MODULE 6

DEWATERING

- *Dewatering means modifying the ground by lowering the water table , redirecting seepage, or simply reducing its water content*
- *Civil eng works such as in the stability of natural slopes and cuts, dams and levees, excavation for structures, pavements etc..*

PURPOSES

- To provide dry working area such as in excavation for building foundations , dams, tunnels etc
- To stabilize constructed or natural slopes
- To reduce lateral pressures on foundations or retaining structures
- To increase the bearing capacity of foundation
- To prevent liquefaction
- To prevent surface erosion
- To prevent or reduce damage due to frost heave

METHODS OF DEWATERING SYSTEMS

- Open sumps and ditches
- Well point system
- Deep well drainage
- Vaccum dewatering systems
- Dewatering by electro- osmosis

OPEN SUMPS AND DITCHES

- Water is collected in sumps or ditches and then removed by pumping.
- Sump is made below the ground level of excavation at one or more corners or sides
- To prevent standing water on the floor of excavation, a ditch is cut around excavation, falling towards the sump.
- Water from slopes falls into sump by gravity and then it is pumped out from the sump.

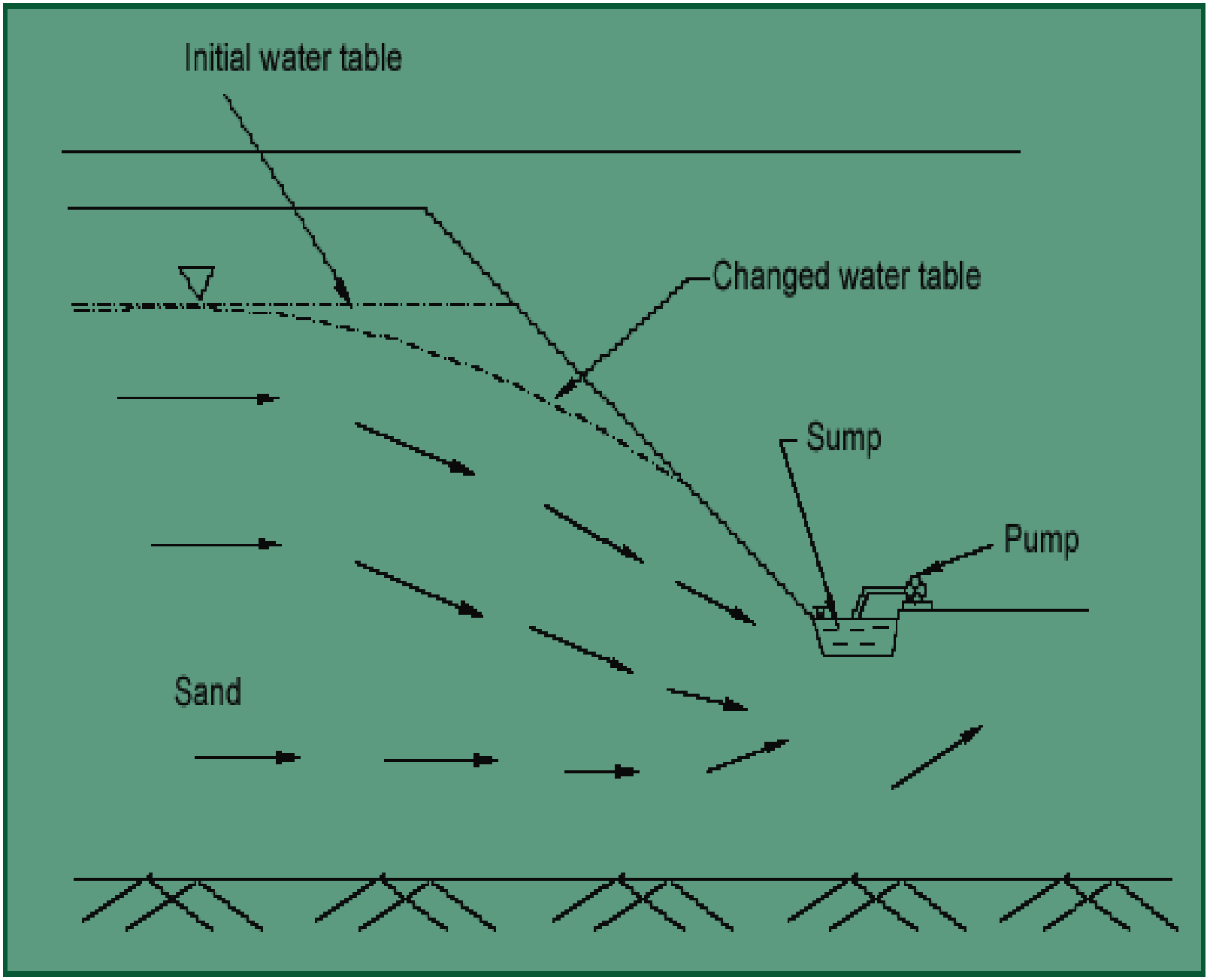

Initial water table
Changed water table
Sump
Pump
Sand

Plate 2.1 Water being dewatered from a ditch

Plate 2.2 Water being dewatered from an open sump

- Most cheapest and common dewatering method.

- This method is suitable in :
- Shallow excavation
- In well-graded soil or in rock
- In permeable soils on impermeable strata

ADVANTAGES

- It is the most economical method for installation and maintenance
- It can be applied to most soil and rock conditions
- This method can also be used in situations where boulders and other obstructions are met within the ground.
- Appropriate for small depth lowering.

The greatest depth to which water table can be lowered by this method is 8m below the pump level

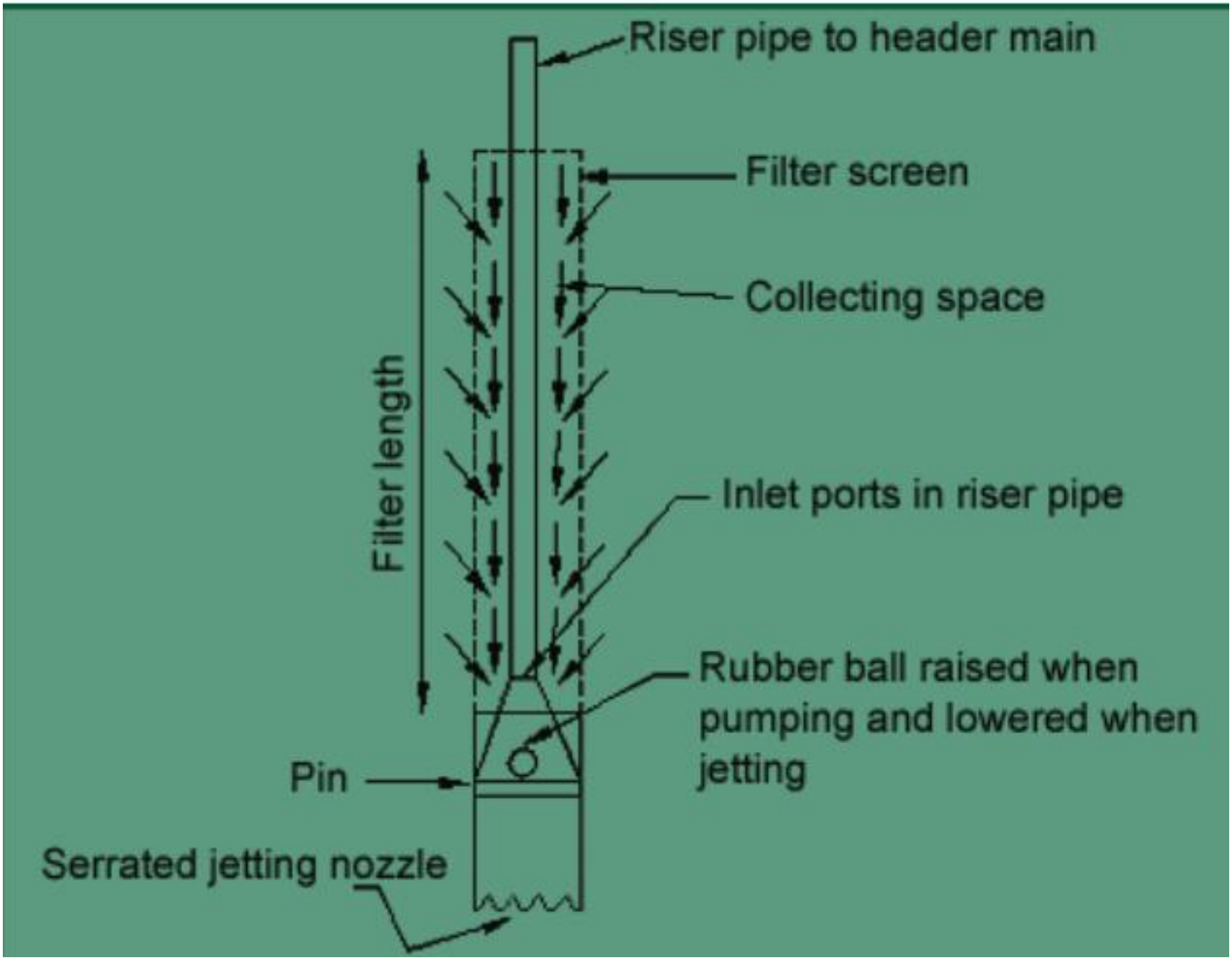
DISADVANTAGES

- In areas with steep slopes, this method is not demanded.
- This method will bring collapse of slopes and causes dangerous problems.
- Use of sumps and ditches in open excavation will bring risk in stability of the base.

WELL POINT SYSTEMS

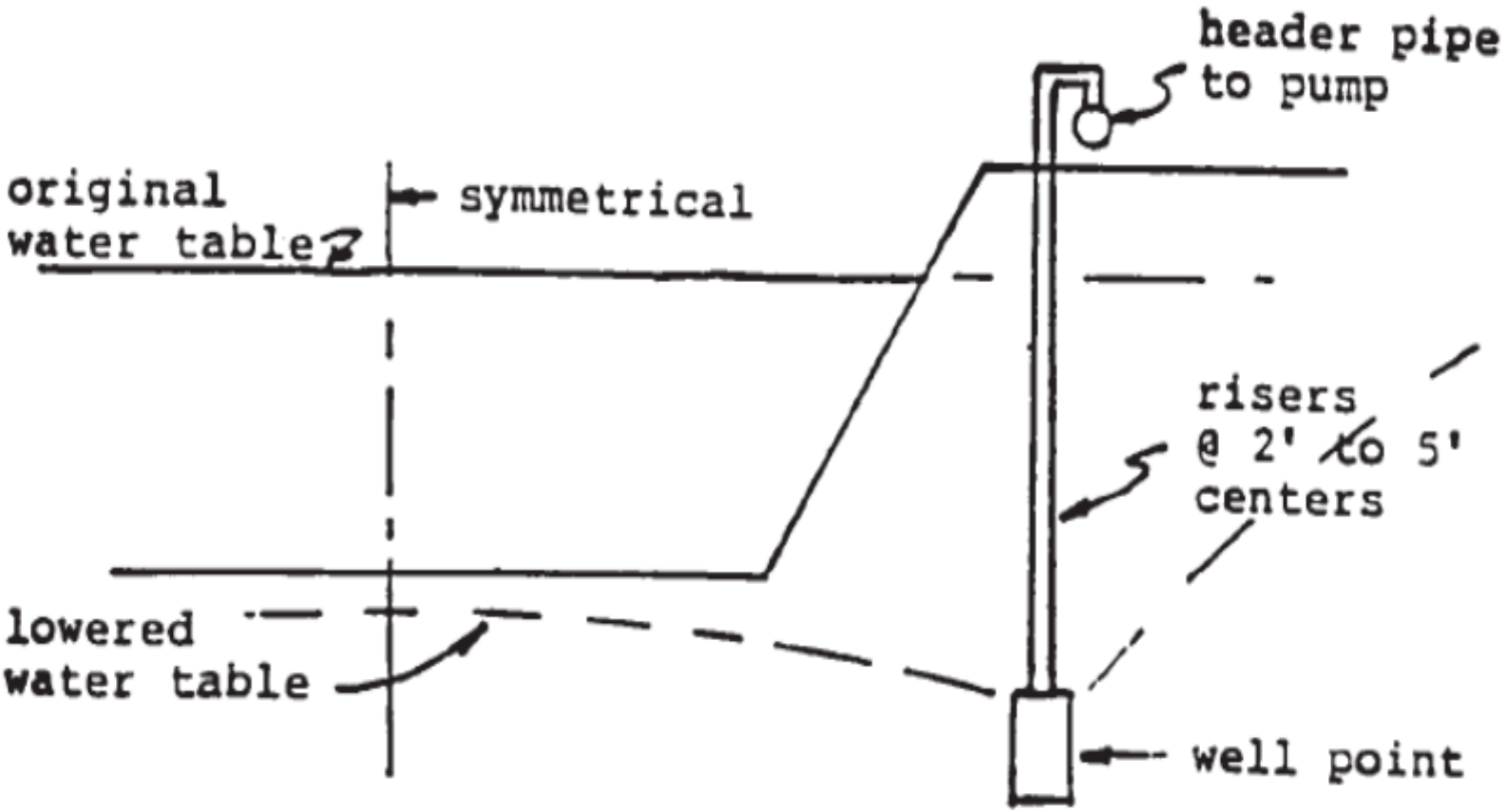
- Small well screens of sizes 50 to 80 mm in diameter and 0.3 to 1m length
- Brass or stainless steel screens and are made with closed ends or self jetting types
- Well points are required to maintain for long period
- *Working:*

➢ Water drawn through the screens enters the space between the gauze and outside of the riser pipe


Riser pipe to header main
Filter screen
Collecting space
Filter length
Inlet ports in riser pipe
Rubber ball raised when pumping and lowered when jetting
Pin
Serrated jetting nozzle

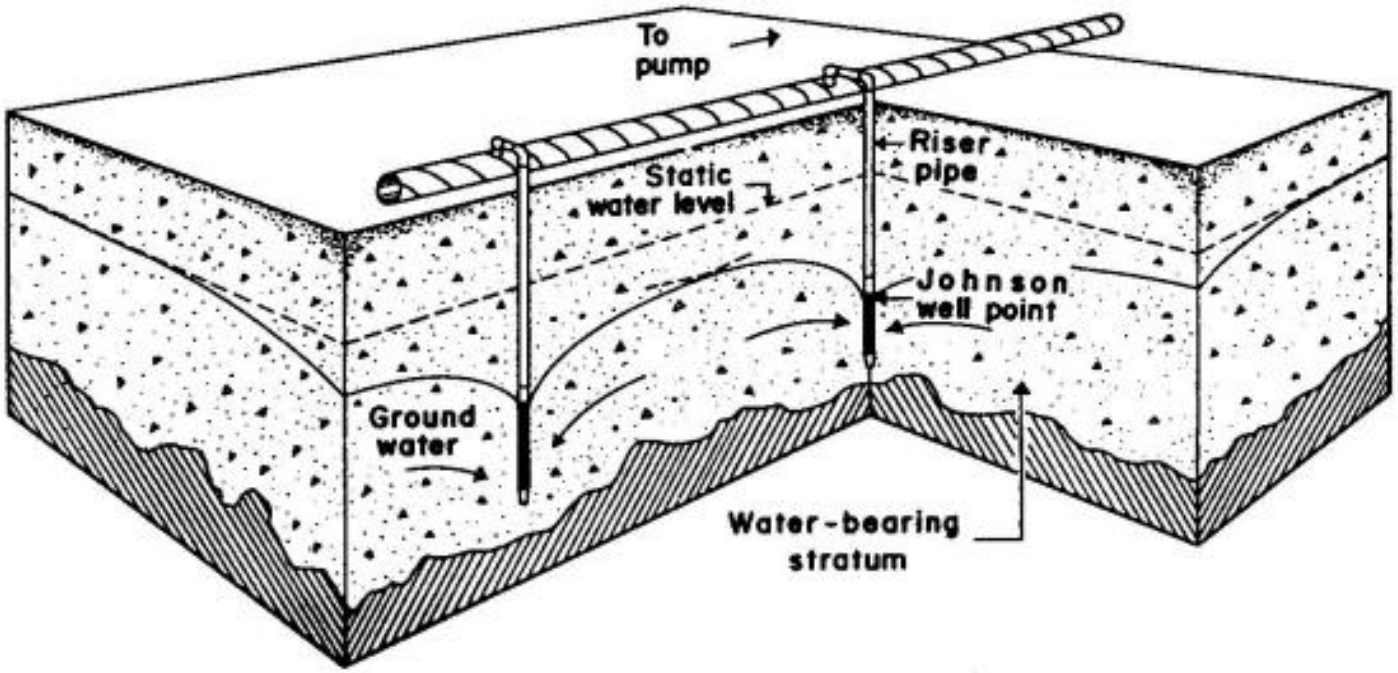
- From riser pipe to holes drilled in the bottom of this pipe and then reaches the surface
- Well points are installed by jetting them into the ground
- Capacity of single well point with 50 mm riser -10 l/m
- Spacing depends on permeability and availability of time to effect the drawdown
- In fine to coarse sands 0.75 to 1 m spacing
- In silty sands with low permeability-1.5 m
- In highly permeable coarse gravels- 0.3 m

Single Stage Well Point System



Single Stage Well Point System

Typical Well Point System



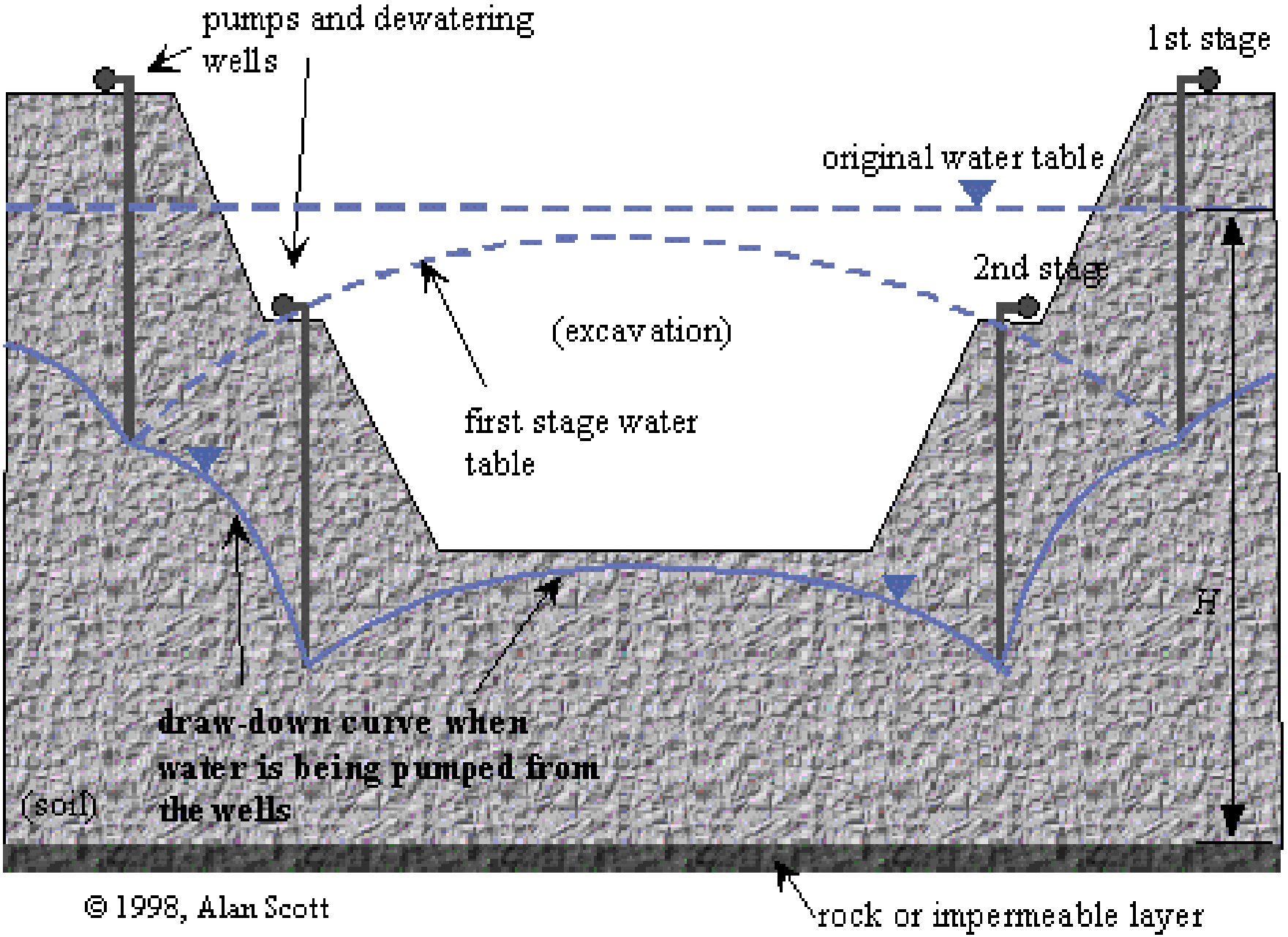
Johnson (1975)

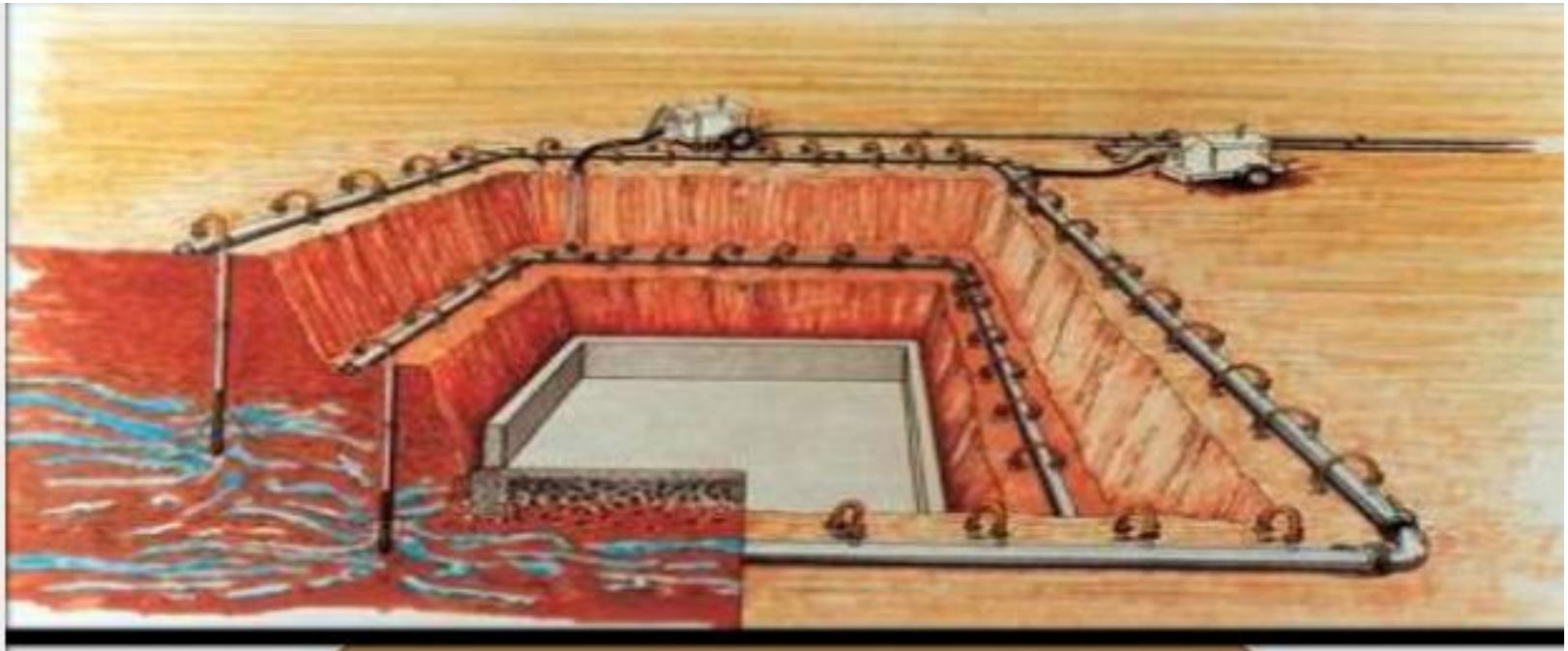
- Commonly used method
- Well point system is suitable when the site is accessible, and where water bearing stratum to be drained is not too deep
- ADVANTAGES
- Installation is very rapid
- Simple and cheap equipments
- Water is filtered and carries little or no particle
- Because there is less danger of subsidence of the surrounding ground than open sump

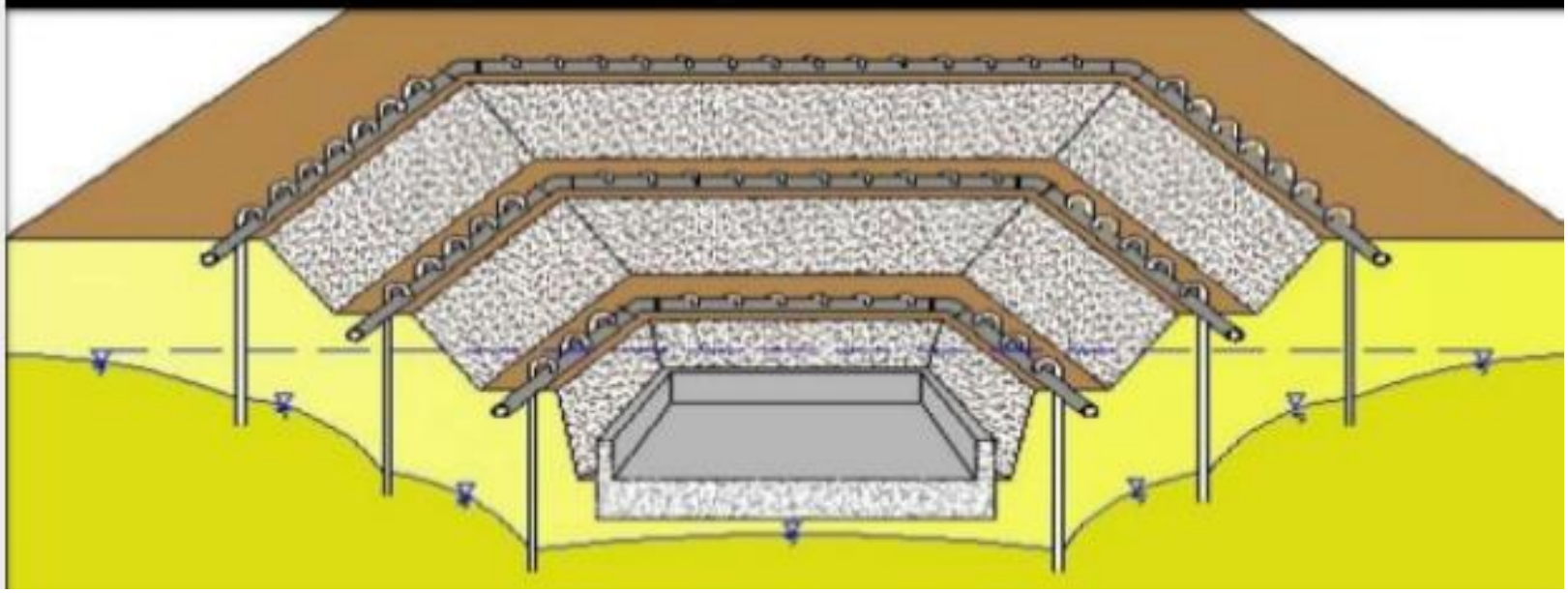
- DISADVANTAGE
- Serious limitation is suction lift
- A lowering of about 6m below the pump level is possible beyond which excessive air shall be drawn into the system through the joint in pipes, valves, etc.
- Resulting in loss of pumping efficiency
- If the ground consisting mainly large gravels cobbles or boulder it is not possible to install well points

Multistage well point system

- Installed two or more stages
- No limit to depth of drawdown in this way, but the width of excavation at ground level becomes very large


pumps and dewatering wells
1st stage
original water table
2nd stage
(excavation)
first stage water table
H
draw-down curve when water is being pumped from the wells
(soil)
© 1998, Alan Scott
rock or impermeable layer

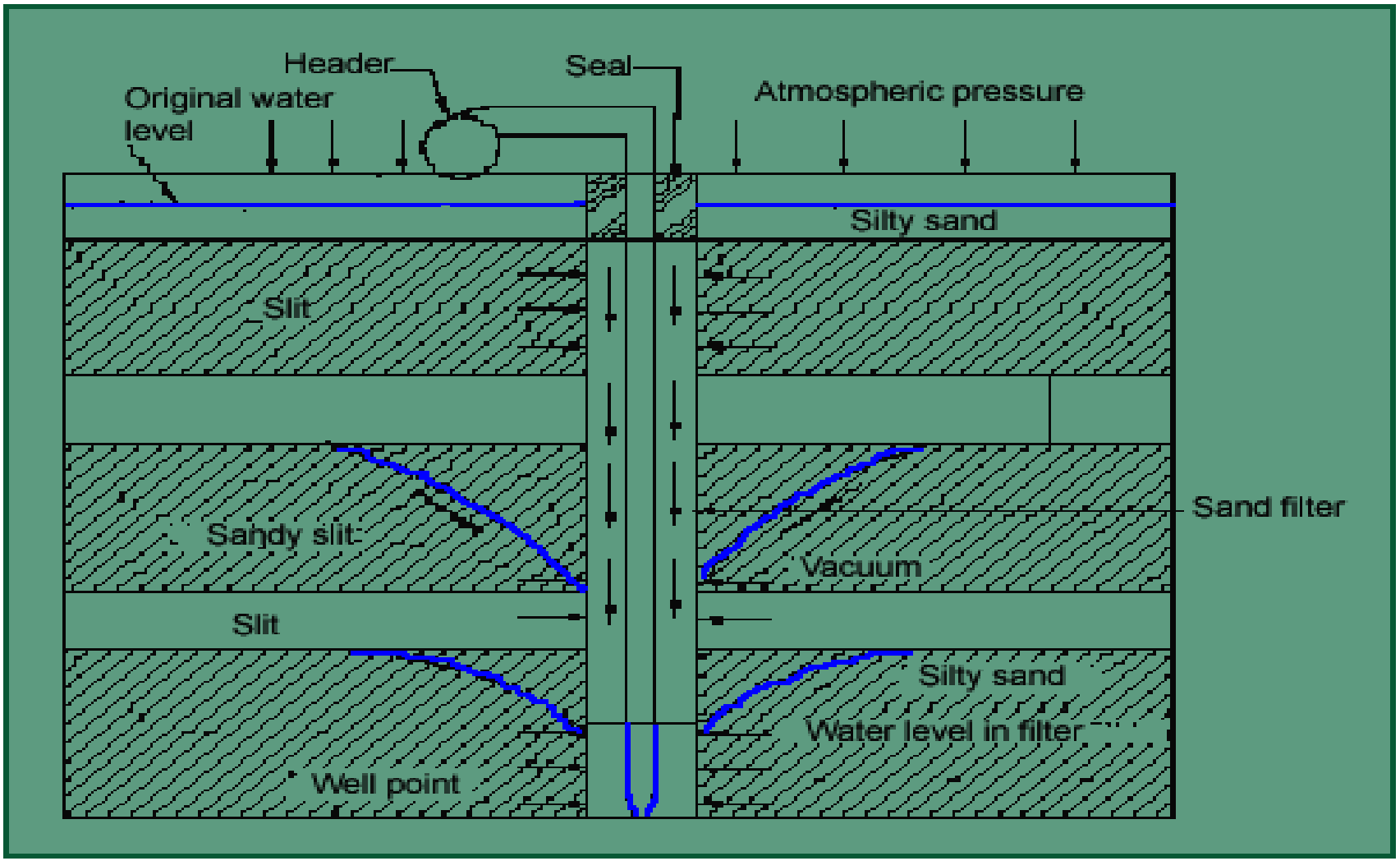




Well points in braced excvation

- Placed close to toes of the sheet piles
- Done in order to ensure the lowering the water level between the sheet pile rows
- It helps to prevent quick condition of the bottom
- To eliminate hydrostatic pressure on the sheet piles

VACCUM DEWATERING SYSTEM



- Suitable for fine grained soils with permeabilty in the range of 0.1 to $10x10^{-3}$ mm/s
- Dewatering system requires well or well point screens, riser pipe surrounded with filter sands
- The top few portion of the hole is sealed or capped with an impervious soil or other suitable material
- By having the pumping main vacuum pressure, hydraulic gradient for flow to the well points is increased.

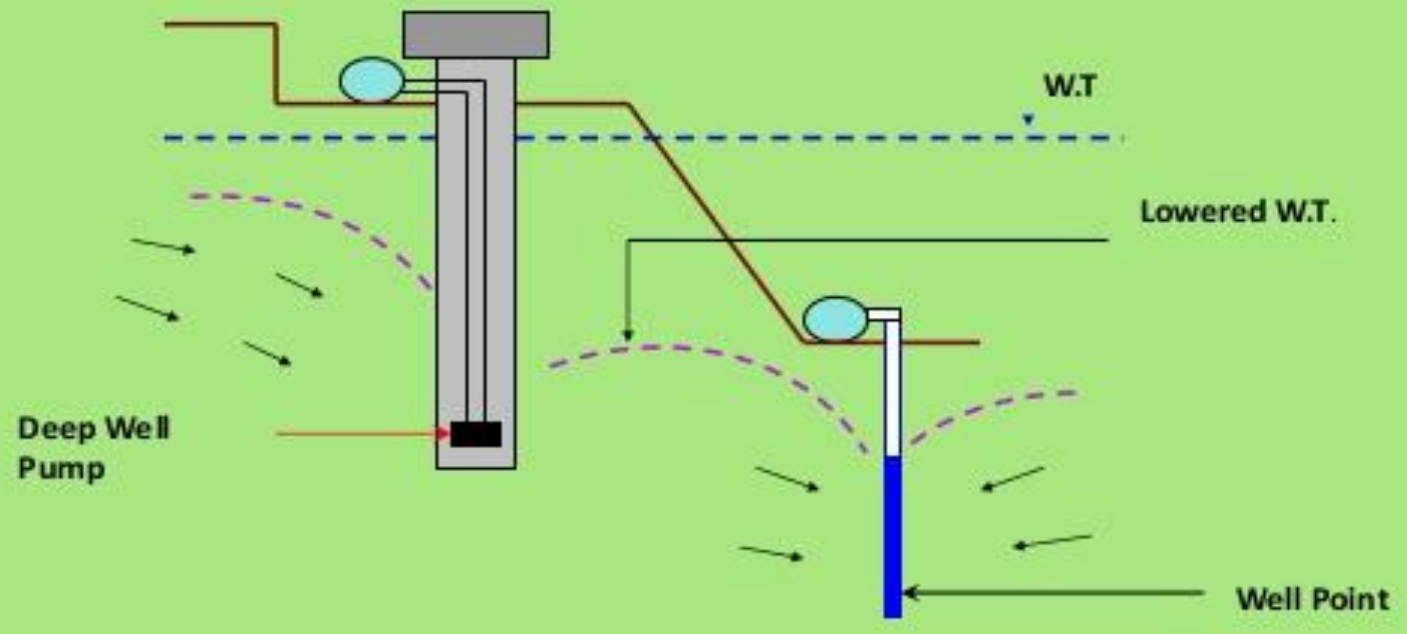
- This method is suitable in layered or stratified soil with k in the range of 0.1 to $10x10^{-4}$ cm/s
- Practical maximum height of lift is about 3 to 6 m.

DEEPWELL DRAINAGE

- Consist of deep wells and pumps installed outside the zone of construction
- And the water table lowered to the desired level
- Spacing- .8 to 8m depending on the level of water table to be lowered, permeability of the strata etc
- Suitable where the soil formation is pervious with depth.
- And also when a great depth of water lowering is required or where head due to artesian pressure has to be lowered

- Deeps wells may be combined with the well point system on certain field condition for lowering the ground water table

Deep well Drainage System



mission. Figure 3.11 shows the details of a completed installation.

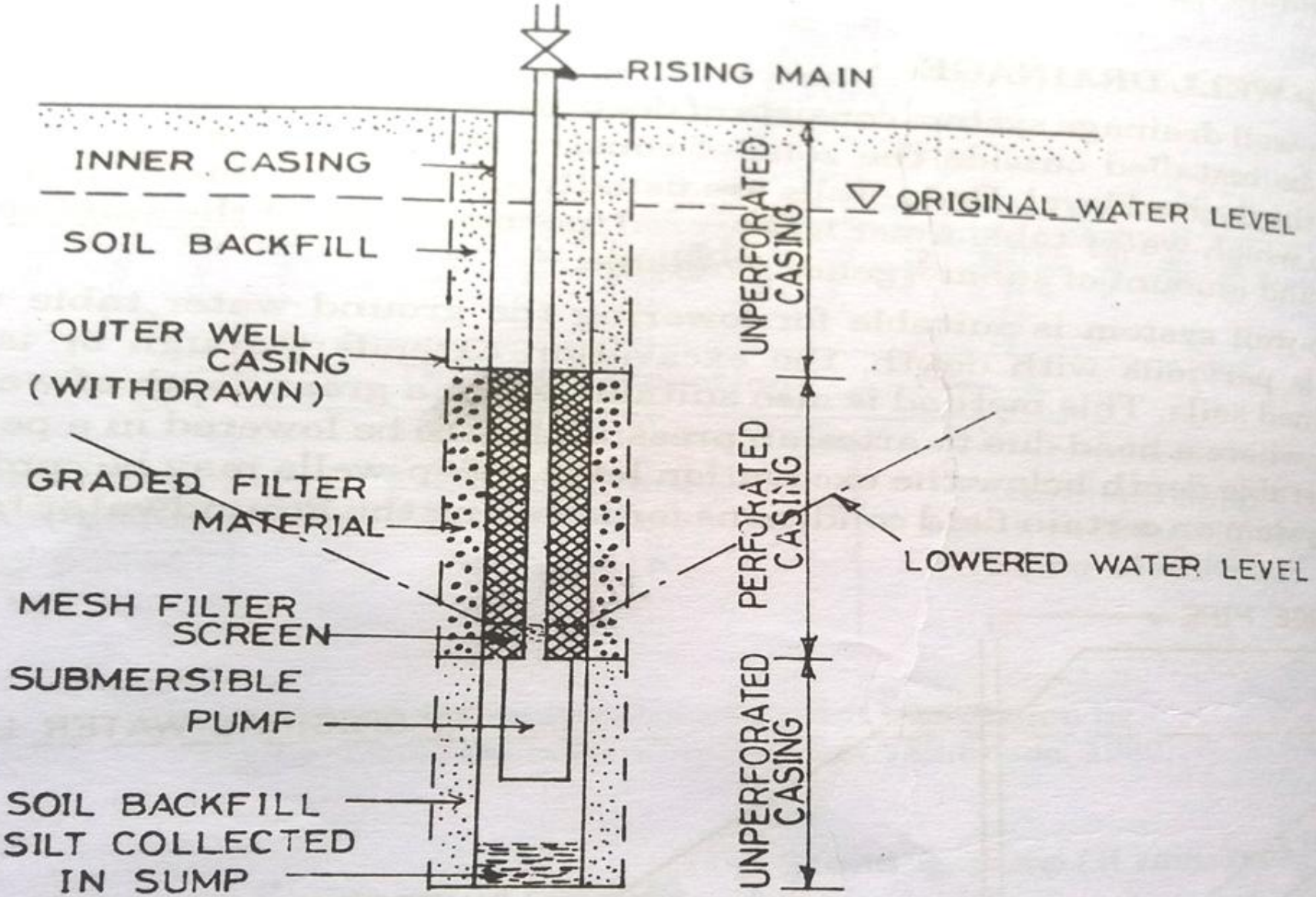


Fig. 3.11. Details of deep-well installation.

- **Installation** is done by sinking a **cased borehole** having dia 200 to 300 mm larger than well casing which depend on size of pump
- The **inner well casing** inserted after the completion of borehole
- A **perforated screen** is installed over the length of soil which required dewatering and is terminated in a 3 to 5 m length of unperforated pipe which act as a sump to collect any fine material which might be drawn through filter mesh.

- Graded **filter material** is placed between the well casing and the outer bore hole casing over the length to be dewatered
- Then the outer casing is withdrawn in stages as the filter material is placed
- The space above the screen is backfilled with any available material.
- The water in well is then surged by a boring tool to promote flow back and forth through the filter
- At the same time any unwanted fines which fall into the sump are cleared out by bailer before submersible pump is installed

- Heavy boring plant is required to sink the well in very adverse formations like boulders rocks or under other difficult environment
- The cost is relatively high

ELECTRO OSMOSIS

- **Electro osmosis:**When an external electromotive force is applied across a solid liquid interface the movable diffuse double layer is displaced tangentially with respect to the fixed layer
- As the surface of fine grained soil particles causes negative charge, the positive ions in solution are attracted towards the soil particles and concentrate near the surfaces.

- Upon application of the electro motive force between two electrodes in a soil medium the positive ions adjacent to the soil particles and the water molecules attached to the ions are attracted to the cathode and are repelled by the anode.
- The free water in the interior of the void spaces is carried along to the cathode by By making the cathode a well, water can be collected in the well and then pumped out

- Hypothetical distribution of ions between external and internal phases in a clay pore shown in figure

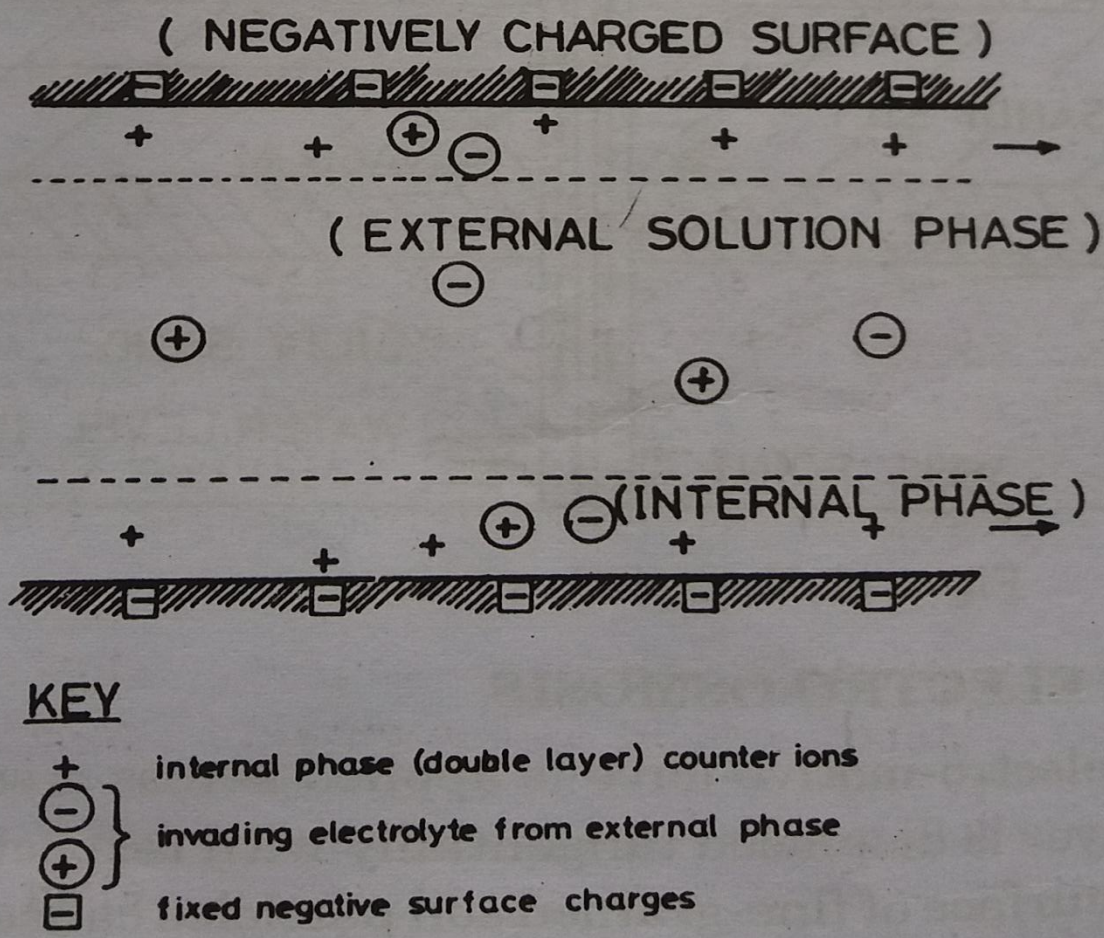


Fig. 3.14. Hypothetical distribution of ions between external and internal phases in a clay pore (After Gray and Mitchell, 1967).

$$Q_e = k_e\, i_e\, A$$

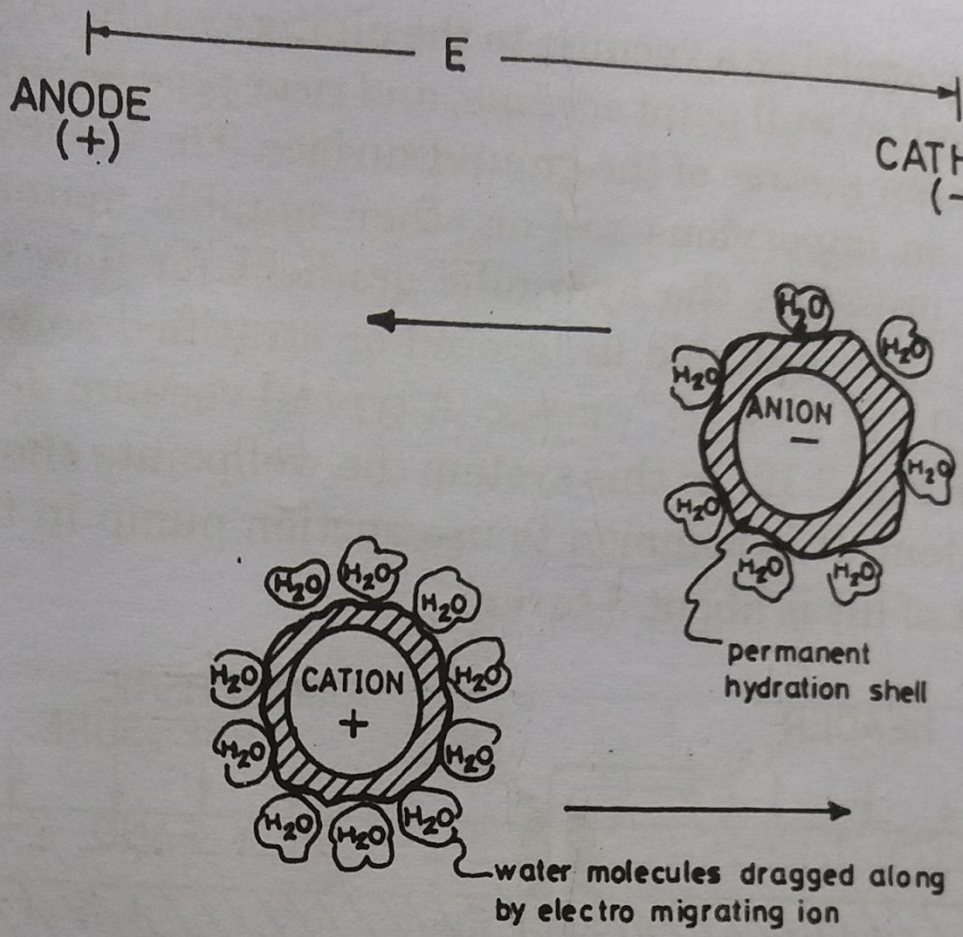


Fig. 3.13. Mechanism of electro-osmosis (After Gray and Mitchell, 1967).

- The electro osmotic flow(Qe) produced by an applied electric field given by

Qe=keieA

Ke= elecrtro osmotic permeability cm/sec

- Hydraulic coefficient of permeability and hydraulic flow depend on the size of voids in the soil and consequently on the grain size

- ELECTRODES
- The simplest type of anode for normal app are old pipes. Of 25 mm or 50 mm dia which can easily driven into the soil
- Can placed either singly or in groups of two or three
- The anode corrode considerably in the course of few weeks of electro osmotic treatment
- They should be relpaced as soon as the current drops to less than 30% of the consumption

- Two basic arrangements of cathode wells are
- Either well arranged seperately but in close proximity to the cathode
- Cathode and the well combined as one body

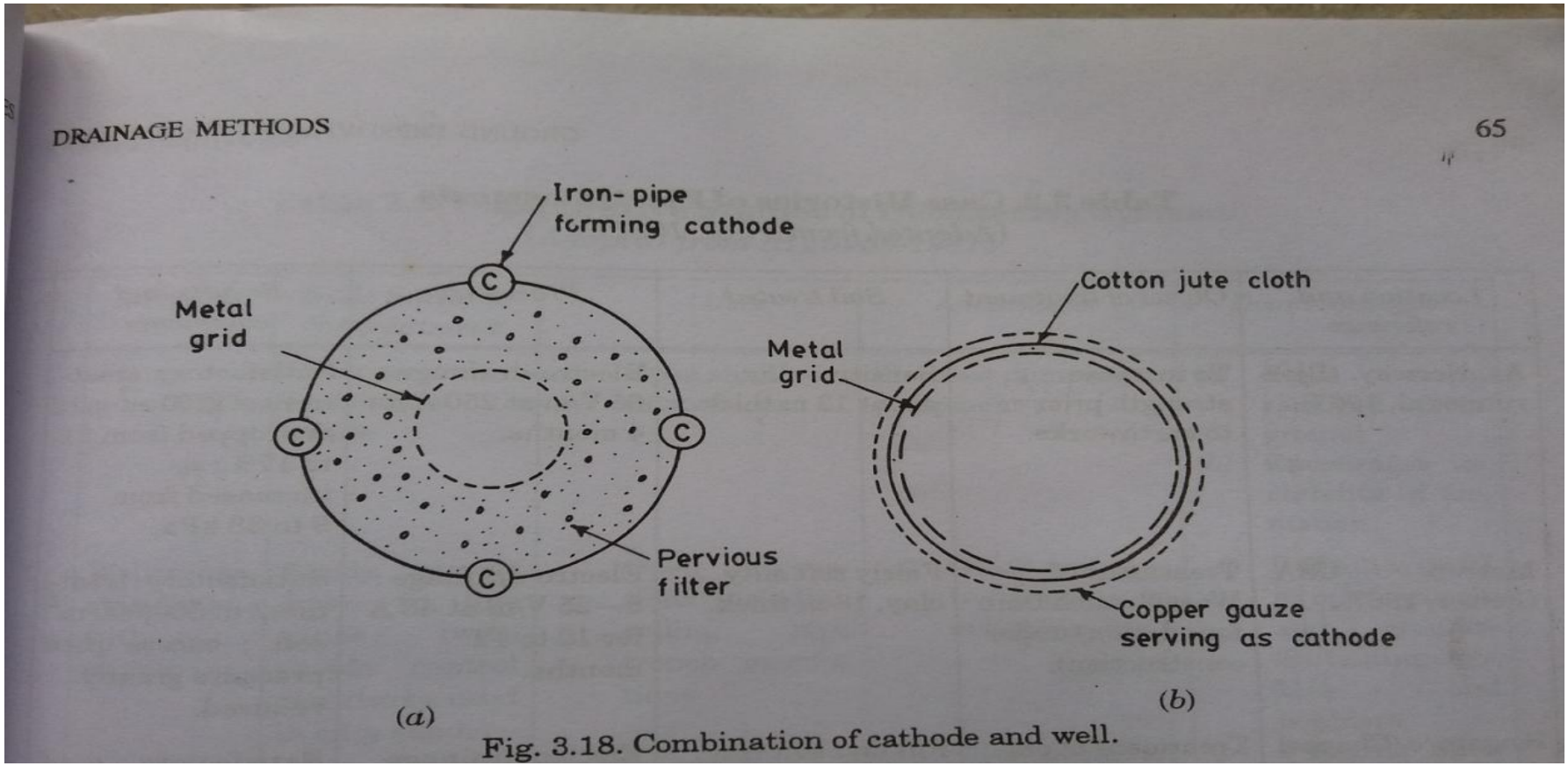


Fig. 3.18. Combination of cathode and well.

Application of electro osmosis for stabilizaing slopes and for sheeted excavations

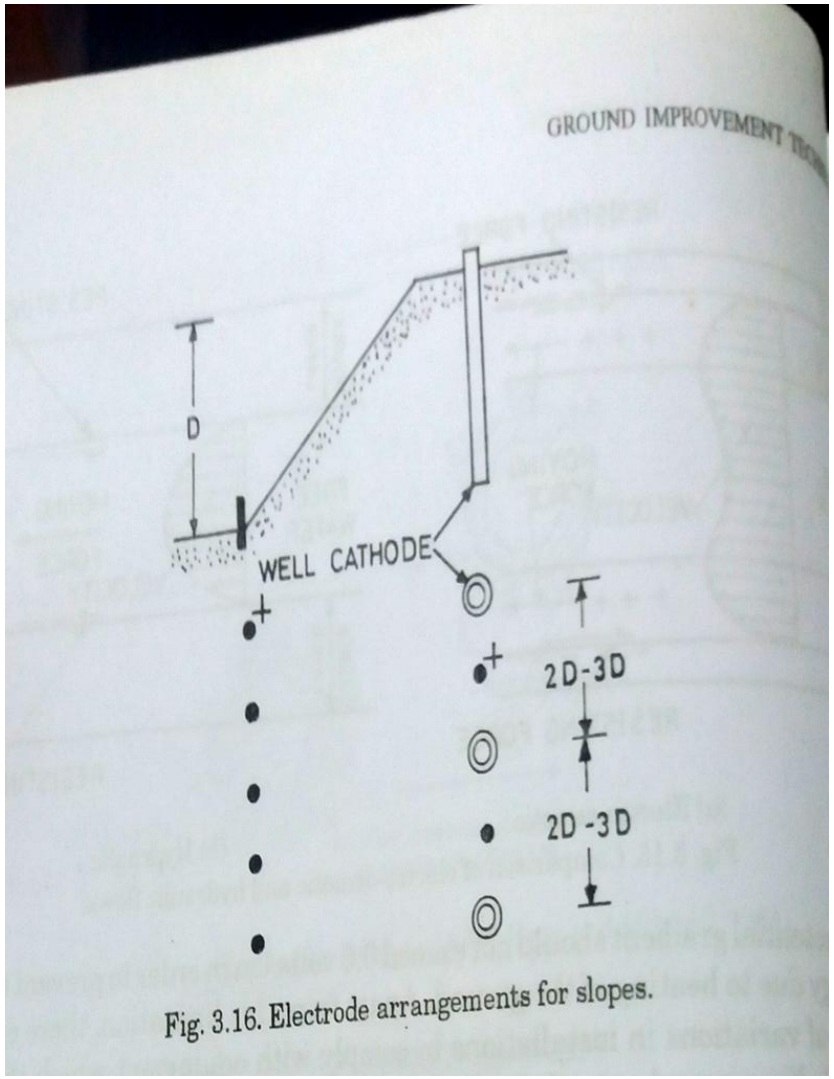
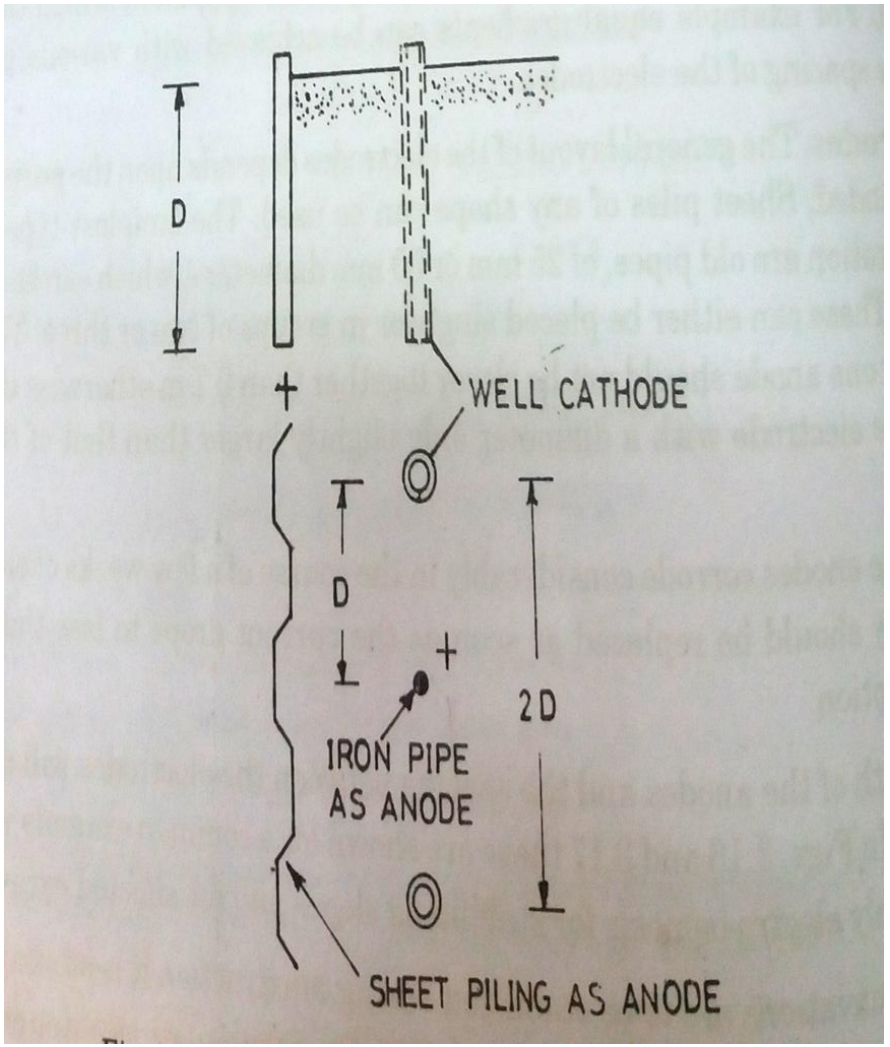


Fig. 3.16. Electrode arrangements for slopes.



DESIGN STEPS FOR DEWATERING SYSTEMS

❖ 1.SUBSOIL INVESTIGATION

- It is done to know the characteristics of soils adjacent and beneath the excavation
- The depth and spacing of boring have to be properly planned
- Samples should be taken at frequent intervals so as to identify each soil type,permeability, characteristics of soil and layers of clay or any other impervious material
- The position of water table and substratum pressure should be recorded

- Grain size distribution and permeability are the two important factors determined from the soil investigation
- Permeability determines from field Pumping test(as per IS 9759:1981)
- Various methods are used to determine the permeability
- A rough approximation of permeabilty may be obtained from table
- A better estimate could be from a comparison of grain size distribution curves of from Hazens empirical relationship.

- $k=C_1 D_{10}^2$

  C_1 =Constant varying between 100 and 150 in case of pumping test is not conducted

  D_{10} = diameter of particle (cm)

This eqn valid for uniform sand with uniformity coefficient not greater than 2

Table 3.4. Permeability Values of Pervious Stratum
(Adopted from IS : 9759-1981)

Sl. No.	Types of Sand	Coefficient of Permeability (k) cm / sec
1.	Very fine sand	1 to 50
2.	Fine sand	51 to 200
3.	Fine to medium sand	201 to 500
4.	Medium sand	501 to 1000
5.	Medium to coarse sand	1001 to 1500
6.	Gravel and coarse sand	1501 to 3000

❖2. Source and water table details

- The source of seepage depends on the geological features of the area, near by streams or other bodies of water, on the degree of perviousness of the stratum and amount of drawdown
- streams close to the well act as line source of seepage depending on the distance of the well from the effective source of seepage
- This distance commonly known as the radius of influence

- Empirical equation based on sichordts eqn used to estimate the radius of influence
- $R = C'(H-hw)k^{0.5}$
- R= radius of influence
- C'= a constant= 0.9(for gravity flow)
- H= depth of natural water flow
- H= head at the well

- The initial elevation of water table is considered in deciding the elevation at which the first stage of well points/wells
- In order to ensure the dry working condition during construction it is preferable in most soils to maintain the water table 1 to 2m below the bottom excavation

❖3Distance of well points /wells from source of seepage

- If the actual radius of influence is large compared with the radius of the well, only an approximate estimation of R may be sufficient.
- An accurate estimation of L should be made for a particular dewatering system , since the discharge is inversely proportional to the value L

❖4. EFFECTIVE WELL RADIUS

- The effective well radius , r_w for a well point/well is decided based on the installation of wells with or without filter
  - If a well point/well is installed without a gravel or sand filter, effective well radius can be taken as one-half the outside diameter of well screen
  - When a gravel or sand filter is used around the well screen the well radius is taken as the one half the outside diameter of the filter

- If a well screen is installed without a filter in the pervious stratum but a natural filter formed around the screen due to surging, the effective well radius will exceed one half of the outside diameter of the well screen

❖5 Discharge computations

- The discharge Q of the well is then calculated using the formula given below:

$$Q = \pi k \frac{H^2 - h^2}{2.3 \log_{10}\left(\frac{R}{r}\right)}$$

- where Q is the discharge, k is the permeability, H is the depth of strata, h is the height of water in the well, r is the radius of well, R is the radius of influence.

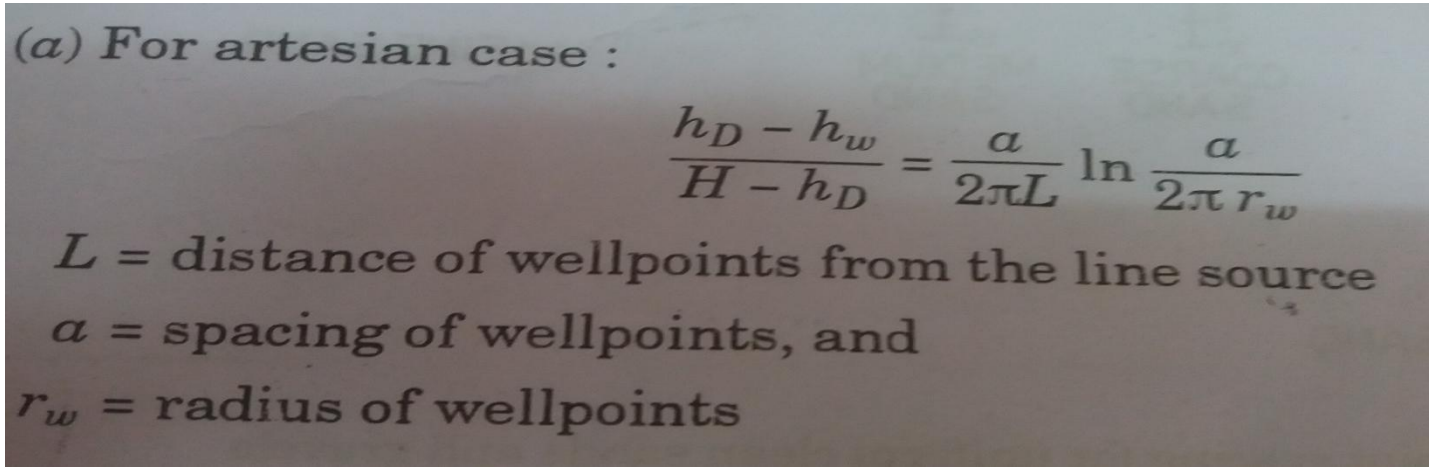
- The following procedure is recommended by IS for the design of filter

i)If H is the head (natural water table) and h_0

is the head at the slot , then head reduction($H-h_0$)at a slot required to produce the desired residual head h_D should be computed from equations 3.5 to 3.8 (*refer* Dr. Purushothama raj page no 71 to75)

ii)Assuming $h_0= h_D$ and that h_0 -hw is the head difference, well point spacing can be computed from the following eqns,

a) For artesian case



(a) For artesian case :

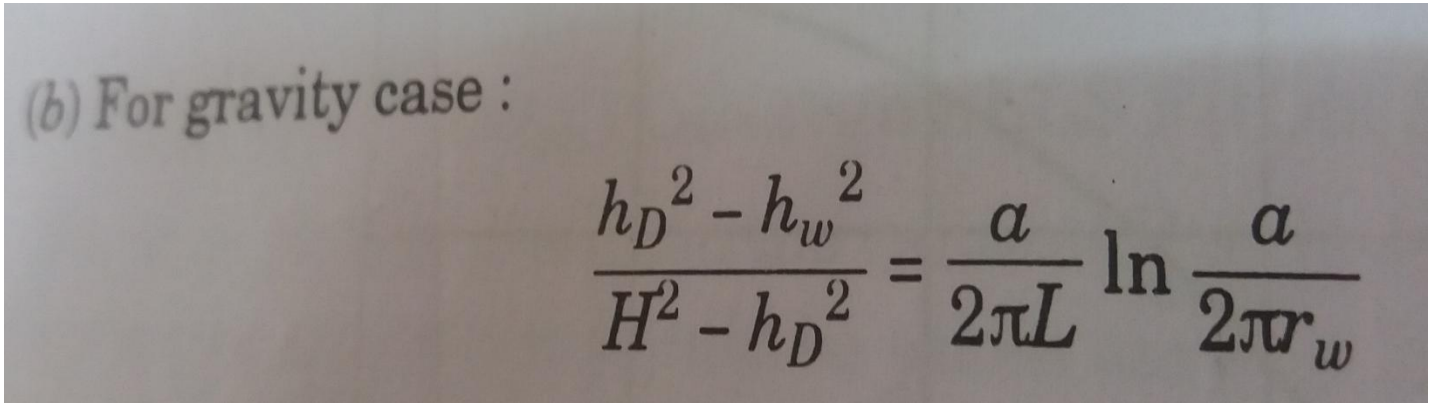
$$\frac{h_D - h_w}{H - h_D} = \frac{a}{2\pi L} \ln \frac{a}{2\pi r_w}$$

L = distance of wellpoints from the line source

a = spacing of wellpoints, and

r_w = radius of wellpoints

b) For gravity case



(b) For gravity case :

$$\frac{h_D^2 - h_w^2}{H^2 - h_D^2} = \frac{a}{2\pi L} \ln \frac{a}{2\pi r_w}$$

❖6.Design of filters

- The filter requirement for the filter material shall be as under:

3.7.6. DESIGN OF FILTERS

Based on the filter criteria, discussed in Section 3.3, the filter requirements for material shall be as under :

Character of Filter Materials	Ratio R_{50}	Ratio R_{15}
Uniform grain-size distribution (C_u = 3 to 4)	5 to 10	—
Well graded to poorly graded (non-uniform) ; subrounded grains	12 to 58	12 to 40
Well graded to poorly graded (non-uniform) ; angular particles	9 to 30	6 to 18

where

$$R_{50} = \frac{D_{50} \text{ of filter material}}{D_{50} \text{ of material to be protected}}$$

$$R_{15} = \frac{D_{15} \text{ of filter material}}{D_{15} \text{ of material to be protected}}$$

❖7. Design and selection of well screens

- Design of wells and well points must ensure that there will be little resistance to water flowing through the screen and riser pipe
- Prevent infiltration of sand during pumping, and resist corrosion by water and soil
- Commercially available well points are of brass, stainless steel screens mounted over galvenized, tin dipped
- High capacity type of well points used when large flows are forseen in the field
- The mesh or slot size of a screen should be smaller than 80% or 70% size to avoid the infiltration of sand

- Screens commonly used for deep large diameter wells are slotted steel or wood or perforated steel pipe wrapped with galvanized
- Slotted steel or wooden screens are commercially available with various width of slots
- In order to enhance the efficiency at the same time to prevent infiltration use graded filter material
- As per IS following criteria should be observed in designing and selecting well screen
- Slot width less than or equal to D70
- Hole dia or width D80

❖ 8.Well point in deep excavation

- If the water table could not be lowered more than 6m or if a deep excavation has to made , it is advantages to use multistage well point system
- The lowest header of the multistage system should be located not more than about 4.5 m above sub grade

9.Selcetion of pumps and accessories

- Pumps, headers, discharge lines and power unit must be of sufficient capacity to remove the required wells or well points
- The selection of pumps and power unit depends on the various factors such as required discharge , suction lift plus positive head including hydraulic head losses, air handling capacity, power available, fuel economy and durability of units
- A well point pump consisting of a self priming centrifugal pump with attached vacuum pump
- If the depth of water table lowering is large(>4.5 m) but the rate of pumpage for each well point is relatively small

- In selecting the power unit to be used for driving pumps, consideration should be given to the initial cost of the unit, and the cost of preparations, including maintenance of fuel
- The capacity of a pump required for a dewatering system is decided by horse power as obtained by the horse power
- $$horse\ power = \frac{total\ discharge\ in\ gpm\ X\ total\ dynamic\ load}{3960X\ efficiency\ of\ the\ pump\ and\ engine}$$
- Where dynamic load=operating vacuum at the pump in take+ discharge friction losses

❖10. Deep bored wells

- Design is similar to well point system
- Well should be sufficiently large to accommodate pump and to keep the lead loss low
- Deep wells are usually 15 to 45 cm diameter with screens of 6 to 22.5 m length
- Pumping from wells done by surface pumps with their suction pipes installed in bored wells
- Effectively used upto a depth of 7.5 .
- For adequate submergence of well screen and pump, sufficient depth of pervious material should be there beloe the level to which water table is lowered

❖11.Control of surface water

- In laying out a dewatering system, proper steps should be taken to control surface water so as to prevent flooding results in failure of the system
- Uncontrolled run off cause serious erosion of slopes
- Required measures are providing dikes, ditches, sumps, pumps, mulching seeding to minimize slope erosion

- The following factors should be considered while designing and selecting measures to control water

a.duration of construction

b. frequency of rainfall occurrence

c. Intensity of rainfall and the resulting run-off

d. size of area to be protected

e. available sump storage