

Unit- 2

Dewatering

Dewatering :—

Dewatering in its broadest sense indicates modification of the ground by reducing the water table, redirect seepage or simply reduce the water content of the soil strata.

Objectives :—

1. To provide dry working areas for construction of foundations of buildings, bridges, dams etc.
2. To increase the bearing capacity of soil.
3. To reduce the lateral pressure on foundations and retaining structures.
4. To reduce the compressibility and settlement of granular soils.
5. To prevent liquefaction of foundation beds.
6. To reduce the damage by freezing and thawing.
7. To reduce the surface erosion.
8. To improve the workability of borrow soils.

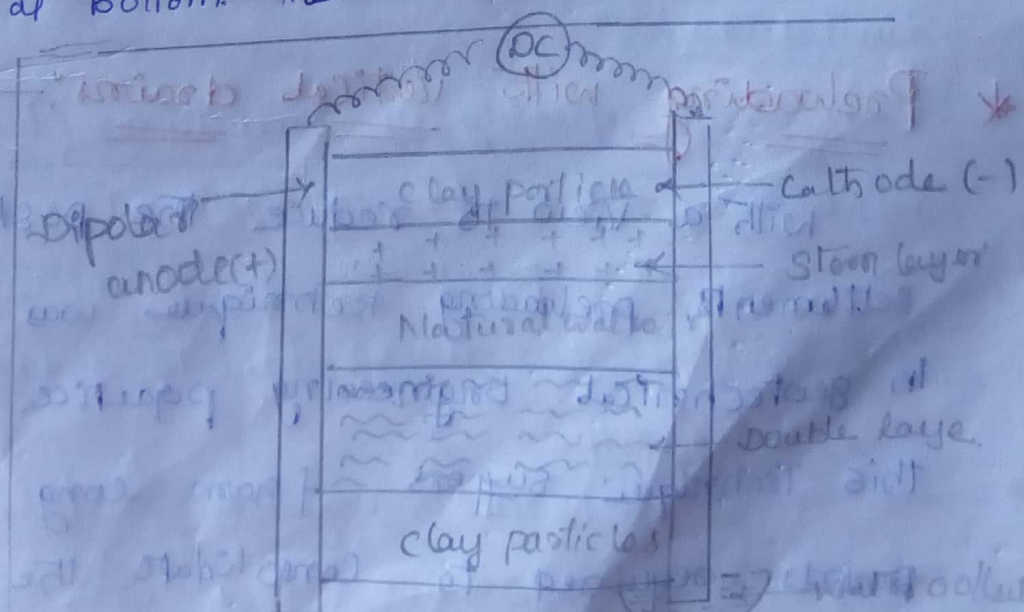
* Electro Osmosis :—

Electro osmosis is a technique for stabilizing and dewatering of soft clay with $K = 10^{-5}$ to 10^{-7} cm/sec.

This Technique is designed by Leo-Casagrande, who applied this Technique for several field problems in Germany. The result of this Technique varied from poor to semi dense soils (silt/clay).

Principle:- when direct current is applied in saturated soil between anode and Cathode, water present in the soil migrates from anode to Cathode. This phenomenon can be explained by using double layer theory. Cathodes are formed in the pore water by dissolved mineral present in the soil. These cations are attracted by the negatively charged particles, cations in turn attract water molecules by what is known as cation hydration.

Hence all thickness of double layer including the neutral layer leaving a small thickness of positive ions (stern layer) will move towards Cathode. Incidentally Cathode is made of a perforated pipe with a well point at bottom. The collected water is immediately pumped out.



Applications :-

Anodes are in the form of steel rods ~~are~~ located near the toe of the slopes and Cathodes are in the form of perforated pipes resembling well points which are installed at 4 to 5 m away from the slope.

Calculations

According to Helmholtz's model of the electro osmotic flow velocity reduced by an applied electric field is given by

$$V_e = (DE \Delta E) / (4\pi M \Delta L)$$

Where V_e = Electroosmotic flow velocity cm/sec

ΔE = applied voltage (volt)

ΔL = spacing of electrodes (cm)

M = viscosity of water (centipoises)

D = Di-electric constant of pore water

E = zeta potential in volts.

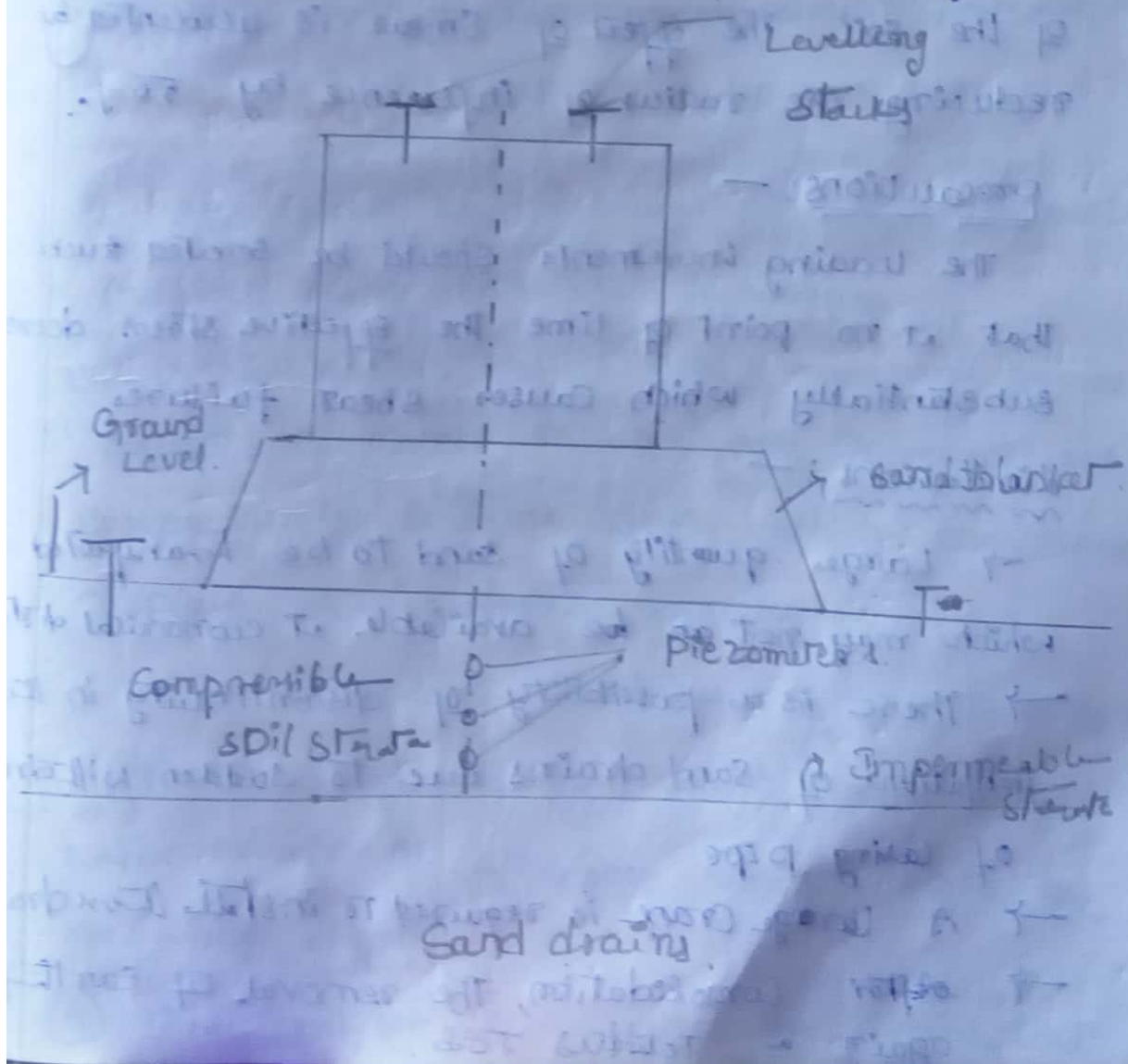
* Preloading with vertical drains :- (Sand drains)

With a view to reduce the post construction settlements, preloading technique was emerged in geotechnical Engineering practice. However this technique suffers from long time periods required to consolidate the natural

deposits of soft compressible soils with low permeability.

In order to accelerate the process of Consolidation, sand drains are installed along with pre-loading. Sand drains are installed by driving a casing pipe with a false bottom to the desired depth and backfilling the hole with compacted sand while withdrawing the casing pipe.

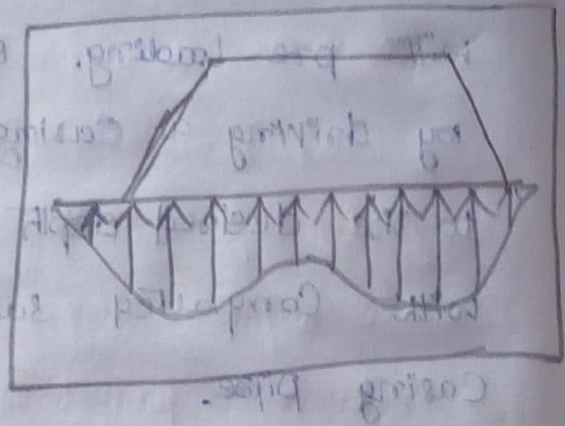
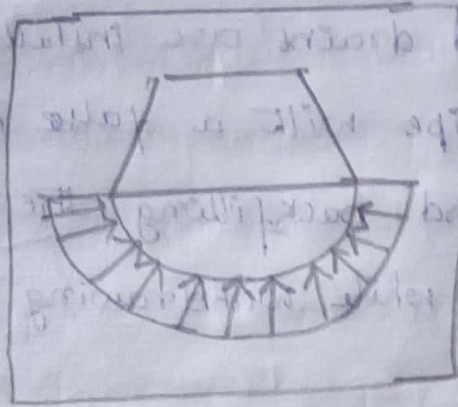
This technique takes advantage of the fact that the horizontal permeability is several times more than vertical permeability.



In the study of sand drains two fundamental places arise.

1. Free Strained Case

2. Equal Strained Case



Another important factor to be considered in sand drains is the effect of smear which is due to the reduction in permeability upon remoulding of the soil. The effect of smear is accounted by reducing the radius of influence by 50%.

Precautions: —

The loading increments should be selected such that at no point of time the effective stress decreases substantially which causes shear failures.

Limitations: —

- Large quantity of sand to be transported which may not be available at economical distances
- There is a possibility of discontinuity in the formation of sand drains due to sudden withdrawal of casing pipe
- A large crane is required to install the drains
- After consolidation, the removal of earth fill again a tedious job.

(*)

Stone Columns:

Columns formed of gravel, sand, cement lime or admixtures have been formed in situ weak soil foundations which act as compression reinforcement and increase the bearing capacity and reduce settlement.

Functions:

- They act as vertical drains.
- They act as reinforcing elements.
- After Consolidation of soft ground and accompanying load redistribution, the column may carry 80% of the load.
- This method is economical up to 15m depth.

Explanation:

1. Also called as granular piles, They are mostly installed using Vibration Techniques.
2. A cylindrical vertical hole is made and gravel backfill is placed into the hole in increments and compacted by suitable device which simultaneously displaces the material radially.
3. The vibrofloat is allowed to sink into the ground due to its own weight assisted by water or air as flushing medium up to the required depth.
4. The soil surrounding the vibrofloat

is disturbed or remoulded and the softened material can be removed by Jetting fluid.
i.e. water or compressed air.

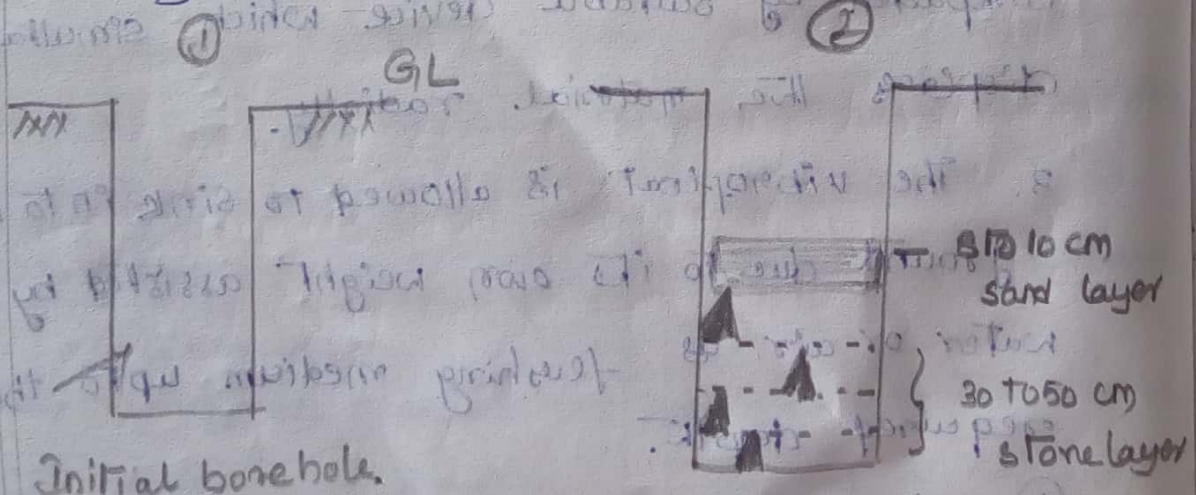
(5) water is used as a Jetting fluid, or fully saturated soils while compressed air for partially saturated soils

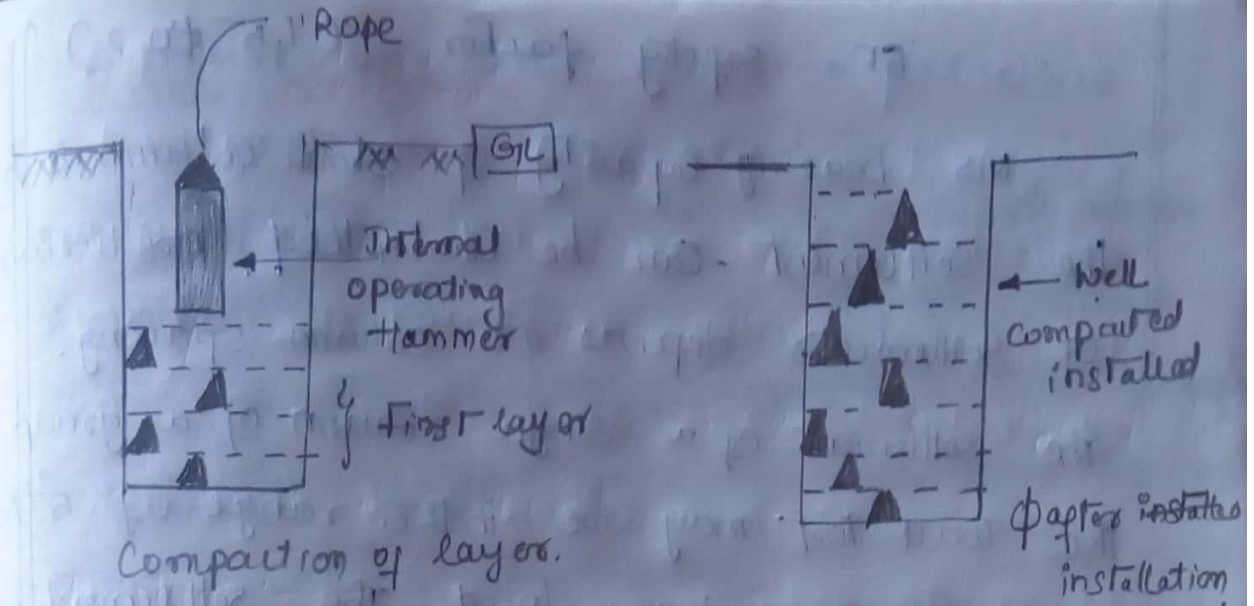
(6) It can be observed from the figure by its process a bore hole of larger than the vibrofloat is found once the vibrofloat is withdrawn

7. The formed borehole is backfilled with gravel of 10 to 75 mm size or furnace slag.

8. with the penetration of the vibrofloat the backfill material is displaced into the sides of the boreholes and Compacting underneath the tip, while backfilling the vibrofloat is raised and lowered

9. This procedure is repeated till the hole is completely filled and Compacted which form a cylindrical granular pile.





On the basis, the stone Column Length (L_c) should be greater than.

$$L_c = \frac{P - A_c (q + c_{pr})}{\Delta d c}$$

where P = Total load on the stone Column

A_c = cross-sectional Area of Column

c, c_{pr} = side and point cohesion

d = average of the stone Column.

The allowed bearing Capacity of Stone Column is

$$q_a = \frac{K (4c + \sigma_r)}{SF}$$

where $K = \tan^2 (45 + \phi/2)$

ϕ = drained angle of internal friction of stone

c = either drained cohesion or

undrained shear strength

σ_r = Effective radial stress or $2c$

SF = safety factor (1.5 to 2)

As bearing capacity of stone column is high the settlement can be controlled, prediction of settlements depends on column spacing.

The settlement of a single column of a group in the load test may be in the range of 5 to 10 mm at the design load. The settlement of the large group is usually about 5 to 10 times the single column settlement.

Uses:

1. Stone columns are suitable for soft inorganic cohesive soil, loose sand deposits to increase the density.
2. Capable of dissipating excessive pore water pressure in the in-situ soil.
3. Reduces the void ratio of zone of influence

Disadvantages:

1. Cannot be used in peat or high organic silt or clays.
2. Used in soils of low shear strength
3. undrained shear strength has increased
4. Settlements are reduced
5. Suitability of embankments and slopes are increased

Lime Columns

A special hollow rod with rotating vanes is augured into the ground to the desired depth and the stabilizing mixture is simultaneously introduced. By the process piles up to 600mm diameter can be constructed.

Lime in order to have 5 to 8% of the dry soil is the best for clays and sandy soils.

Generally it is essential to obtain optimum %

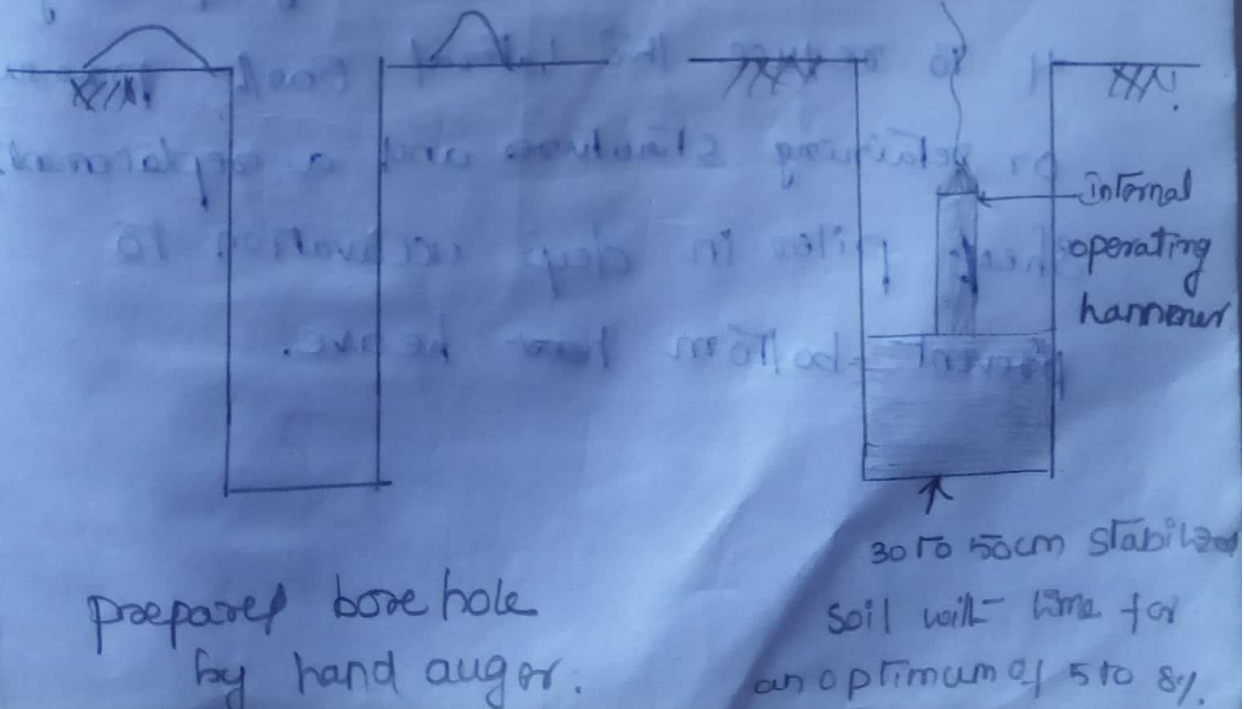
of lime to be added to the soil. In these

soils compressive strength more than 10 MN/m^2

can be achieved. Lime is effective in both

expansive plastic clays i.e. compressive strength

1 to 2 MN/m^2



unbaked or quick lime was mixed with clay and columns upto 10m long and 50cm diameter were constructed. Lime clay mixture has substantially increased the strength of natural clay. Lime columns are most significant than others and increases the shear strength.

The strength increases rapidly in fresh and brackish water deposited glacial clays. In soft organic clays and salt deposited clay the strength increases was low.

Uses —

1. To reduce the negative skin friction on pile.
2. To prevent the displacement of soil around the pile foundation from creep.
3. To increase the stability of clay slopes.
4. To reduce the lateral earth pressures on retaining structures and a replacement for sheet piles in deep excavation to prevent bottom ~~ho~~ heave.

UNIT-2 Dewatering

* SUMP AND DITCHES

Essential feature * sump below the G.L. of excavation at 1 or more corners or sides.

- * To prevent standing water on the floor of excavation.
- * A small ditch or grip cut around the bottom of excavation falling towards the sump.
- * Large excavations have to remain open over long periods
- * The greatest depth to which water table can be lowered about 8m below the sump.

* PRECAUTIONS:-

→ Advisable to design these drainages with much more care.

* ADVANTAGES:-

Most widely used of all methods of ground water lowering economical method for installation and maintenance soil & Rock condr. Appropriate where boulders or massive obstructions met with in the ground.

* DISADVANTAGE:-

Ground water flows towards the excavation with high head / steep slope

— Risk of collapse of the sides.

— open / Timbered excavations:- Risk of instability of base due to upward seepage towards pumping sump

* WELL POINT:-

Filter wells

Well points

Small well screens



* Either with brass or

stainless steel screens with either closed ends or self jetting types.

* Economical to use disposable plastic well points - nylon mesh screens surrounding flexible plastic Riser pipe.

* SINGLE STAGE WELL POINT:-

Capacity: 50mm riser about 10 lit/m.

spacing: depends on permeability of the soil and availability of time to effect the draw↓

* Fine-coarse sands / sandy gravel: 0.75m-1m.

Very sandy - Fairly low permeability: 1.5m.

Well pointing equipment comprises 50-60 well points to a single 150-200mm pump with a separate jetting pump.

- * It has an air/water separator and a vacuum pump & normal centrifugal pump.

→ Used for construction purpose.

where site is accessible: water bearing stratum to be drained is not too deep.

- * They act most effectively in sands & sandy gravels.

ADVANTAGE:

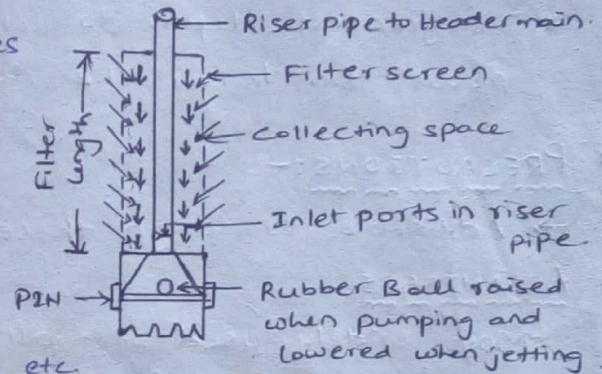
The water is filtered and carries little or no soil particles.

LIMITATION:

Suction Lift:-

Lowering of about 6m below pump level - Excessive air shall be drawn into the sys to join the pipes; valves etc.

- Loss of pumping efficiency.



WELL POINT SYSTEMS

IMPOSSIBLE CONDITION FOR WELL POINT INSTALLATION:

LARGE gravel: ~~stiff~~ clay & soil containing cobbles or boulders.

SINGLE STAGE WELL POINT INSTALLATION

MULTI STAGE WELL POINT dewatering deeper excavations —

- * Well point must be installed in 2 or more stages.

- * No limit to the depth of drawdown in this way.

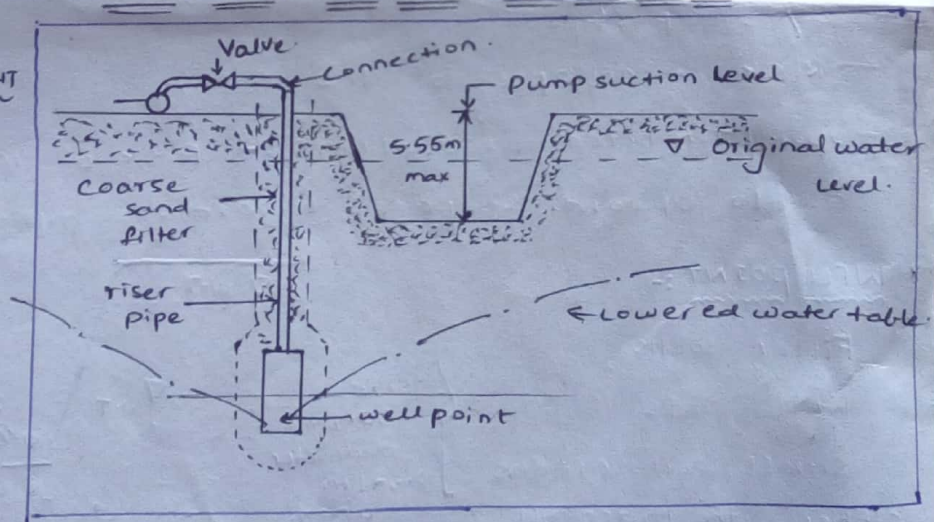
- * overall width of excavation @ G.L becomes very large.

- * It is possible to avoid this by excavating down to water table - before installing pump & header.

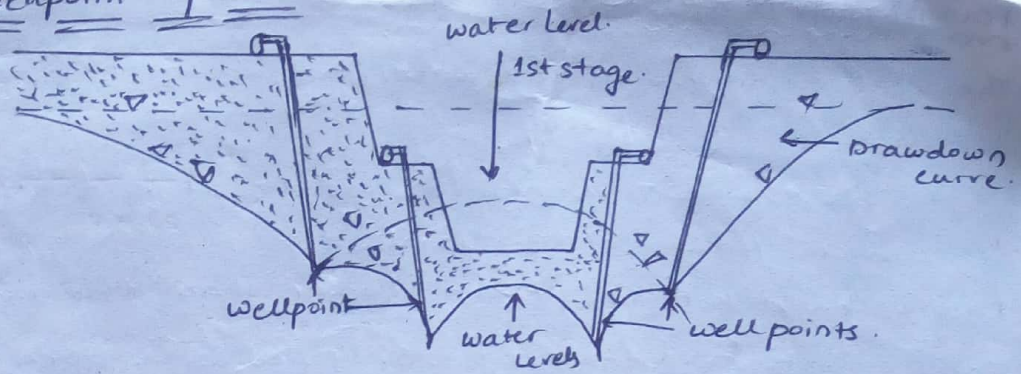
- * Well points used in Braced Excavations - placed close to the toes of sheet pile.

→ To prevent quick condition of bottom when sheet piles are of limited penetration.

→ To eliminate hydrostatic pressure on the back of sheet pile



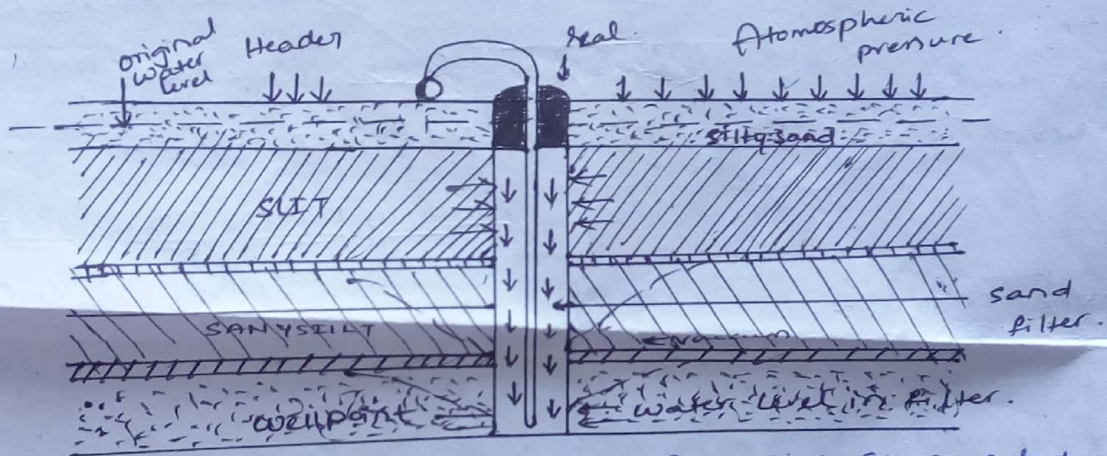
Multistage Wellpoint operation



* VACUUM DEWATERING SYSTEM (OR)

WELL POINT SYSTEM :-

- * Wellpoints } Not much effective in fine grained soils.
- * deep wells }
- * such soils can be dewatered satisfactorily by applying vacuum to piping system.



- * It Req well and well point screens : Riser pipe surrounded with filter sand.
- * Top portion of hole is sealed or copped with impervious soil or other material
- * By vacuum pressure - Hydraulic gradient for flow to wellpoint ↑
- * suitable in Layered or stratified soils.
- * Coeff of permeability : 0.1 to $10 \times 10^{-4} \text{ cm/sec}$.

* HORIZONTAL DRAINS OR WELLS :-

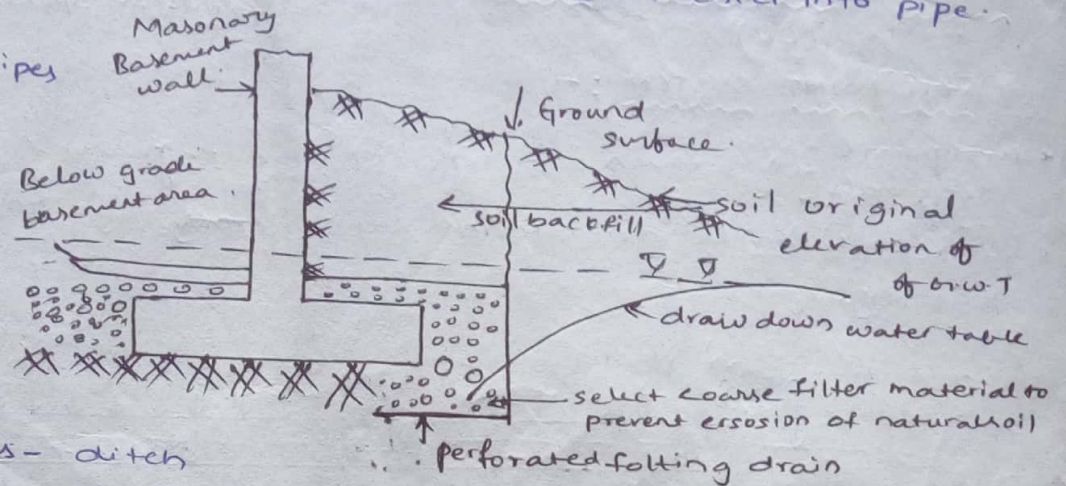
- Groundwater is surrounded lowered by means of Ranney drainage system.
- It consists of Reinforced concrete shafts or wells —
No. of Horizontal perforated pipes are fixed
- They may ~~extend~~ extend to req length in any direction.
- water collected is pumped out by means of turbine pump
(Not effective in lowering water in stratified soils)

FOUNDATION DRAINS:-

- * The worst condition - Ground water may be allowed only on the exterior side of building
- * depth b/w the W.T is not too great; It is feasible to control the water by foundation drains.
- * Drains should not be placed lower than the bottom of footing
- * They consists perforated pipes or pipes with open joints.
- so G.W can't enter into pipe.
- * Filler should surround the pipes

- * collected water is disposed off by gravity flow - storm drain system.

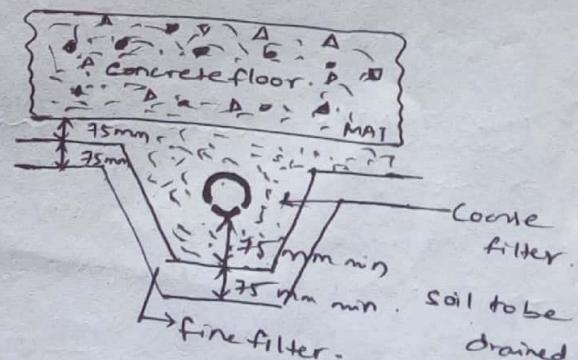
- * other drainage facility such as - ditch dry well etc.



FOOTING DRAIN TILE INSTALLATION
FOR disposing of G.W

* BLANKET DRAINS:-

- These are constructed beneath dams & basement floor slabs.
- They provide highly permeable drainage path for removal of G.W.
- If escape path provided with uplift pressure can be reduced
- It consists of a fine filler layer in contact with soil.
- coarse filler: collector layer - contact with masonry dam / Basement floor.
- Blanket connected by conduits to sump - collector water pumped out to drainage pipe.



Dewatering in its general sense indicates lowering the water table, redirecting the seepage (or) simply reduce the water content.

Objectives of dewatering:

- * To provide dry working area for laying the foundation, bridges, dams etc.
- * To increase the bearing capacity.
- * To reduce the compressibility in case of coarse grained soil.
- * To reduce the susceptibility for Liquefaction.
- * To reduce the damage due to freezing & thawing.
- * To reduce the lateral pressures on foundation and retaining structures.
- * To reduce the surface erosion.
- * To reduce the Liquefaction potential due to seismic activity.
- * To prevent migration of soil particles by ground water.
- *.

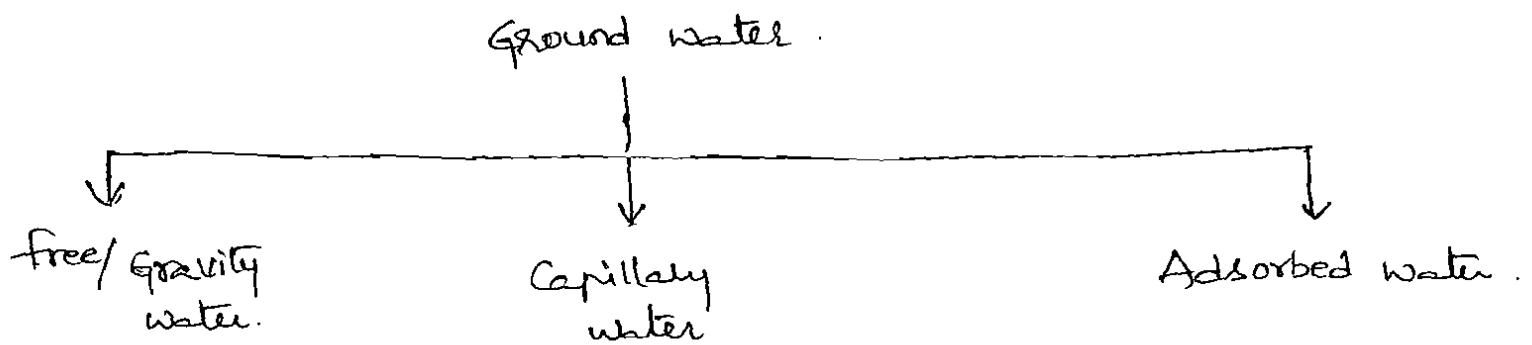
Dewatering is required for not only civil engineering projects but also these are useful in mining projects.

Soil is a multiphase system consisting of solid phase called skeleton and fluid phase called pore fluid. The physical & chemical interaction b/w mineral skeleton and pore fluid in general dictates the engineering behaviour of any soil.

Under many field situations during construction operations it may be necessary to eliminate seepage pressures to increase shearing resistance (or) to reduce erosion, foot damage etc.... It can be done by reducing the neutral stresses (caused by pore fluid) effectively by adopting "dewatering" methods.

Ground water is usually considered as one of the most difficult problems that has to be handled in any civil engineering constructions.

The Methods of dewatering are based on the various forms of ground water existence in soil can be graphically ~~also~~ represented as



Methods of dewatering:

The following methods are controlling the Groundwater, they are

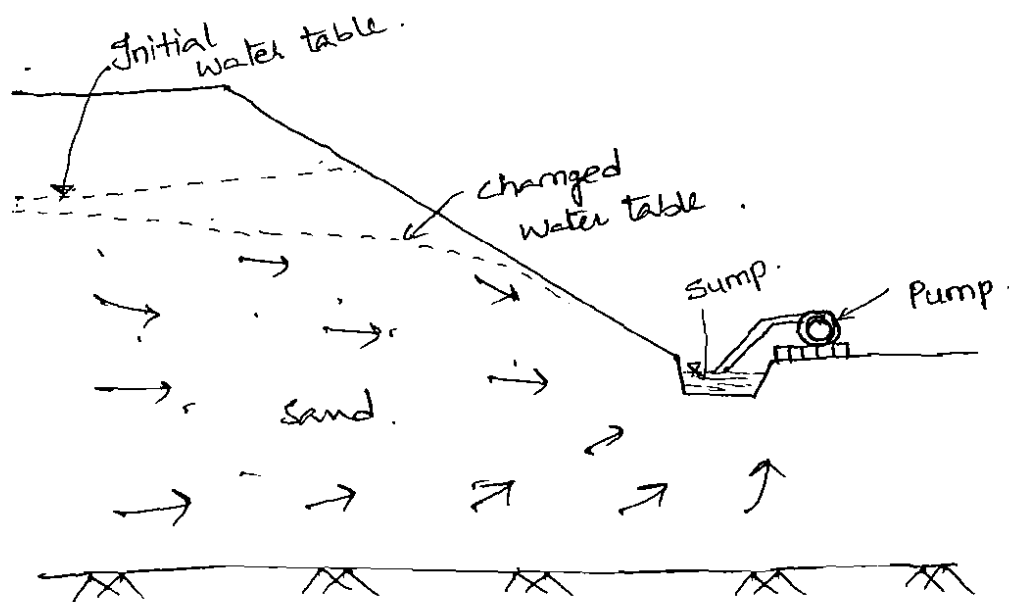
1. open sumps and ditches.
2. Well point system.
3. Deep well Drainage system.
4. Vacuum dewatering system.
5. Dewatering by electro-osmosis.

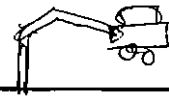
①. Open Sumps & Ditches :

In this method the important feature is a sump below the ground level of the excavation at one (or) more corners. In order to reduce the standing of water on the floor of excavation, a small grip is cut around the bottom of excavation. care should be taken while designing the ditches which are kept open for a long period.

This method is widely used for the lowering of ground water. this method is economical and easy to install and as well as simple maintainance requires. This method is effective in situations where boulders & massive obstructions are met with the ground.

The max. depth to which the water table can be lowered by this method is about 6m below the pump, effective in coarse sand & clean gravels.





③

Well point system

filter wells (or) well points are small well screens of sizes 50 to 80 mm in diameter and 0.360 m length well points are either with Brass (or) stain less steel screens and are made with either closed ends (or) self jetting types. Usage of plastic disposable well points in the places where requires to remain in the ground for long period.

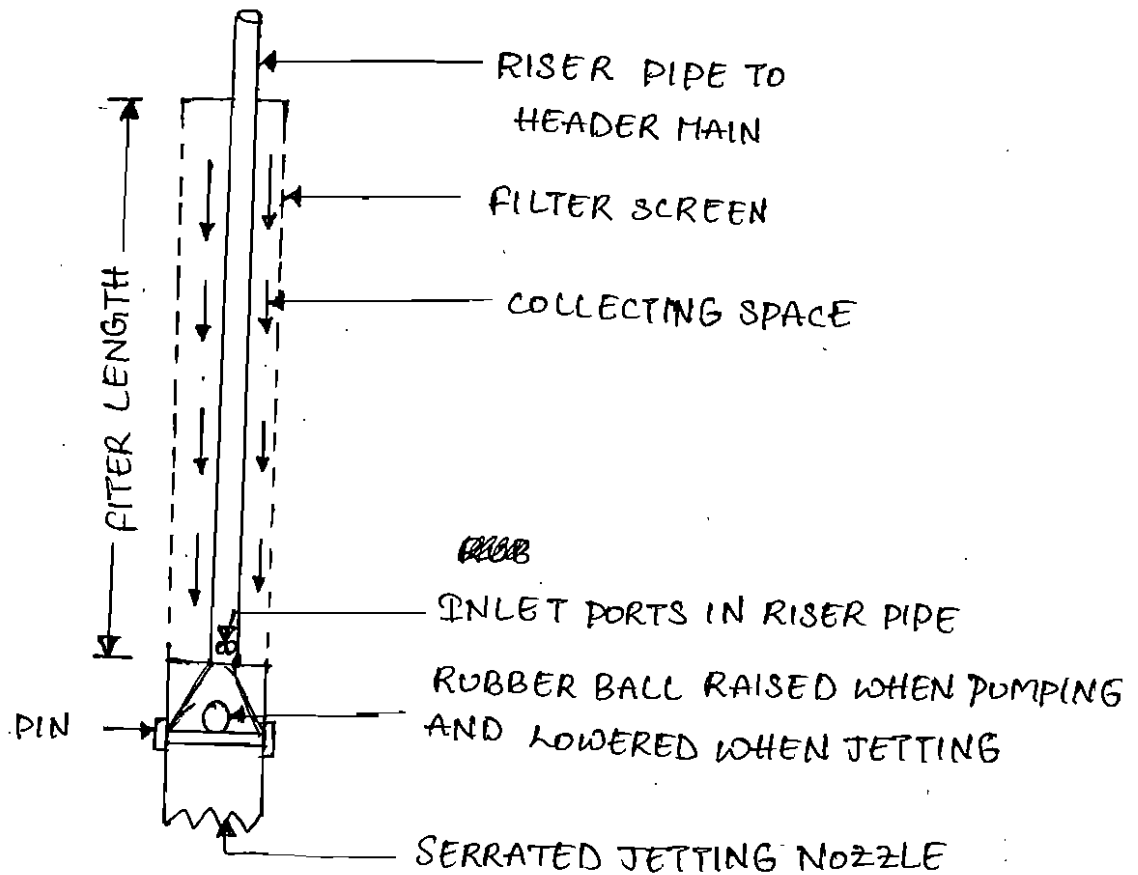
Water drawn through the screen enters the space between the gauge and the outside of the riser pipe to holes drilled in the bottom of this pipe and then reaches the surface. The well points are installed by jetting them into the ground.

The capacity of a single well point with a 50 mm riser is about 10 litres/min. Spacing of well points depends on the permeability of the soil and on the availability of time to effect the drawdown.

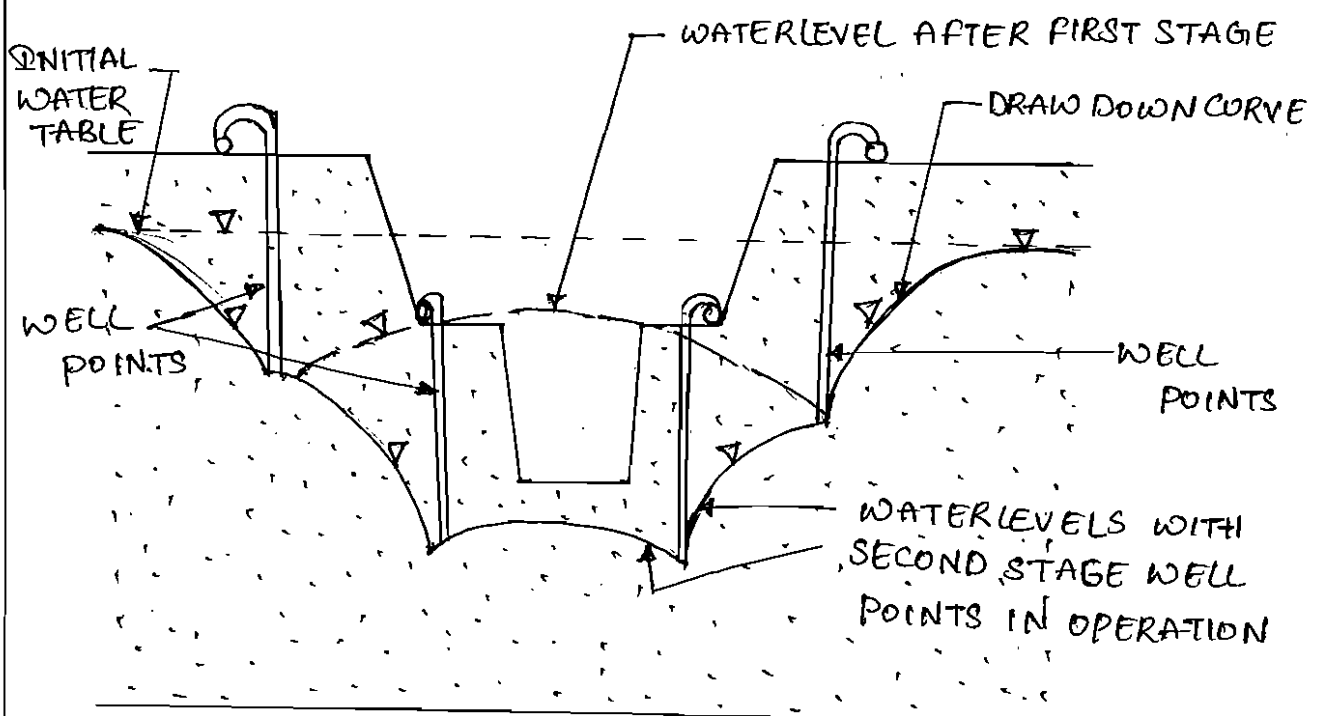
A spacing of 1.5m for silty sands & 0.3 m c/c for coarse gravels.

well point system is the most commonly used Method for construction purposes. A well point system is suitable when the site is accessible, and where water Bearing Stratum to be drained is not too deep from the Excavation.

Diagrammatic arrangement of a well point



Multi stage well point operation



The installation of well point system is very rapid and requires reasonably simple and cheap equipment. In this there is an advantage that the water is filtered and carries little (or) no soil particles. The serious limitation of the well point system is the suction lift. A lowering of about 6m below pump level is generally possible beyond which excessive air shall be drawn into the system through joint in the pipes ~~pipes~~, valves, etc., resulting in loss of pumping efficiency.

For dewatering deeper excavations, the well points must be installed in two (or) more stages. There is no limit to the depth of drawdown in this way, but the overall width of excavation at ground level becomes very large. On the other hand it is possible to avoid multi-well point stages by excavating down to water level before installing the pump and header.

When well points are used in braced excavations they are placed close to the toes of the sheet piles. This is done in order to ensure lowering the water level between the sheet pile rows. Well points are provided in conjunction with the sheet piles under the following conditions:-

- i) To prevent quick condition of the bottom when the sheet piles are of limited penetration and.

- (ii) To eliminate hydrostatic pressure on the back of a sheet pile Cofferdam thus allowing higher bracing to be used.

As an alternative to the conventional wellpoint system with surface pumps, one can use a jet - Eductor well point system, with one pressure pipe and a slightly larger return pipe. These two pipes along with the wellpoint and jet - Eductor pump are installed in a cased hole and surrounded with a filter sand, if necessary.

This method has the advantage that the drawdown of the groundwater is not limited in depth by the suction lift of a pump at ground level. The serious disadvantage with this system is that the jet - Eductor pumps usually have a low efficiency.

For large excavations (or) where the depth of excavation below the water table is more than 10 to 15 m (or) there is a necessity to reduce the artesian pressure from a deep aquifer it is desirable to use deep - wells with (or) without wellpoints.

Wellpoints are installed either by the progressive system or the ring system. In this progressive system the header is laid out along the sides of the excavation.

Deep - Well Drainage

(21) R-150 (5)
R-108
CE-10, 8, 13.

Deep well drainage system consists of deep wells and submersible or turbine pumps which can be installed outside the zone of construction operations and the water table lowered to the desired level. Deep-wells are usually spaced from 8 to 80 m depending upon the level to which water table must be lowered, permeability of the sand stratum, source of seepage and amount of submergence available.

Deep-well system is suitable for lowering the ground water table where the soil formation is ^{or} pervious with depth, the excavation extends through or is underlain by coarse-grained soils. The method is also suitable when a great depth of water lowering is required or where a head due to artesian pressure has to be lowered in a permeable strata at a considerable depth below the excavation level.

The installation of a deep well is done by sinking a cased bore hole having a diameter of about 200-300 mm larger than the well casing which depends on the size of the submersible pump. A perforated screen is installed over the length of soil which required de-watering and is terminated in a 3 to 5 m length of unperforated pipe to act as a sump to collect any fine material which might be drawn through the filter mesh. Graded filter material is

placed between the well casing and the outer borehole casing over the length to be de-watered.

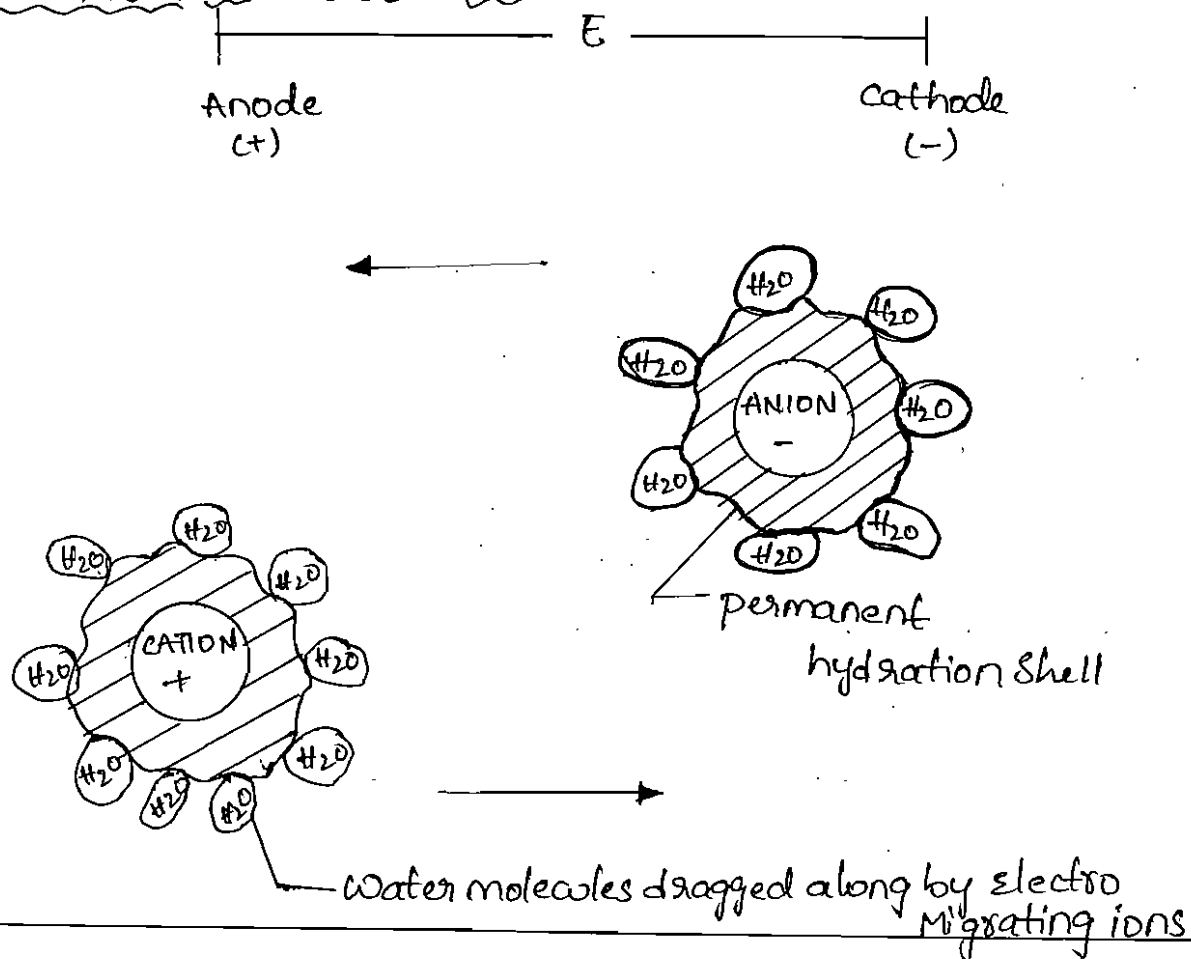
If centrifugal pumps are used in a deep-well system, the tops of the screens should be set below the computed water surface in the well. As heavy boring plant is used to sink the well in very adverse formations like boulders, rocks or under other different field environment, the cost of deep-well system is relatively high. Thus, it is advised to restrict this method to jobs which have a long construction period such as dry docks or access shafts for long sub-aqueous tunnels.

Vacuum Dewatering Systems:-

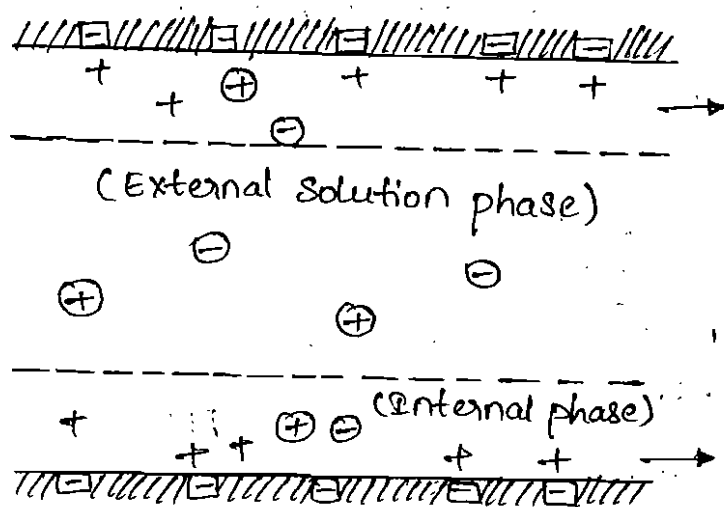
Gravity methods, such as well points and deep-wells, are not much effective in the fine-grained soils, with permeability in the range of 0.1 to 10×10^{-3} mm/s. A Vacuum dewatering system requires that the well or well point screens, and riser pipe be surrounded with filter sand extending to within a few metres of the ground surface.

This method is most suitable in layered or stratified soils with co-efficient of permeability of the range 0.1 to 10×10^{-4} cm/sec.

Mechanism of Electro-osmosis



Hypothetical distribution of ions between External and internal phases in a clay pore:-



Key

- + : internal phase (double layers) Counter ions
- ⊖ } invading electrolyte from external phase
- ⊕ }
- ▨ fixed negative surface charges

$$Q_e = K_e i e A$$

The potential gradient should not exceed 0.5 Volts/cm in order to prevent considerable loss of energy due to heating of the ground.

Electrodes :-

The general layout of the electrodes depends upon the purpose for which they are intended. Sheet piles of any shape can be used. The simplest type of anode for Normal application are old pipes, of 25 mm or 50 mm diameters, which can be easily driven into the soil.

These can either be placed singly (or) in groups of two (or) three.

Since the anodes corrode considerably in the course of a few weeks of electro-osmotic treatment they should be replaced as soon as the current drops to less than 30% of the initial consumption.

In contrast to normal well points these cathode wells should extend from the surface to the bottom. So as to allow the water to discharge into them over the whole of their height. Such cathode - wells have the advantage of serving also as drainage wells for layers and pockets of sand which are frequently present in silty soils and which otherwise would hardly be affected by electro-osmosis.

Safety Measures

The following simple rules should be made, which everyone knows on the site:-

- i, only persons wearing rubber boots should be admitted into the neighbourhood of the electrodes.
- ii, while working between anode and cathode neither the electrode nor the wiring should be touched in such a manner that while one hand is on the electrode, the other gets into contact with the ground (or) with the other electrode. Serious harm could be the consequence,

even with less than 100 volts.

- iii) Where the excavation is carried out by machinery special attention has to be paid by the operator to avoid the occurrence of short circuits. This may endanger the operator himself in the first place. No particular precautions are necessary if the machine operates within a space enclosed by anodes such as sheeted excavations.

Filter Requirements

In any drainage system perforated pipes and conduits of perforated pipes or pipe lines with open joints are usually provided. The space between the natural soil and the pipe is filled with a coarse grained material known as filter. If the voids of filter are larger than the finest grains of the adjoining soil, there is a possibility of these fine particles to fill the voids and accumulate and block the flow. On the other hand if the voids in the filter are as small as those in the soil, then there is a possibility of the filter material washed into the conduits and pipes and thus leading to erosion of the natural soil. Both these are undesirable conditions. A filter material that overcomes the ~~natural~~ above two conditions is referred to as a filter.

Filters are also used in earth dams, cofferdams and sheet pile structures as a transmission medium or to prevent piping. To prevent piping, the filter material should have adequate weight. If a filter extends across a boundary between coarse and fine soils, different materials have to be used.

Thus in general a filter or a drain material should satisfy the two requirements apart from adding weight.

- (i) the gradation of filter material should be capable of forming small size pores such that migration of

adjacent particles through the pores is prevented.

(ii) the gradation of the filter material should be such that it allows a rapid drainage without developing large seepage forces.

The above requirements are satisfied by adopting a suitable grain-size distribution for the filter material based on the material to be protected. The following filter criteria are to be adopted (Bextam, 1940).

$$\frac{D_{15}(\text{filter})}{D_{85}(\text{protected soil})} < 4 \text{ to } 5$$

The criterion emphasizes that the D_{15} size of the filter soil should not be more than four or five times the D_{85} size of the protected soil. The second criterion is

$$\frac{D_{15}(\text{filter})}{D_{15}(\text{protected soil})} > 4 \text{ to } 5$$

This criterion emphasizes that the D_{15} size of the filter soil should be more than four or five times the D_{15} size of the protected soil.

The additional requirement which has to be satisfied as regards to openings in the mesh screen or perforated pipe is that the maximum size of the filter material should be at least twice that of the openings in the mesh screen.

Drains

A complete drain consists of three components, viz, filter, conduit or collector and disposal system.

As discussed earlier a filter is essential for continued efficiency of the drain and to prevent seepage erosion during high hydraulic gradients. The water is collected in the drain conduits from the filter and is carried away. Ordinarily, the conduit is 5 to 10 times larger than its hydraulic dictate to allow for variation in soil permeability and to accommodate some silting. Commercial pipes have perforations of 8 to 9 mm in diameter and require a gravel filter with a maximum size of 12-15 mm. The permanent and simple disposal system is Gravity. During adverse conditions such as wet weather, high water table and a difficult topography, gravity system of disposal cannot function. In such situations pumps have to be resorted to which will be costlier over a long period.

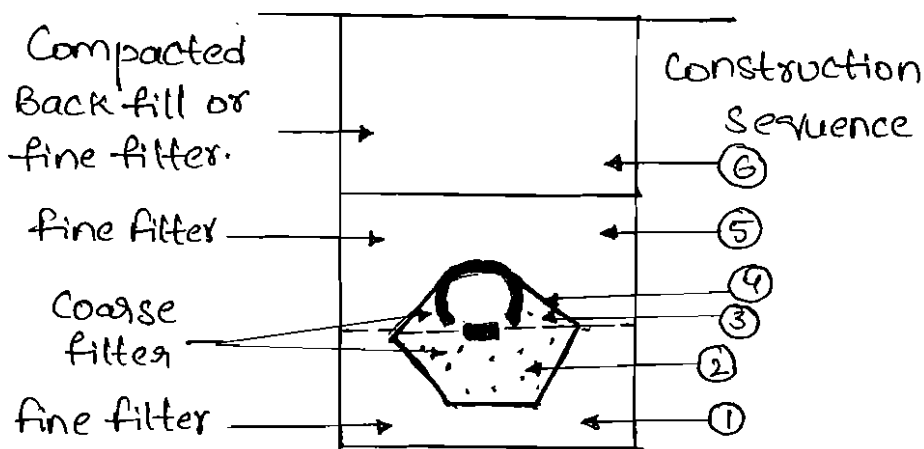
Open Drains

The oldest method of draining excavations, roads etc. is by open drains, viz., a ditch or a sump. A sump is merely a shot ditch which could be constructed easily with unskilled labour. Details of this method are discussed earlier.

Closed Drains

When seepage erosion or piping is troublesome or where a permanent drain is desired, perforated pipe can

be laid at a required depth in ditches and the ditch is back filled with a suitable filter material. As far as possible pipes should be laid in straight lines. openings should be provided for every 30 to 50 m to flush out the pipe occasionally. Also manholes should be provided at changes in direction and at intervals of 100 to 150 m along straight sections.



Pipe drain with double filter layers.

Horizontal Drains

If field situations warrant to avoid open-cut work or non-availability of adequate submergence, the ground water can be lowered by means of a Ranny drainage system. This system consists of a reinforced concrete shafts or wells from which a number of horizontal perforated pipes are fixed. These pipes may be extended to a required length in any direction. Water collected in the well is pumped out by means of a turbine pump. This system may not be effective in lowering water in stratified soils.

Drainage After Construction

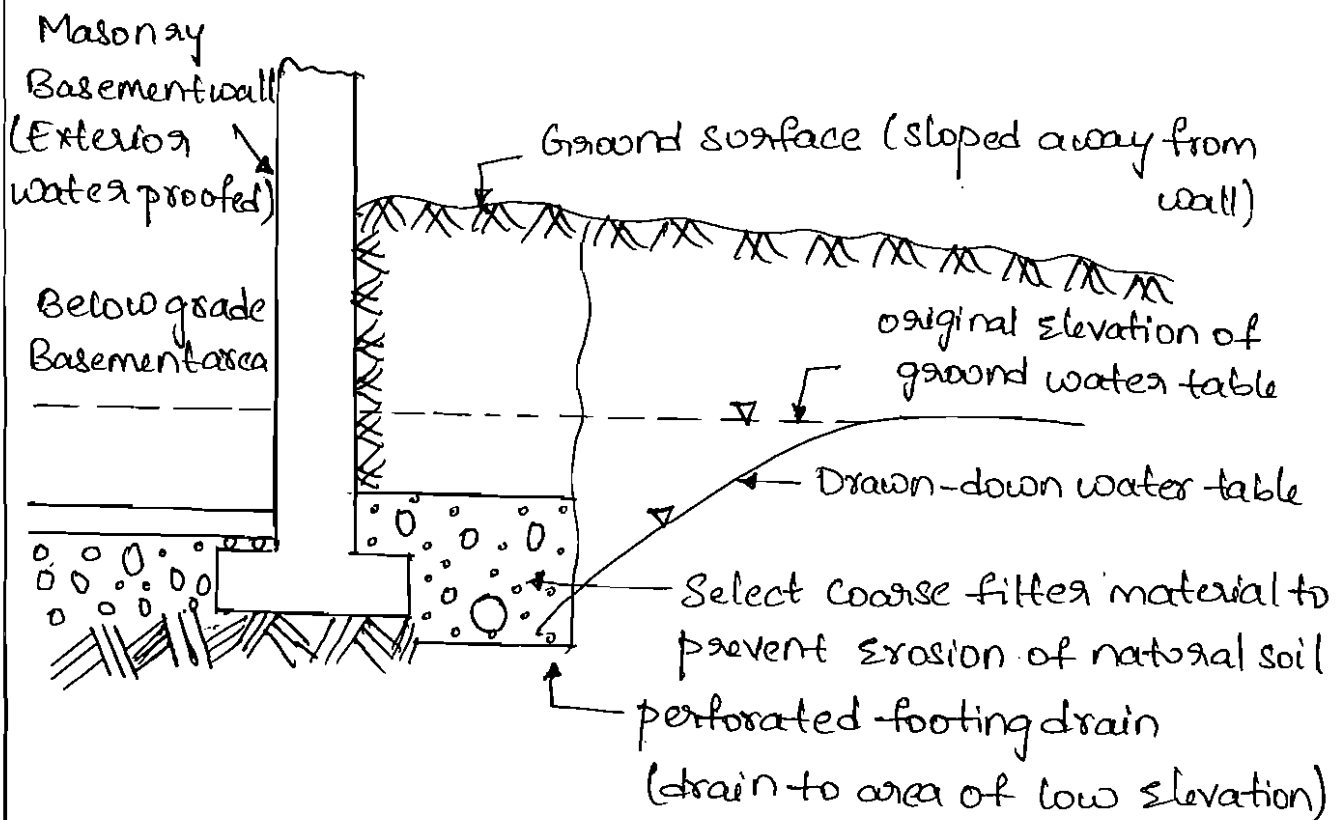
preventing groundwater from seeping into an structure or through a finished structure may be necessary in order to obtain proper use of the structure or to protect it from drainage. In some situations, the dewatering systems utilized during construction may be further used to protect the structure.

In a particular field condition if it is necessary that an usable part of a structure has to be located below the ground water table, it is essential to build the facility utilizing water proof design and construction techniques. one of the desirable features for a sub-aqueous structure is to have all seams and joints with water stops or to avoid completely seams and joints.

Foundation Drains

Where groundwater is present in the vicinity of a structure, provision should be made to quickly carry away the water from the Building. In the worst condition the effect of ground water may be allowed only on the exterior side of a Building. When the depth below the water table is not too great, it is feasible to control the water by foundation Drains. An arrangement of such a drain is shown Below. However, such drains should not be placed lower than the bottom of the footing. Such drains consist of perforated pipes or pipes with open joints so that the ground water can enter into

the pipe. A suitable filter should surround the pipes. The collected water in the pipes is disposed off by gravity flow to a storm drain system or other drainage facility such as ditch, dry well, etc. If disposal by gravity flow is not possible, the drainage water has to be directed to sump pit or other collector and pumped to a disposal.

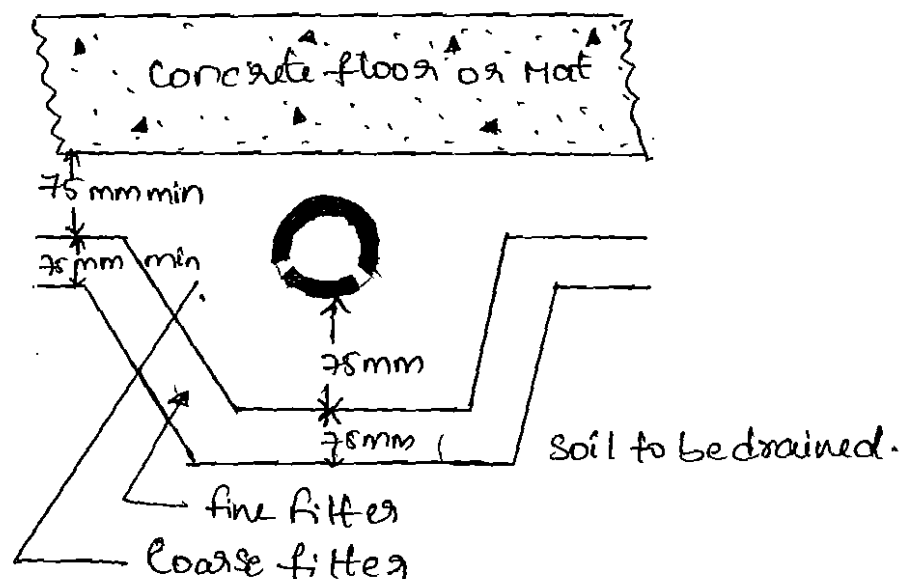


footing drain tile installation for disposing of ground water against a Basement wall.

Blanket Drains

Continuous Drainage Blankets are sometimes constructed beneath dams and Basement floor slabs to provide a highly permeable drainage path for removal of groundwater acting against the bottom of the slab. If an escape path is provided the uplift pressure can be reduced and the possibility of seepage through the floor arrested. The blanket consists of a fine filter layer in contact with the soil followed by a coarse filter cum collector layer and the latter is in contact with the underside of masonry dam or Basement floor. The Blanket is connected by conduits to a Sump where the collector water is pumped out or to drainage pipe where disposal is by gravity. Such Blankets are also provided beneath pavements to prevent capillary flow upward.

Blanket under drain with pipe disposal - minimum

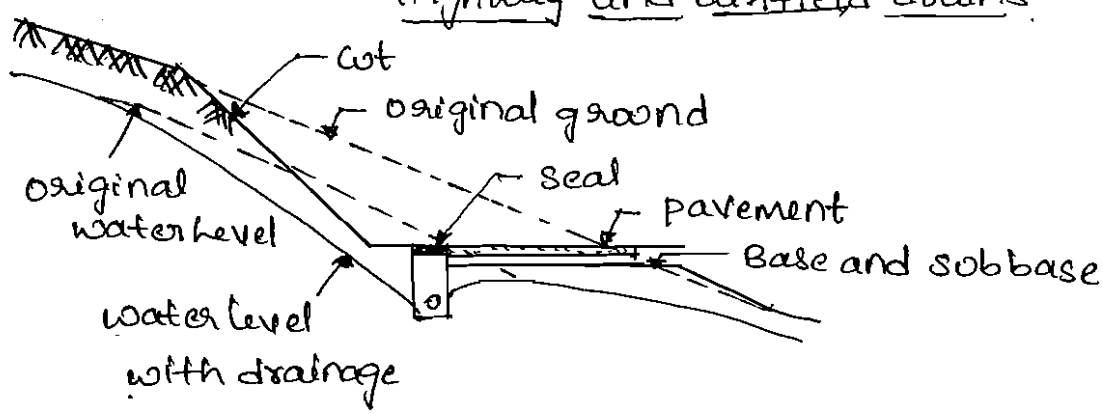


Interceptor Drains

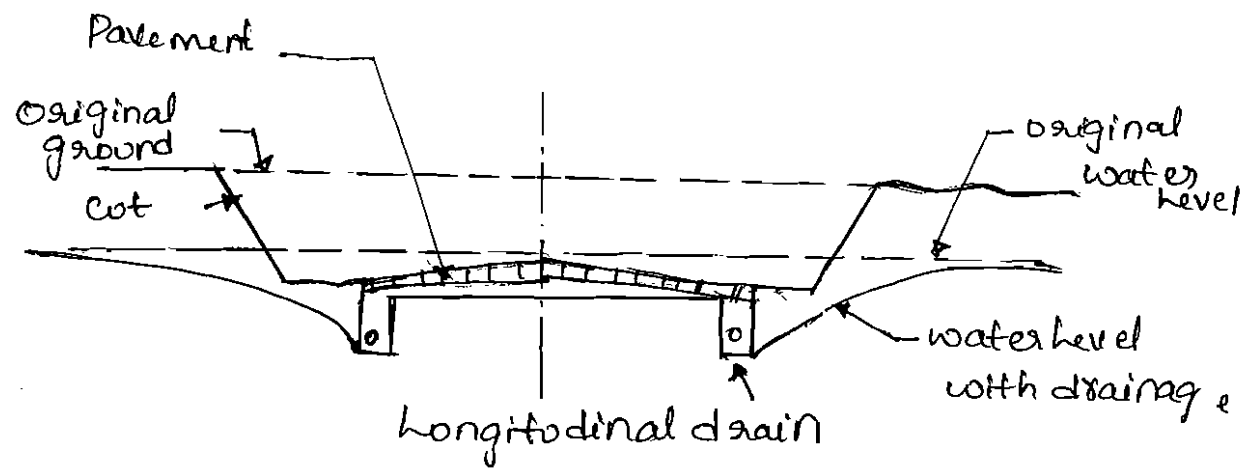
In paved highways and airfield runways trench drains are provided parallel to the shoulder. Such drains are termed as interceptor drains which are provided to lower the ground water table to a level beneath the pavement and to permit easy lateral drainage facility is to keep the base and subgrade soils dry so as to maintain adequate strength and stability. The drains also provide a means for disposal of surface and near surface water and also shall help to intercept underground flow trying to enter the pavement from the side areas. Similarly, open drainage ditches located adjacent to shoulder area may help to intercept surface and near surface water flowing towards the road way area from the sides also prevent development of excess pore water pressure.

- (a) Interceptor drain for highway constructed in a side hill (Adopted from Cedergren, 1967);
- (b) Interceptor drain for highway in flat terrain (Adopted from Cedergren, 1967);
- (c) Typical airport runway interceptor drains (Civil Aeronautics Administration)
- (d) Typical open - shoulder ditch for roads.

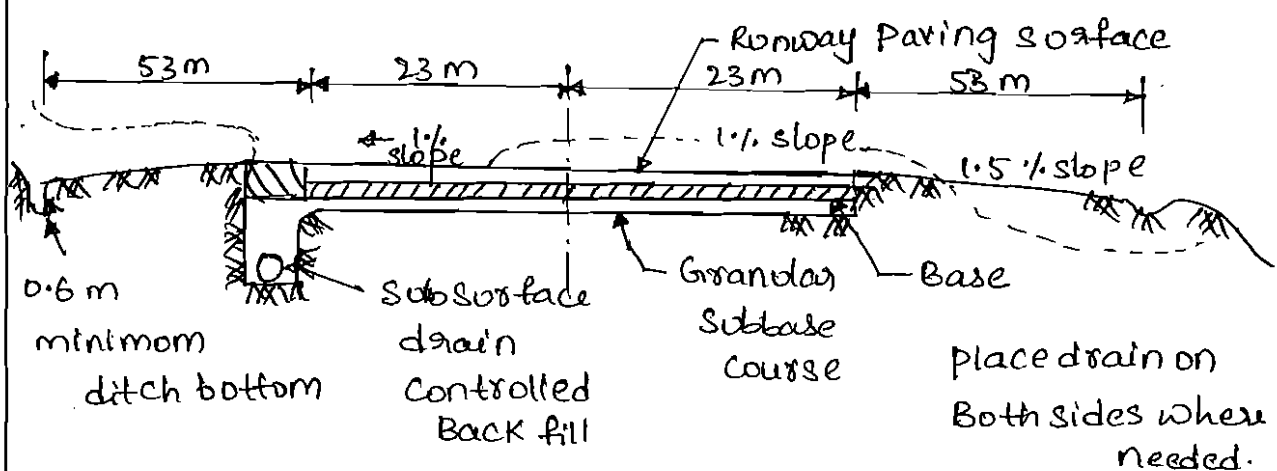
Highway and airfield drains



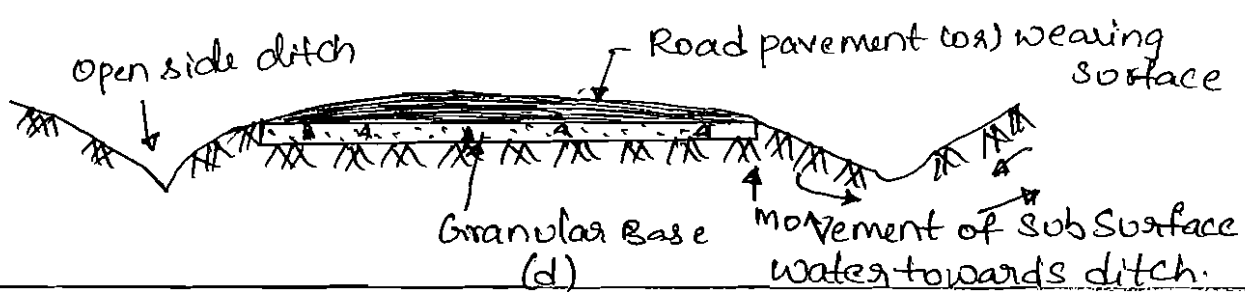
(a)



(b)



(c)



(d)