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Drainage Systems and It's Efficient Method of Constructions

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ABSTRACT: drainage is the system of pipes underground of sometimes at ground in the form of open drainage line to carry the waste water from household, industries etc. now a day in large cities where a big population lives we cannot adopt the drainage at ground. We have to construct a underground pipe network. For the proper working of this underground network we have to construct this system in perfect manner so that it will serve the respective city for the design period of time without the pondage of waste water and contamination of the water supply line. so to achieve this and reduce the expenditures of laying the drainage pipe line we adopt the quality function deployment.

The growing population of India has created many problems one of the challenging problems is drainage. Maintaining a drainage line for the clear passage of water is a very important task in the manner of a civil engineering to avoid the pondage of water on road, footpaths and subways for hassle free movement of human and vehicular traffic. To maintain these civil engineers need to construct the proper drainage line to avoid the blockage and free flow of sewage and rain water towards the water treatment plant and towards the outflow of basin which is basically a river.

KEYWORDS: Drainage system, Drainage problems, Drainage pipes, Cost of the work, Carry out sewage, Waste water.

I. INTRODUCTION

1.1 Functions of the drainage system

One of the drainage system's functions is to collect surface water and/or ground water and direct it away, thereby keeping the ballast bed drained. The drainage system must also protect the substructure from erosion, from becoming sodden, and from losing its load-bearing capacity and stability. Figure 1 shows the principle for the location of ditches, basins, storm water drainage pipes and pipe drains.

1.2 Ditches in natural terrain and slopes

If the ballast bed cuts across the natural drainage flow of any terrain, flood ditches must be installed to prevent the water running out uncontrolled and down the slope of the cutting, thereby causing erosion. The flood ditch must be designed to suit the local conditions, both in terms of design and location. A common location would be just inside the top of the cutting. However, there should be at least 1.0 m between the ditch and the edge. If the ditch or natural course of a stream flows into the slope of a railway cutting, channels must be constructed that direct water down to the culvert or line side ditch. If the volumes of water are large, these channels must have a frost-free or virtually frost-free foundation, and must be protected from erosion, for example by being properly paved with stone. If there is a severe fall in steep cuttings, it must be possible to reduce the water velocity along the channel, or at the latest, where the water flows out of the channel. It may be necessary to interrupt the flow by installing basins at intervals along the channel. The dimensions of the cross-section should be sufficient to ensure that there is no danger of flood water erosion outside the channel. The water must feed directly from the channel into a water channel or basin and closed storm water drainage pipe.

1.3 Channel with frost-free foundation

At locations where the ground is susceptible to frost, where there are major water flows and/or severe falls, the channel must be solidly constructed, with a frost-free foundation. Where the channel contains water or is covered with snow, the frost foundation may be calculated at a thickness = $0.5 \cdot Z$ below the base of the channel.

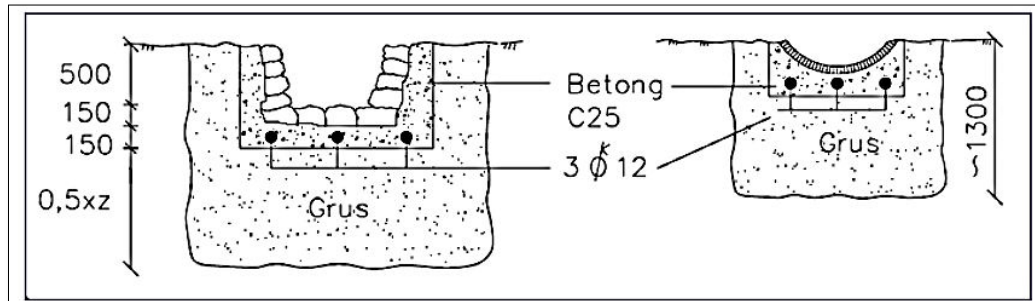


Fig1: Channel with frost-free foundation

1.4 Open line side ditch

This form of drainage will be formed of open, usually shallow ditches, whose primary function is to intercept and divert floodwater, thereby preventing such water from leaking into ballast and reinforcing layers. Longitudinal ditches form part of the cutting profile, and their design is specified in Underbygning. The base of the ditch must be at least 0.5 m under FL, and for new installations, the standard (practical) width of the base has been set to 0.5 m. At any point, the ditch must have a fall of at least 5‰ (1:200). In instances where the line effectively falls in the opposite direction to the ditch, surface water in the line side ditch may be fed down into basins and away in closed pipes. In instances where the cutting and its line side ditch transition into an embankment, surface water must be fed into a channel or into the natural terrain in a controlled manner. As in the case of the line side ditch, the construction of outflows along the slope of the embankment must be such that surface water is prevented from penetrating the backfill material. Deep line side ditches will make the ballast bed more susceptible to frost penetration from the side. Therefore, line side ditches must not be designed deeper than necessary based on prevailing conditions. Longitudinal ditches should have watertight bases, and be watertight up to 0.2 m below formation level.

1.5 Closed line side ditch

Special conditions may make it necessary to enclose the line side ditch. There may be locations where, for extraordinary reasons, the route of the ditch is interrupted by permanent structures (e.g. acoustic barriers, various foundations for pylons, cabinets, retaining walls, etc.). In new installations, this will usually only apply to short sections. A pipe must then be laid around the 'obstacle', in order to ensure continuity in the line side ditch. Recommended pipe dimension in such cases is 400 mm. If longer sections need to be enclosed (e.g. at stations/stops, platforms built in deep cuttings, etc.), in principle this must be constructed as a closed ditch with pipe drains or a combined drainage/storm water ditch. The minimum permissible dimension of the pipe drain is 150 mm. The ditch must be filled to the top with open, water-permeable material that allows storm water to pass down easily to the pipe. To reduce the risk of soil penetration, fiber membrane must be laid along the bottom and sides of the ditch.

1.6 Closed drainage ditch

'Closed drainage' refers to closed ditches containing drainpipes and/or drainage material that must be capable of drawing in/collecting groundwater and directing it along the bottom of the ditch to a secure outlet. The purpose of this system is primarily to lower groundwater to a controlled level, and keep it at this level. The need for closed drainage must be evaluated on the basis of local geotechnical/hydrological conditions. Longitudinal drainage lines in earth cuttings must be laid at the edge of the cutting or under the line side ditch. Refer to Figure. The pipe drain must have a fall in the right direction for its entire length, minimum 5‰. Permitted deviation from theoretical height is normally ± 50 mm. It is not normally necessary to have both closed drainage and a closed line side ditch. For technical reasons relating to frost, it is not advisable to drain the formation completely dry. In order to ensure that there will be some water in the formation, closed drainage ditches may be laid slightly higher than the base of the formation, but no higher than the base of the reinforcing layer.

1.7 Ditch materials

In the drainage zone, the ditch must be filled with permeable material that either has filtration properties itself or is protected with suitable filters. In more secondary ditches over short sections, it may occasionally suffice if the

ditch is filled with coarse drainage materials protected with fiber membrane. However, the general rule is for pipes to be laid, packed around with drainage and filter materials.

The upper part of the ditch normally contains densely compacted materials, such as compacted clay and/or black peat, in order to prevent storm water penetrating down into the groundwater drainage.

1.8 Problems Caused By Poor Drainage

Poor drainage creates many problems to both road users and road owners. Typically these are:

1.9.1 Traffic safety (aquaplaning and ice)

Poor drainage is a traffic safety risk. Water may accumulate on the road like ponds. The accumulated water creates a risk of aquaplaning during rain. A wet surface reduces friction which leads to longer braking distances. Surface water can freeze during the night at those times of the year with frost nights, and thaw again when temperatures rise above freezing during the day. Where this happens roads may become very slippery and the change in friction may come as a surprise to those who are driving.

1.9.2 Erosion-

Uncontrolled water flows on the road area can cause erosion. Culverts are also risk places for erosion. Small diameter and clogged culverts can cause water to flow towards the road and produce erosion. Water exiting from culverts can similarly cause erosion when it discharges directly on to erosive soil. The sensitive soil types for erosion are silt, silty moraine and sand. Vegetation can reduce erosion.

II. RELATED WORK

2.1 Carlier, J. P., C. Kao, and I. Ginzburg. 2013. *Field Scale Modeling of Subsurface Tile Drained Soils Using an Equivalent-Medium Approach*. *Journal of Hydrology*, Volume 341, Issues 1-2, 20 July 2013, Pages 105-115.

Research conducted for the last 35 years has shown that subsurface drainage has a significant impact on hydrology and contaminant transport. This can be observed at the field-scale and also at the watershed scale. Impacts are always associated with modifying otherwise natural flow paths. Most computer model representations of drainage have been drawn at the field-scale. These models require relatively precise data that are usually unavailable when simulating hydrology and water quality in large watersheds. We believe that in this case drainage representation should be simplified and yet closely match observations. As a first step towards incorporating drainage systems into large-scale hydrological models, we propose an equivalent representation of drains buried in a soil profile by Using a homogeneous anisotropic porous medium without drains.

This representation is based on a “self-consistent” approach and on geometrical considerations. Simplification is such that calculating the equivalent hydraulic conductivity requires only information on the main length and spacing of the tile drains and not on their precise location. This approach also provides a much simpler discretization of the domain because of the absence of internal boundary conditions on the drainage pipes. Compared to other methods that have simplified drainage representation in existing watershed models, it requires no parameter fitting. Two alternatives to the method are presented: in the first one, the soil profile equipped with the actual drain pipes is represented by an equivalent, horizontally layered system with no pipes; in the second, the layered system has been replaced with an equivalent homogeneous profile. The efficiency of these approaches was tested against a classical representation of tile drains using the SWMS 3D code, which solves the Richards equation for a typical drained plot configuration.

2.2 Ale, S., L.C. Bowling, J.R. Frankenberg, S.M. Brouder, and E. J. Klavivko. 2010. *Climate variability and drain spacing influence on drainage water management system operation*. *Vadose Zone Journal*. (1):43-52.

The effects of climate variability drain spacing, and growing season operational strategy on annual drain flow and crop yield were studied for a hypothetical drainage water management (DWM) system at Purdue University's Water Quality Field Station Using the DRAINMOD model. Drainage water management showed potential for reducing annual average (1915–2006) drain flow from all drain spacing's (10–35 m) regardless of the growing season operational strategy, with reductions varying between 52 and 55% for the drain spacing's considered. Approximately 81 to 99% of the annual drain flow reduction occurred during the non-growing season, depending on the operational strategy.

Fixed DWM operational strategies led to an increase in mean predicted yield for narrower spacing's compared with conventional drainage systems. Maximum yield was achieved with no control for drain spacing's wider than 20 m in 50% of the years. Overall, the height of control had more influence on relative yield than the date of initiation of control. The greatest positive impacts of DWM on relative yield (1.2%) occurred in cool, dry years, while the greatest average negative impacts (-0.2%) occurred in cool, wet years. On average, with the best-case operation selected for annual weather conditions, DWM increased relative yield by approximately 0.8, 0.4, and 0.2% for the 10-, 20-, and 30-m drain spacing, respectively. Accumulated growing degree days and antecedent precipitation index show promise for identifying appropriate operational strategies for DWM.

2.3 Etherington, J.R. 1984. Comparative studies of plant growth and distribution in relation to waterlogging. J. of Ecol. 72:389-404.

Geum rivale L. and *G. urbanum* L. were grown in drained, continuously flooded or transiently flooded compost for 21 weeks. Leaf and root material harvested after this time was analyzed for Fe, Mn, Ca and P. Mn and Fe concentrations in roots and leaves of both species were increased by flooding. Higher Fe concentrations accumulated in the roots, while Mn was present in roughly equal concentrations in both roots and leaves. Leaf Ca concentration of both species was higher than that of roots. Although Ca concentrations were significantly higher in *G. rivale* than in *G. urbanum*, there were no readily interpretable effects of waterlogging. P concentration was decreased in leaves and increased in roots of flooded *G. urbanum*, although there was much less effect of flooding on P concentration in *G. rivale*. Fe may be precipitated by phosphate in *G. urbanum* roots, but this may lead to P deficiency in shoots and roots, resulting in poor growth of this species in waterlogged soil. A different mechanism of Fe immobilization is likely to occur in *G. rivale*, which does not result in phosphorus deficiency.

III. METHODOLOGY AND EXPERIMENTAL RESULTS

3.1 General

The primary purpose of a road drainage system is to remove the water from the road and its surroundings. The road drainage system consists of two parts: dewatering and drainage. "Dewatering" means the removal of rainwater from the surface of the road. "Drainage" on the other hand covers all the different infrastructural elements to keep the road structure dry. In Indian "dewatering" is further divided into two parts: runoff ("avrinning") and dewatering ("avvattning"). "Runoff" covers the water flowing from the surface of the pavement via road shoulders and inner slopes to the ditches. "Dewatering" covers the collection and transport of water from the surface and structure of the road so that there will be no ponds on the road or in the ditches.

"Dewatering" consists of following elements:

Cross fall, Road shoulders, Impermeable road surface materials

A typical "drainage" system consists of following elements:

Outlet ditches, Side ditches, Culverts, Inner/outer slopes, Road structures, Under drains

The general score of road drainage system is dependent on its "weakest link". This means that if any of its elements is out of order, the whole system will not operate as planned and the road will be damaged. On the other hand a well built and maintained road drainage system is a very sustainable investment policy. The main advantages of a good drainage system are: effective removal of rainwater out of the road surface and its surroundings, road structures that stay dry, good bearing capacity, and a road that is nice and safe to drive.

3.2 Pavement and wearing course

The pavement or wearing course is the top layer of a road. One function for the pavement is to provide a waterproof covering for the lower pavement structure. This can be achieved if the pavement is impermeable and has no cracks. The topmost wearing course must also have an adequate cross fall to lead water (from rain, melting snow or ice) immediately away from the road surface.

The recommended cross fall will depend on the road type and on the material of the topmost layer. On a straight road cross fall will range between 3 and 5 %. On asphalt the recommended cross fall is 3 %, and for gravel roads it is 5%. On a straight road cross fall is normally applied as a crown section..

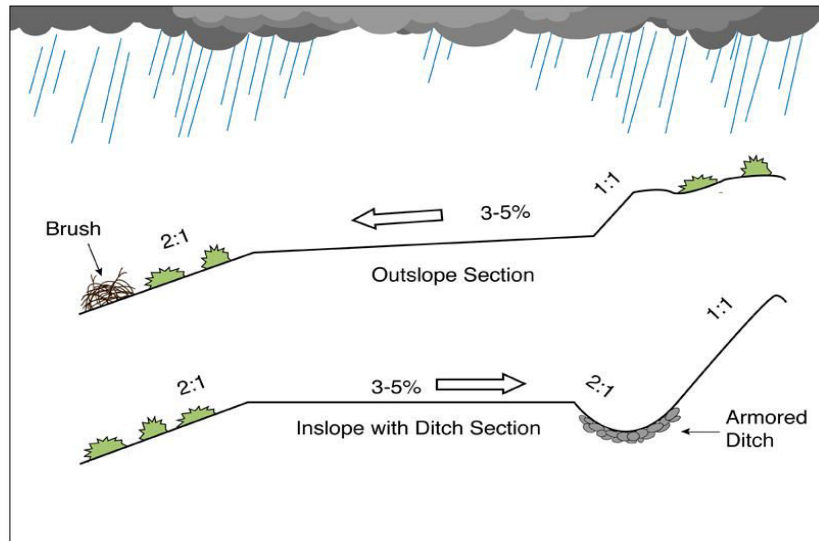


Fig 2: Inslope and out slope

In Indian side ditches are classified into two categories: 1) road cut ditches (“skärningsdike”) and 2) rainwater ditches (“dagsvattendike”). According to Swedish guidelines the depth of the side ditch (“skärnings dike”) should be at least 30 cm below the bottom of the pavement structure. The same minimum depth in Finland is 25cm. Norway has the highest requirements of 35 cm on a newly constructed road. Deeper side ditches than these values do not significantly improve drainage. ROADDEX tests in Indian have confirmed these recommendations are valid.

A rainwater ditch means that the ditch only collects rainwater from the road and its surroundings, i.e. the surface soil is dry and the groundwater table is deep. In Indian the design depth of this type of ditch is 0.5m measured from the road surface. This ditch type can be used where the sub grade is water permeable and the groundwater table is deeper than 1.0m below the lower surface of the road. According to old Finnish road design guidelines the depth of this ditch type (rainwater ditch) should be 15 cm below the pavement structure bottom. Additionally the sub grade should be non-frost-susceptible.

The condition of ditches has traditionally been evaluated visually, but the method is accepted to be subjective and sensitive to the time when the evaluation was made. Additionally the shape of ditches usually change very slowly with the result that only the worst spots are detected visually, and the ditch bottom is usually unseen. The ROADDEX project has tested a number of techniques to resolve these difficulties and the best results were achieved using a combination of laser scanners and GPR techniques.

3.3 Main road culverts

A culvert is a pipe or box structure generally used as cross drains for ditch relief and to pass water under a road at natural drainage and stream crossings. In Finland a culvert is defined to be a culvert if its clear opening is less than 2m, if it is more than 2m it is defined as a bridge. If the construction is a large pipe with a clear opening of 2-4 m, the culvert is defined as a pipe bridge. The shape of a culvert is usually a round pipe, but culverts can also be pipe arch, structural arch or box. The shape depends on the site, the required area and the allowable height of soil cover. Culverts pipes are expensive, and the relatively small culvert pipes used for cross-drains can be susceptible to clogging and require cleaning. That is why, when planning the installation of a culvert, the most important thing to keep in mind is to make sure that the culvert is adequately sized and has overflow protection. Culverts should also be installed in accordance with the manufacturer’s instructions and suitably protected from erosion, scour and road maintenance equipment. Main road culverts should be installed in the lowest point of the terrain. The rule of thumb when installing a culvert is that natural channel modifications should be minimized and that any constriction of the channel flow width must be avoided. This can be done by maintaining the natural grade and alignment of the channel through the culvert.

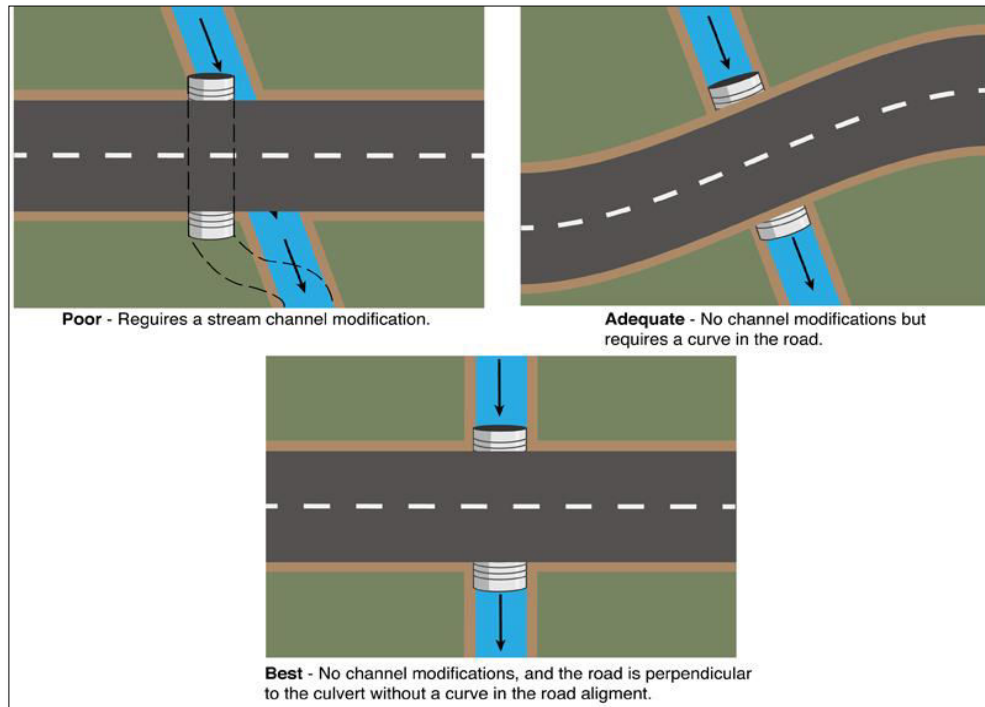


Fig 3: Main road culverts

The height and position of a culvert will be dependent on a number of matters:

- An adequate longitudinal gradient (at least 1% to prevent the accumulation of silt or mud)
- The depth of the side ditch
- The level of the drainage system in the surrounding terrain
- It should be also kept in mind that many times, in weak soil areas, the road will settle around the culvert which will cause ditch bottom level to rise.

Culverts should normally be installed orthogonally to the road alignment. They can also be installed at an angle to the road alignment if required by local circumstances.

Materials for the foundation and backfill, as well as material for transition wedges, should be non-frost susceptible and should not contain rocks larger than 75mm. The foundation material should not contain rocks larger than 40 mm. A moist, well graded granular or sandy gravel soil with up to 10 % of fines is an ideal backfill material.

In Finland the recommended minimum size for a main road culvert in low volume roads is 400mm (if the length of the culvert is not more than 10m). The “size” of the culvert is defined as the inner diameter of the pipe. There are some exceptions to this rule. For example, installing a new smaller pipe inside an old pipe, when it is known that the old culvert has been too large. Ideally, the width of a culvert should be as wide as the natural channel to avoid channel constriction.

When designing the size of culvert a number of matters should be taken into account, i.e. size of drainage area, surrounding terrain type, rainfall intensity, etc. The table below gives some examples of different sizes of culverts. The table is modified after Geller & Sherad: “Low volume roads engineering – Culvert use, installation and sizing”. Rainfall intensity has been assumed to be 75 – 100 mm/h. The situation of bare land with light vegetation and steep slopes has a higher runoff coefficient than forest land with heavy vegetation terrain and gentle slopes. For an intermediate terrain the pipe size can be interpolated. If the suggested pipe size is not available, the next larger pipe size should be used.

The outlet of a culvert pipe should ideally be located in a stable, non-erosive area. Well-vegetated or rocky areas are good places to locate a culvert. Water flowing from a culvert can cause erosion problems where it discharges directly on to erosive soil. Channel protection, riprap or other structural solutions are not as good as a correctly sized and well placed pipe

3.4 Road drainage structures & layers

Horizontal road drainage structures include structures such as filter courses, special geotextiles, and special asphalt mixtures (like porous asphalt) that lead the water away from the road, or cut the capillary rise connection from the sub grade to the upper part of the pavement structure.

The main purpose of the filter course in road drainage is to cut the capillary rise to the road structural courses above of it. Filter course material should be well graded with a maximum grain size of 31.5mm and should be non-frost-susceptible. The thickness of filter courses varies across the Nordic countries from 0.4m to 0.6m thick. The filter course is the lowermost structural layer and is normally spread across the bottom of the excavation. A filter course should always be used in the road structure when the sub grade is frost-susceptible (like clay, silt and silty moraine). The filter course is normally separated from the sub grade soil by a geotextile. Porous asphalt is used in countries suffering from large amounts of rainfall. This special asphalt mix ensures a fast drainage of water away from the pavement surface. This reduces the risk of hydroplaning and bad visibility conditions due to “splash and spray”, and improves overall road safety.

Water does not easily collect on a porous asphalt surface during the heavy rains as the majority of the stones in the mixture are of a similar size (i.e. a very steep grading curve). The thickness of a porous asphalt layer is typically 20-100mm and it is placed on top of an impermeable asphaltic base. Although the material is good in wet conditions, it has a few disadvantages. It has a lack of durability and it has to be ensured that there is enough bitumen to coat the stones. If there is too much bitumen, the mixture will rut easily and the pores will block with bitumen. If there is too little bitumen, raveling will occur. Porous asphalt can become clogged and lose its efficiency with the ingress of particulates and dust from the environment, blown soil, engine wear and cargoes. Snow, ice and de-icing salts in winter can also clog the pores and prevent the flow of water.

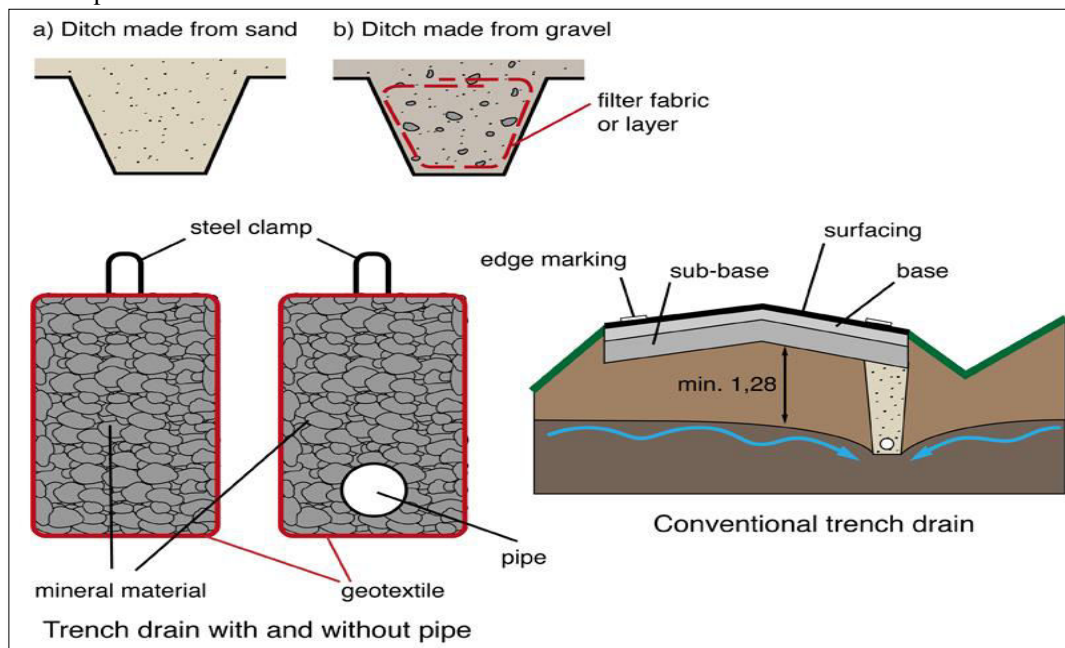


Fig 4: Trench Drainage

A step by step-example of how to make the Trench drain:

1. Excavate a narrow trench
2. Clean out the excavated trench
3. Line the surfaces of the excavation with a geotextile
4. Place a layer of aggregates in the bottom of the lined trench
5. Install a carrier pipe if needed
6. Fill the drain with aggregates
7. Close the drain and wrap over the geotextile (minimum overlap is 30cm)
8. Cover the closed drain surface with at least 3-5cm of top soil or other low permeability material. If surface runoff is to be collected also the covering material should be permeable.

Fin drains are longitudinal drains, manufactured from composite materials. A fin drain usually comprises two geotextiles outer faces, to provide a filter function with the surrounding soil, and a rigid plastic core that is sandwiched

between geotextiles. A fin drain can also feed into an integral collector at the bottom of the drain. Water flows through the geotextile facings into the core that then transports the water to an outlet ditch.

3.5 Inner and outer slope drainage structures

The goal in designing the inner and outer slopes on a road is to use as gentle slopes as possible. Gentle slopes are friendlier for the environment, are better for traffic safety and have a higher resistance against erosion. The inclination of a typical slope will depend on the road category (rural road, main road, motorway etc.) and the local topography. The recommended inclination for an inner slope on a main road according to old Finnish guidelines is a minimum of 1:2 and for outer slopes a minimum of 1:4

IV. CONCLUSION

As the population of India growing up then the requirements of water is also increasing which results in increase in the waste water generation. This waste water has to carry out of the city in proper manner without poundage and clogging if sewer line. It has become a tedious task for civil engineers. We have given the detailed analysis of existing sewer line and proposed remedies for construction of the sewer line efficiently to fulfil the demand which have arisen today. By using above methods and remedies a civil engineer can construct sewer line which will serve the growing population.

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