

Vertical drains





The construction of a new embankment or structure induces additional stresses on the ground that can create unacceptable long term residual settlements during the life of the structure or highway.

A preloading program can be designed to induce these settlements in an accelerated timeframe and therefore minimize the long term residual settlements to within acceptable limits for the structure.

Consolidation phenomenon

When a load is applied on granular sandy soils, the settlement under the structure weight is quasi-immediate and quasielastic. Inversely, on saturated cohesive compressible soils (clays, silts), the structure can settle for a long time at a continuously decreasing rate. These phenomenom of long term slow settlement under constant load is called "consolidation". Fine grained cohesive soils such as clays and silts are usually saturated and therefore, settlements can only occur if the excess water is expelled through the voids between the soil grains and particles.

Amid the very low permeability characteristics of clays, the reduction of this excess pore water pressure is a slow process that can last for years after application of the loads.

Vertical drains

Implementation and methods

Vertical drains can be used in low permeability soils (clays, silts) and can significantly increase the rate of consolidation. Prefabricated vertical drains (PVD) consist of a flexible plastic core (flat or cylindrical in shape) wrapped in a spun-bond filter fabric and can be installed to depths of more than 50 m. Depending on the type and nature of the soils to be treated, it is also possible to install sand or stone drains.







Wick drains and cylindrical drains with anchor plate

1) PVD are installed by pushing a hollow steel mandrel which houses the wick drain material itself. The mandrel is driven into the ground by a mast attached to an excavator.

2) At the base of the mandrel, the wick material is looped through a steel anchor which holds the drain securely in place. Once the required depth or refusal is reached, the mandrel is extracted while the drain stays anchored at depth. Once the mandrel has been fully extracted from the ground, the drain is cut about 15 to 20 cm above the working platform.

3) To be able to push the mandrel into the ground, the tip resistance of the soils (particularly, the working platform made of draining granular material as well as any geotextile layer) should not exceed about 5 MPa. In the case of very stiff soils, the mandrel may be vibrated or hammered into the ground or predrilling might be required.







Vertical drains



A temporary surcharge embankment needs to be combined with the installation of the vertical drains in order to expedite full or partial primary consolidation as well as induce several decades of secondary consolidation (creep) settlement.



Pore pressure release through the vertical drains and draining platform during the consolidation period



The typical pre-consolidation program usually includes:

1) installation of PVD to the bottom of the compressible layer. PVD are laid out and installed on a grid pattern and to the depth required by the design (to reduce the consolidation time and increase the apparent mass permeability of the soft soils);

2) placement of the preloading embankment in phases (due to potential risk of slope failure) and additional temporary surcharge embankment as designed.

The real-time evolution of the main geotechnical parameters (settlements, pore water pressure, horizontal displacements...) is monitored through out the consolidation period. Instruments are installed to validate the design and the safe phasing of the construction of the embankment.

The monitoring of the geotechnical parameters is also used to backanalyze the main design hypothesis and results. The design parameters and calculations are optimized to fit the observed results and updated settlement and consolidation targets are used to assess the consolidation process.

