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POLLACHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

(Approved by **AICTE** and Affiliated to **Anna University**)

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Department of Civil Engineering

Regulation 2021

III Year – V Semester

CE3016 Ground Improvement Techniques

CE3016 GROUND IMPROVEMENT TECHNIQUES

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UNIT I HYDRAULIC MODIFICATIONS 9

Scope and necessity of ground improvement in Geotechnical engineering basic concepts. Drainage – Ground Water lowering by well points, deep wells, vacuum and electro-osmotic methods. Stabilization by thermal and freezing techniques - Applications.

UNIT II MECHANICAL MODIFICATIONS 9

Insitu compaction of granular and cohesive soils, Shallow and Deep compaction methods – Sand piles – Concept, design, factors influencing compaction. Blasting and dynamic consolidation design and relative merits of various methods – Soil liquefaction mitigation methods

UNIT III PHYSICAL MODIFICATION 9

Preloading with sand drains, fabric drains, wick drains – theories of sand drain - Stone column with and without encased, lime stone – functions – methods of installation – design, estimation of load carrying capacity and settlement. Root piles and soil nailing – methods of installation – Design and Applications.

UNIT IV MODIFICATION BY INCLUSIONS 9

Reinforcement – Principles and basic mechanism of reinforced earth, simple design: Synthetic and natural fiber based Geotextiles and their applications. Filtration, drainage, separation, erosion control.

UNIT V CHEMICAL MODIFICATION 9

Grouting – Types of grout – Suspension and solution grouts – Basic requirements of grout. Grouting equipment – injection methods – jet grouting – grout monitoring – Electro – Chemical stabilization – Stabilization with cement, lime - Stabilization of expansive clays.

TOTAL: 45 PERIODS

UNIT-I

6) Ground Improvement Potential [May 18] - 10 Marks

* Hazardous
* Poor
* Favourable

1) Hazardous Ground Conditions:

* A regional or a local field condition is such that a regular design approach or an economical treatment technique may not be feasable and construction in such a location may result in ultimate disaster.

* construction on sites located on or in close proximity to faults, particularly in seismically active regions may serve ground shocks. are unsuitable and hazardous and should be avoided

* Loose to medium dense fine sands may easily leading to liquefaction. Due to liquefaction loss of ground support and lateral movement could occur. (In such situations locations the treatment will be costly and the potential risk also is very high.) → last Point

* Ground collapse may takes place in dormand (volcano) or active mines or cavernous limestones (dark) and also in the locations of ground water from adjacent site is drawn enormously.

* Natural slopes, thick deposits of residual soils, may lead to slope failures in the form of landslides, avalanches, flows etc.

* Flood plains and low (moist) ground may lead to ground subsidence.

* Any land fill of (motion) hazardous waste should never be selected for construction or any other activity. (These conditions may be categorized as hazardous and such locations should be totally avoided

2) Poor Ground conditions:

(* Loose, Porous lightly cemented clays, low-density of arid climate valleys may collapse on saturation followed by subsidence) → 2nd Point.

(* A local condition including regional conditions which may require special design or special treatment for development) → Ist Point.

* Expansive clays and rocks including the black cotton soils may changes in moisture content - Active zone has to be identified & structures should be designed.

* Soft to firm clays having low bearing capacity - design of suitable deep foundations or treatment techniques.

* Organic soils are highly compressible in nature - Deep foundation can be designed.

* Loose sand silts - Need a proper treatment.

* Ground water location, also needs design methods and treatment techniques.

3) Favourable ground conditions:

* Cohesive granular soils such as sandy-clay mixtures, are relatively strong & form good supporting medium for moderately to heavily loaded foundations.

* Cohesionless granular soils such as medium dense to dense sands and sand-gravel mixture provide excellent foundation conditions for most loading conditions.

* shallow (less deep) rock without any discontinuities provides the best foundation to support any type of loading. Its supporting capacity depends on rock quality, characteristics or discontinuities & long term [illegible]

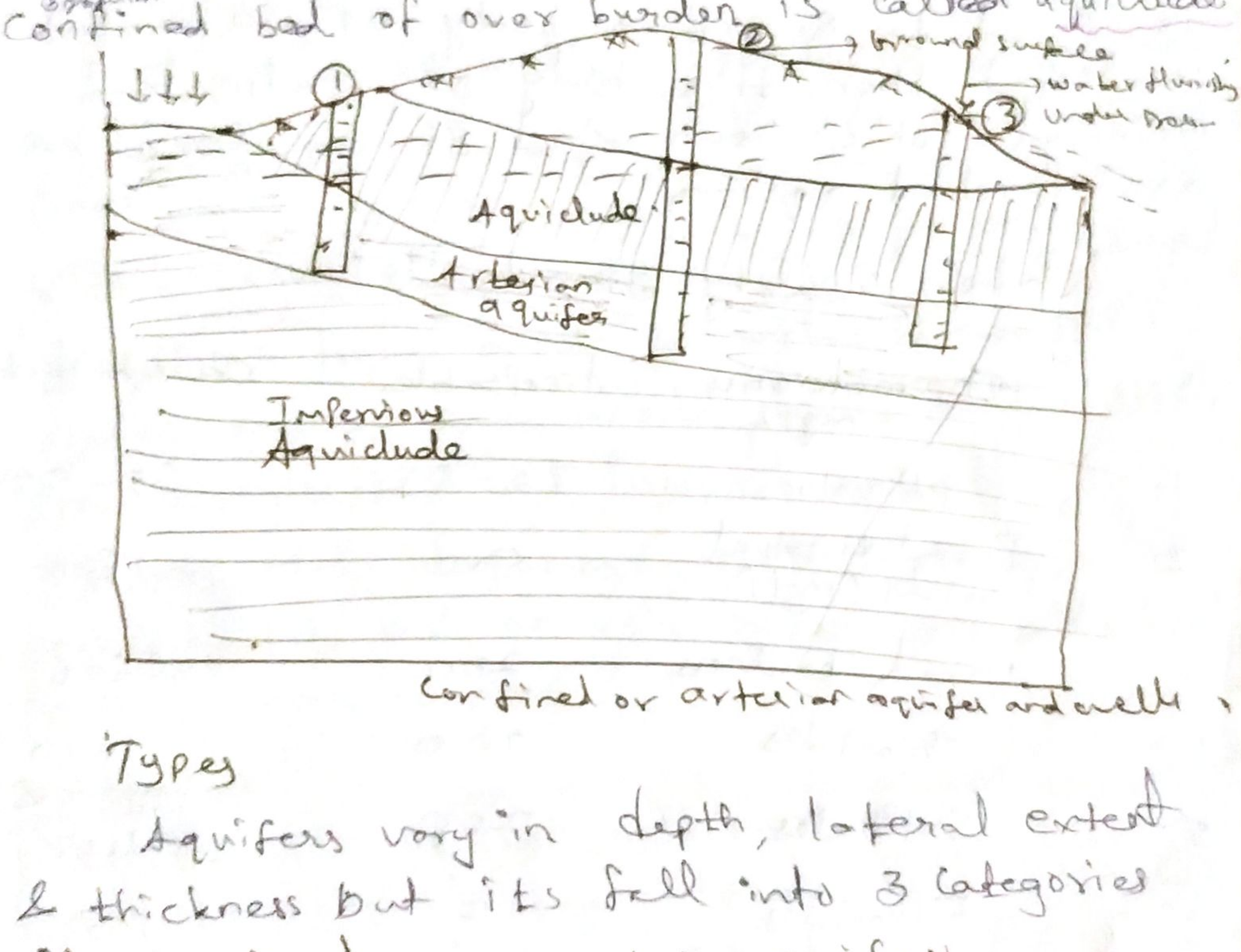
Aquifers and their types [Nov 17] [7 Mark]

Aquifer:-

* A Permeable stratum which is capable of yielding appreciable quantities of ground water under gravity is known as an aquifer.

Aquiclude:-

* When an aquifer is overlaid by a confined bed of impervious material, then this confined bed of over burden is called aquiclude.



Confined or artesian aquifer and wells.

Types

Aquifers vary in depth, lateral extent & thickness but its fall into 3 categories

i) Unconfined or non-artesian aquifers:-

The top most water bearing stratum having no confined impermeable over burden lying over it, is known as an unconfined or non artesian aquifer.

ii) Confined or artesian aquifers:- Containing ground water under positive pressure

* When an aquifer is confined on its upper and under surface by impervious rock formations is called a confined aquifer.

iii) Perched aquifers:-

* It is a special which is sometimes found to occur within unconfined aquifer.

* If within the zone of saturation, an impervious deposit below a pervious deposit is found to support a body of saturated material then this body of saturated material which is a kind of aquifer is known as "Perched aquifer".

Water Quality Standards [Nov 17 6 Marks]

S.No	Characteristic in mg/l	Acceptable	Cause for rejection
1.	pH value	7.0 – 8.5	6.5 – 9.2
2.	Total dissolved solids (mg/l)	500	1500
3)	Total hardness	200	600
4.	Chlorides	200	1000
5.	Sulphates	200	400
6.	Fluorides	10	1.5
7.	Nitrates	45	45
8.	Calcium	75	200
9.	Magnesium	30	150
10	Iron	0.1	1.0
11.	Manganese	0.05	0.1
12	Copper	0.05	1.5

Electro-osmosis [Nov 16 - 8 Mark]

* Electro osmotic consolidation means the consolidation of soft clays by the application of electric current.

* It was studied and applied for the first time by Casagrande.

* It is inherent that fine grained clay particles with large interfacial surface will consolidate & generate significant settlement when loaded.

* E-O was originally developed as a means of dewatering fine grained soils across the sediment layer.

* It is the process where in positively charged ions move from anode to cathode ie. water moves from anode to cathode where it can be collected and pumped out of soil.

* E.O flow depends on soil nature, water content, pH and on ionic type concentration in the pore water.

Dis Advantages:

* The pH of soil will increase to as high as 11 or 12 at the cathode and decrease to almost 2 at the cathode.
* Metal anodes will corrode.
* The applied voltage & electric current generates heating.
* The heating effect increases power consumption.

Advantages:-

* The consolidation period can be reduced by electro osmotic consolidation technique.

* The process is very efficient in low permeability clays in which the electro osmotic permeability is > than the hydraulic permeability.

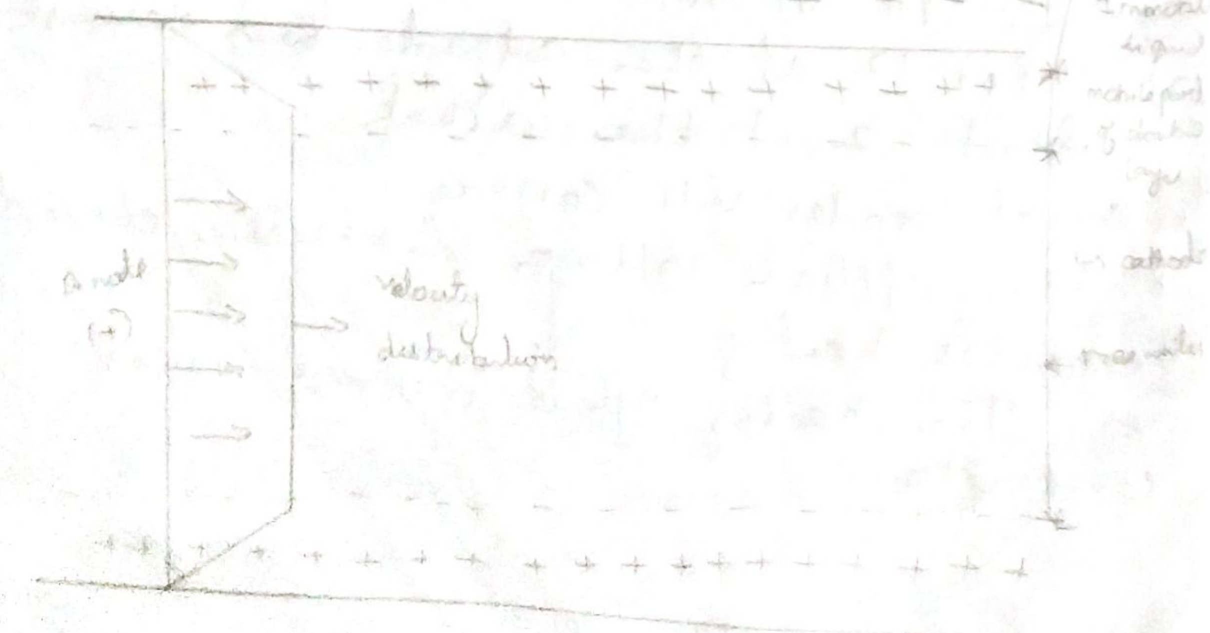
* It is suited for local application on small volumes or for impermeable barrier construction.

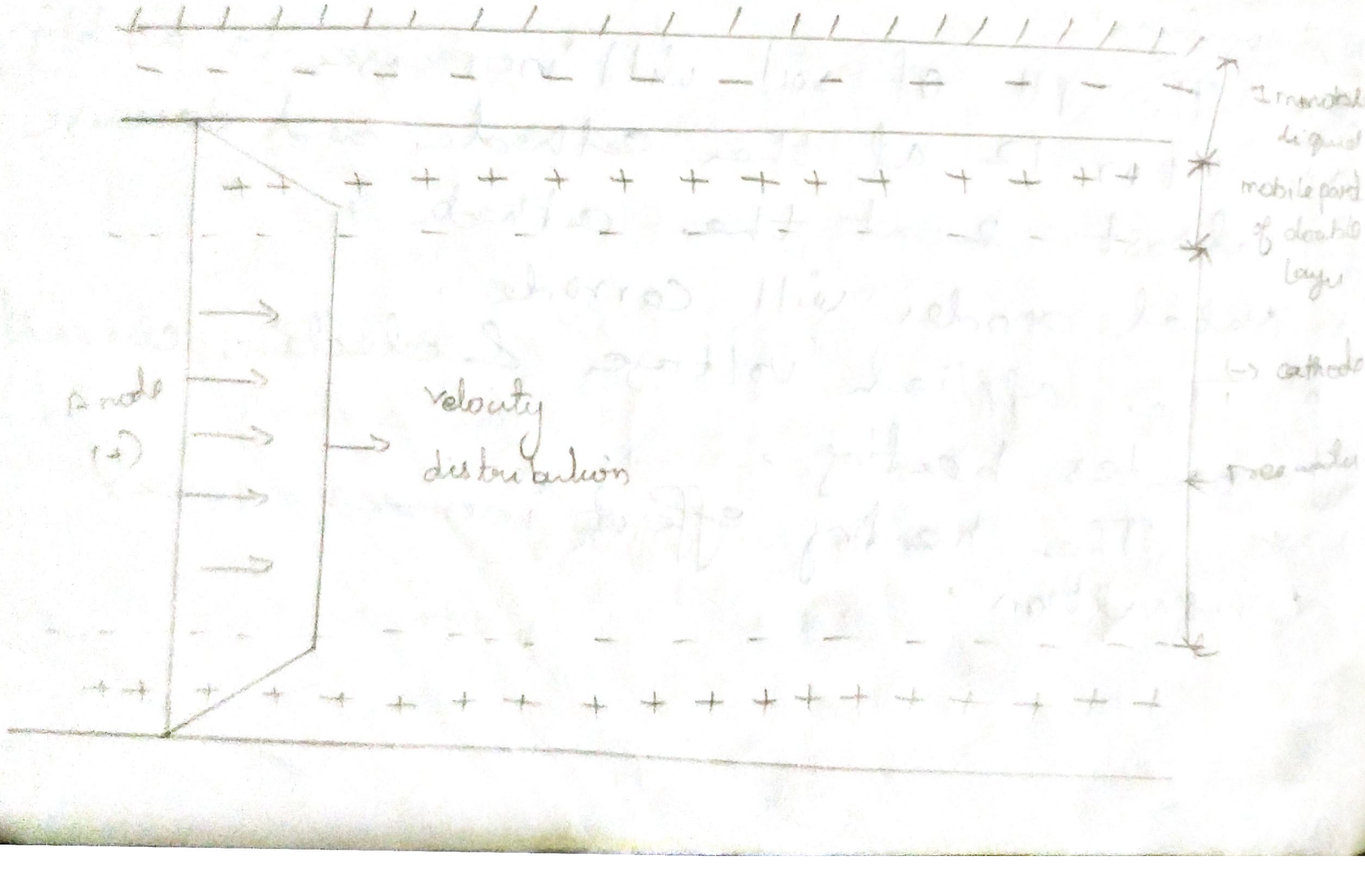
Method:

* 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. This is electro-osmosis.

* Upon application of an electromotive force between two electrodes in a soil medium the positive ions adjacent to the soil particles and the water molecules attracted to the cathode & repelled by anode.

* By making the cathode a well, water can be collected in the well and then pumped out.





Immobile liquid
mobile part of double layer
(-) cathode
Anode (+)
velocity distribution

CE 6012 - Ground Improvement Techniques ①

UNIT-I

Problematic soils and Improvement Techniques

Role of Ground Improvement in Foundation Engineering - Methods of ground Improvement - Geotechnical Problems in alluvial, Laterite and Black cotton soils - Selection of suitable ground improvement techniques based on soil conditions

1. Methods of Ground Improvement [Nov 17] - 2 Mark [May 17] - 2 Mark

* Compaction
* Dewatering
* Pre Loading
* Lime column
* Heating
* Freezing
* Vibro compaction
* Grouting

[Note - Each type is expected for 2 Mark]

* Compaction :- [Nov 17] 4 Mark

* It is the process of increasing the density of the soil by means of suitable compaction device
* This Method is predominantly adopted for cohesive soils Ex:- clay, silt, loam etc
* However cohesionless soils can also be compacted

* Dewatering

* Dewatering is the process of continuous removal of water to lower the ground water table to the required depth.

Methods

* Open sumps & ditches
* Well Point system
* Deep well system
* Vacuum dewatering
* Electro - osmotic dewatering

* Pre-Loading: [Nov 19] - 4 Marks

* It is the Process of Placing additional vertical stress on a compressible soil to remove Pore water over time.

* The pore water dissipation reduces the total volume causing settlement.

* Surcharging is an economical method for ground improvement.

* The various soils that can be treated using this method are organic silt, soft clays etc.

* The main applications are Reduction of Post construction settlement, improvement of densification & bearing capacity

* Lime column:

* It is the process in which soft clays & silts are mixed with dry unslaked lime to form a column to treated soil.

* This process uses a mixing tool that combines the lime with in-situ material during treatment.

* The main applications of lime columns are in improvement of fills, embankments and deep trenches

* Heating

* Heating or vitrification breaks the soil particles down to form a crystalline or glass product

* It uses electric current to heat the soil & modify the physical characteristics of soil.

* Its application areas include immobilization of contaminant & soil stabilization.
* The expected property changes are increase in shear strength & modulus of elasticity.

* **Freezing:-**
  * Ground freezing is the use of refrigeration to convert insitu pore-water to ice.
  * The ice then acts as cement or glue bonding together to soil or rocks to increase their strength.
  * Its applications are Temporary underpinning, Slope stabilization etc.

* **Vibro compaction:-** [NOV 17] 4 Mark
  * It is sometimes referred to as vibroflotation, is the rearrangement of soil particles into a denser configuration by the use of powerful vibrators.
  * It is mainly adopted to reduce settlements and permits construction on granular fills.
  * It can be adopted in sands & silty sands and not adopted for clays.

* **Grouting:-**
  * It is the process of ground improvement attained by injection of a fluid like material to form a gel & binding the soil particles.
  * Types
    1) Permeation grouting
    2) Compaction grouting
    3) Hydraulic grouting

2) Geotechnical Problems in soils :- [May 18 - 8 Marks]

* Soil is a material which exhibits a very wide range of characteristics that, it led a whole branch of study to understand it better.

* In this endeavour man has encountered a wide variety of soils posing problems to his development activities.

* Different soils exhibit different levels of difficulty in their handling & not all soils are problematic from engineering point of view.

* Black cotton soil :- - Residual deposits from basalt rocks.

* This is well known group of soil characterized by dark grey to black colour with high clay content.

* They are neutral to slightly alkaline in reaction.

* It has high compressibility & low bearing capacity.

* Major black soils are found in Maharashtra, Madhya Pradesh, Gujarat, Tamilnadu etc.

Problems with black cotton soils: Nov-16 - 2 Mark

* Expansive nature due to the presence of clay mineral.

* Surface is hard in summer and becomes slurry in rain & loses its strength substantially.

* This swell and shrink nature results in movements leading to heaving of lightly loaded structures and road pavements.

* Laterite soil :- It is formed from chemical decomposition of rocks. (8)

* The upper horizons of laterite soils are rich in oxides of iron & aluminium.
* The texture is light with free drainage structure.
* Clay is predominant and lime is deficient and contain more humus and are well drained
* They are distributed in summits of hills of deccan Karnataka, Kerala, Madhya Pradesh etc.

Problems with Laterite soils :- [May 18] [2 Mark]

* Porous in nature
* Medium to high permeability.
* Stability problems
* Difficulty in assessment of lateral stresses.
* Wide ranging characteristics.

* Alluvial soil :- It is deformed due to the decomposition of sediment by the river
* The soils are sandy loam to clay loam with light grey colour to dark colour. Structure is loose and are very fertile.
* The distinct characteristics of alluvial deposits is the existence of alternating layer of sand, silt and clay.
* These soils are distributed in Indo-Gangetic plains, Bhramaputra valley and almost all states of North & south India

* Problems with Alluvial soil

* Loose deposits with good water holding capacity.
* Low density
* Liable to liquefaction in earthquake prone areas.
* Variation in thickness of deposits.

3) Factors influencing the selection of ground improvement Techniques:- [May 17], May 18 - 6 Mark, Nov 18 - 8 Mark

* Soil type - soil, clay, organic, silt etc
* Area & depth of treatment required
* Types of structure & load distribution,
* Soil Properties - Strength, compressibility, permeability etc
* Permissible total and differential settlement
* Material availability ; Stone, sand, water, admixture, stabiliser etc.

Availability of skills & Equipment:-

* Environmental Considerations - water disposal, erosion, Population etc
* Local experience and preference
* Economics

* The various ground improvement techniques based on the types of soil are discussed below,

S.No	Ground Improvement	Types of soil
1.	Compaction	-
2.	Smooth wheeled roller	* Paving mixtures
3.	Sheep foot roller	* Clay & silt clays
4.	Grid rollers	* Coarse grained soils
5.	Pneumatic rollers	* Low cohesive soils like clayey sand & sandy clays * Cohesionless soils like gravels, sand etc.
6.	Vibratory rollers	* Coarse grained soils
7.	Dynamic compaction (Laterite soil) May 17, 8 Mark	* Best in cohesionless but other types of soils can be compacted
8.	Sumps & ditches (Granular soil) [May 17, 16 mark]	* clean gravels & coarse sands
9.	Well Point system (Granular soil) [May 17, 16 mark]	* Most effective in sands, Sandy gravels to fine sands
10.	Deep well system (Granular soil) [May 17, 16 mark]	* Gravels to silty fine sands & water bearing rocks
11.	Vacuum dewatering (Laterite soil, Granular) (May 17)	* Fine grained soils
12)	Electro osmotic (Alluvial soil) - May 17, 8 Mark	* Silts, silty clays, Soft clays.
13)	Preloading with vertical drains. (Black cotton soils)	* Silts, soft clays etc
14)	Lime columns (Black cotton soils)	* Clayey soils & expansive clays

15) Heating (Lateritic soils) [May 17 - 8 Mark] — * Fine grained soils, Saturated clays, Silts etc.

16) Freezing — * Sands, cohesionless silts & clays

17) Vibro compaction (Alluvial soils, Granular) (May 17 - 8 Mark)(16 Mark) — * Effective in Sands & silty sands.

18) Stone columns — * Granular & cohesive

19) chemical stabilisation — * Different soils by using different chemicals & resins

20) Grouting — * Gravels to silts, saturated cohesive soils

4) Role of ground improvement in Foundation Engineering: [NOV 17] NOV 16 - 2 Mark

* Improves bearing capacity
* Reduces formation Foundation settlements
* Enables construction on granular fills
* Provides temporary underpinning
* Provides excavation Support
* Reduction of foundation dimensions
* Construction of shallow Foundations.
* Enables dry working conditions for Foundation excavations.

5) Factors which contribute ground alternatives (9)

16 mark [Nov 16]

* Effect of seasonal moisture variation
* Effect of water seepage & surface erosion
* Effect of vegetation
* Effect of temperature variation
* Effect of vibration
* Effect of Mining Subsidence & Pumping
* Effect of construction operation

* Effect of seasonal moisture variation:

* Soils may undergo volume changes caused by seasonal moisture content variation.

* Shrinkage is formed in the fine-grained soils due to the voids at the soil surface.

* Swelling is also caused due to the repulsive forces which separate the clay particles leading to volume increases

* Effect of water seepage and surface erosion:-

* Mainly in sandy soils troubles occur due to water seepage and erosion.

* Surface erosion may occur due to loss of materials in strong winds or erosion by flowing water.

* Internal erosion can result in fine soil soil particles by ground water seeping in broken sewers or culverts.

* Erosion can be prevented by providing adequate depth of foundation, vegetation or blanketing the erodable soil by gravel, crushed rock etc.

* Effect of vegetation:

* Swelling & shrinking problem is also aggravated due to the effect of the roots of vegetation.

* The removal of water by the roots caused shrinkage both vertically & horizontally.

* Care should be taken to assess the settlement and also the forces tending to tear the foundations.

* Effect of temperature variation

* Both low & high temperature cause volume change leading to heave & shrinking.

* When the temperature remains below 0°c for a long period the soil moisture near the ground surface freezes.

* When soil is subjected to very high temperature severe shrinkage cracks may occur.

* Such conditions may arise on soil beneath foundation of boilers, kilns & furnaces.

* Effect of vibration:

* It is a common experience that a sandy soil when subjected to vibrations vibrations from such sources as moving machinery, traffic, pile driving, blastic or earth quakes increase the density of sand & cause subsidence.

* Experimental studies & field experience have shown that most serious settlements in sand due to vibrations are caused by high frequency vibrations in the range of 50 to 2500 impulses per minute.

* Effect of mining subsidence & Pumping:

* Ground subsidence due to mining pumping or dredging is generally of high magnitude.

* "Pillar & stall workings" technique was developed followed by the present day method of coal mining by "longwall workings".

* Excessive pumping from oil wells reduces the neutral stress in the oil bearing rocks are increases the effective stress.

* Effect of construction operation:

* Ground subsidence during construction may also occur due to increasing loads on surrounding soil and excavation apart from vibrations & lowering of water table.

* Load applied on one area of ground surface above a soil may cause the surface.

* Settlement is occurs due to excavation.

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6. Alternative approaches [Nov 16] 8 mark

* [cont - Ground Improvement Potential]

* In urban environment sites with favourable conditions become scarce.

* To satisfy clients, the engineer may construct at locations other than ground support conditions.

Procedures:-

1) By pass the unsuitable soils by means of deep foundations,

2) Redesign the structure

3) Removing the poor material & either treat or replace it.

4) Treat the soil in place or improve its properties.

* Geotechnical Processes

* Ground improvement is the alteration of any property of a soil or rock to improves the engineering performance.

* Various process of ground improvement are to increase the strength, reduce compressibility, reduce permeability or improve ground water condition.

* Various techniques of ground improvement are compaction, drainage methods, pre compression and vertical drains, vibration methods, grouting & injection, chemical stabilisation & geosynthetics etc.

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Two Marks [Not in notes]

1. what is the necessity (need) of ground improvement? [May 17]

* Reclamation of unsuable land
* Betterment of soil Properties for Improved Performance.
* Cost effective design of foundations.

2. Define ground improvement. [Asked in R-2008]

* Ground improvement technique is the Process of improving the geo-technical characteristics of soil used in construction.
* It is mainly used to increase the strength, improve ground water condition, reduce compressibility & Permeability.

3. what are the difficulties faced with soft clay? [Nov 17]

* When the soft soil is so poor, it is very difficult to construct anything, because the bearing capacity is very low, shear strength is low, consolidation settlements are going to be very high and Permeability is very low.

4. List out the materials that are used in Practise for reclamation purposes [May-18]

* Hydraulic fills of dredged soil
* Sanitary fill
* Paper sludge
* Flyash including slag
* Rubbish & debris

Expected - Two Marks

5. What are the Major Problematic soils?

* collapsible soils
* Expansive & shrinkage
* Liquefiable soils
* Marshy & soft soils
* Waste Materials

6. What is expansive soil?

* Expansive soils are soils that expand when water is added, and shrink when they dry out. This continuous change in soil volume can because homes built on this soil to move unevenly and crack. Ex:- Deccan Plateau, in AP

7. What is a collapsible soil?

* These are the soils, which have a tendency to collapse upon loading. Many of the reasons such as, the stable or unstable structure or capillary structures.
* If there is a volume change, it leads to a reduction in volume and that leads to collapse

8. What are the advantages of using Pre-loading with vertical drains?

* The main applications of this method are in areas of transportation, highway embankments, housing projects, hazardous waste remediation, and in reducting negative skin friction on Pile foundations.
* Vertical drains are nowadays, Primarily Constructed with Prefabricated vertical drains

[Note:- other FAQ two Marks are mentioned in notes.]

UNIT - 2

Dewatering

Dewatering Techniques - Well Points - Vacuum and electro osmotic methods - Seepage analysis for two-dimensional flow for fully and partially penetrated slots in homogeneous deposits - simple cases - Design.

Dewatering techniques

* Dewatering is an action of removing ground water or surface water from construction site.

* Normally dewatering process is done by pumping or evaporation and is usually done before excavation for footings.

Need for dewatering

* To provide suitable working surface of the bottom of excavation,

* To stabilize the banks of excavation thus avoiding the hazards & sloughing.

* To prevent disturbance of the soil at the bottom of excavation caused by boils or piping.

* Lowering the water table can also be utilized to increase the effective weight of the soil and consolidate the soil layers.

* Reducing lateral loads on sheeting & bracing is another way of use.

Methods of dewatering [May 17 - 16 mark] ②

1) Open sumps & ditches
2) Well Point systems
3) Deep well system
4) Vacuum dewatering
5) Electro-osmosis dewatering

1) Open sumps & ditches: [May 18 - 2 Mark]

* A sump is merely a hole in the ground from which water is being pumped for the purpose of removing water from the adjoining areas.

* In order to prevent standing water on the floor of excavation, a small grip or ditch is cut around the bottom of excavation falling towards the sump.

* The greatest depth to which the water table can be lowered by this method is about 8M below the Pump.

Advantages

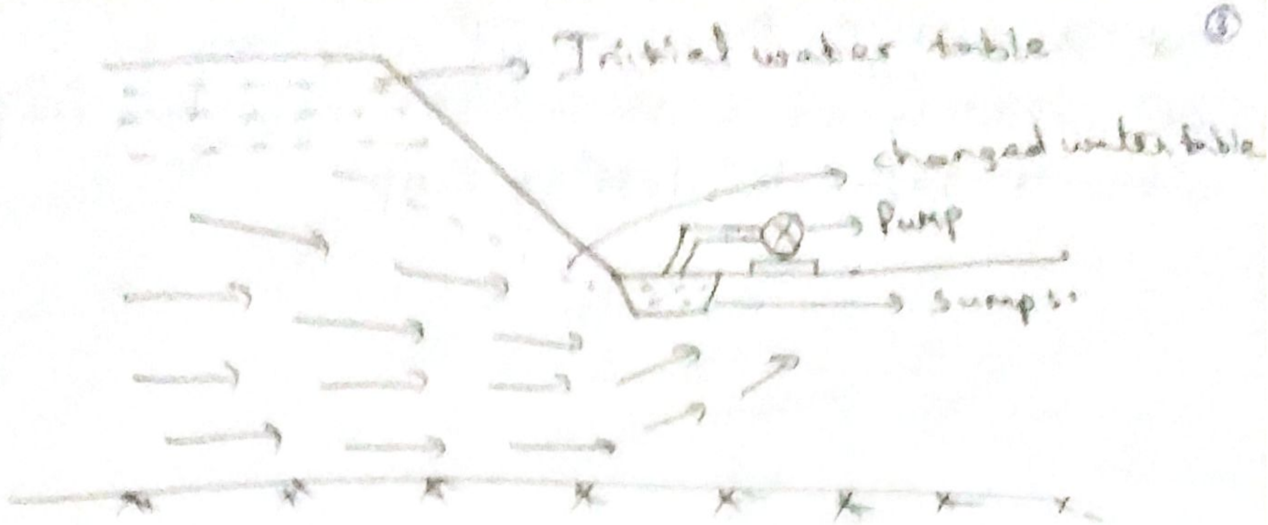
* It is the most widely used and economical method for installation & maintenance which could be applied for most soil or rock conditions.

* Gravels & coarse sands are more suitable.

Disadvantages

* Ground water flows towards the excavation with head or steep slope may lead to risk or collapse of the sides.

* Subsidence of adjacent ground and sloughing of the lower part of a slope may occur



2) Well Point systems: [Nov 17 - 16 Mark] [Nov 17 - 2 Mark]

* Filter wells or well Points are small well screens of size 50 to 80MM in diameter and 0.3 to 1M length.

* Well Points are either with brass or Stainless - steel screens are made with either closed ends or self jetting types,

* Well Points are installed by jetting them into the ground.

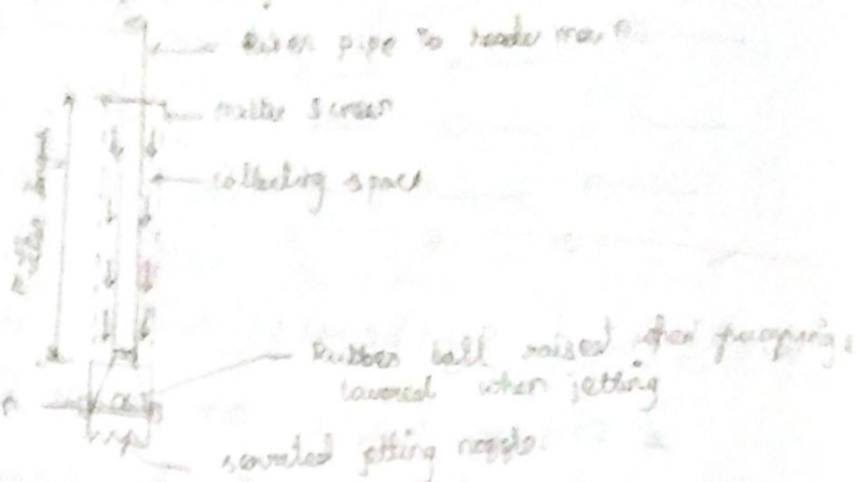
* The capacity of a single well Point with a 50MM riser is about 10 litres/M,

* Well Points are connected to riser pipes and are inserted into the ground by driving or jetting

* It is usually installed with 0.75M-3M spacing. some of the different soils and its spacing are

Sl.No	Soil	Typical spacing(M)	Time (days)
1.	Silty sand	1.5 - 2	7-21
2.	Clean Fine to coarse sand & Sand gravel	1.0 - 1.5	3-10
3.	Fine to coarse gravel	0.5 - 1.0	1-2

* A well Point equipment comprises of 50 - 60 wellPoints to a single 150 or 200mm Pump with a separate jetting Pump.



Advantages:

* It is the most commonly used Method for construction Purposes.

* The installation of well Point is very rapid & required reasonably simple & cheap equipment.

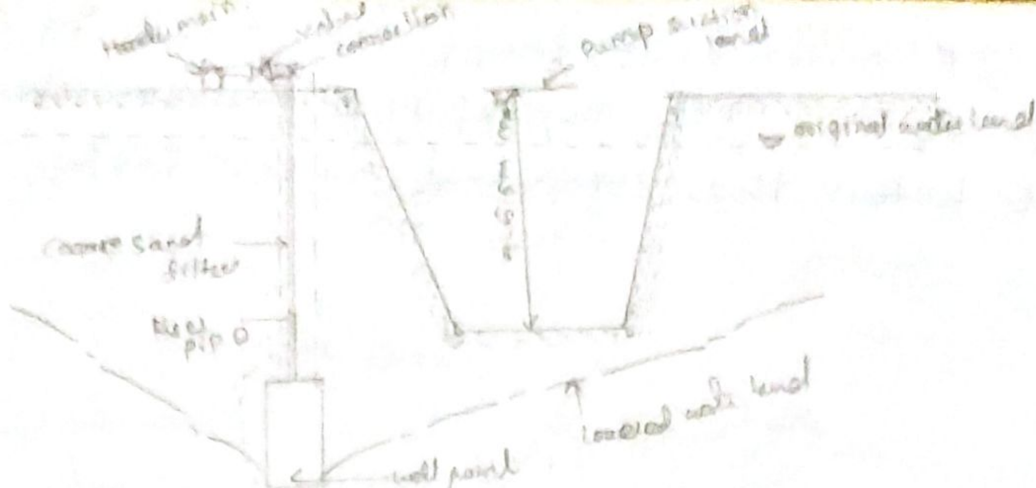
* The water is filtered and carries little or no soil Particles.

Disadvantages:

* A lowering of about 8M below Pump level is generally Possible beyond which excessive air shall be drawn into the system through joint in the Pipes, valves etc results in loss of Pumping efficiency.

* If the ground containing large gravel, stiff clay or soil containing cobbles or boulders is not Possible for this Methods.

* For dewatering deeper excavations the well Points may be installed in two or more stages.



3) Deep well dewatering.

* Deep well drainage system consist of deep wells and submersible or turbine pumps which can installed outside the zone of construction operations

* Deep wells are usually spaced from 8 to 80M depending upon the level to which water table must be lowered, permeability of the sand stratum, source of seepage & amount of submergence available.

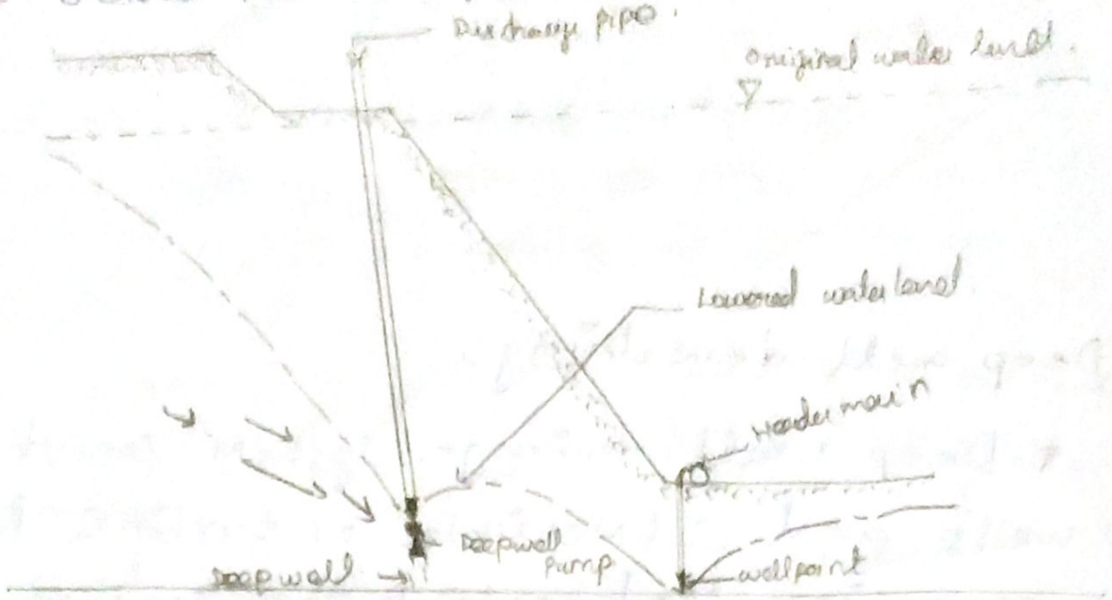
* The installation of deep well is done by sinking a cased bore hole having a diameter of about 200 to 300MM.

* The inner well casing is inserted after the completion of the bore hole.

* A perforated screen is installed over the length of soil and it terminated in a 3 to 5M length of unperforated pipe.

* Graded filter material is placed between the well casing and the outer bore hole casing over the length to be dewatered.

* If centrifugal lumps are used in a deep well system, the top of the screen should be set below the computed water surface in the well



Advantages:

* It is suitable for lowering the ground water table where the soil formation is pervious with depth.

* It is also suitable for great depth of water lowering is required.

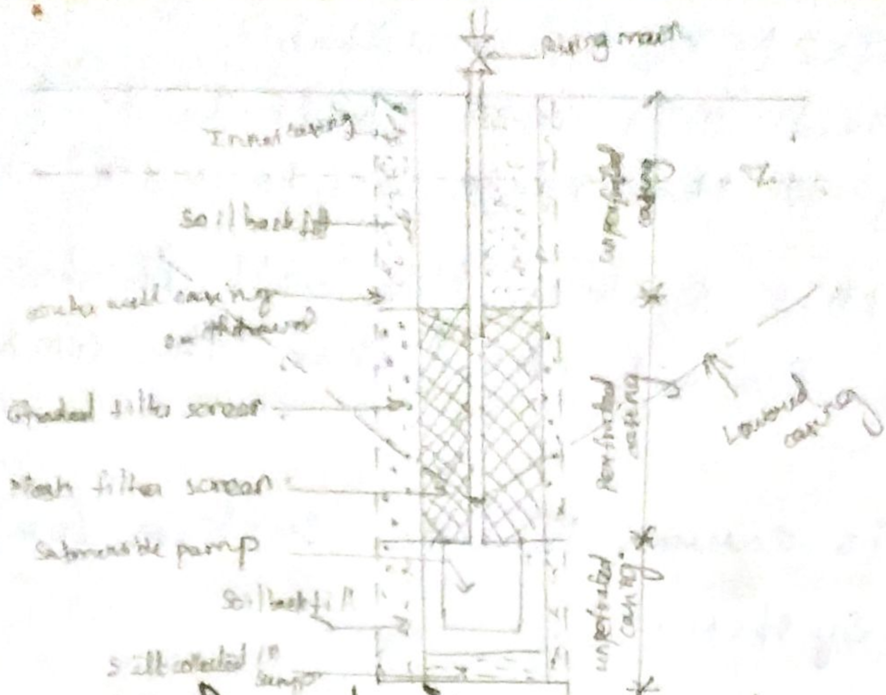
* It may be combined with well point system on certain field conditions

Disadvantages:

* The cost of deep-well system is high.

* It is very difficult to used in boulders, rocks etc.

* It is not suitable for long construction period such as dry docks or sub-aqueous tunnels etc.



4) Vacuum Dewatering systems.

* Gravity methods such as well points & deep wells are not much effective in the fine grained soils with permeability in the range $0.1 \times 10 \times 10^{-3}$ mm/s

* Such soils can be dewatered satisfactorily by applying a vacuum to the piping system

* 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.

* The top few portion of the hole is sealed or capped with an impervious soil or other suitable material.

* By having the pumping main a vacuum pressure, the hydraulic gradient for flow to the well points is increased.

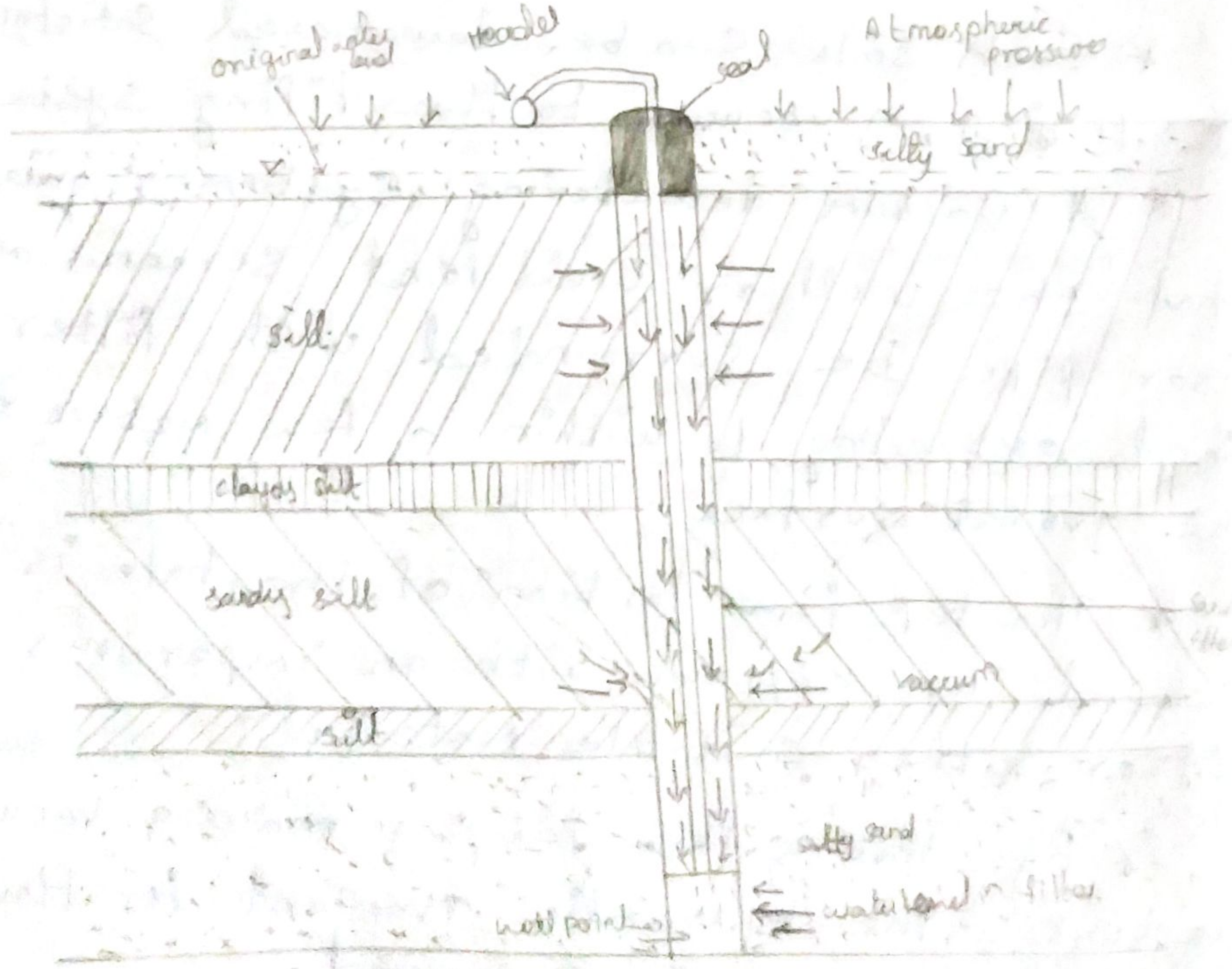
* The practical maximum height of lift is about 3 to 6m.

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

* In this system the well points should be placed closer than the conventional system.

* It is common to use suction pump in this system.

* A typical vacuum dewatering system in a stratified soil is shown in figure.



6) Various steps for designing a dewatering System: [May 19 - 14 Mark]

* Design of a dewatering system requires the determination of the number, size, spacing and Penetration of wells or well Points.

* Water must be removed from the Pervious Strata to achieve the required ground water lowering or Pressure relief.

* The Pumps capacity and size also depend on the required discharge and draw down.

The various steps are,

* Subsoil investigation

* The characteristics of the soils adjacent and beneath the excavation should be investigated well.

* Grain size distribution and Permeability are the two Parameters to be determined.

* Indian standard recommends a field Pumping test for this case.

* Source and water table details:

Source of seepage and knowledge of the water table at a Particular site are the most important factors.

* It depends on the geological features of the area, nearby streams or water bodies and amount of draw down.

* A flow may be from an aquifer being drained the distance to which is known as the radius of influence.

* It can be estimated from the draw down curve established from a field pumping test.

* **Distance of well points from the source of seepage**

* If the radius of influence R is large compared to the radius of the well, only an approximate estimation of R may be sufficient since the discharge is not much sensitive to the value of R.

* An accurate estimation of the distance L from the well to the river should be made for a particular dewatering system, since the discharge is inversely proportional to L.

* **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 without a gravel or filter, the radius can be taken as one half the outside diameter of the well screen.

* **Design and selection of well-screen:**

* The design of wells and wellpoints must ensure that there will be little resistance to water flowing through the screen and riser pipe.

* A high-capacity type of wellpoints should be used when large flows are foreseen in the field.

* Selection of Pumps and accessories:

* The selection of Pump and Power unit depends on various factors such as head loss, air handling capacity, Power available, fuel economy and durability of units.

* Centrifugal Pumps are used to Pump water in collector Piles connected to wells.

* Well Pointing in deep excavation:

* If the water table could not be lowered more than 6M, multistage wellPoints are used.

* The well should be sufficiently large to accommodate Pump and to keep head loss low.

* Control of Surface water:

* 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
(d) Size of area to be Protected
(e) Available Sump Storage.

xxxxxxxxx

7) Various components, stages and methods of drainage: [Nov 17 - 16 Mark] [May 18 - 8 Marks]

Drainage:

* Drainage means the removal of excess water from a given place.

(a) Components:-

* A complete drain consists of three components, (i) filter, (ii) conduit or collector and (iii) disposal system.

(i) Filter:

* Filter is essential for continued efficiency of the drain and to prevent seepage erosion during high hydraulic gradie

* The water is collected in the drain conduits from the filter and is carried away

(ii) Conduits:-

* 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 perforation of 8 to 9 mm in diameter and require a gravity filter with a maximum size of 12 to 15 mm

(iii) Disposal system:

* The permanent and simple disposal system is gravity.

* During adverse conditions such as wet weather, high water table, topography etc

1) Land drainage:

* This is large scale drainage where the objective is to drain surplus water from a large area by such means as excavating large open drains, pumping etc.

2) Field drainage:

* This is the drainage that concerns us in agriculture. It is the removal of excess water from the root zone of crops.

Two types of drainage exist. [May 18 - 2 Mark]

1) Surface drainage system:

* Surface drainage involves the removal of excess of water from the surface of the soil.

* Surface drainage is done by removing low spots where water accumulates by land forming or by excavating ditches or a combination of the two.

* Design of drainage channels or ditches is based on the estimation of peak flow.

It can be done by using the following Method;
a) Rational formula
b) cook's Method
c) curve number Method
d) soil conservation service Method.

2) Sub surface drainage:

* Sub-surface drainage is the removal of excess ground water below the soil surface.

* It aims at increasing the rate at which water will drain from the soil and so lowering the water table, thus increasing the depth of drier soil above the water table.

* Sub-surface drainage can be done by open ditches or buried ditches drains

* open ditches

* It have lower initial cost than buried drains and applicable in some organic soils where drains are unsuitable.

* It reduces the land available for cropping

* Buried drains:-

* It having open joints, or perforations which collect and convey drainage water

* It can be arranged in a parallel double main or random fashion.

Need for drainage:- [2 mark, May 17]

* To bring soil moisture down from saturation to field capacity.

* It improve hydraulic conductivity.

* It is used to leach excess salt.

* It is needed in irrigated areas.

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Two Marks [High in notes]

1) Name the suitable ground condition in which the vacuum dewatering methods is more effective. [Nov 16]

* Suitable for fine grained soils.
* Permeability range – 0.1 to 10×10^{3} mm/s
* It needs well (or) well point screens
* Lateral soils and granular soils.

2) What is a blanket drain drain? Name any few field application of it? [Nov 16]

* A blanket drain is a drainage structure used to accommodate seepage zones on the road cut * The objective is to disperse low-velocity flows over the hillslope rather than concentrating them in cross-ditches.

Application:

* Behind retaining walls
* Under landscape water features

3) Illustrate the problems occurred due to seepage of water. [May 17]

* Leakage in the drainage pipes of the upper adjacent or your own flat.
* Leakage in the water supply pipes of the upper adjacent or your own flat.
* Deteriorated waterproofing of floor slabs or bath tub seals.

4) Define Permeability [NOV'17]

Permeability of soil its capacity to transmit a fluid to pass through its interconnected void spaces.

$$k = v/i$$

v - Discharge velocity, i - hydraulic gradient

Expected Questions:

1) Define Seepage:

Water flows through the voids in a soil which are interconnected. This flow may be called seepage, since the velocities are very small.

2) What are the various types of drains?

* open drains
* Closed drains
* Horizontal drains.
* Foundation drains
* Blanket drains.

3) Define sensitive clay:-

Clay whose shear strength is decreased to a fraction of its former value on remolding at constant moisture content.

4) What are the requirements of drains should be satisfy.

* Sand drains consists of column of pervious sand placed in a cased hole, either driven or drilled through the soil.

* The capacity can be significantly increased by installation of pile inside the sand drain.

****

INSITU TREATMENT OF COHESIONLESS AND COHESIVE SOILS

Densification is the most popular quefaction resistance measure but its performance is poorly understood. Therefore, evaluation of densification should be carried out in a particular field situation is currently based on semi-empirical principles derived from post-failure analysis of liquefaction effects.

Cohesionless soils:-

Cohesionless soils are defined as any free-running type of soil, such as sand or gravel, whose strength depends on friction between particles (measured by the friction angle ϕ

Characteristics:-

* Noncohesive soils also may be called cohesionless soils or granular soils. They tend to transmit water readily and exhibit shear strength that has only a friction component with zero cohesion intercept.

Cohesive soils:-

Cohesive soils are fine-grained, low strength and easily deformable soils that have a tendency for particles to adhere.

The soil is classified as cohesive if the amount of fines (silt and clay-sized material) exceeds 50% by weight.

Properties:

1. Cohesive soil means clay or soil with high clay content, which has cohesive strength.

* Cohesive soil does not crumble, can be excavated with vertical side slopes and is plastic when moist.

* Cohesive soil is hard to breakup when dry and exhibits significant cohesion when submerged.

Various methods of In-situ densification.

1) Rapid Impact compaction.
2) Deep dynamic compaction
3) Vibro compaction method.

Insitu Compaction of granular and cohesive Soils,

Vibro - Compaction

* Vibro - compaction, Sometimes referred to as vibro - flotation is a deep compaction ground treatment technique for densifying granular Soils in situ by means of a vibrating probe, or "vibroflot".

* It is mainly adopted to reduce Settlements reduce liquefaction hazard and permit Construction On granular fills

* Equipment

(i) vibroflot

(ii) Power Supply

(iii) water Supply

(iv) Crane

(v) front and loader

* A vibroflot is a long, Slender, hollow tube of cylindrical Shape, consisting of two parts

* The lower part, termed the Vibrator, is connected by means of a Special elastic energy coupling to the upper follow tubes

* The Vibrator houses two components, including a 150 kW electric motor in the upper part, to drive an eccentric weight in the lower compartment

* Capable of 15,00 to 18,00 revolution per minute, the Vibrator develops an unbalanced (Centrifugal) force of 30 to 50 tonnes, creating vibrations in a horizontal plane

* The device is provided with water flow from jets at a rate of 225 to 300 lit/min at a pressure of 400 to 600 KPa

* The front end loaded in used to supply backfill material.

* follow tubes are custom made to length to suit the required penetration depth

* In compaction operation, the Vibroflot is freely suspended from the crane and the Vibrato gyrates about the vertical axis with a maximum (peak - to - peak) displacement of 23 to 32 mm

* Under the Influence of Simultaneous Vibration and Saturation, lose particular are Rearranged into a more compact State Improving the Engineering properties of the treated profile

* Vibro - Compaction is Suitable for granular Soils with Silt Contents up to 10%

* The vibroflot first penetrates Under its own weight and vibrations, with the Jetting action of water or compressed air

* Water is Switched from lower to top Jets and pressure is reduced causing water to return to surface, eliminating arching and continuous feed of back fill

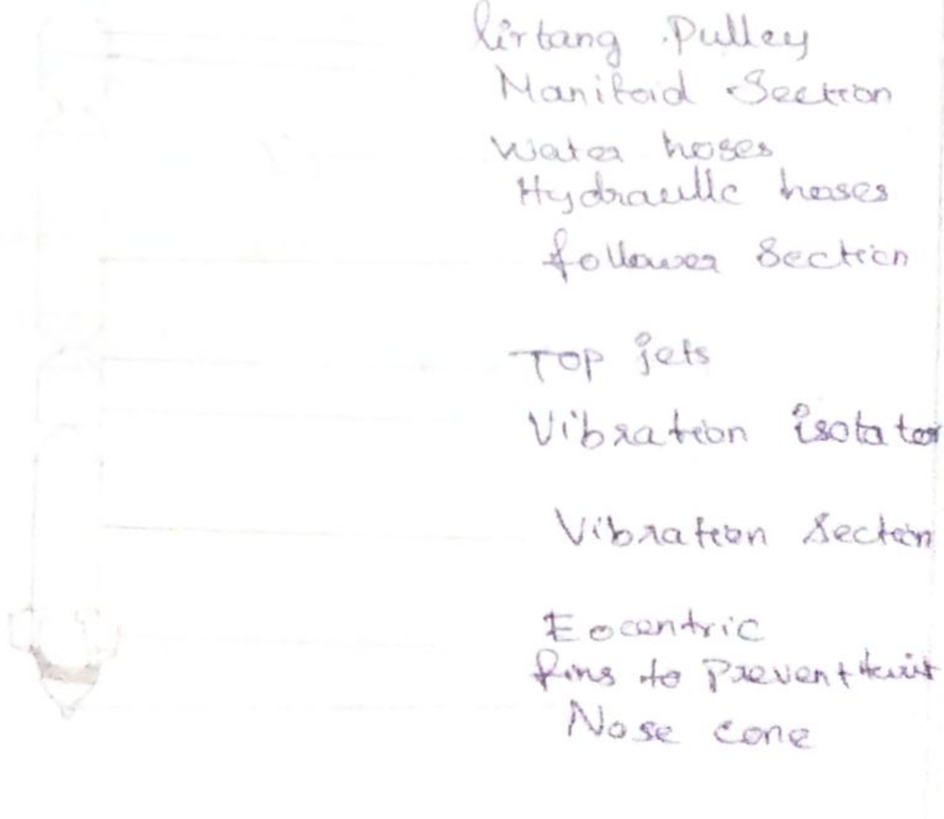
* After reaching the desired treatment depth, the Vibroflot is extracted at 0.5m intervals While maintaing Vibration energy at each increment until the power consumption rises to then specified maximum.

Benefits :

* Vibro - compaction increases both the moist and submerged unit weights of the soil and improves the angle of internal friction, consequently bearing capacity is increased

* Anticipated foundation settlements are reduced due to increases in compressibility moduli, resulting from pre-straining prior to loading

* Resistance to liquefaction is improved since void ratios are decreased and confining pressure are increased



Shallow and Deep Compaction methods

* Sand Compaction pilling (SCP). also known as Vibro-composer method is a cost-effective

* Method of ground improvement which is commonly used to improve soft seabed soils prior to land reclamation works.

* This method involves driving closely-spaced sand columns into the soft seabed to form a grid of sand columns, which imparts higher strength and stiffness to the improved ground.

* Equipment Used

  (i) Impact Hammer or Vibratory Driver

  (ii) Hopper

  (iii) Casing pipe.

* Installation procedure

  (i) This method involves the driving of a hollow steel pipe with a detachable bottom to the desired depth

(ii) The driving can be done by either Vibratory driver or Impact hammer

(i) Sand is introduced in lifts with each lift compacted concurrently with the withdrawal of the casing pipe.

(ii) Compressed air is driven down the pipe to hold sand down in place

(iii) The in situ soil is densifeed while the pipe is driven down.

(iv) The compacted sand pile prevents the collapse of surrounding soil while the casing is with drawn

(v) During compaction, compacted column expandslatatera lly below the pipe to form a Caisson pile

Advantages:

(iv) Economical for moderate depths upto 15m

(v) Treated grounds generally has uniform properties

(vi) Soft clay strength is improved upto 50%.

Disadvantages:

* Soil at shallow depth may have less density and density decrease radially

* Too close spacing may result in construction difficulties while too wide spacing may lead to no effect (2.5 < (spacing / diameter) < 4)

* Spacing of sand compaction pile

$S = \{\pi (1+e_0)/e_0 - e\}^{1/2} \times d$ pattern

$S = 1.08 \{\pi (1+e_0)/e_0 - e\}^{1/2} \times d$ Δ pattern

Sand Piles:

* Sand drains are basically boreholes filled with sand.

* For the displacement type of sand drains a closed mandrel is driven or pushed into the ground with resulting displacement in both vertical and horizontal directions

* The installation therefore causes disturbances which reduces the shear strength and horizontal permeability.

* Diameter ranges from 180 - 450 mm
* Methods of sand drain construction
  1) High pressure water jetting
  2) Displacement of natural ground
  3) Wash boring
* In all methods, steel pipes are inserted and sand is filled in the hole as it is withdrawn
* Spacing of drains - 2.5 to 5m

Limitations of Sand Drain:

* To receive adequate drainage properties, sand has to be carefully chosen which might seldom be found close to the construction site
* Drains might become discontinuous because of careless installation or horizontal soil displacement during the consolidation process
* During filling, bulking of the sand might appear which could lead to cavities and subsequently lead to collapse due to flooding

Shallow Wells:

* Shallow wells comprise Surface pumps which draw water through Suction pipes installed in bored wells drilled by the most appropriate well drilling and or bored piling equipment

* The limiting depth to which this method is employed is about 8 m. Because wells are pre-bored this method is used when hard or variable soil conditions preclude the use of a well-bored point System

* These wells are used in very permeable Soils when well-pointing would be expensive and often at inconveniently close centres

* The Shallow well can be used to extract large Quantities of water from a single hole. On Congested Sites use of Smaller number dewatering points is preferred (no hinderance to construction Operations) hence shallows wells may be prefered in cases where dewatering lasts Several months more

Soil

Deep Wells :

* When water has to be extracted from depths greater than 8 m and it is not feasible to lower the type of pump and suction piping used in shallow wells to gain a few extra meters of depth the deep wells are such and submersible pumps installed within them.

* A cased borehole can be sunk using well drilling or bored pilling rigs to a depth lower than the required dewatered level, the diameter will be 150 - 200 mm larger than the well inner casing, which in turn is sized to accepts the submersible pump. the inner well casing has a perforated screen over the depth requiring dewatering and terminates below in 1m of un-perforated pipe which may serve as a sump for any material which passes the filter.

Soil Nailing :

* Soil nailing is the method of reinforcing the soil with steel bars or other material. It has been alternative technique to other conventional supporting system as it offers flexibility, rapid construction & competitive cost

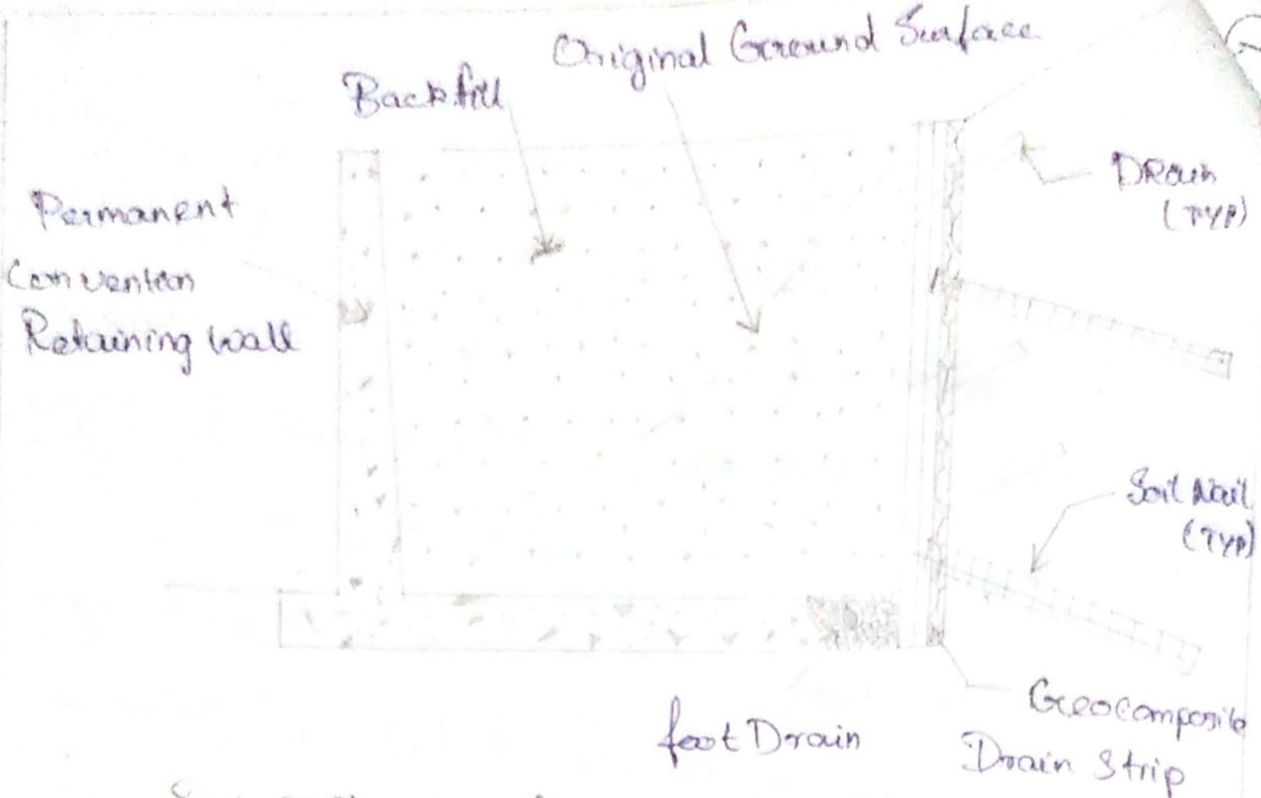
* The purpose is to increase the tensile & shear strength of the soil & restrain its more stable. In this technique, soil is reinforced with slender element such as reinforcing bars which are called as nails. These reinforcing bars are installed into pre-drilled holes and then grouted

Application :

* Soil Nail walls for Temporary and permanent cut slopes

* Retaining structure under existing Bridge Abutments

* Repair and rehabilitation of existing retaining structure



Soil Nail WALL for Temporary Shoring

Advantages of Soil Nailing:

Economic Advantages: 10% to 30% Saving in cost when compared to an Anchored Diaphragm wall

Simple & light construction Equipment: Drilling Ring for nail installation, Guns for Shotcrete Application

Adaptability to site conditions: In heterogeneous ground where boulder or hard rocks may be encountered.

Space: Soil nailing provides an obstruction free working space which can result in considerable reduction in construction time for basement works and tunnel construction.

Dynamic Consolidation :

* Dynamic Compaction is also known as heavy tamping. A technique which uses an heavy hammer of weight up to 45000 kg and will be dropped freely from a height of 15 to 20m to the ground surface.

* The heavy impact causes its mark on the ground surface and creates vibrations in adjacent soils. This process is repeated at same location over the subsequent parts of the area with spacing 5 to 10m

* Usual energy per blow is 185×10^3 - 450×10^3 kg-m. Generally 2 to 3 blows per square meter is used

* When the weight strikes the ground surface vibrations pass through the Adjacent soil layer in the form of P, S and R waves

* Considering effective depth as a function of impact energy, the depth of penetration is within the following range

$$1.26\sqrt{Wh} < D < 3.16\sqrt{Wh}$$

D is effective depth (m)

W is weight of drop (Kg)

h is height of drop (m)

Merits:

* One of the simplest methods of compacting loose
* Depth of compaction can reach upto 30m
* Any type of soil can be compacted
* Produces equal settlement throughout the area

This method depends upon the following

* Magnitude of the weight
* Size of the weight
* Height of the drop
* No of drops
* Distribution of drops throughout the site
* Homogenity of soil throughout the site
* Strength & permeability of soil
* Degree of saturation (water content)

BLASTING :-

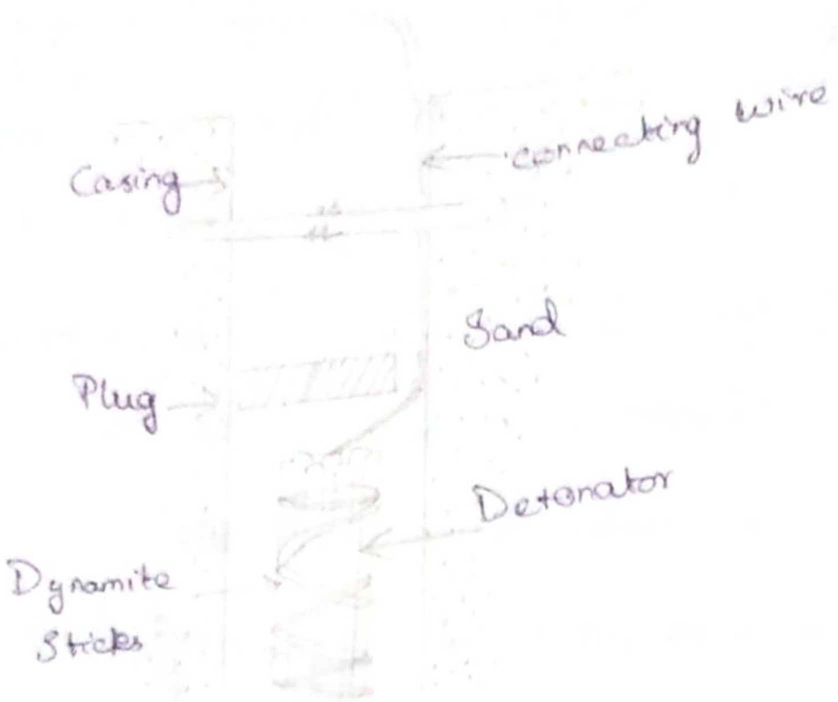
* In this technique a certain amount of explosive charge is buried at a certain depth of cohesionless Soil required to be compacted and then detonated.

* A borehole is made and pipe of 7.5 to 10cm is driven to the required depth of the Soil.

* Then the sticks of dynamite and a electric detonator are wrapped in the water proof bundles and lowered down through the casing. the casing is withdrawn and a wad of paper or wood is placed against the charge of explosives to protect it from interfere

* The hole is back filled with Sand in Order to obtain the full force of blast. The electric Circuit is closed to fire the Charge

* In this manner a series of holes are made ready, Each hole is detonated in Succession and the resulting large diameter holes are formed by lateral displacement are back filled



*Usually Explosions are arranged in the form of horizontal grid of which Spacing is depended on the depth of strata to be densifeed, the Size of the charge and the overlapping of the charges. Generally a Spacing of 3-8 m is used and should not be lose than 3m

* Weight of charge required can be computed from the following relationship

$$W = 164 C R^3$$

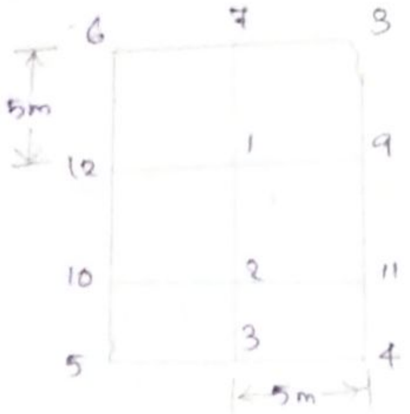
* Where W = Weight of the explosive (N)

C = Coefficient (0.0025 for 60% detonator)

R = Radius of influence (m).

* Generally, a charge mass of 2kg to 30 kg are to be used.

* A typical pattern of firing the explosions are as follows



a. GRID SPACING

However, adequate data regarding to the following are to be collected before planning this kind of technique

* TYPE of Soil

* Depth of compaction

* Degree of Saturation

* Degree of densification

* Sometimes Some preliminary tests are required to ascertain spacing, depth, sequence of operation

Advantages:-

* This technique requires less time, less labour, Less expensive

* More Successful for greater depth

* Large Volume Compaction

Disadvantage:

* It requires experienced person and Special Supervision

* Non uniformity

* Adverse affects on adjacent Structures

* Only suitable when the soil is in dry or completely Saturated

* Very fine grained Soils with cohesion cannot be compacted.

MODIFICATION BY INCLUSIONS

Reinforcement - Principles and basic mechanism of reinforced earth, simple design. Synthetic and natural fiber based Geotextiles and their applications. Filtration, drainage, separation. erosion control.

Reinforcement:

* Reinforced earth has been in use by man since ancient times with the fundamentals of the techniques being mentioned in the Bible.

* The earliest remaining examples of soil reinforcement are the Agar-Quf Ziggurat and the Great wall of china.

* The Romans, Gauls, Dutch and British have been documented using reinforced soil for various applications.

* The Modern concept of earth reinforcedment was proposed by Casagrande.

* He idealized the problems in the form of weak soil reinforced by high strength membranes laid horizontally in layers.

* The modern ~~fo~~ form of earth reinforcement was introduced by Henry vidal in the 1960s

* Vidals concept was for a composite material formed from flat reinforcing strips laid horizontally in a frictional soil.

* The interaction between the soil and the reinforcing members was solely by friction generated by gravity.

* This he described as "Reinforced Earth", a term now generally being used to refer to all reinforced works.

Principle of Reinforced Earth:

* It is analogous to reinforced concrete but direct comparison is not completely valid.

* The mode of action of reinforcement in soil is to carry tensile loads or anisotropic reduction of normal strain rate.

* Introduction of reinforcement into soil results interaction between the two.

* The interaction between the soil and reinforcement can be in the form of either adhesion or friction.

* Failure can occur only if the adhesion or friction force is overcome or the reinforcement itself ruptures.

* The reinforcement disrupts the uniform pattern of strain that would have developed if it did not exist.

Components of Reinforced Earth:-

* A reinforced earth structure consists of
* Soil fill or matrix
* Reinforcement or anchor system.
* Facing (if necessary).
* Soil fill
* Theoretically any soil can be used as a fill material
* Conventionally well graded cohesionless soils are used as fill material but are costly.
* Cohesive soils are cheap and easily available but have long term durability problems.
* A convenient compromise is a fill material that has both cohesive and frictional properties.

Sometimes waste materials as fill materials for reinforced soil structures is an attractive option from the point of view of environment as well as economy.

Reinforcement :-

* They can be of a variety of materials and in various shapes.

* The principal requirements of reinforcing materials are
  - ⇒ Strength
  - ⇒ Stability
  - ⇒ Durability
  - ⇒ Ease of handling
  - ⇒ High coefficient of friction
  - ⇒ Adherence with the soil
  - ⇒ Low cost
  - ⇒ Ready availability.

Facing :-

* For vertical structures a facing is required.

* The function of facing is to stop erosion of the fill and to provide a suitable architectural treatment to the structure.

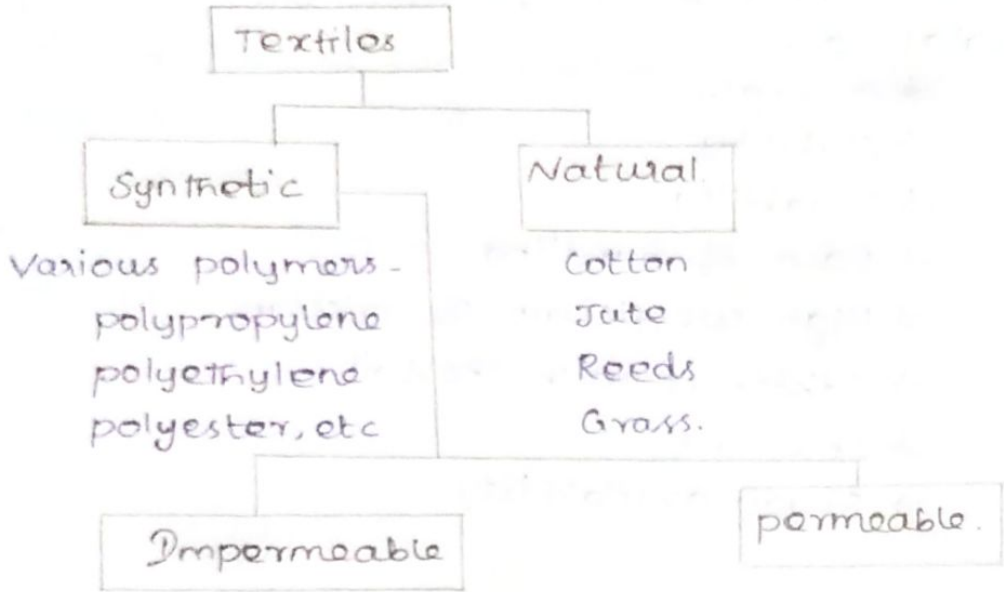
* Various materials can be adopted to form the facing and will have its own merits and demerits depending upon scale of structures, shape and material.

* Some materials used for facing are aluminium, brick or masonry, precast concrete slabs, pressed concrete slabs, geotextiles, plastics, GRC, GRP, steel, timber etc.

—*—

Simple design : Synthetic and natural fiber based Geotextiles and their applications :-

Simple design: Synthetic and natural fiber based Geotextiles and their applications:-



Geomembrane polymers.

polyethylene (HDPE, VLDPE, etc)
polyvinyl chloride (PVC)
Cholorosulphonated Polyethylene (CSPE)
Ethylene Interpolymer Alloy (EIA)
Rubber, etc.

Geotextiles:-

*. One of the two largest groups in geosynthetics.

*. They are textiles in the traditional sense, but they consist of synthetic fibers rather than natural ones such as cotton, wool or silk.

*. These synthetic fibers are made into flexible, porous fabrics by standard

⇒ Weaving machinery or are matted together in a random nonwoven manner or knitted.

⇒ The major point is that geotextiles are porous to liquid flow across their

⇒ Manufactured plane and also within their thickness, but to a widely varying degree.

⇒ The fabric always performs at least one of four discrete functions: separation, reinforcement, filtration, and/or drainage

Geogrids :-

*. They represent a rapidly growing segment in geosynthetics.

*. Geogrids are polymers formed into a very open, grid like configuration, i.e. they have large apertures between individual ribs in the transverse and longitudinal directions.

*. They are made by either.

*. Stretching in one or two directions.

*. On weaving or knitting machinery

*. By bonding straps or rods.

*. There are many specific application areas, however, they function almost exclusively as reinforcement materials.

Geomembranes :-

*. They represent the other largest group in geosynthetics.

*. They are relatively thin, impervious sheets of polymetric material used primarily for linings and covers of liquids or solid - storage facilities.

*. This includes all types of land-fills, reservoirs, canals and other containment facilities.

*. Thus the primary function is always containment as a liquid or vapor barrier or both.

Geonets :-

*. Geonets, also called geospacers, constitute another specialized segment within the geosynthetics area.

*. They are formed by a continuous extrusion of parallel sets of polymetric ribs at acute angles to one another.

*. When the ribs are opened, relatively large apertures are formed into a netlike configuration.

*. Two types are most common, either biplanar or triplanar.

*. Their design function is completely within the drainage area where they are used to convey liquids of all types.

Geomats :-

A three-dimensional water permeable mat made from extruded and bi-oriented polyethylene grids.

*. The underside of the mat is made flat to provide even contact with the prepared soil surface.

*. The upper surface is made cuspated to provide excellent soil retention.

*. Geomats are applied to create stable vegetation along river, pond banks and slopes to prevent erosion processes of surfaces.

*. Geomats are used in combination with geotextiles to reinforce foundations and increase bearing resistance.

Geosynthetic :-

*. Geosynthetic can separate two layers of soil and thereby prevent intermixing.

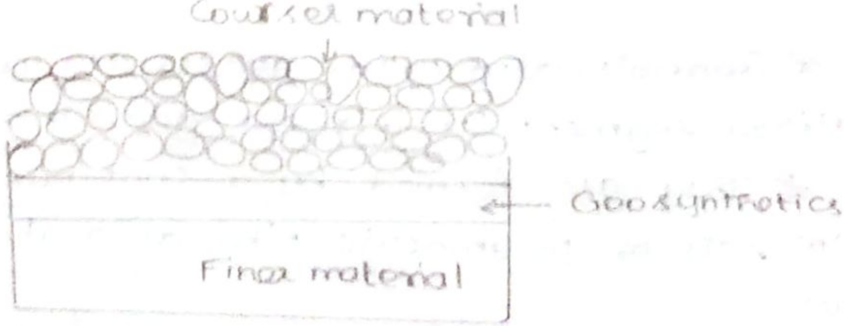
*. Separate two layers of soil with different particle size distributions.

⇒ prevent road base materials from penetrating soft underlying soils.

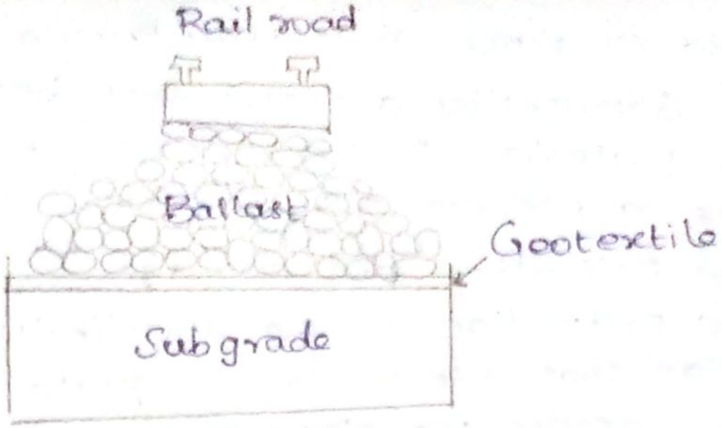
⇒ prevent pumping of fines from subgrade.

⇒ Encourage lateral drainage

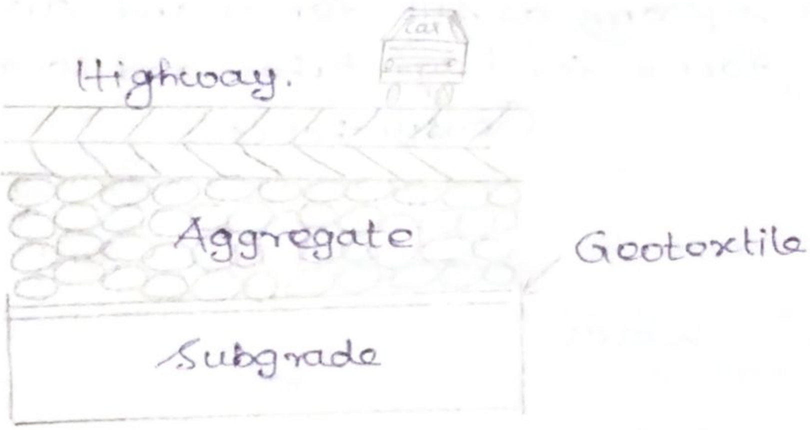
⇒ Usually nonwoven geotextiles.



Geosynthetic placed between ballasts and sub-grade soil in a rail road.



Geosynthetic placed between aggregate and foundation soil in a paved road.



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Filteration:-

Geosynthetics can allow water to pass across the plane while prevent or retain the soil particles Act similar to sand filter.

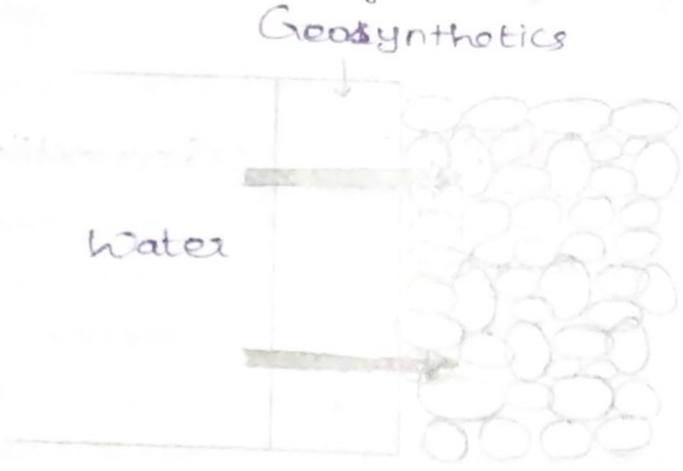
* Allow water to move through soil while retaining upstream soil particles.
* Prevent migration through drainage aggregate and pipes.
* Prevent soil erosion below rip rap and armour materials

The geosynthetic acts similar to a sand filter by allowing water to move through the soil while retaining all upstream soil particles. For example, geotextiles are used to prevent soils from migrating into drainage aggregate or pipes while maintaining flow through the system. Geotextiles are also used below rip rap and other armour materials in coastal and river bank protection systems to prevent soil erosion.

*. Filtration and drainage.

*. Filtration is the equilibrium soil-to-geotextile interation that allows for adequate liquid flow without soil loss, across the plane of the geotextile over a service lifetime compatible with the application under consideration.

*. Filtration applications are highway underdrain systems, retaining wall drainage, landfill leachate collection systems, as silt fences and curtains, and as flexible forms for bags, tubes and containers.



~~Filtat~~
Filtration.

Drainage:-

*. Drainage is the equilibrium soil-to-geosynthetics system that allows for adequate liquid flow without soil loss, within the plane of the geosynthetic over a service lifetime.

*. Drainage applications for these different geosynthetics are retaining walls, sports fields, dams, canals, reservoirs and capillary breaks.

Separation:-

The geosynthetic acts to separate two layers of soil that have different particle size distributions. For example, geotextiles are used to prevent road base materials from penetrating into soft underlying soft subgrade soils, thus maintaining design thickness and roadway integrity. Separators also help to prevent fine-grained subgrade soils from being pumped into permeable granular road base.

*. separation is the placement of a flexible geosynthetic material, like a porous geotextiles, between dissimilar materials so that the integrity and functioning of both materials can remain intact or even be improved.

*. Paved roads, unpaved roads and rail-road bases are common applications. Also, the use of thick nonwoven geotextiles for cushioning and protection of geomembranes is a separation technique.

*. Nonwoven geo-textiles prevent aggregate and ballast from punching into the subgrade and intermixing, reducing maintenance costs and ensuring long-term durability and drainability.

Unit 5

Chemical Modification

Grouting

Grouting is defined as the process of injecting suitable fluid under pressure into the subsurface soil (or) rock to fill voids, cracks and fissures for the purpose of improving the soil.

The fluid may be collidal sollutions, cement suspensions, chemical solutions etc.

Applications of grouting

* vibration control
* seepage control in soil
* Soil stabilization and solidification
* Producing mass concrete structures and piles.
* defects on building masonry or pavement
* Repairing a ground underneath a formation or cracks.

Types of Grouting

1. Suspension grouts
2. Solution grouts
3. Colloidal solution grouts
4. Compaction grouting

5. Permeation grouting
6. Hydraulic fracturing
7. Jet grouting

1. Suspension grouts

These are multi-phase system capable of forming sub systems after being subjected to natural sieving processes, with chemical properties with must ensure that they do not militate against controlled properties of setting and strength.

* water in association with cement, lime, soil, etc..., constitute suspensions.

* Emulsion with water is a two-phase system which is also included under suspension

2. Solution Grouts

These are intimate one-phase system retaining an originally designed chemical balance until completion of the relevant reactions.

* Silicate, derivatives lignosulphite, phenoplast resins etc. come under this category.

Grouting Plant and Equipment

A grouting plant includes a mixer, an agitator, a pump, and piping connected to grout holes

* The basic items required for a grouting plant and their functions are

* Measuring tank - to control the volume of grout injected.

* Mixer - to - mix the grout ingredients

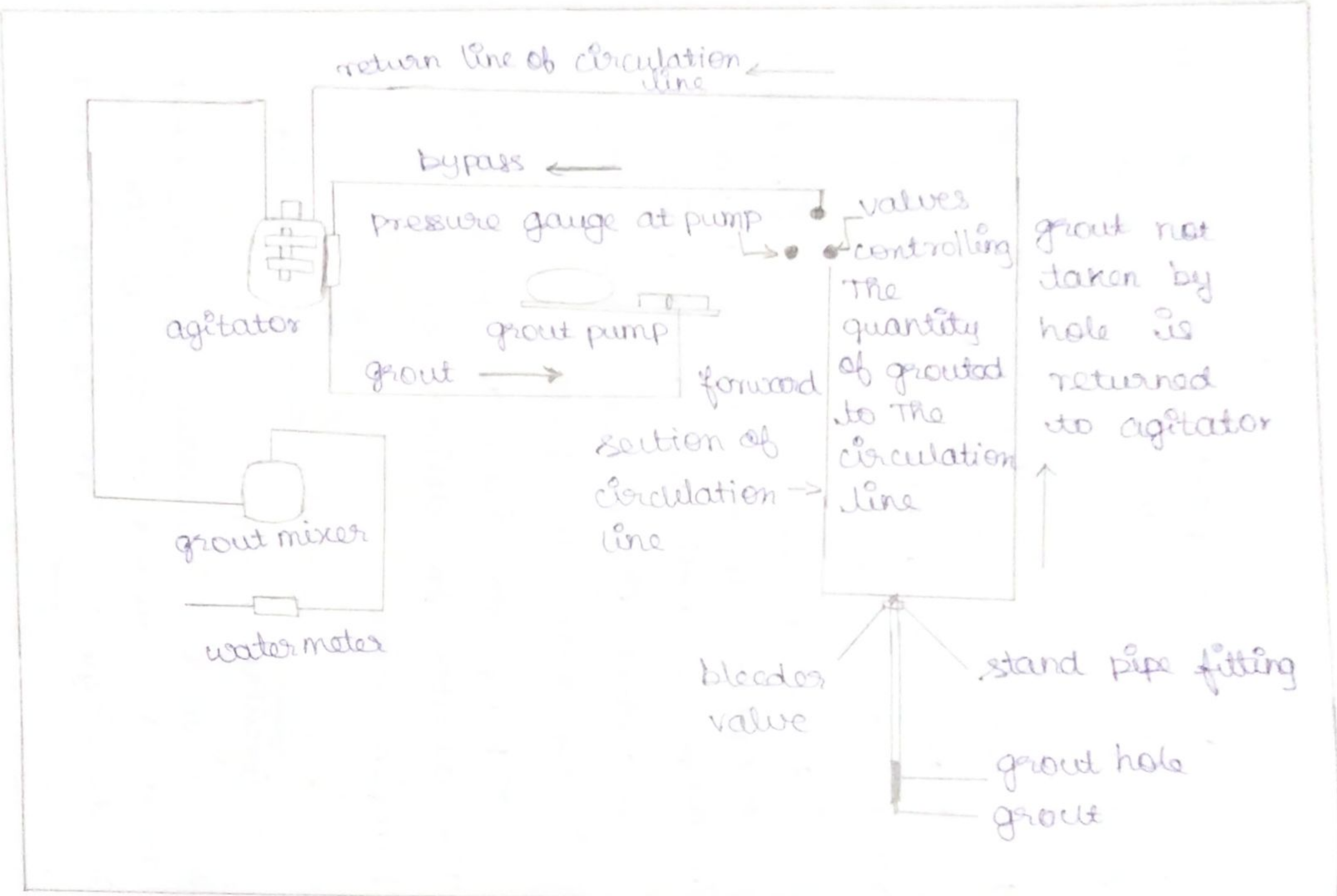
* Agitator - to - keep the solid particles in suspension until they are pumped.

* control fittings - to - control the injection rate and pressure.

* Pump to draw the grout from the agitator to deliver to the pumping line.

* Two systems : single line type and circulating type.

* In the circulation type, the unused grout is returned to the agitator and in the single line type the grout refused is wasted


return line of circulation line
bypass
pressure gauge at pump
values controlling The quantity of grouted to The circulation line
grout not taken by hole is returned to agitator
agitator
grout pump
grout
forward
section of circulation line
grout mixer
water meter
bleeder value
stand pipe fitting
grout hole
grout

Infection methods

It has 7 types of infection methods.

1. Bottom up
2. Top down
3. Circuit grouting
4. Tube-a-manchette
5. Point grouting
6. Pressure injected time
7. Electro-kinetic injection

1. Bottom up

Grouting is done from bottom of the hole upwards.

2. Top down.

Grouting is done from top of the hole downwards.

3. Circuit grouting

Similar to bottom up but the excess grout pumped down comes out via drill hole, which eliminates clogging.

4. Tube - a - manchette

Grouting is done through a tube called tube a manchette with rubber sleeves through which grout spreads to surrounding soil.

5. Point grouting

Injection of lime is done through the tip or point of a driven or jetted lance.

6. Pressure injected lime.

Injected of lime slurry under high pressure of 350 to 1400 kN/m2 usually for shallow stabilization depths of upto 8 m.

7. Electro - kinectic injection.

chemical stabilizers are introduced at anode and are carried towards cathode via electro osmosis mainly under condition that require confinement or to avoid distrubance.

Jet grouting

The jet grouting technique is developed in the 1960's.

* However, because of it unique properties, it is becoming quite popular in the civil engineering works.

* It is the application are

* Grouting of clay / silt soils which is not suitable for TAM grouting Technique.

* Jet grout wait and roof are used to reinforce funnei portal excavation works.

Grout monitoring

* Grouting monitoring is not just measuremente pressure periodically which usually take a dreadful battering

* It is not a measurement of flow rate, pressure, etc. but it is making aa positive assessment of he results of The injected grout.

* Grout monitoring procedures at The various times during The grouting process.

Grouting Activity.

* Prior grouting
* During drilling
* Grout materials
* During grout
* After grouting.

Minor monitoring effect only.

* plot grout. take log
* Have measurements on survey paints

* certificates of compilance trial grout mixes.

* Final heave survey final review an sign off

<u>Intense monitoring effort.</u>

* Inspect equipment set elevation survey points and establish monitoring plan and procedures.

* Conduct pre grout radar and cross hole acoustic surveys.

* certificates of compilance trial grout mixes, independent lab tests

* Monitor and record injection pressure and flow rate grout emplaces for gel time and storage

* plot grout take log.

* Heave measurement on survey points.

* In Situ deformation measurements as appropriate
* Pore - pressure data
* Insitu resistivity
* Acoustic emission monitoring for hyre fracturing
* Final heave survey
* Post grout radar and acoustic surveys.
* Final review and sign off

Electro stabilization

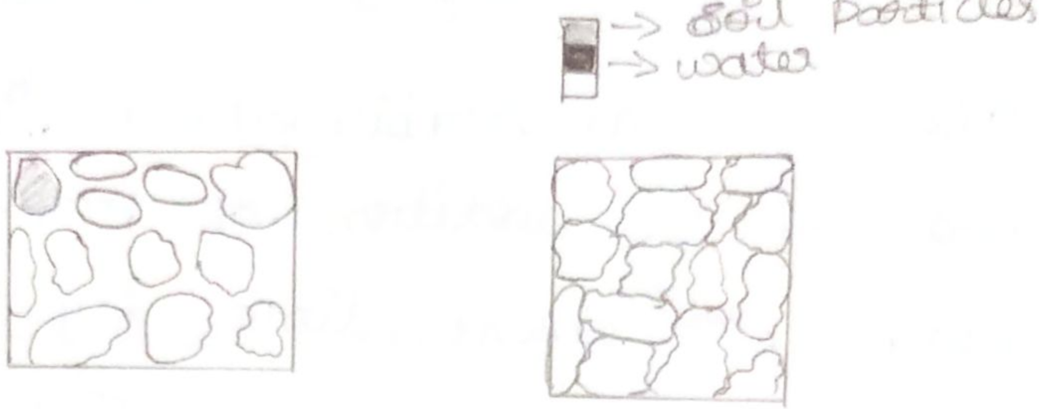
Electrical stabilization is The process of passing an electrical current Through a soil mass in order to migrate charged particles in The soil and change its properties

Chemical Stabilizations

The chemical stabilizations is achieved by the addition of proper percentage of cement, lime, fly ash, bitumen or combination of these material to the soil.

* The selection of type and determination of the percentage of chemical to be used is dependent upon the soil classification and the degree of improvement in soil quality desired.

* After the additive / chemical has been mixed with the soil, spreading and compaction are achieved by conventional means.



Non compacted   compacted

Portland Cement Stabilisation

cement treatment takes two forms:

1. cement modification
2. cement stabilisation.

cement modification.

which uses up to about 3 percent cement and aims to reduce plasticity without producing a right material

cement stabilisation.

which uses higher percentages of

cement produces a stiff, semi rigid pavement material.

* construction Practices significantly effect The subequent performance of cement stabilised material and each of The following aspects must be closely controlled

1. Pulverization
2. cement content
3. moisture content
4. mixing
5. Compaction
6. Finishing
7. curing

Rapid compaction after mixing is possibly most important as cement hydrates relatively quickly.

Hydrated Lime Stabilisation.

* when hydrated lime is aded to a soil in the presence of moisture a series of reaction is set in motion.

* The actual physical and chemical processes which occurs are quite complex.

* The reaction between lime and soil can be considered in Three major, overlapping stages.

* Agglomeration of lince clay particles Through base exchange

* weak cementing action. due to calcium carbonate formation

* Slow, long-term cementing action.

* The reaction of lime with soil depends on the type of clay minerals present in the soil.

* If the clay minerals are little illite (or) chlorite, a pozzolan must added to produce the desired effects.

* The normal pozzolan which is used is fly ash.

* Construction processes are similar to those used for cement stabilisation

* Adequate pulverisation of the soil to be stabilised is very important and this may be facilitated by partially pulversing, adding portion of the lime, repulverising and then adding the balance of the lime

Stabilisation of expansive clays.

* Natural Hazards causes billion of dolars of damage to transfer portation facilities each year. only flooding causes more damage Than expansive soils

* Nearly all types of transportat -ion facilities have been affected by expensive soil behaviour and as a result, many have been affected failed (or) are no longer serviceable