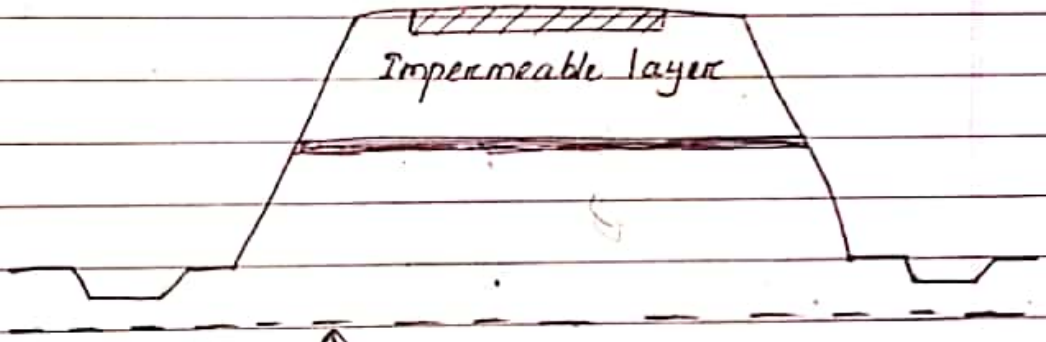
iii) Methods to lower water table.

i) Methods to control capilary rise :- When there are changes for water to reach the level of subgrade through the capillary rise, it becomes

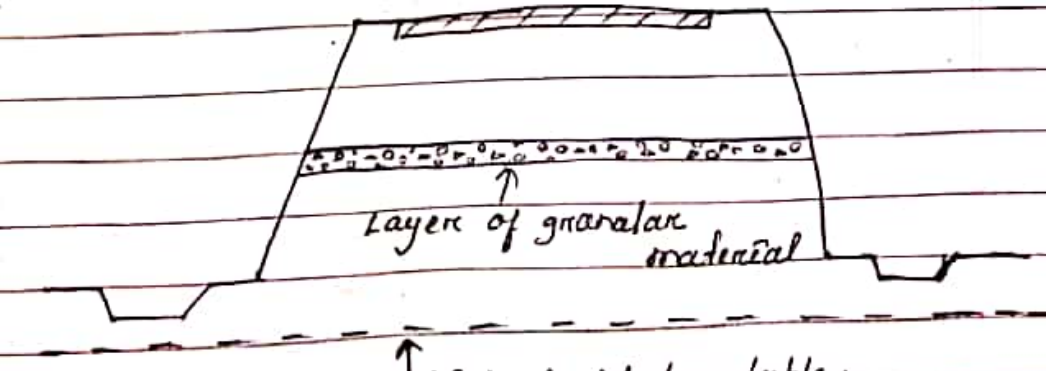
necessary to correct such action by providing suitable capillary cut-off between the subgrade and highest water level.

a) Inserting an impermeable or a bituminous layer as shown in fig 11.6

b) providing a layer of granular material of suitable thickness, as shown in fig 11.7.

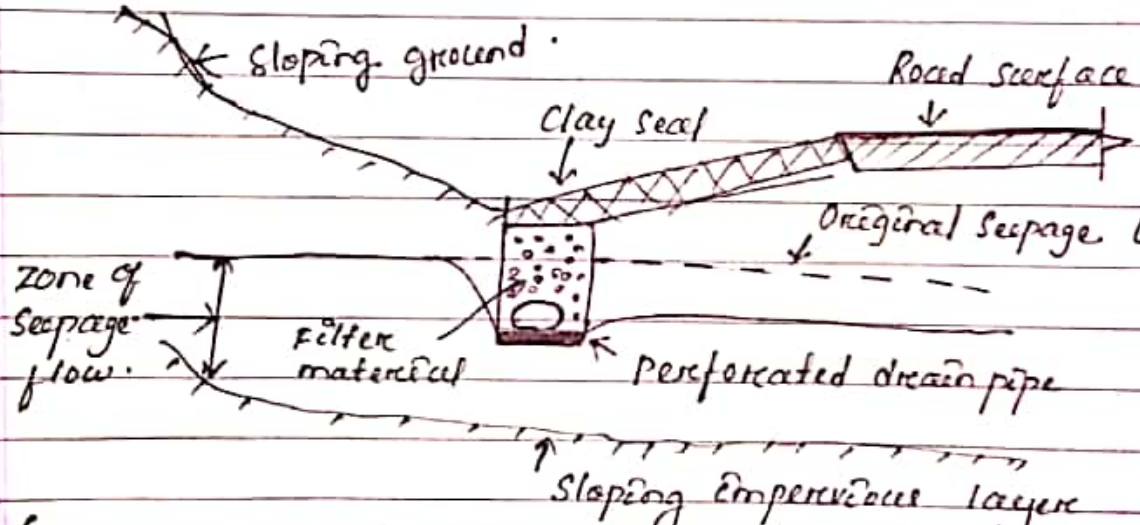


(Method to control capillary rise). (Fig 11.6).



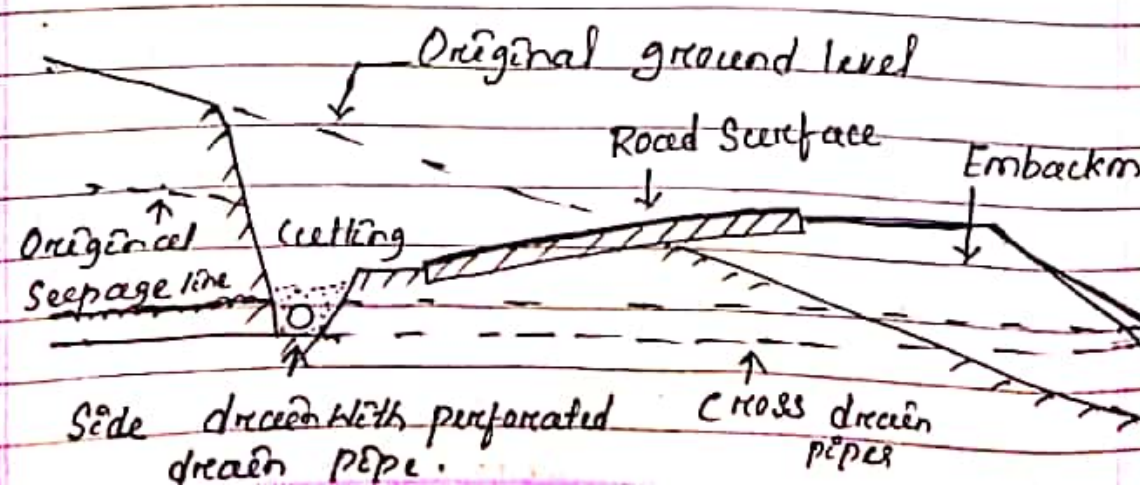
(Method to control capillary rise). (Fig 11.7).

Methods to control seepage flow :- If the ground is sloping and the seepage zone is at a depth of about 600 mm to 900 mm from the edge of road, the perforated drain pipe with filter material is provided as shown in fig 11.8 to lower the seepage line. The trench for laying the drain pipe is kept above the slopping impervious layer.



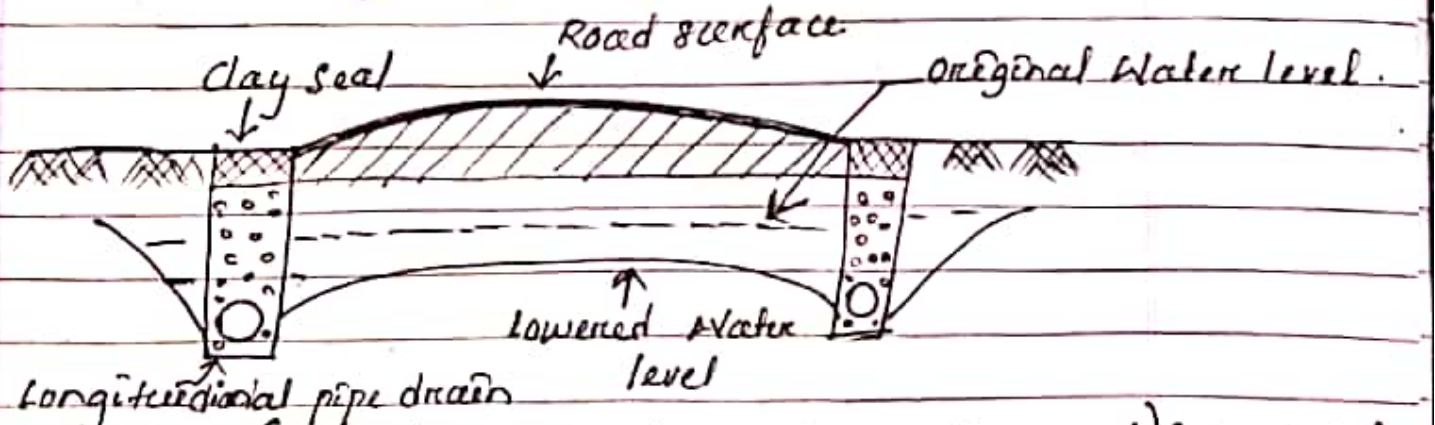
(Method to control seepage flow for pipe drain hill road).

(Method to control seepage flow for cutting embackment).
Fig. (11.9).

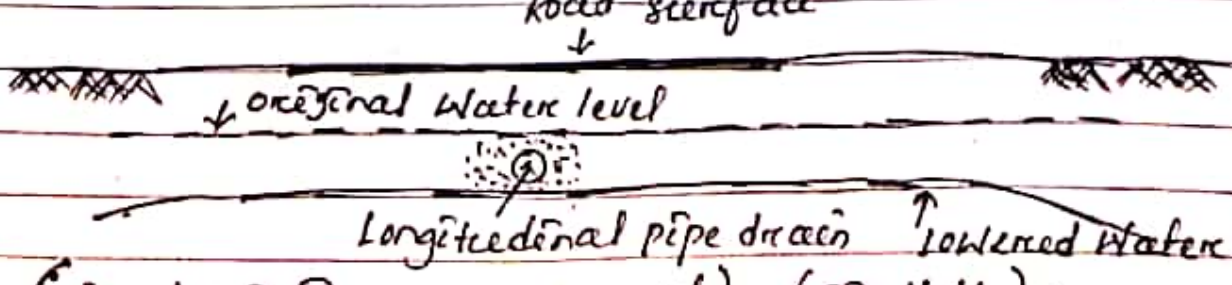


If the road is partly in cutting and partly in embankment as shown in fig 11·9, the seepage flow can be arrested on the cutting side by perforated drain pipe and the water can be disposed off through cross-drain pipes on the sloping side.

(iii) Methods to lower water table :- 1) In order to bring down the level of water table for roads running in flat country with low embankments, the longitudinal sub-surface drains or pipes drains are placed below the surface of the ground in the permeable saturated stratum
2) The pipe drains may be of vitrified clay with open joints butting against each other or they may be perforated at top. They may also be constructed of cement concrete or brick masonary with covering of perforated shut.



(pipe drains on both sides of the road) (Fig 11·10)

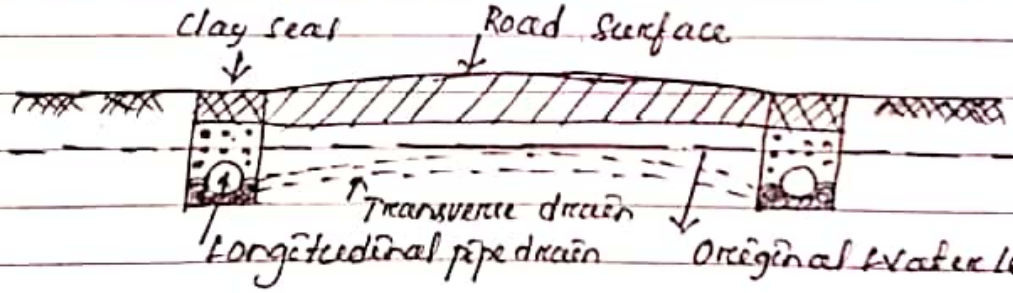


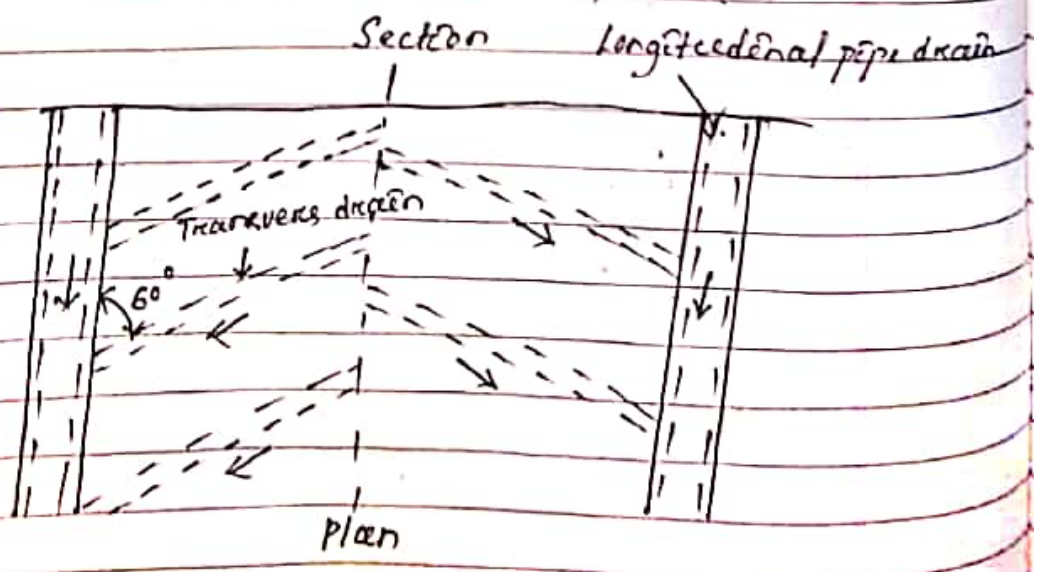
(pipe drain in centre of road) (Fig 11·11).

1) The longitudinal pipe drains may be laid on both the sides of the road, as shown in fig 11.10 or in the centre of the road, as shown in fig 11.11, depending upon the moisture conditions.

2) These pipes are placed in the trench when placed on sides with proper slope and they discharge the water into the surface drain. The pipe drains are usually laid on both the sides of the road.

3) If the provision of two longitudinal pipe drains on the sides of the road does not prove adequate to lower the ground water table to the desired extent, the transverse drain are laid in addition.





(Longitudinal and transverse) (section 11.12)

Cross drainage Structures:- Whenever streams have to cross the roadway. Facility for cross drainage is to be provided. Also often the water from the side drain is taken across by these cross drain in order to divert the water away from the road side drain to a water course or valley. The cross drainage structures commonly in use are culverts and small bridge. When a small stream crosses a road with a linear waterway less than about six metres, the cross drainage structure provided is called culvert; For higher values of linear waterway, the structure is called a bridge.

The common types of culverts in use are:
Slab culvert, Box culvert, Arch culvert, pipe culvert.
In slab culverts RCC slab is placed over abutments made of masonary and the span is generally limited to 3m. Box culvert of square or rectangular shapes is made of RCC. Arch culvert is generally built using brick or stone masonary or plain cement concrete. pipe culverts of minimum diameter 75cm and made of steel or prefabricated RCC is used when the discharge is low.

Intercepting drains:- Where the topography of the area is such that the water flows towards the roadway itself, it becomes essential to construct intercepting drains parallel to the road, but outside the road limit, to intercept water before it reaches the road.

Side drains:- It is necessary to construct sufficient by wide and deep side drains with suitable longitudinal

Slope to carry away all the water that accumulates to some drainage structure. The water level in these drains should remain at all times below the subgrade level.

Storm drain ~~loading~~ :-

A storm drain is defined as that portion of the storm drainage system that receives run off from inlet and conveys the runoff to some point where it is then discharged into a channel, water body or piped system. It consist of one or more pipes connecting one or more inlets. A storm drain may be a closed - conduit, open - conduit, or some combination of the two. The terminology "storm sewer" which has been in general use for many years, is generally being replaced with the term "storm sewer" to differentiate between sanitary sewers and ~~storm~~ drains. ~~Storm~~ Storm drain will be used throughout this manual.

The purpose of a storm drain is to collect storm water runoff from the roadway and convey it to an outfall. Storm drain design generally consists of three major parts:

- System planning which includes data gathering and outfall location.
- pavement drainage which includes pavement geometrics and inlet spacing.
- Location and sizing of the mains and manholes.