SOME APPLICATIONS OF DRAINS IN GEOTECHNICS

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Abstract: Drains are widely used to control the water regime in the ground during geotechnical constructions. In modern times it is not accepted to wait decades for soil settlement. Furthermore increasing pore water pressure can influence the stability of soil structures. By means of drains overburden pore water is better under control, so that the consolidation process can be fastened and destabilisation of the soil can be prevented. Drains can also be applied for in situ cleaning polluted soil.

INTRODUCTION

Drainage of soil layers is used since centuries to improve the properties of the soil. Probably the first applications of drainage found its origin in the agricultural area. Low land was made dry by cutting open drains, where the excavated soil was used to raise the land. In a later stage drains were placed in the cuts, so that that land becomes better accessible for tools and so on. In the first instance matter like faggots have probably been used. In agriculture tubes of backed clay are used for a long time to enable the discharge of surplus water, so that the land remains also in wet times suitable for growing crops. The coming up of plastics causes that the drains of backed clay are replaced more and more by perforated plastic tubes with a filter cover to protect the drain again silt up. Thanks to the plastic drains the installation of the drains could be automated strongly.

In civil engineering horizontal drainage of soil is for a long time a common practise to control the groundwater table. The needs of drainage for other applications become more and more relevant since the production speed in groundwork increases. It is not longer acceptable to wait 10 years for reaching the final settlement after a soft soil (clay, peat) is improved by supplying a layer of sand. The settlement of a soft soil deposit is in the first instance mainly dependent on the consolidation process. The supplied layer of sand causes an increase of the pore water pressure, so that water is squeezed out of the soil. This process proceeds until the pore water over the depth is reduced to the initial hydrostatic pressure. The speed of this process is linearly dependent on the permeability of the soil and square with the thickness of the soil layer.

There are no possibilities to change the permeability. However, by means of drains a smaller thickness can be simulated. Since it is not the task of the drains to keep the surface dry the drains can be installed vertically. It is much easier to reach a large depth with vertical drains than with the horizontal method. The principle of vertical drainage is applied several decades before plastic drains are available. At that time sand columns are used as drainage material. A vertical shaft is drilled up to the required depth, where the borehole is filled with sand during pulling up the drilling device. One of the disadvantages of sand columns is that the draining path can be locked soon at large settlements. However, drains of sand are still used in this area, where also the stability of soft soil is improved by sand columns with a larger diameter.

Since synthetic material becomes cheaper several applications in engineering become attractive. In the geotechnical area applications are soil improvement and stabilisation by geo-textiles and drains. The typical drains used in civil engineering are rectangular (e.g. 100x5mm). The general configuration is a woven filter cloth around a core which is good permeable in the lengths. The matter is flexible, so that it can be wind up easily. Furthermore the drain is so strong that they can resist the rough civil environment. Several methods are developed to install the drain. In soft soil the drain can be installed by means of a lance. The lance protects the drain against damage. An anchor plate takes care that the drain is remaining into the soil when the lance is pulled up. The advantage of plastic drains is that the installation is much easier and more reliable than sand drains. Furthermore the drainage capacity is better than that of sand

and the operation of the drains are less sensitive for large settlements. To day drains of synthetic material are used in several differed applications, such as: drainage, fastening consolidation process, stabilisation soil during ground construction, cleaning polluted soil.

SOME APPLICATIONS

Several applications of synthetic drains can be mentioned. The following separation in the different applications can be made:
- Reducing consolidation time (no speed up of creep)
- Soil stabilisation during ground work
- Extraction of pollution in soil

It has to be noted that drains are reducing the consolidation time. However, after consolidation significant settlement can be taken place due to creep. Drains do not directly influence creep.

Reduction consolidation time

In several European countries geotechnical work has to be carried out on soft soil. In most cases it is required that the soil is improved before the real work can be started. An example is when houses have to be built on soft soil. Since the houses are founded on piles no worries have to be made about the construction of the house itself. Problems arise, however, about the infrastructure because the soft soil is not a very good base for roads. Furthermore in living areas the groundwater table has to be lowered in most cases, so that settlement occurs. Since the houses are founded on piles they will not follow the settlement of the subsoil. This means that large variations in level can occur, which is of course not convenient for living. To minimise the settlement after building the houses and to homogenise the surface behaviour of the soil, the soil is stabilised by supplying a sand layer of a few metres. However, perhaps it would take more than ten years before the consolidation process has been finished. A significant reduction (.5 to 1 year) in consolidation time can be achieved by using vertical drains (Fig.1). If the clay layer is overlaying a well-drained sand layer the drains can be penetrated up to the sand layer, so that an extra discharge can be realised. Eventually some extra reduction of the consolidation time can be obtained by connecting the drains to a suction pump. Since only ca. 0.7 bar under pressure can be realised this method has a limited effect.

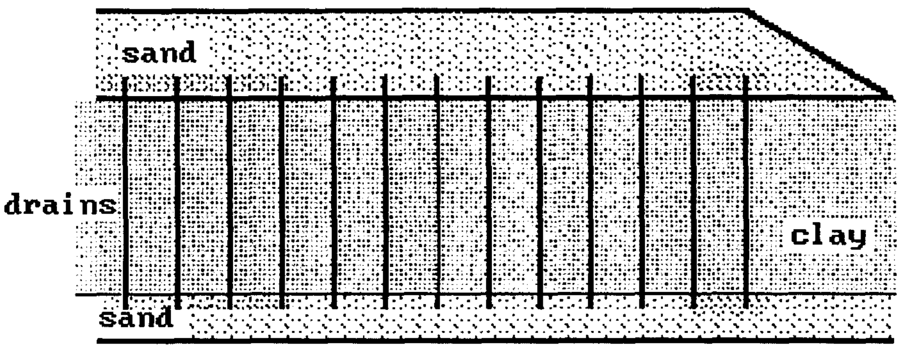

Fig.1 Diagram of the application of vertical drains to reduce the consolidation time.

To prevent large local settlements, the construction of roads on soft soil requires that a foundation is made for the asphalt pavement. In practise this means that an embankment of sand has to be made. These embankments can have a height of more than 10 metres, so that large settlements will occur in the subsoil. Since the settlements are not uniform over the lengths of the embankment road construction can not be started before the ultimate settlement is reached. To day roads have to be built quickly to handle the fast growing traffic. Therefore vertical drains are used in several cases to reduce the waiting time.

Special attention has to be paid to locations where a road is connected to a founded structure, such as a bridge. Settlement will soon led to level differences between the founded construction and the road embankment. Preloading the road embankment close to the bridge can solve this problem by an extra layer of sand. After it is believed that the final settlement is reached the extra loading is removed, so that the residual settlement is minimised. The extra loading will also reduce the creep. Locally an extra dense drain pattern can be used in this case to achieve that the final settlement of all the soil involved is reached in the same time.

Stabilisation of soil during ground work

When an embankment of e.g. sand is constructed on clay the increasing pore water pressure can cause instability of the clay layer. In the most bad case failure will occur along a shear band, following the theory of Bishop or Fellenius. The reason for this failure is that the increasing pore water pressure reduces the effective stress and so the shear resistance of the soil. Adding the sand over a long period can prevent failure. Vertical drainage can be applied in this case to prevent that the pore water is reaching too high pressure (Fig.2), if the sand is supplied too fast.

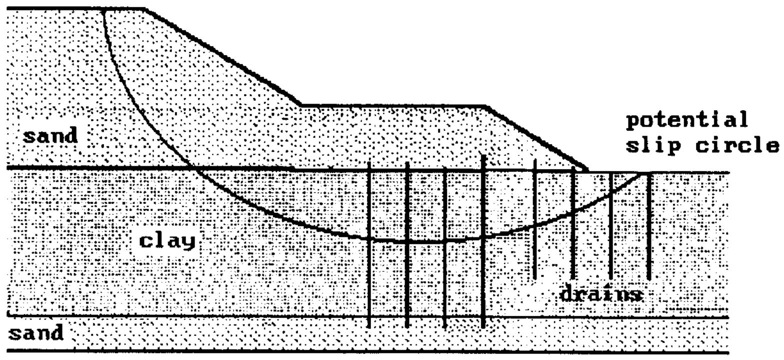

Fig.2 Application of drains to prevent failure during construction of embankment.

The increasing traffic requires a higher capacity of roads. As a result of some floods and almost floods in Europe much attention is paid to the dikes, which protects low land against a high water level in the rivers. The roads as well as the dikes are improved by modifying the existing construction. The roads are made wider, where the height of the dikes are increased.

If roads are located on soft soil a sand embankment is used to obtain a stable foundation for the asphalt pavement. Widening of the asphalt lanes means therefore that in the first instance the sand embankment has to be widened (Fig.3). The reconstruction of the road hampers the traffic, so that the process has to be proceeded as fast as possible. Also in this case vertical drainage can be applied to fasten the consolidation process. The widening of the embankment can cause cracks in the asphalt pavement of the existing road. Since this road is still in servant dangerous situations can occur. In geotechnical centrifuge tests it is examined in how far the sequence of the sand suppression can influence the cracks. It was found that the so-called gap method (an embankment is made at some distance first, after which the gap is filled) reduces the cracks. Perhaps also the drains can have a positive influence on the cracking behaviour of the asphalt. This will be a research item in the geotechnical centrifuge of the University of Delft in the near future.

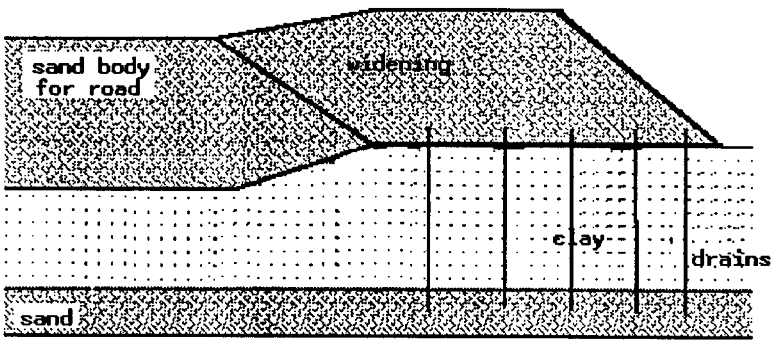

Fig.3 Widening of embankment for road construction.

In Fig.4 an example is shown where vertical drains can be applied to control the freatic line. In this application it is supposed that an excavation has been made. To keep the floor of the excavated area dry, water is extracted from the sub soil by means of a well. If no special precautions are taken seepage can occur in the slope of the excavation, which can cause gradual failure of the embankment. By means of vertical drainage the freatic line can be controlled in such a manner that seepage cannot occur.

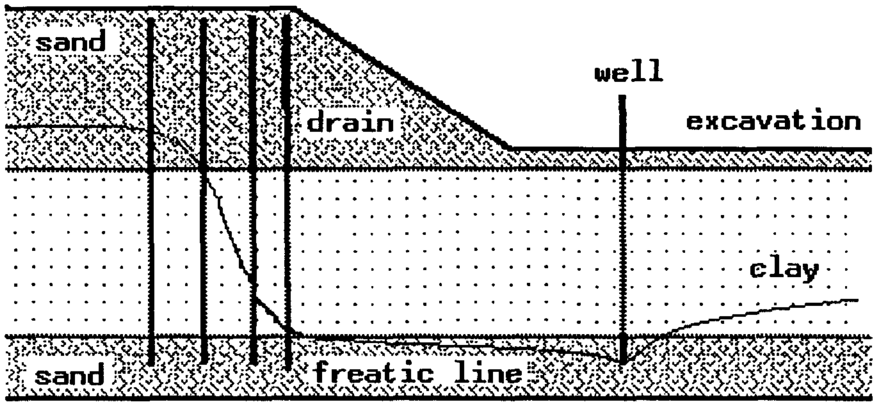

Fig.4 Controlling of the freatic surface during extraction of water in an excavation.

Extraction pollution
In Fig.5 an example is shown where vertical drains can be applied to extract pollution from the soil in situ. At several locations in Europe the soil is contaminated by leakage of bad liquids. Rigorous ways to remove the contaminant is by cutting out the soil and replace it by a clean soil. This is a very expensive operation, which can cause lot of inconvenience for people. A preferred method would be where the soil is cleaned without cutting. In the Fig.5 it is shown how a contaminated area can be cleaned in principle by washing. Water is extracted from the soil by suction, where water is supplied from a sand layer underneath the clay layer. Thanks to the water circulation contaminates are transported to the surface. The extracted water can be decontaminated and feed back to the deeper layer.

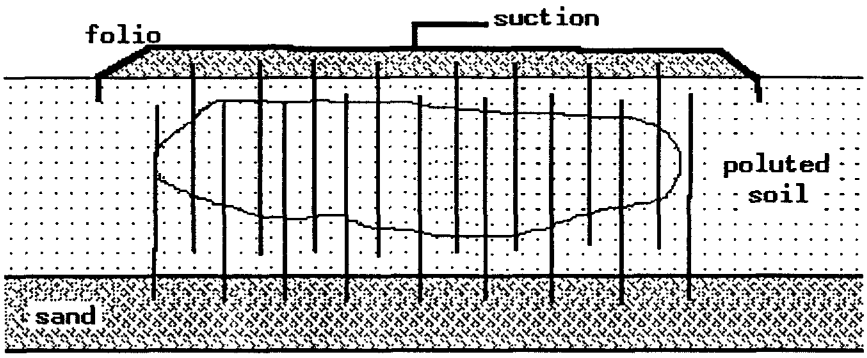

Fig.5 Drainage system for in situ extraction of pollution.

CONCLUSION

Drains can be applied usefully in several geotechnical projects. Drains reduce the waiting time of the consolidation process significantly. Furthermore soil can be stabilised during construction by using drains. Since drains are more commonly used more and more applications are found. An example is the use of drains for in situ cleaning of polluted soil.