Chemical Modifications

Grouting

- Grouting technology has become a common ground improvement method used frequently for underground and foundation constructions.
- 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.
- When the adhesives are injected under pressure through a pipe or boreholes into the voids of ground or in between the structure, the process is termed as grouting.
- Mixing adhesive and special material either in the soil surface or column of soil if required.

Application of Grouting for different outcomes

The operational limits of different grout mix are dependent on the type of soils and the grain size distribution of the soil.

- Control of ground water during construction
- Void filling to prevent excessive settlement
- Strengthening adjacent foundation soils to protect them against damage during excavation.
- Soil Strengthening to reduce lateral support requirements
- Stabilization of loose sands against Liquefaction
- Foundation Underpinning

Sealing pores or cavities

By liquid form material

1. Decrease permeability
2. Improve shear strength virtually(cohesion)

- <u>The grout mix can be generally classified into four types:</u>

(1) mortar and pastes such as cement to fill in holes or open cracks;

(2) suspensions such as ultra-fine cement to seal and strengthen sand and joints;

(3) solutions such as water glass (silicate) and

(4) emulsions such as chemical grout.

The operational limits of different grout mix are dependent on the type of soils and the grain size distribution of the soil.

Types of grouting materials

- A. Cementitious Grouts. Cementitious grouts are the most commonly used materials for grouting and can be categorized based on their mobility.
- For a grouting program to be cost effective, the grout must have sufficient mobility to fill the discontinuities intended for treatment.

(1) High-Mobility Grouts :

- High-Mobility Grouts (HMGs) behave as a fluid and can be mixed, circulated, and injected with relative ease using normal grout mixing and pumping equipment. HMGs range from pourable to a thick consistency that is just barely able to be mixed and pumped with normal equipment.

(2) Low-Mobility Grouts

- Low-Mobility Grouts (LMGs) are of a mortar-like consistency and exhibit both plasticity (they stay together when deformed) and internal friction. LMGs expand as a non-permeating bulb of plastic material to either fill open voids or displace soil materials.
- HMGs are commonly used for permeation grouting of coarse soils and fractured rock, while LMGs are typically used for soil densification (compaction grout) and void filling

Low mobility grouts

- B. Non-Cementitious Grouts:
- There are times when the desired impact of a grouting program requires the use of materials other than cement. Applications such as structural grouting in soil and control of strongly flowing water commonly lead the grouting specialist to chemical or solution grouts.

(1) Chemical Grouts: Chemical grouting is a ground treatment method for soils with a relatively low-viscosity grout. There are many types of chemical grout, each having different strength, cost, viscosity, toxicity and durability.

- Commonly used solution grouts are sodium silicate these Sodium silicate has commonly been used for structural or water control applications
- Urethanes are the material of choice for control of flowing water in structures
- Acrylates and acrylamides are highly penetrable in all mediums and form a gel when reacted

Disadvantages

- However, there are disadvantages, including shrinking and swelling during wetting and drying cycles, and some real and some perceived environmental impacts

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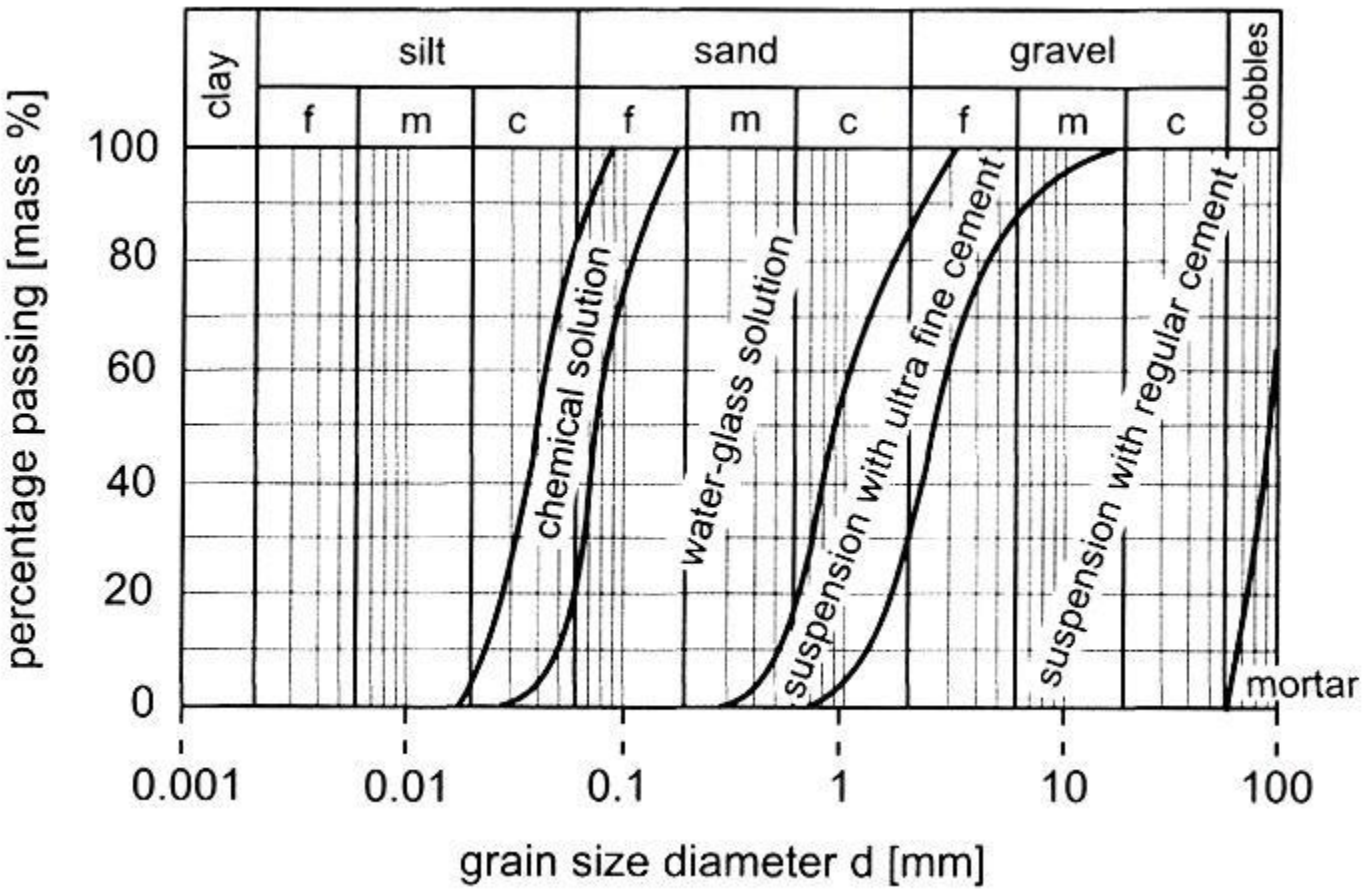
(2) Asphalt Grouts: Asphalt grouts or hot bitumen are used in special circumstances to stop rapidly moving water.

- Asphalt is a solid at room temperature and must be heated to above 275 °F (135 °C) to create a flowable, viscous liquid

(3)Clay Grouts: Clay grouts are inexpensive grouts created from a suspension of clay minerals and cement


clay
silt
sand
gravel
cobbles
f
m
c
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m
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c
100
80
60
40
20
0
percentage passing [mass %]
chemical solution
water-glass solution
suspension with ultra fine cement
suspension with regular cement
mortar
0.001
0.01
0.1
1
10
100
grain size diameter d [mm]

Criteria for design

- The use of various grout mixes are very much dependent on the nature of soil and gradation of soil
- N= (D15)soil / (D65)Grout
- If N > 24, Grouting is considered feasible
- If N < 11, Grouting is considered not feasible.

Categories of Grouting

a. Permeation grouting

b. Displacement grouting

c. Compaction grouting

d. Grouting of Voids

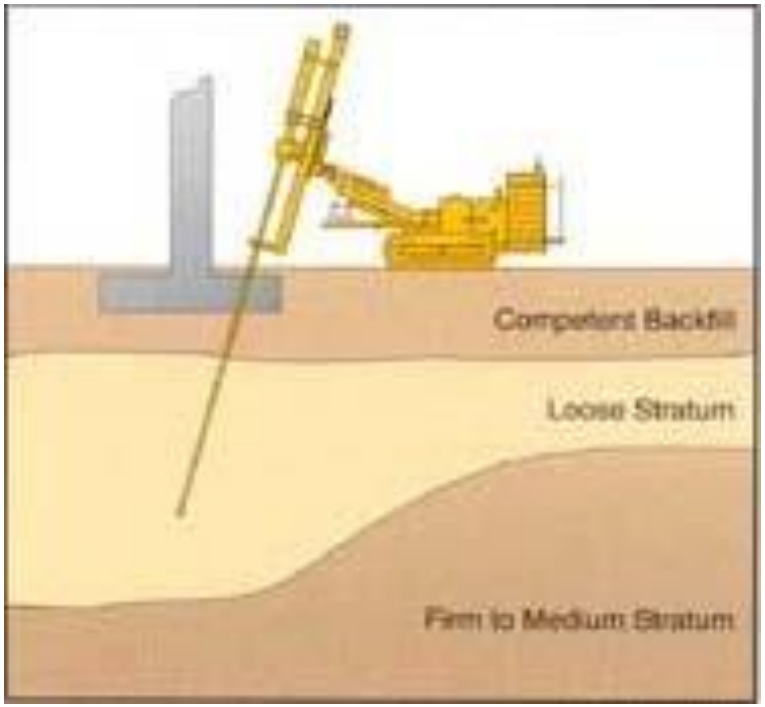
e. Jet grouting

Compaction grouting

- Compaction grouting, also known as Low Mobility Grouting, is a grouting technique that displaces and densifies loose granular soils, reinforces soils and stabilizes subsurface voids or sinkholes.

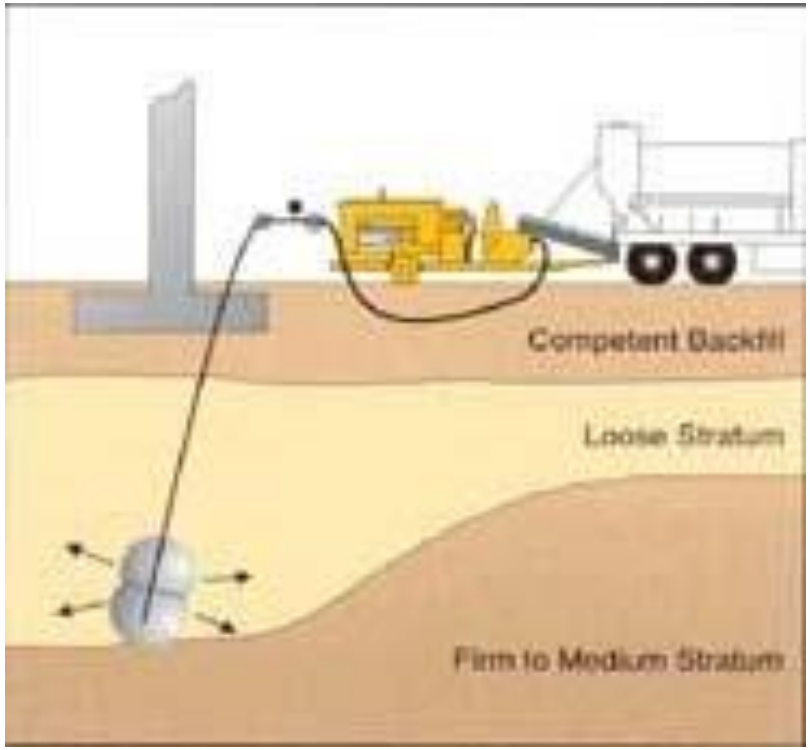
- Compaction Grouting improves ground conditions by displacement

Compaction Grouting Delivery Methods



Installation of grout pipe:

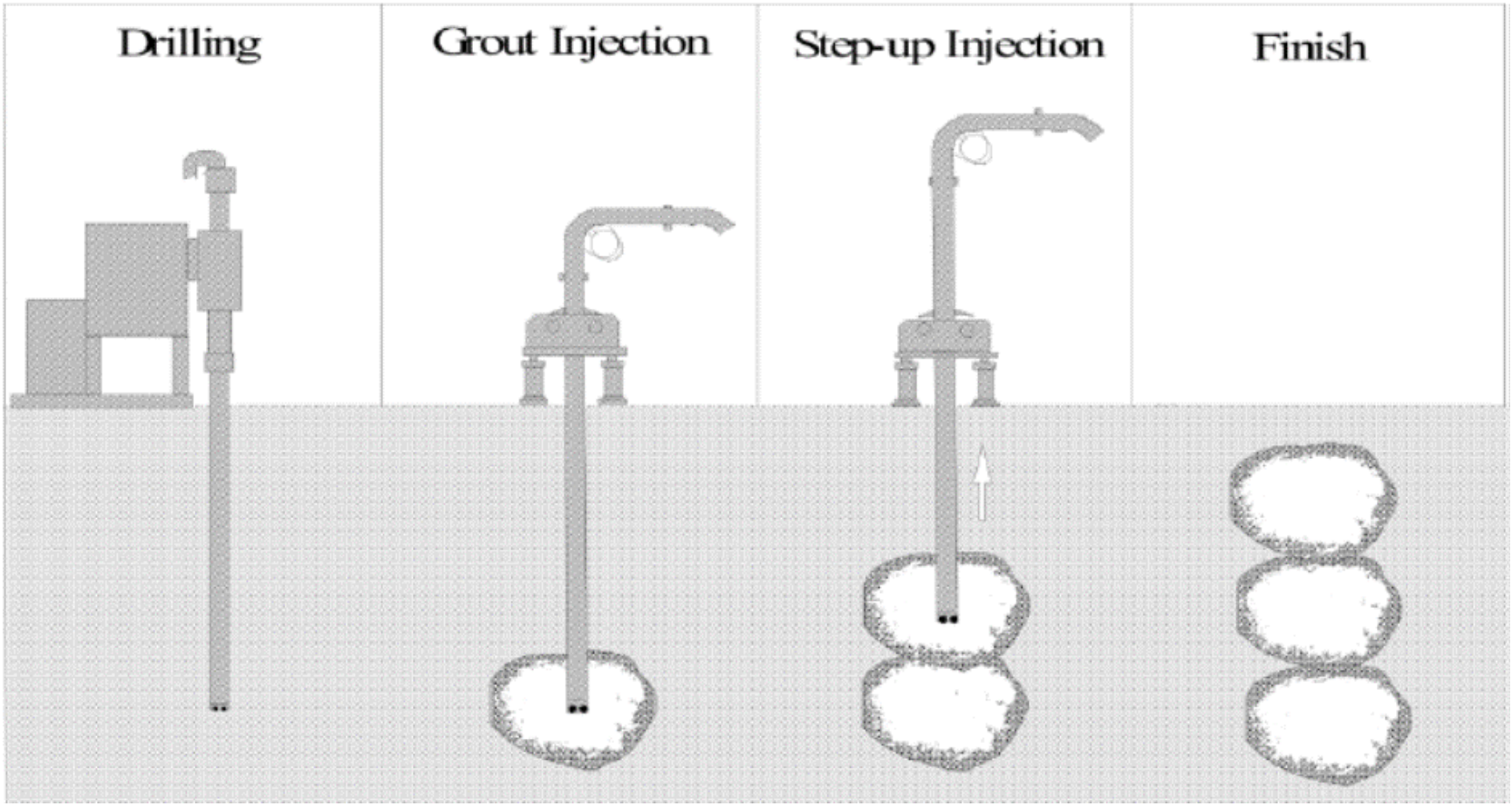
- Drill or drive casing
- Location very important
- Record ground information from casing installation



Initiation of grouting

- Typically bottom up, but can be top down
- Grout quality important
- Pressure and/or volume of grout is usually limited
- Slow, uniform stage injection

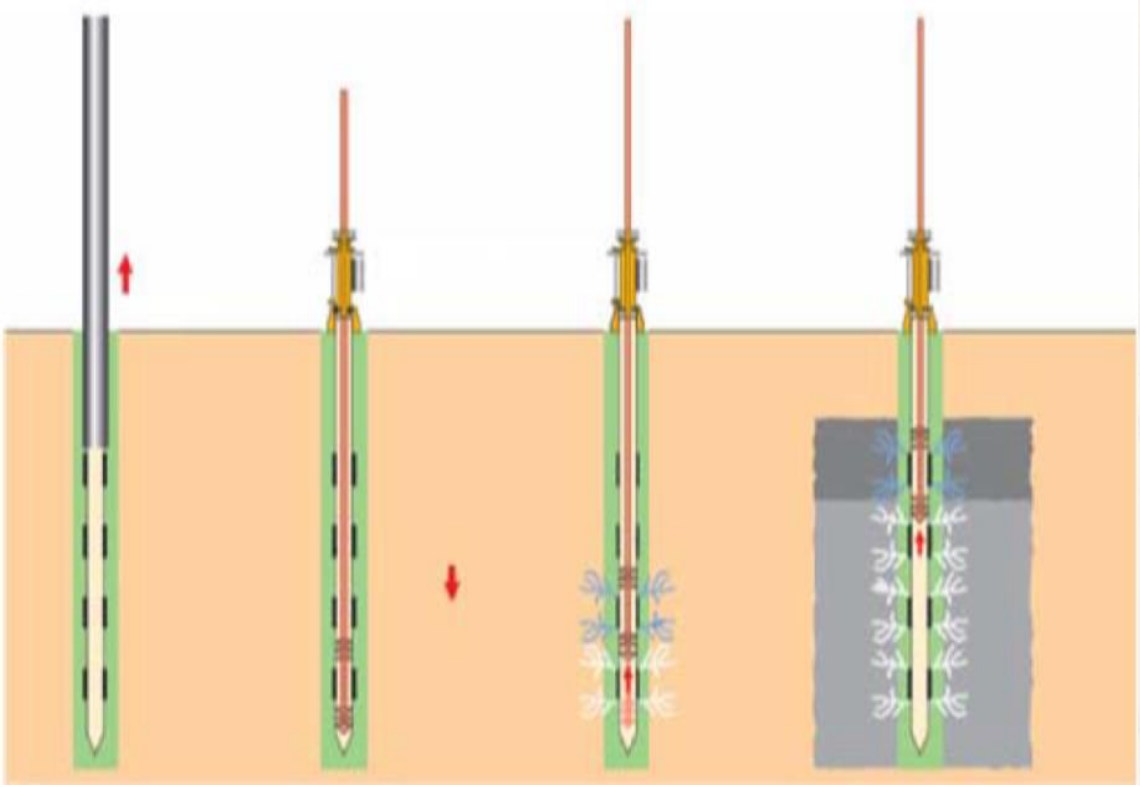
Compaction grouting

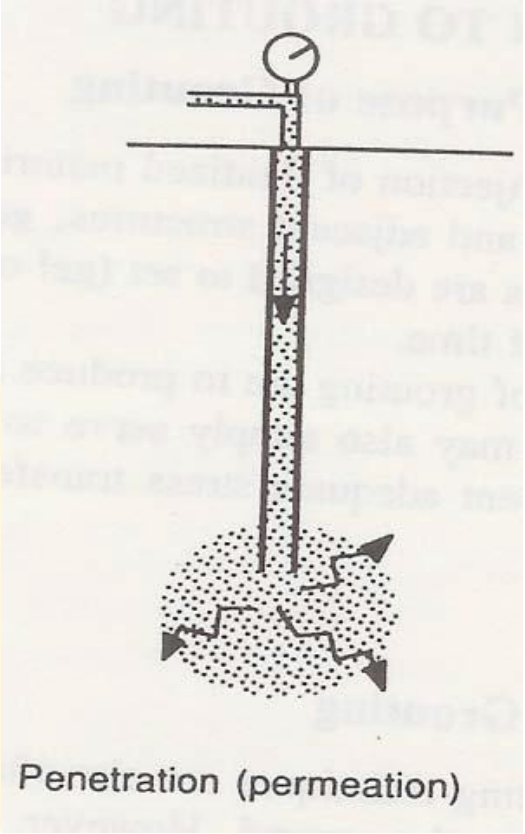


Permeation Grouting

- Permeation 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 used for permeation grouting, but there are distinct limits on the grout mix used for specific types of soil or rock.
- Applications are for enhanced foundation bearing value, improvement of excavation character in sands and reduction of liquefaction potential.

Permeation Grouting





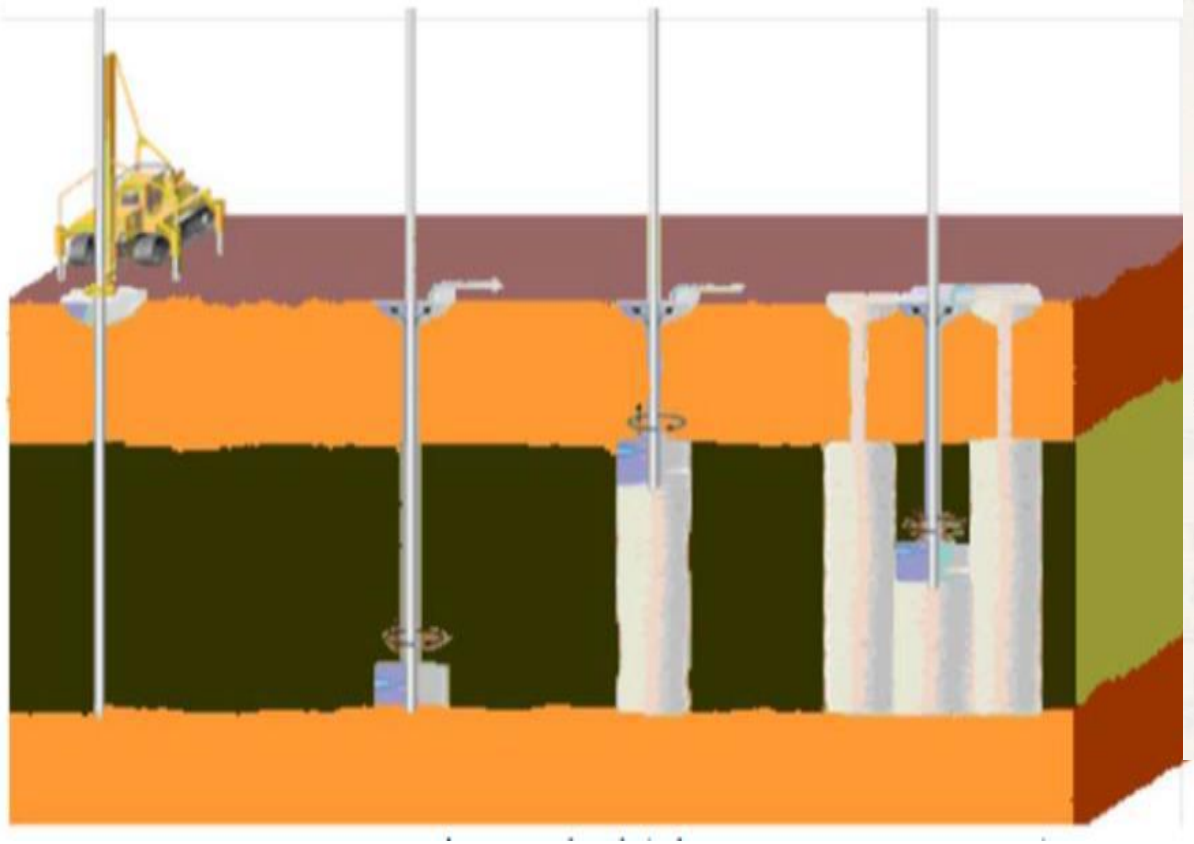
Permeation Grouting

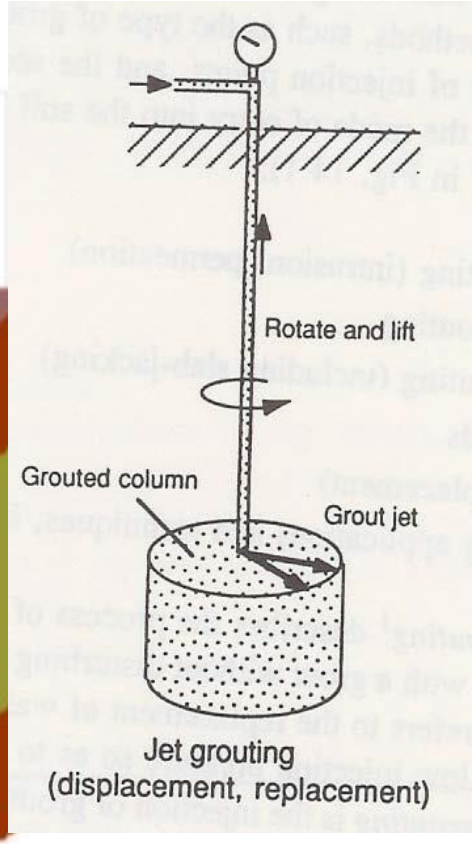
The image shows a sample of permeation grouted sand from a project that required steep-walled footing excavations in running sands. The proposed excavation area was permeation grouted with a microfine cement slurry prior to cutting footing trenches, resulting in a significant reduction in project cost. Unconfined compressive strength tests performed confirmed the improvement

Jet Grouting

- The method consists of soil injection of a mixed fluid at high pressure forming jets that erode and replace the existing soil with the injection mixture.
- In general this method begins by drilling small-diameter holes (90-150 mm) up to the final injection depth.
- Cement mixture is injected into the soil with a metal rod that runs a rotational and withdrawal motion whilst.
- High velocity fluid jets are then initiated from ports in the side of the monitor

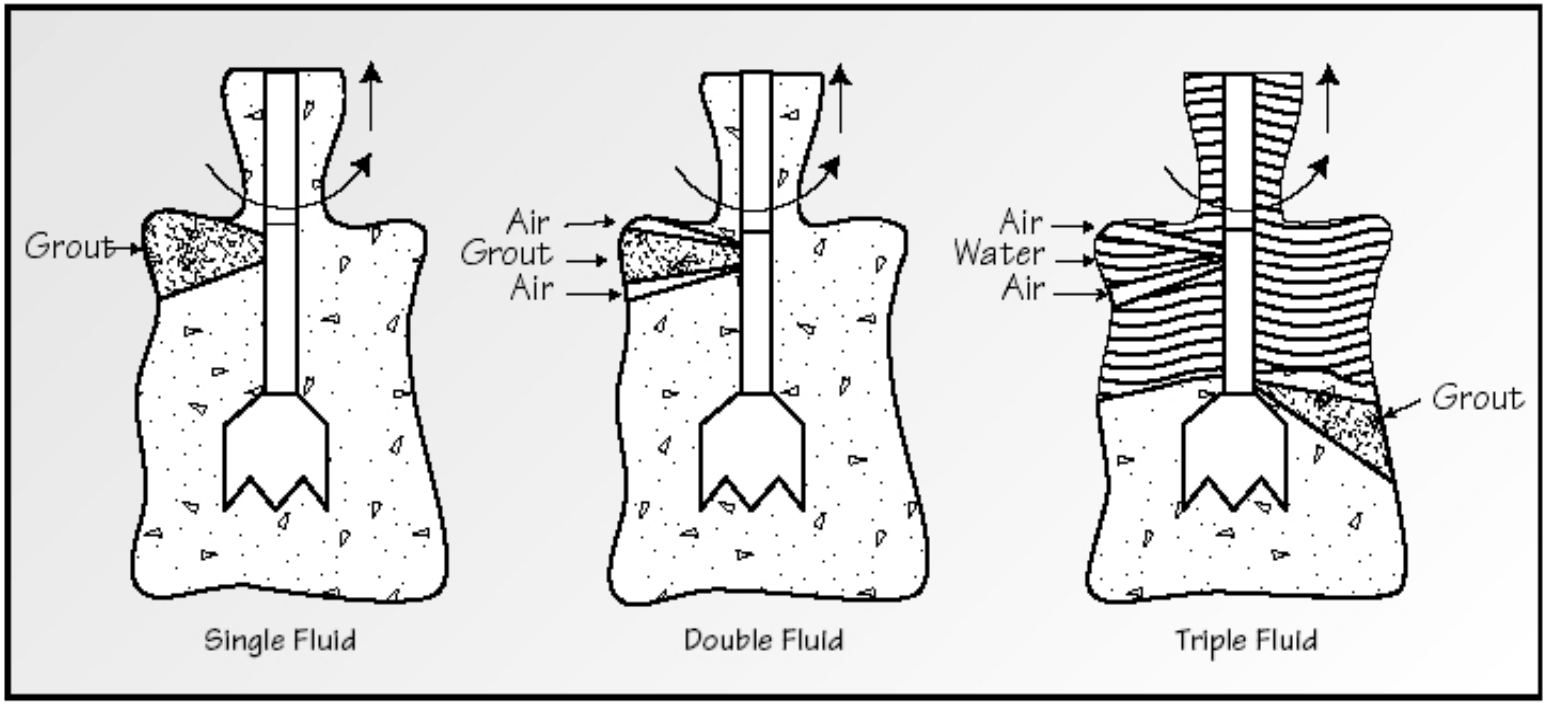
Jet Grouting





TYPES OF JET GROUTING

– SINGLE JET OR ONE FLUID SYSTEM
– DOUBLE JET OR 02 FLUID SYSTEM
– TRIPLE JET OR 03 FLUID SYSTEM



The three most common Jet grouting systems

Jet grouted soilcrete columns to underpin and provide excavation support for this wall at the Bayer Healthcare facility in Walpole, MA.

Jet Grouting Procedure

Predrilling or foundation coring may be necessary to access the treatment zone. Other emerging jet grouting systems include SuperJet and X-Jet grouting.

- SuperJet System: a double fluid system reliant on specialized tooling and high injection energy for enhanced erosion capability (up to 5m diameter)

- X-Jet System: a triple fluid system using a pair of colliding erosion jets to create a more uniform and controlled diameter of treatment.

Deep soil Mixing technologies

- The properties of soft cohesive soils can be improved by mixing of a variety of chemical additives.
- The addition of lime, fly ash and cement in different combinations can significantly improve the shear strength and compression properties of such soils.
- Deep soil mixing (DSM) is achieved using either a wet or a dry process where metered quantities of additives are injected into the soil through the hollow stem of a rotary drill string fitted to a drilling rig.

- The method helps to achieve significant improvement of mechanical and physical properties of the existing soil, which after mixing with cement or compound binders becomes the so-called soil-mix (or soil-cement).
- There are different mixing methods of deep soil mixing.
- The existing soil which has to be improved can be mixed mechanically, either with a slurry including binder (wet DSM) or with a dry binder (dry DSM).
- Jetting of slurry can be also used to boost the mechanical mixing

Mixing technologies

- Dry mixing
- Wet mixing
- Jet mixing
- Mass mixing

Dry mixing

- Dry mixing (DM) method is clean, quiet with very low vibration and produces no spoil for disposal.
- The dry method is more suitable for soft soils with very high moisture content, and hence appropriate for mixing with dry binders.
- It has for many years extensively used in Northern Europe and Japan.
- The method involves the use of dry binders injected into the soil and thoroughly mixed with moist soil.
- The soil is premixed using specialized tool during downward penetration, until it reaches the desired depth
- the treatment for the soil is possible to depths up to 60 feet

Dry mixing tool

Dry soil mixing is a ground improvement technique that mechanically mixes the soil with dry cementitious binder to create soilcrete so as to improve the weak soils such as soft, high moisture clays, peats. A high speed drill moves into the ground with a drill rod which has radial mixing paddles near the bottom so as to construct the columns. During the penetration of the tool into the ground, it shears the soils to prepare them for mixing. As and when the tool the specified design depth, the binder is injected through the drill steel where it is assorted with the soil as the tool is taken out.

Wet Deep Soil Mixing method

- This method consists of a special mixing tool which is inserted into the soil on site. This mixing tool comprises of a drilling rod, transverse beams and a drill end with a head. The drilling does not cause any vibrations, and is accommodated by cement slurry outflow from nozzles intentionally placed at the end of the soil auger. When the design depth is reached, the construction phase of deep soil mixing (DSM) columns is started.
- The binder slurry is injected through a feed pipe which is attached to the arm.
- With this method, the treatment of soil is possible to depths up to 100 feet.

Wet Deep Soil Mixing method

Jet soil mixing methods

- Ultra high-pressure fluids or binders that are injected into the soils at high velocities

Mass soil mixing

- Mass Soil Mixing is a ground improvement technique that improves soft or loose soils, by mechanically mixing them with either wet grout or dry cementitious binder to create soilcrete.
- The mass soil mixing process is typically constructed in pre-defined ‘cells’ of the order of 4m x 4m in plan area.
- Commonly the cells are mixed adjacent to others to form a 100% mass stabilised zone, all with a designed strength and stiffness.
- Mass soil mixing is low vibration, quiet, and uses readily available materials.
- This process is often used in high groundwater conditions and has the advantage of creating almost no spoil for disposal.