Unit-6

Grouting

Grouting - objectives of Grouting - Grouts and their applications - methods of grouting - stage of Grouting - hydraulic failure fractures in soils & rocks - Rosh Grout Test.

Grouting :—

Grouting is the process of Ground improvement attained by injecting fluid like material into subsurface soil or rock. Grouting is particularly valuable in foundation works before Construction e.g. to control water problems, to infill voids to control settlement, to increase soil bearing capacity. during Construction - to control groundwater flow to stabilize loose sand against liquifaction, to provide adequate lateral support etc., and after Construction - To reduce the machin foundation vibrations, to eliminate new seepage. There are the objectives of Grouting to eliminate the errors at any time of Construction process.

Some of them are

1. Machine foundation vibrations should be reduced
2. Seepage pressure should be eliminated
3. It is applicable in both Temporary and permanent works that are applied on

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Ground surface

4. Grouting fills the empty spaces (i.e voids) present below the ground surface

5. It produce less permeable soil or rock surface

(*) Grouts and their applications:—

→ Types of Grouts:—

1. Suspension Grouts:— These are multi phase systems capable of forming subsystems after being subjected to natural sieving processes, with chemical properties which must be carefully scrutinised so as to ensure that do not militate against Controlled proportion of setting and strength.

2. Solution Grouts:— These are intimate one phase system retaining an originally designed chemical balance uptill Completion of the relavent reactions.

1. Types of Suspension Grouts:—

When Grouts (particularly Suspensions) are injected into the soil formation the relationship between the grout particle size and the soil void size should be Considered

$$GPR = \frac{D_{15}\ (formation)}{D_{85}\ (Grout)} > 20.$$

D_{15} = Particle size at which 15% of the soil finer

D_{85} = " " " 85% " " "

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(i) Grouting with soil: —

Soils itself can be used to fill up some of the voids in coarse-grained soils. Even fine sands and silts may be used for this purpose which would settle out quite quickly after injection.

The soil to be used as a grout should be a very fine-grained soil. clay is a complex compound with particles < 0.002mm and is thus suitable for injection into medium coarse sands and other soils with permeability of the order 1 to 10 mm/sec. clay grout behaves like bingham-fluid and gels when undisturbed. This type of grout will exhibit low shear strength and hence can be ~~used~~ used to reduce loco permeability.

(ii) Grout with cement mixes: —

A satisfactory cement based grout depends on the water cement ratio, the rate of bleeding and subsequent ultimate strength of the grout. Although water may be giving mobility for a grout, if in excess may cause separation of ingredients of the grout leading to high bleeding

Cement grouts are usually formed from ordinary portland cement (OPC) and water. The water cement ratio may be varied from about 0.5:1 to 5:1 depending upon the grout.

When selecting a particular grout for use, one would obviously like to know its final strength flow rate, set time, shrinkage and permeability

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and durability.

Other ingredients sometimes used in cement mixes are clay, fine sand, flyash, fluidizers, accelerators and retarders or expansion additives. clay is considered as a filler in cement grouts when used in amounts less than 3% by weight. Sand is a true filler in cement grouts and is used to reduce the overall cost of the grout material.

(iii) Grouting with asphalt Emulsion:—

Residues of oil refining industry in an emulsifying plant is processed to produce nearly circulate droplets of asphalt suspended in water matrix. Slow setting emulsions are generally recommended since they can travel the longest distance into the material being grouted.

(2) Types of Suspension Grout :—

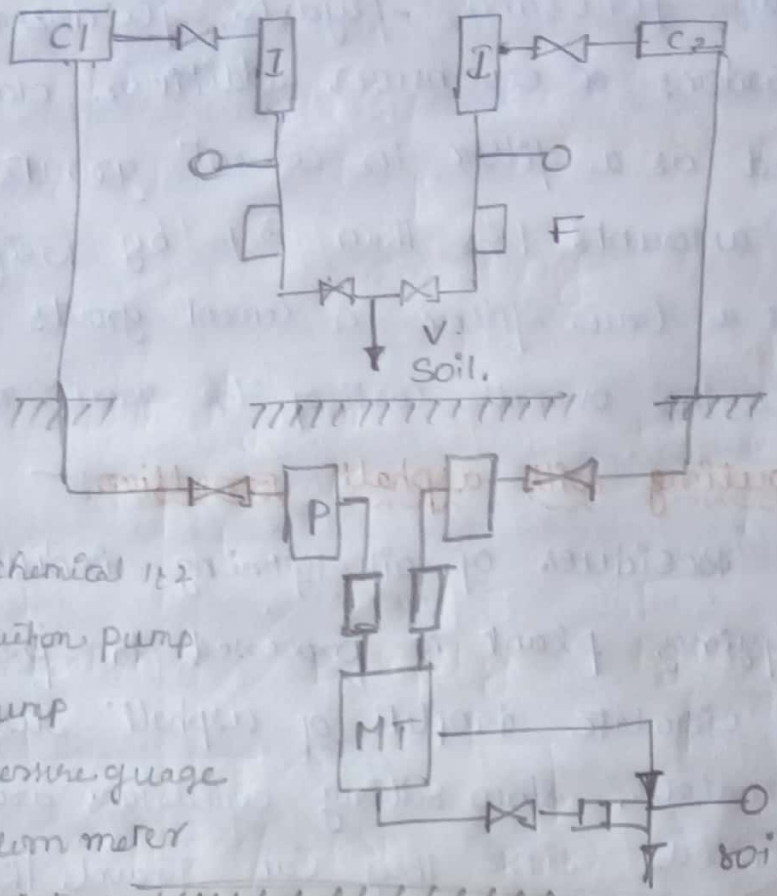
There are numerous solution grouts are available. solution grouts can generally permeate finer soils than can suspension grouts. Many of the solution grouts are termed as chemical grouts such chemical grouting is done by using one shot system or Two shot system

In the one shot system where all chemicals are injected together after pre-mixing

In Two shot system wherein one chemical is injected to followed by injection of a second chemical

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which reacts with the first to produce a gel which subsequently hardens.



C_1, C_2 = chemical 1, 2
I = Injection pump
P = pump
P' = pressure guage
F = flow meter
V = Inlet valve
MT = Mix Tank

Two shot and one shot methods of chemical grouting.

(i) Silicate Derivatives :—

Sodium silicate, also called as water glass, is a commonly available and relatively an inexpansive aqueous solution. Here the sodium silicat is a solid and acid which further breakdown to water and silicondiaxide.

(ii) Lignosulphate Derivetives :—

This grout can be used similar to Silicates and procesing a viscocity increasing with Time. It is basically made from lignin, a residual product from wood industry.

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The raw lignin can be used directly. Setting Time varies from 10 min to 10 hours which is a function of bichromate Concentration.

(iii) Acrylamides :—

The acrylamide grouts are characterised by Constant viscosity, good penetrability, effective control of gel time and adequate strength. There are no. of acrylamide grout penetrated in the market.

(iv) phinoplast Resins :—

The resorcinol - formaldehyde Combination is a resin results from the polymerisation of resorcinol with formaldehyde in aqueous solution when Ph is changed. This gives higher strength than acrylamide.

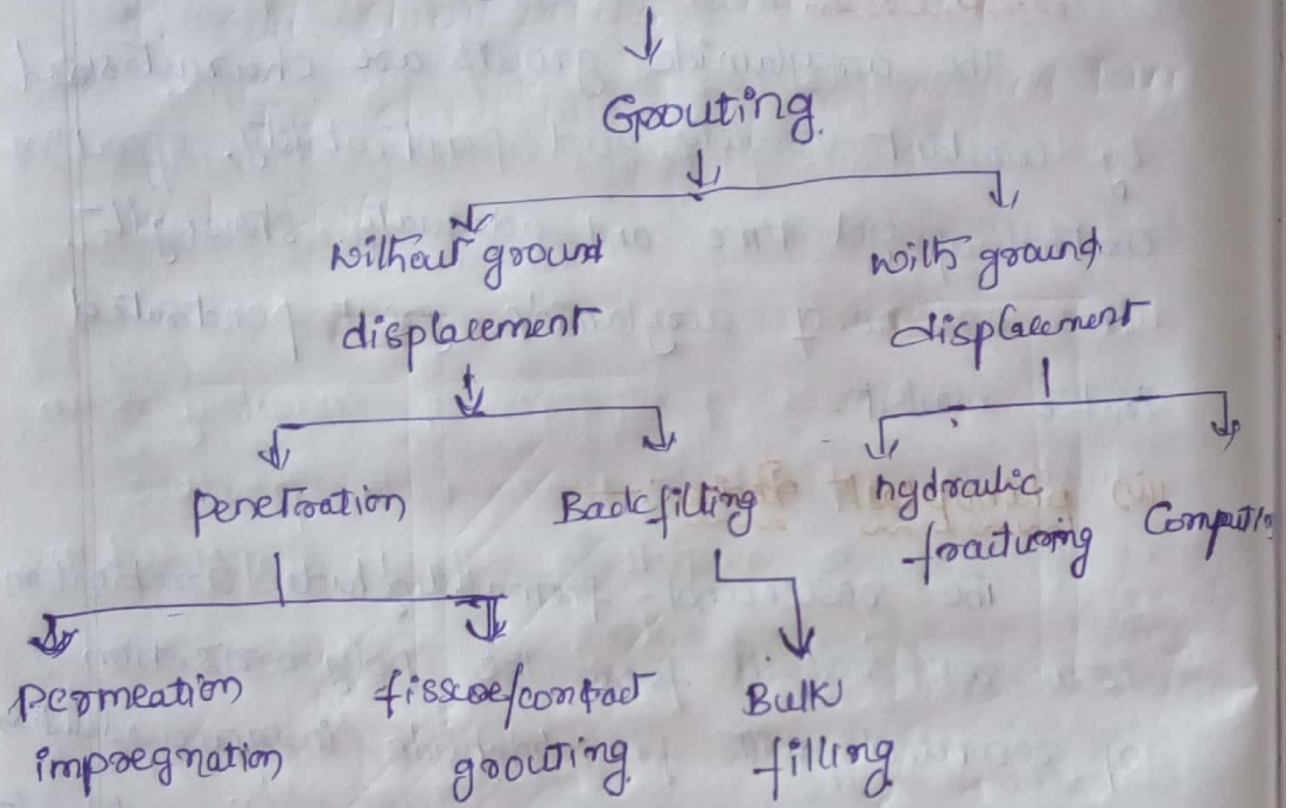
(*) Methods of Grouting :—

Grouting technology has become a Common ground improvement method used frequently for underground and foundation Construction. The process of grouting Consists of filling pores or cavities in soil or rock with a liquid form material to decrease the permeability and improve the shear strength by increasing the cohesion when it is set

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Cement base grout mixes are commonly used for gravelly layers or fissure rock treatment.

classification



Criteria for Design :—

The grout volume to be injected depends on ground porosity, geometry of treated zone, grout hole spacing, state length and total depth to be treated.

The groutability of soil with particulate grouting has been evaluated based on the N value.

Grouting is considered feasible if $N > 24$ and not feasible in $N < 11$.

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* Categories of grouting :—

a. penetration grouting
b. displacement grouting
c. Compaction grouting
d Grouting of voids
e. Jet Grouting.

(a) . penetration Grouting :—

penetration grouting is a term used to describe a ground treatment method in which grout is injected into a porous medium without disturbing its original structure.

In Geotechnical engineering, this usually refers to the process of filling the pores and joints in a soil and/or rock deposit to change its geotechnical properties. Almost any grout material may be used for permeation grouting, but there are distinct limits on the grout mix used for specific types of soil or rock.

Applications of permeation grouting :—

→ Seepage Control :-

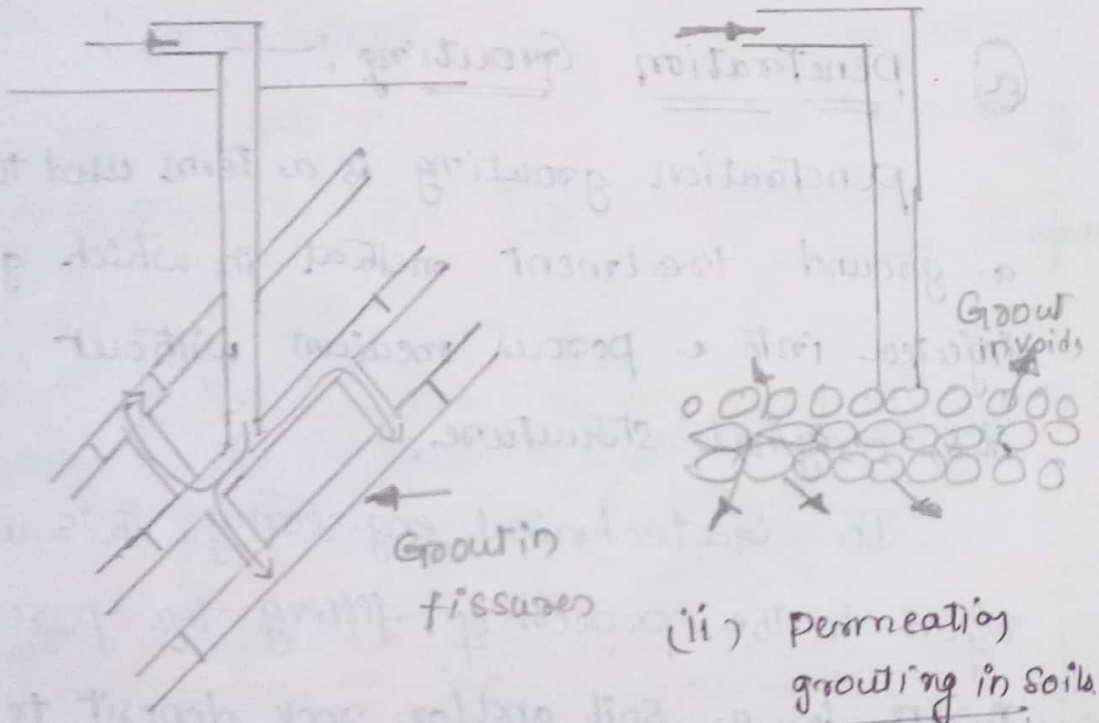
* for making vertical seepage barriers beneath hydraulic structures.

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*. Stoppage of seepage through joints of underground structures such as Tunnel Lining/ basement Wall, etc.

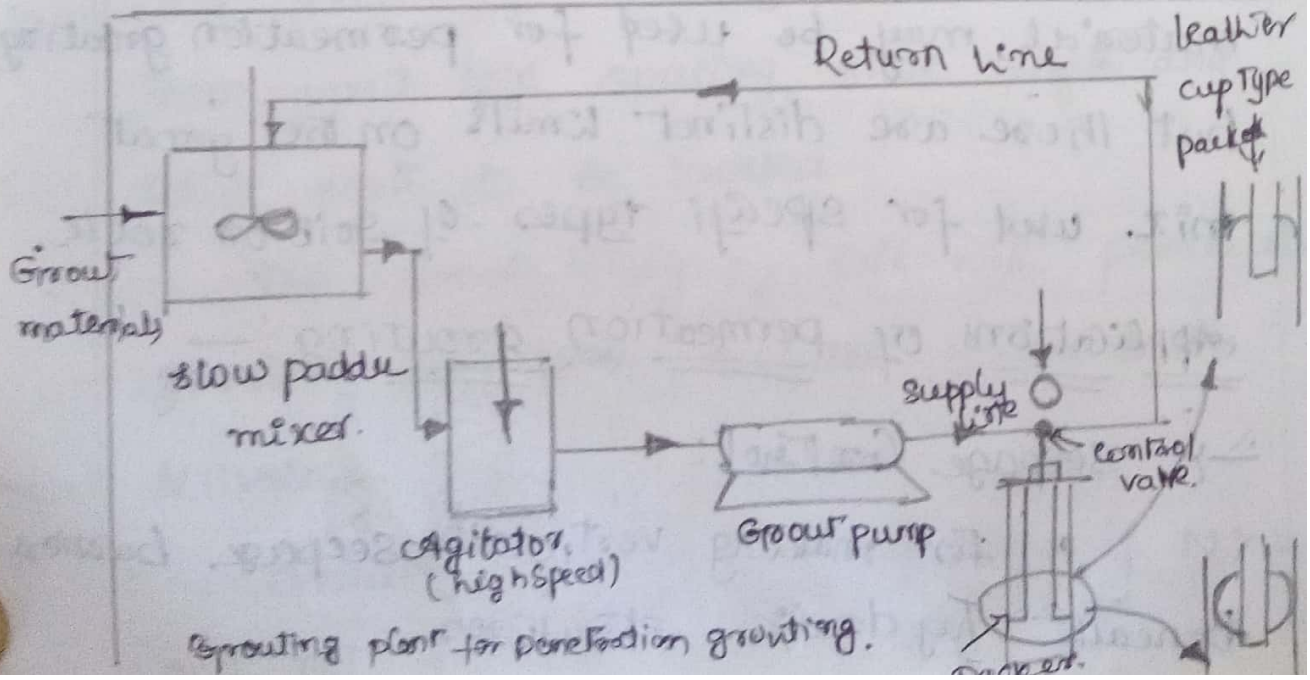
*. Soil stabilization and solidification

For stabilization of soil around Tunnels and Shafts.



(ii) Permeation grouting in soils

(i) permeation grouting in rocks.



Grouting plant for penetration grouting.

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(2) Compaction Grouting :—

* A good option if the foundation of an existing building requires improvement, since it is possible to inject the grout from the side or at an inclined angle to reach beneath the building.
* A bulb shaped grout mass is formed
* soil - cement grout
* can be performed as pretreatment before the structure is built.

Applications of compation grouting :—

→ densification of loose stratum
(i) underlying dense soil
(ii) beneath foundations or floor slab - slab Jacking
→ filling of large underground cavities.
→ densification of collapsible soils
→ densification of soils showing organic degradation

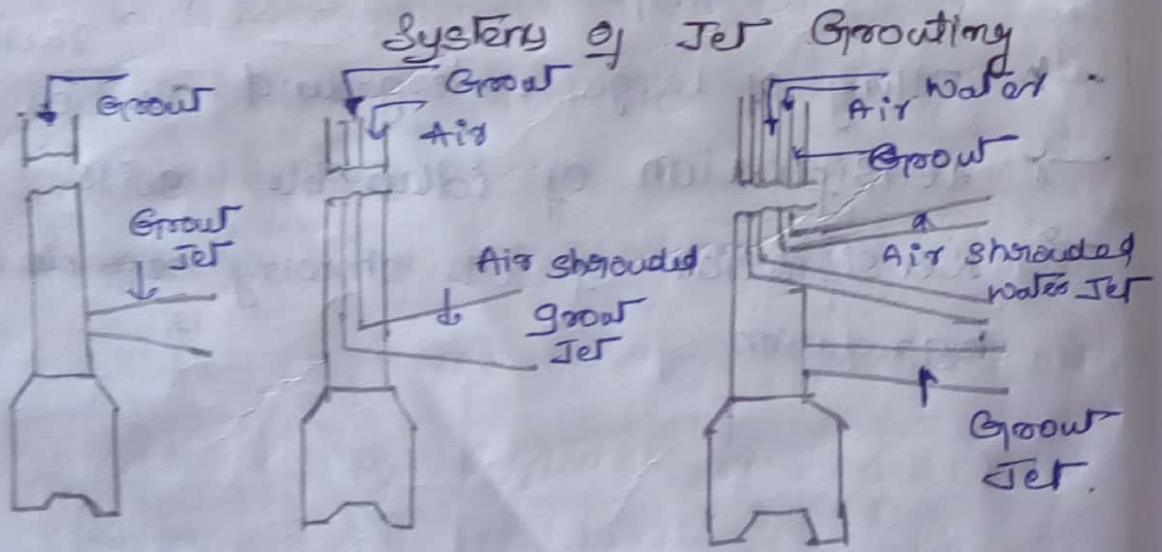


Compaction Grout

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Jet Grouting :—

* Involves the injection of low viscosity liquid grout into the pore spaces of Granular soils. This creates hardened soils to replace loose liquefiable soils.
* Jet Grouting is used as replacement Technique in which soils ranging from silt to clay and weak rocks can be treated.
* This method Consists of lowering a drill pipe into a 150 mm dia bore hole.
* The drill pipe is specially designed which simultaneously Conveys pumped water, Compressed air and grout fluid.
* Three systems of Jet grouting
  Single, Double and Triple



a Single b Double (c) Tripple

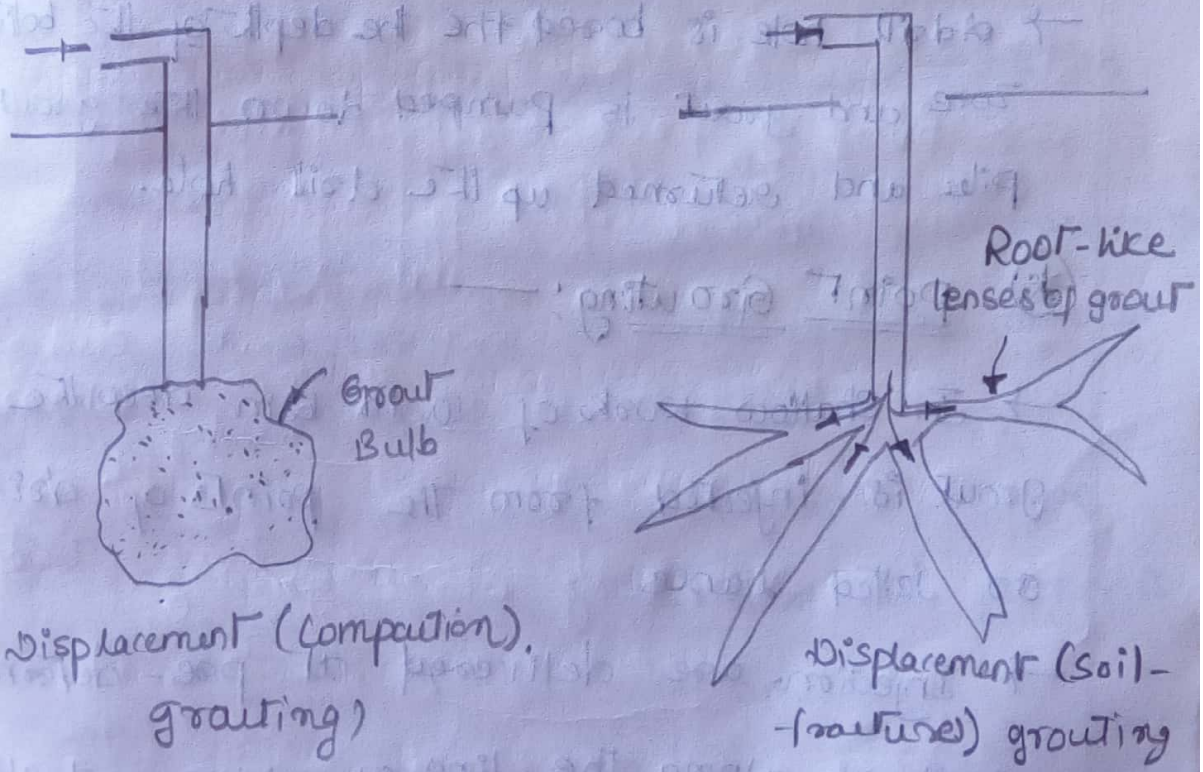
Jet Grouting

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Displacement Grouting :—

If however, the process of injection displaces the soil grains, the method is termed as Displacement Grouting.

Displacement grouting is further divided into two Sub-Types, Namely Compaction and Soil-fracture grouting. Compaction grouting consists of injecting a thick viscous paste-like slurry at high pressure to form a bulb shaped grouted mass in soil as shown in fig. (1)



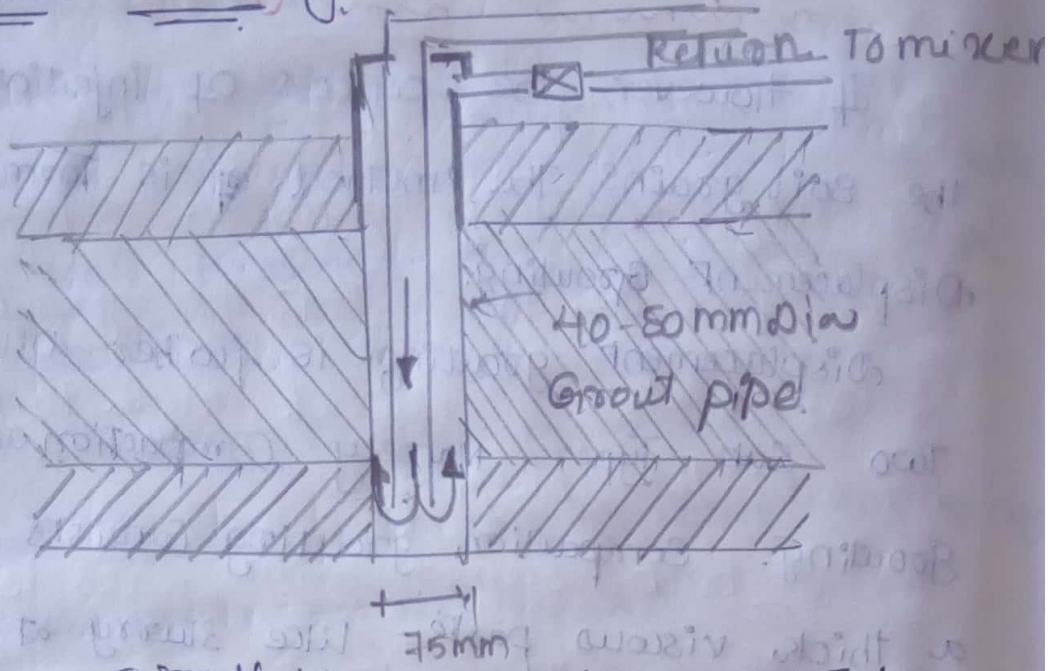
Displacement (Compaction) grouting

Displacement (Soil-fracture) grouting

On the other hand when a lean slurry of high fluidity is injected into the soil at high pressure to form Root like lenses of Grout material in the soil mass as shown in fig (2) this method is termed as Fracture Grouting.

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(*) Circuit Grouting.



Circulation grouting method

→ Based on the principle of grouting from the top downwards

→ A drill hole is bored the the depth of the bottom zone and grout is pumped down the grout pile and returned up the drill hole.

(*) Point Grouting:—

→ In shallow work of 10 to 12m deep the grout is injected from the points of driven or jetted lance

→ Injections are delivered at pre-determined positions along the line of drive and also on the return in systems where a second reacting grout ingredient is to be placed independently of the initial injection.

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Stages of Grouting :—

→ For grouting to larger depths, grouting is executed in stages.

→ In the descending stage grouting, drilling and grouting are executed alternatively in stages of 3 to 5m in the downward direction as shown in fig.

→ For each stage, as one goes deeper, one can use higher grout pressure.

→ Ascending stage grouting shown in fig. is executed in a reverse manner.

→ The grout hole is drilled to full depth in one operation.

→ Subsequently the grout pipe is lowered to the deepest segment of the hole and the annular space sealed using a packer.

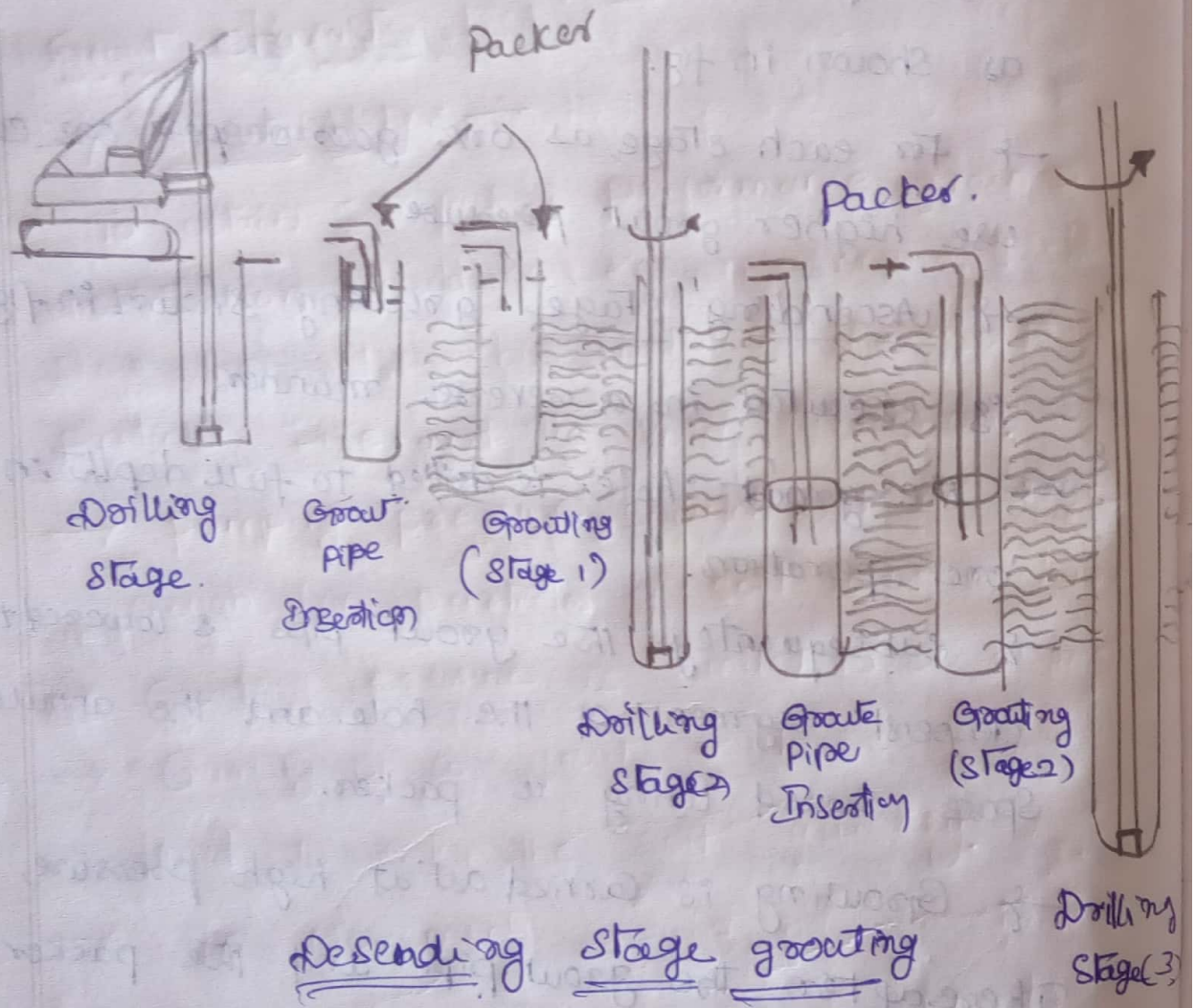
→ Grouting is carried out at high pressure, Thereafter, the grout pipe and the packer is raised in stages of 3 to 5m and the

→ Ascending stage Grouting has the advantage that the drilling is all done in one go.

→ In Desending stage grouting, one can use higher grout pressure as one moves to lower stages.

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→ Not only Because of greater depth but also Because the upper levels have been Grouted and the soil formation is more firm especially when grouts used are of Types that set and add to strength.

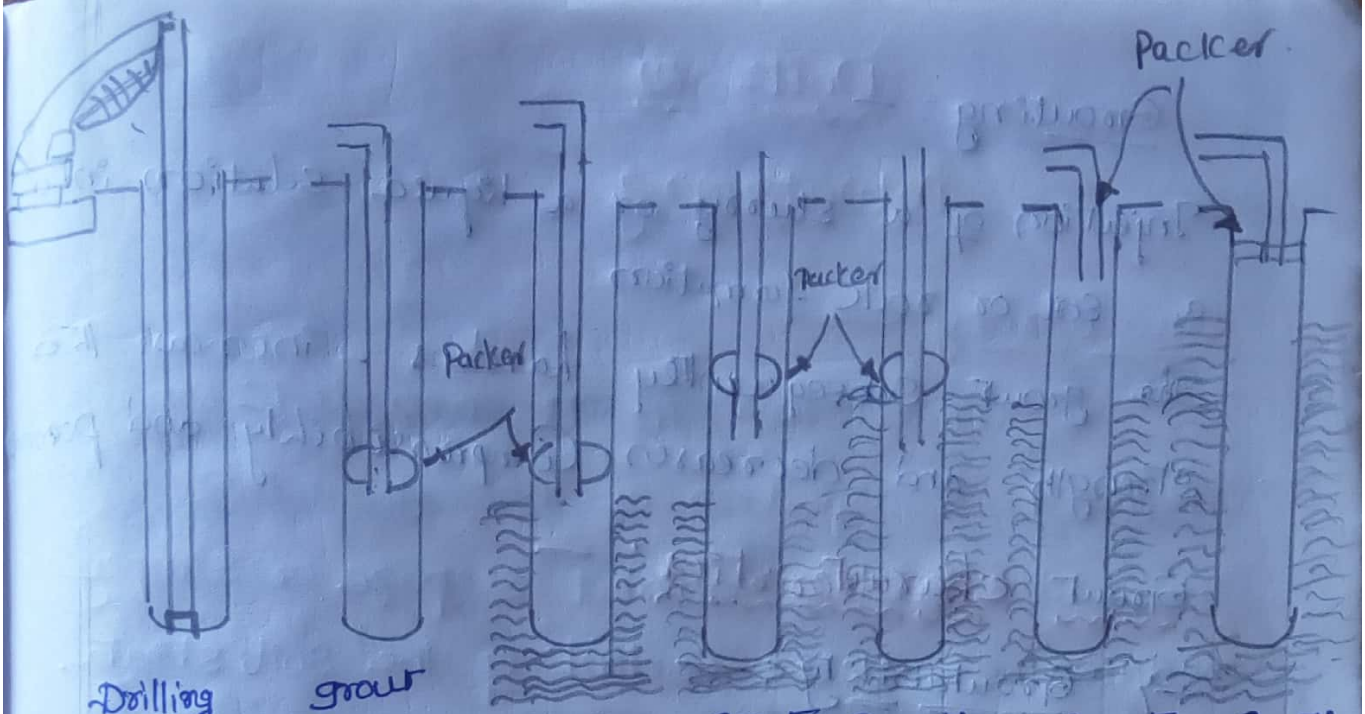


Desending stage grouting

Grouting using sleeved pipe

→ Desending stage grouting in soil may be hampered due to improper functioning packer when pushed or expanded against rough Grout hole wall.

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Ascending Stage Grouting

(*) Hydraulic fractures in soils and rocks

Hydraulic fracturing is a well stimulation Technique in which rock is fractured by a pressurized liquid. The process involves the high pressure injection of fracking fluid into a wellbore to create cracks in the deep rock formation through which natural gas, petroleum, and brine will flow more freely.

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Grouting :-

Injection of a slurry or a liquid solution into a soil or rock formation
The grout subsequently hardens - increase the strength and decreases Compressibility and permeability

Grout characteristics :-

→ Groutability :-

To obtain satisfactory performance, grain size distribution should be known because it shall show the relationship between the grout particle size and the void dimension.

→ pumping pressure should not be large enough for particles of soil to be disturbed.

→ Grouting pressure is limited to 20 kn/m²

→ Quality of a grout must be sufficiently fluid to enter the soil quickly.

→ The Movement should not be too fast.

→ Rate of injection of a grout depends on
viscosity of the grout
permeability of soil.
shear strength of the soil.

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→ Stability

Capacity of grout to remain in a fluid state and not segregate into separate components.

→ Setting Time:-

Time required for the grout to set into cemented mass or gel.

Early setting causes difficulty in the grout reaching its destination.

Late setting causes the grout being washed away if seepage is occuring through soil

→ Permenance:-

Resistance the grout possesses against being displaced from the soil voids with time

→ Toxicity.

Capacity of grout to contaminate the grout water.

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