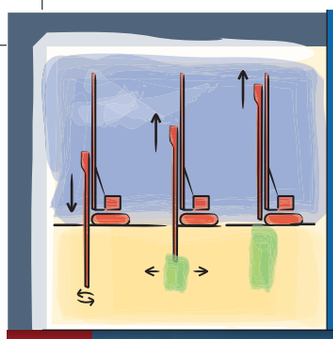
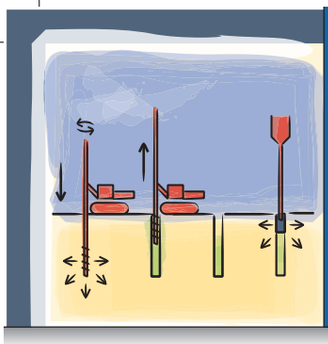


Compaction grouting

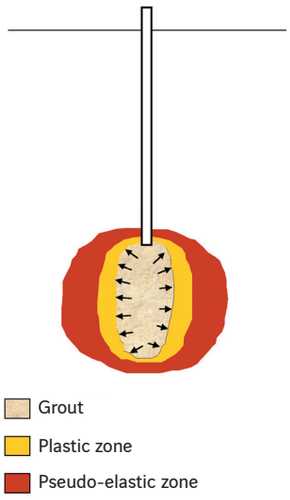
Compaction grouting is a pressure grouting technique, with the primary objective to densify the surrounding soils. Compaction grouting is performed by pumping a cement mortar under pressure through the tip of a drilling tool to displace laterally and densify the surrounding soil over a predetermined volume, resulting in a global compaction of the soil.

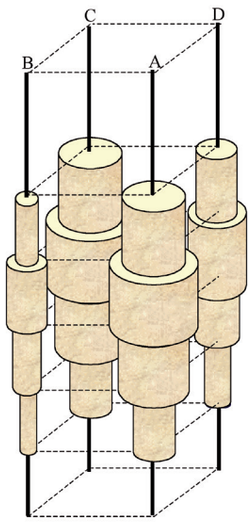
The compaction grouting columns are vertical cylinders of a viscous low-slump grout. By sequencing the grouting work during the controlled continuous extraction of the tool, a grout column is formed within the densified surrounding soils.

A global improvement of a volume of compressible soils requires sequencing the grouting work into a series of primary, secondary and even tertiary grid locations.



Compaction grouting



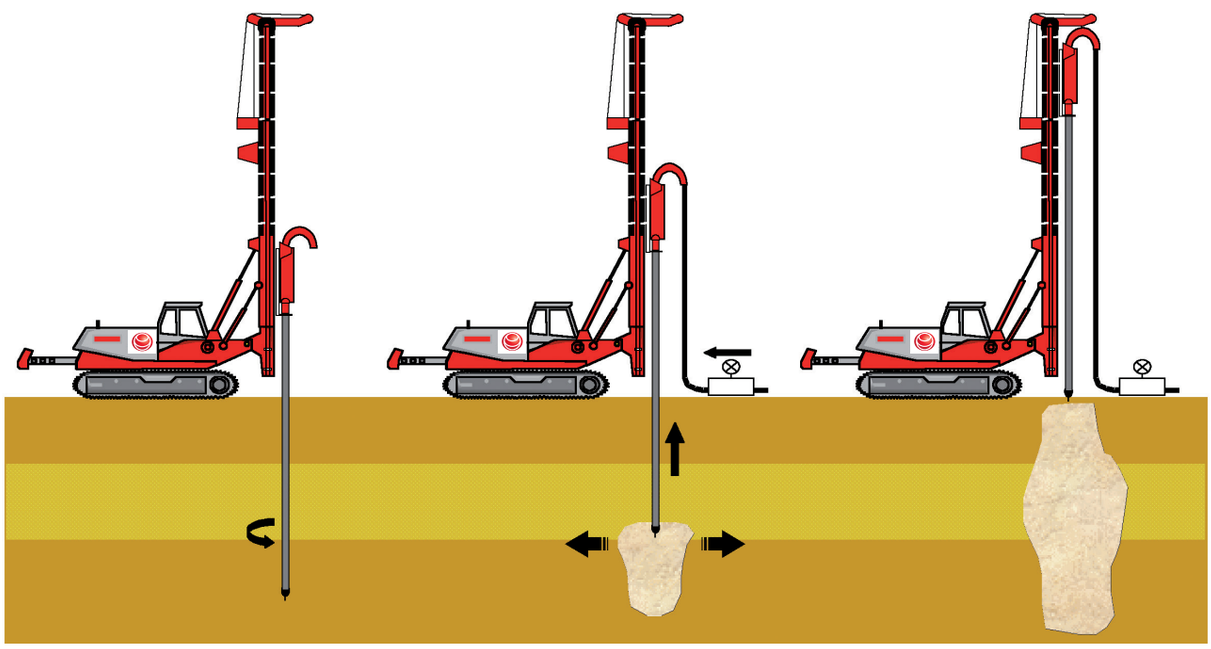


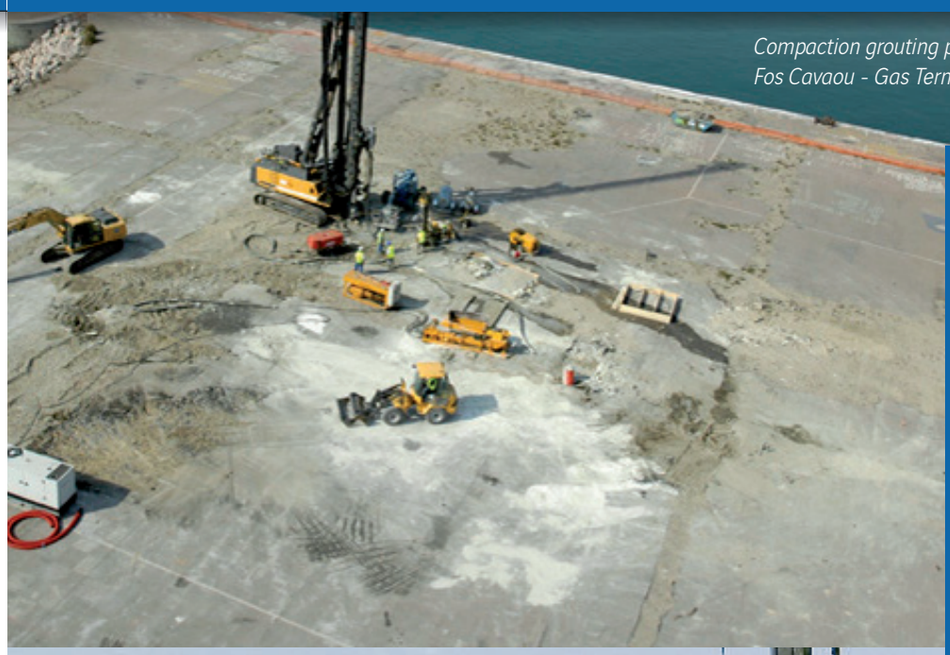
Implementation and methods

Drilling using a displacement auger produces an initial lateral displacement of the soil over the volume of the auger (typically smaller than 280 mm). During the extraction phase, a secondary compression is achieved by pressure injection of a highly viscous low slump cement-mortar, combined with a time controlled extraction of the injection tool.

Compaction grouting columns are generally performed on a square grid pattern to allow for multiple grouting phases which would be more complex with triangular grids. With the fist phase grouting locations, the surrounding soil is first stabilized. Subsequent phases (installation of the Compaction grouting columns installed in the following sequence : A, C, D, B – see following sketch) result in a more homogeneous densification effect.

The speed of withdrawal of the tool is controlled to avoid soil fracturing (formation of large cracks in the soil, enlarged by the pressure grouting). The final diameter of the column and the densification improvement are dependent on the initial compressibility of the soils. For compaction grouting, a highly viscous cement mortar mix with very high friction angle is recommended. The grout mix is made of sand, cement and cementitious fines (slag, fly ashes,...), water and chemical admixtures (retarders, plasticizers,...). The mix is rich in sand and cementitious fines to get a well graded grain size distribution.





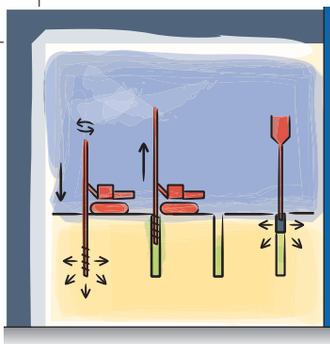
Compaction grouting pilot test
Fos Cavaou - Gas Terminal (France).

Pilot test area / Calibration:

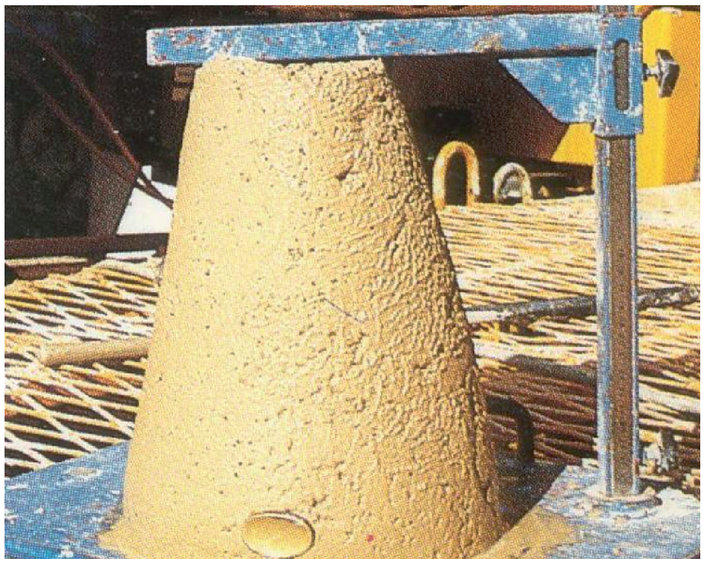
A pilot test area is always carried out at the beginning of each compaction grouting project to select/validate the following parameters :

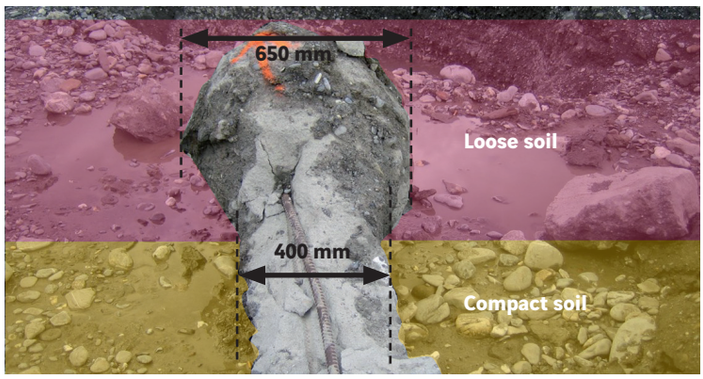
- Optimal grout mix depending on locally available agregates;
- Define maximum pressure and injection parameters;
- Select the replacement ratio required to obtain the design improvement;
- Optimize the method of performance of the treatment : grid of installation for each phase, volume of grout per column and grouting parameters (speed, pressure...);
- Ground improvement can be assessed by in-situ testing as CPT with measurement of the pore pressure (piezocones or CPTU).

Fos Cavaou Gas Terminal (France).



Compaction grouting





The requirements for the mix properties are:

- The grout shall be pumpable under high pressure;
- Injection shall not induce soil fracturing;
- The grout shall not prematurely lose its free water which would prevent an efficient expansion of the injected volume.

The required replacement ratio and densification are controlled by carefully monitoring the volume of grout incorporated in the soil with depth. Data recording of the drilling and grouting parameters provides an efficient quality control tool.

Compaction grouting is classically used to densify loose sands for liquefaction mitigation.
Compaction grouting is particularly well-adapted to liquefaction mitigation for the following reasons:

- Compaction grouting increases the relative density of sandy soils;
- Compaction grouting increases the horizontal coefficient of earth pressure at rest K0;
- Compaction grouting induces aging of the soil by low amplitude shear deformation.

Advantages

- Compaction grouting is used to stabilize and improve compressible soils, including for liquefaction mitigation;
- It is not necessary to improve the whole length of the columns. A selective treatment limited to compressible layers can be achieved;
- Deep treatment can be achieved;
- The technique is vibration free, creates no apparent damage to surface layers and can thus be performed in close vicinity of sensitive structures;
- Compaction grout columns can also be used as vertical reinforcement elements similar to rigid inclusions.

22 rue Jean Rostand - 91400 Orsay, France
Tel: +33 1 69 01 37 38 www.menard-group.com