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Ground Improvement by using Grouting Technique- an Overview Study

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Abstract:- Recent past years have faced rapid growth of population, fast urbanization and more development of infrastructures like buildings, highways , railways and other structures, resulted in reduction of availability of good quality of land. Therefore engineers have no choice left except to use soft and weak soils around by improving their strength by means of suitable modern ground improvement techniques for construction activities. At present the available ground improvement techniques such as replacement of soil, vertical drains, stone columns, compaction, dynamic compaction, soil reinforcement, piers, in-situ densification, pre-loadings, grouting and stabilization using admixtures. The aim of these techniques is to increase the bearing capacity of soil and reduce the settlement. The soil grouting is most important procedure for the ground improvement. In soil grouting many method such as pressure grouting, jet grouting, chemical grouting, cement grouting etc. Pressure grouting technology has been widely adopted in ground improvement and soil stabilization.

Key word: -Ground Improvement, Grouting, Pump, Injection.

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1. **Introduction:** -Soil grouting is a familiar technique in the field of civil engineering, especially in foundation engineering. The technology of grouting finds applications in almost all the fields of foundation engineering such as seepage control in rock and soil under dams, advancing tunnels, cut off walls etc (Nonveiller, 1989). The primary purpose of grouting is to fill the voids of the formation material by replacing the existing fluids with the grout and thereby improving the engineering properties of the medium especiall reducing the permeability. Grouting is effective in both sand and silt deposits. Grouts are liquid suspensions or solutions that are injected into the soil mass to improve its behavior. Such liquids can permeate into the void space of the soil and bind the soil particles together. For medium sands or coarser materials, the grout used most often is slurry of water and cement (Budania R, 2016).

Even though grouting has found several applications in the practice of civil engineering, available studies on grouts and grouting have been very limited. Even today, the grouting operations are based on thumb rules and existing practices rather than rational design principles or well defined procedures substantiated by research data (Shroff and Shah, 1992).

2. History of Grouting: -Grouting has been using in civil engineering for quite a long time. Its traceable record can be as early as in the beginning of 1800s.

- In 1802, the idea of improving the bearing capacity under a sluice by the injection of self-hardening cementations slurry was first introduced (Henn, 1996).
- In 1864, Peter Barlow patented a cylindrical one-piece tunnel shield which could fill the annular void left by the tail of the shield with grout. And it is the first recorded use cementations grout in underground construction (Henn 1996).
- In 1893, the first systematic grouting of rock in the USA as performed at the New Croton Dam, in New York (Henn 1996).
- In 1960s, jet grouting technique was developed (Henn 1996).
- In 1977, first application of compaction grouting for controlling ground movement during construction of the Bolton Hill Tunnel (Henn, 1996).
- In 1995, the first industrial application of the compensation grouting concept was conducted at the construction site of the Jubilee Line.

3. Types of Grouting: -

3.1 Contact Grouting: -Contact grouting involves the filling of void space between a cast-in-place (CIP) structure and the in-situ geo-material or another structure.The primary function of contact grouting is to ensure intimate contact of a CIP structure and the host material. Examples of where contact grouting may be used include the following:

- Within pressure tunnels to prevent expansion of the tunnel liner under pressure
- Around bulkheads and mine plugs to ensure contact with the surrounding rock
- To ensure a minimum thickness of liner is achieved in any cast in place liner system
- Within sewer tunnels to prevent sulfate attack of concrete liners from behind the liner

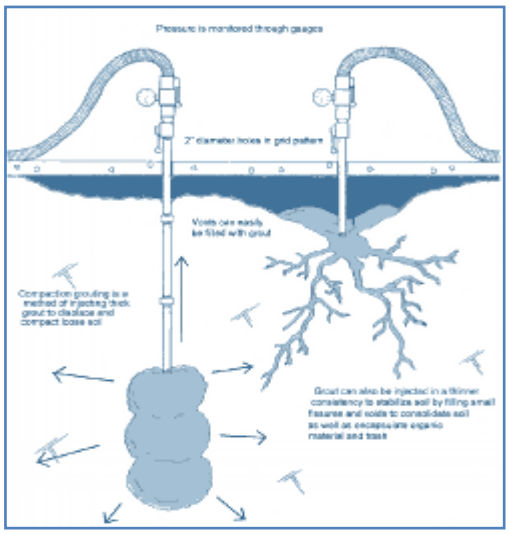

Fig 1: -Contact Grouting

3.2 Permeation Grouting: - Permeation grouting is a general term for grouting that is carried out to fill pervasive void space inherent to the formation of the material being grouted. Generally, this type of grouting is done within soil, however, also may be applied to consolidated materials, such as poorly cemented sedimentary formations. Permeation grouting is commonly utilized for the following applications:

- Pre-excavation grouting for excavations in soil or poorly cemented sedimentary rock
- To improve excavation conditions at portals, shallow shafts, or along alignments
- Support of Excavation
- Ground Modification

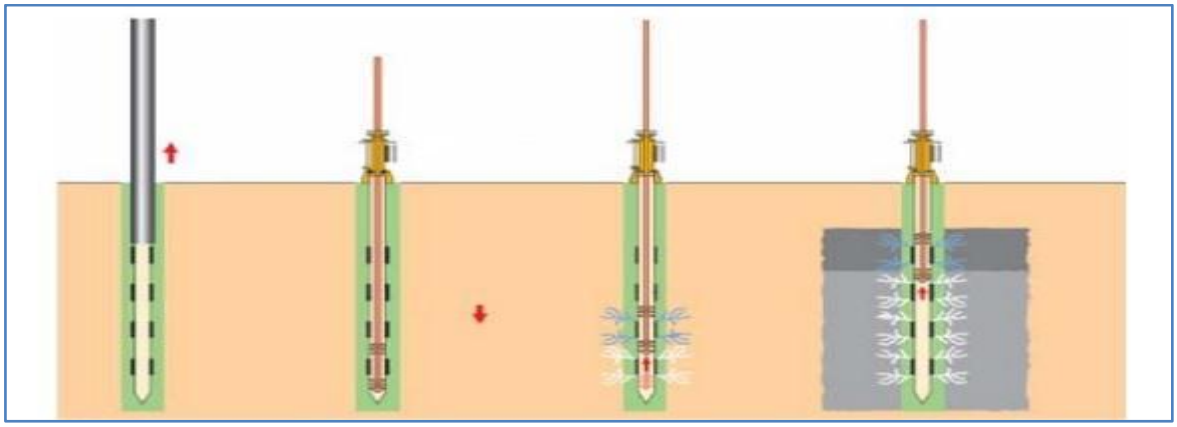

Fig. 2:-Permeation Grouting

3.3 Consolidation Grouting: - Consolidation grouting is a general term for grouting that is carried out within a rock mass with the intent of filling rock mass discontinuities. The process involves injecting a grout material to fill the discontinuities, which are the pathways through which fluids or gases migrate in most rocks. With grout filling the rock discontinuities, the hydraulic gradient is reduced as the liquids or gases move through the grout, ultimately reducing or stopping migration. The following grouting operations often employ consolidation grouting:

- Pre-excavation Grouting
- Grout Curtain
- Foundation Grouting
- Water Cut-Off Grouting

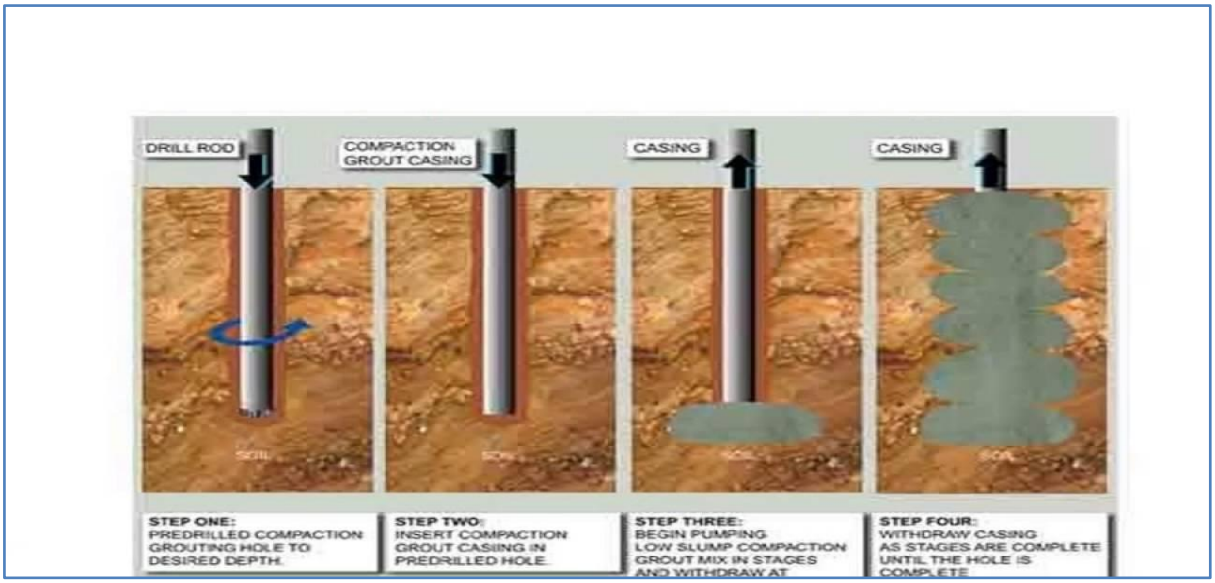

Fig. 3:-Consolidation Grouting

3.4 Hydro fracture grouting:-Hydro fracture grouting is the deliberate fracturing of the ground (soil or rock) using grout under pressure. Typically it is used to compact and stiffen the ground or to access otherwise inaccessible voids.

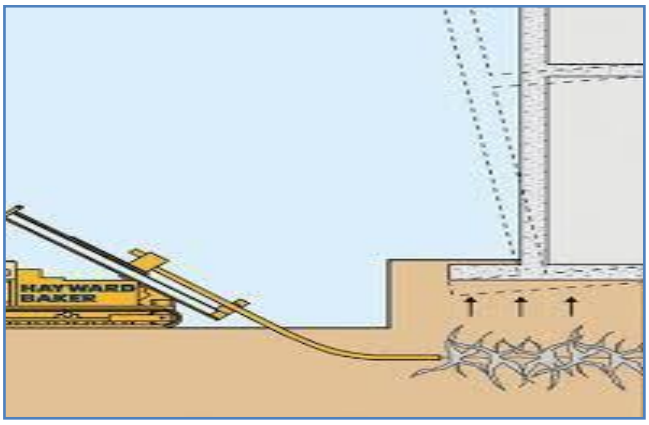

Fig. 4:-Hydro fracture grouting

3.5 Jet grouting:-Jet grouting is a method of soil stabilization which involves the injection of a stabilizing fluid into the subsoil (or the soil under treatment) under high pressure under high velocity. The injection process involves a certain amount of site preparation as well as injection equipment.

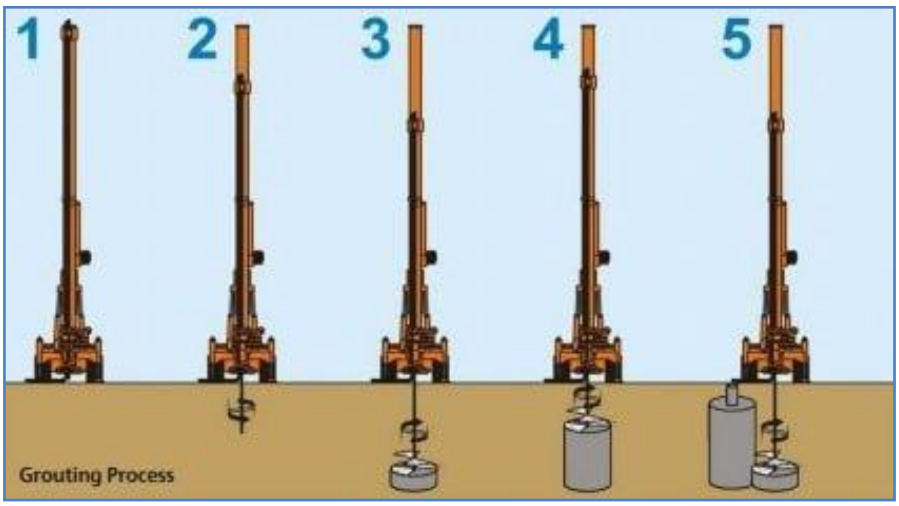

Fig. 5:- Jet grouting

3.6 Rock grouting:-Grout holes in rock are usually drilled with a rotary or percussion rotary rig and left as drilled (uncased). Grouting proceeds in stages several meters long from bottom up or from top down, using an inflatable packer. The packer may be set at the whole collar on very short holes.

Grouts most commonly used in rock-where the purpose is to fill fissure are unstable water/cement mixes. The process is rather like placing hydraulic fill, the solids being the cement grains. Very high grout pressures may be used. Work begins with a very thin grout mix and the W/C (water/cement) ratio is progressively lowered to thicken the mix.

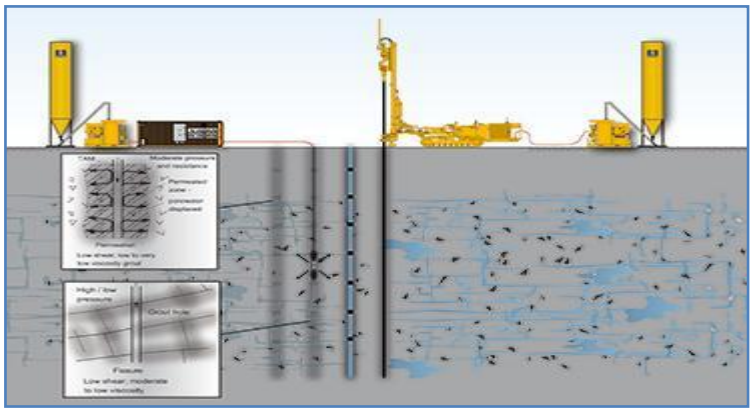

Fig. 6:-Rock grouting

4. Grouting materials: - The selection of proper grouting materials depends upon the type of granular medium and the purpose of grouting. Cement, bentonite, clay and lime are the grouting materials normally used for grouting a granular medium.

5. Grouting Equipment:-

5.1 Grout-Mixing Equipment: - Mixing and blending tanks. Mixing and blending tanks for chemical-grouting operations should be constructed of materials that are not reactive with the particular chemical grout or with individual component solutions. Tanks can be of aluminium, stain- less steel, plastic, or plastic-coated as appropriate. Generally, the capacity of the tanks need not be large. The number and configuration of the tanks depend on the mixing and injection system used.

Fig. 7:- Grout-Mixing Equipment

5.2 Pumping Equipment: - Pumps that could be used satisfactorily for chemical grouting include positive-displacement and piston pumps.

5.2.1 Positive-displacement pumps: - Probably the most commonly used positive-displacement pump is the screw, in which a stainless steel rotor turns within a flexible erosion- or chemical-resistant, forming voids that carry the material toward the discharge end of the pump at a constant rate.

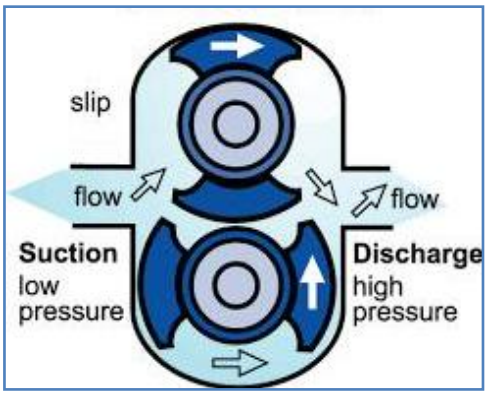

Fig. 8:- Positive-displacement pumps

5.2.2 Piston pumps: - In the event piston pumps are used, there are some advantages of specific varieties that should be recognized. Better volume and pressure controls in the lower ranges can be obtained using simplex pumps. The simplex pump operates with the one piston activating four fluid valves and produces a flow that pulsates more than that of the duplex.

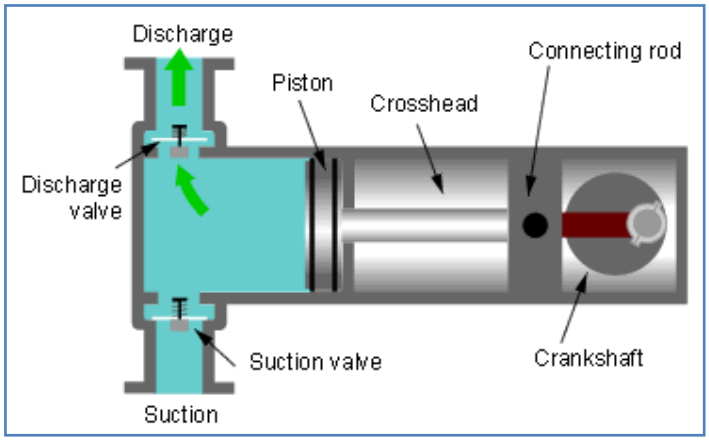

Fig. 9:- Piston pumps

5.3 Pumping Systems: - Pumping systems that can be used to satisfactorily inject chemical grout are listed below:

5.3.1 Variable-volume pump system or proportioning System: - This system is used to vary gel times, pumping rates, and pumping pressures and allows one man to control all of these factors rapidly by mechanical means. The need for solution composition or concentration adjustment is eliminated during an application.

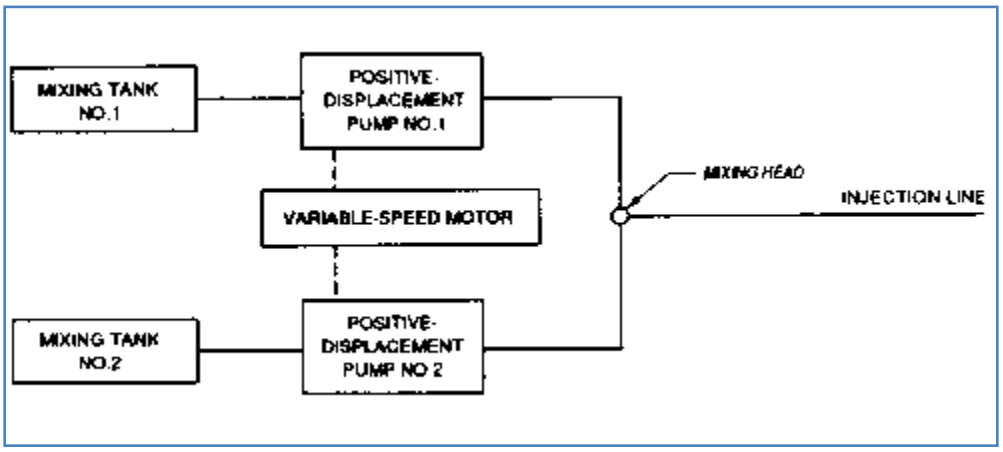

Fig. 10:- Variable-volume pump system or proportioning System

5.3.2 Two-tank gravity-feed system:- This system normally permits only one pre determined gel time. Any attempt to change gel time requires that carefully weighed amounts of catalyst sand accelerators are added to the proper tanks. The mixing tanks should be of identical size and volume, and the surface of the solutions should be at the same height in the respective tanks. Equal volumes of solutions are drawn from the two mixing tanks into the blending tank, where they are mixed and fed to the pump. This system can be modified by using two pumps of equal capacity driven by the same motor.

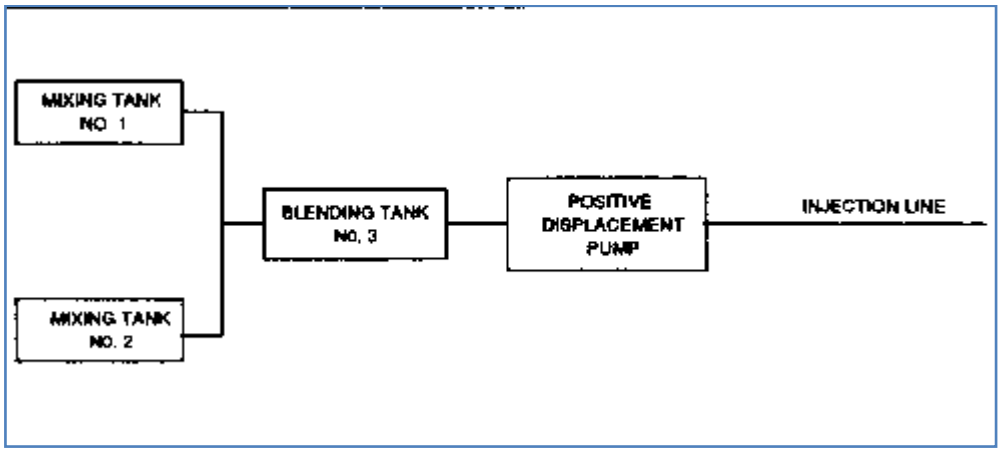

Fig. 11:- Two-tank gravity-feed system

5.3.3 Batch system:-In this system, all materials are mixed in one tank. This system has three basic limitations:

- The entire batch must be placed during the established gel time; however, because pumping rates often decrease as injection continues, this is not always possible, and the danger of gelation in the equipment is always present.
- Difficulty is experienced in varying the gel times during pumping.
- Very short gel times cannot be used unless only small batches are used.

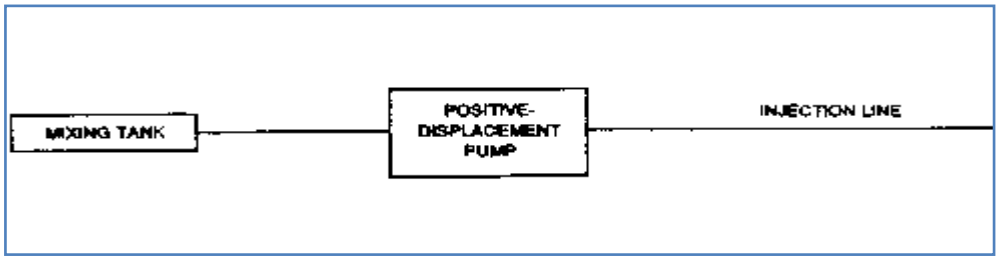

Fig. 12:-Batch system

5.3.4 Gravity-feed system: - In some instances, it may be desirable to pump or pour the grout to its desired location and allow the grout to seek its own level. The most economical means of doing this would be to discharge directly from mixing units; however, a pump is required if the area to be grouted is some distance from the mixing setup and the mixing setup cannot be moved.

5.4 Injection Methods:-

5.4.1 General: - The ultimate goal of grouting is to place a specified amount of grout at some predetermined location. Grout placement down hole can be accomplished by several means. The simplest grouting situation is to pump or pour the grout directly onto surface or into an open hole or fracture. The simplest down hole method using pressure for placement involves the use of one packer to prevent the grout from coming back up the hole while it is being pumped.

5.4.2 Packers:- Selective down hole grouting, for use in a competent hole, can be accomplished by placing two packers, one above and one below the area to be treated, and then injecting the grout. Another selective grout placement method is by use of "tubes manchettes." This method entails using a tube with a smooth interior that is perforated at intervals and sealed into the grout hole. The perforations are covered by rubber sleeves, "manchettes," which act as one-way valves. Selective grout placement is obtained by a double-packer arrangement that straddles the perforations.

5.4.3 Other methods: - Other methods include driving a slotted or perforated pipe into a formation; grouting, or driving, an open-end pipe to a desired elevation; and then grouting. The pipe can be kept open by temporarily plugging the open end with a rivet or bolt during driving. When the desired elevation is reached, the pipe is raised several inches to allow the rivet or bolt to work free from the open end when pressure is applied by grouting. The pipe may also be unplugged by placing a smaller rod inside the injection pipe to the total hole depth and slightly beyond. The rod is withdrawn from the pipe, and grout is injected. Another method, which can be used with the two-solution process, is to drive a perforated pipe certain distance and inject the grout solution. This process is continued until the total depth is reached; then, grout solutions of the remaining chemicals are injected to complete the grout hardening reactions as the pipe is extracted.

6. Advantages of grouting:-grouting provides with the following advantages when implemented which are the root causes behind its success:

- Large cemented material column creation without causing huge ground disturbances (subsoil)
- Columns form continuous elements forming in different shapes thus improving the mechanical properties and decreasing porosity.
- Improvement in construction process thus emerging out with a better design philosophy
- It's attractive nature in terms of confined space working and under difficult site condition.

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