BENTONITE - LINING BARRIER
Around a former landfill in Maassluis

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INTRODUCTION

From October to November 1993, the team of Cofra B.V. and Fundamentum B.V. installed approximately 7,000 m² of a cement-bentonite/liner composite wall as gas- and fluid tight barrier. This wall is part of the site remediation of the former landfill at the Dr. Albert Schweitzer dreef in Maassluis, the Netherlands.

The Province of South Holland, Dienst Water en Milieu (the Water and Environmental Department) commissioned Ballast Nedam Milieutechniek B.V. as the general contractor. DHV Milieu en Infrastructuur B.V. was retained by the Province to prepare the specifications and to provide construction and environmental management.

The 100mm thick cement-bentonite wall was constructed to a depth of approximately 10 meters below the existing ground surface. To ensure that the barrier met the low permeability required by the specifications, 2 mm thick GEOLOCK HDPE panels were installed to form a composite wall.

This paper gives a short overview of the remediation project, after which the construction of the cement-bentonite iner composite wall will be examined.

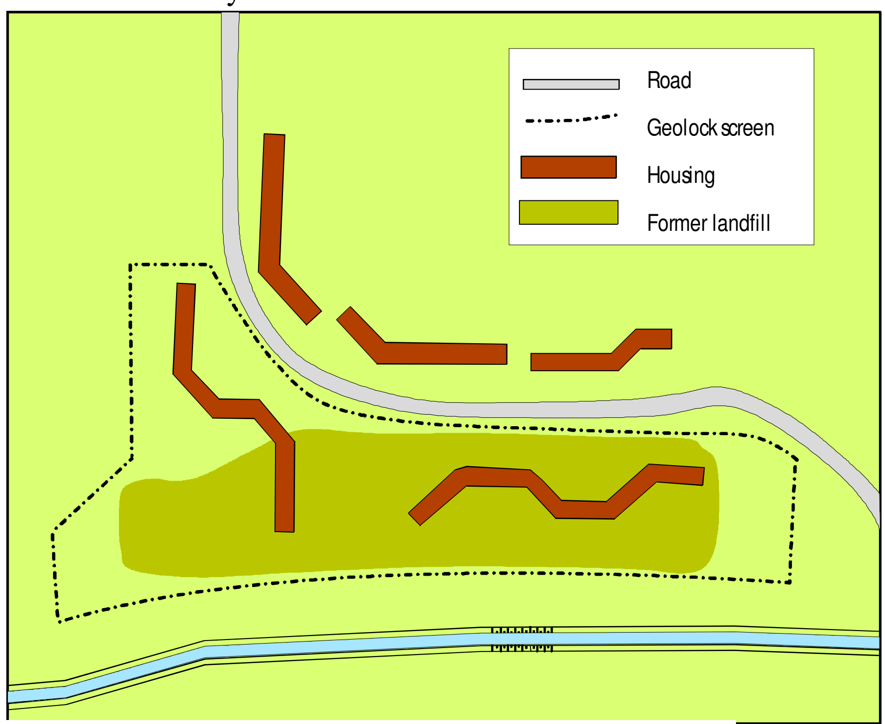

Figure 1 Situation

DESCRIPTION OF THE PROJECT

The Maassluis landfill is located in the southernmost part of the Steendijkpolder-South (figure1). Between 1922 and 1924 dredge material from the harbour was deposited on the site raising the ground elevation by approximately 4 meters. In 1960 the site was excavated to its old ground surface for the construction of a municipal controlled tip. The landfill was closed in 1972 and covered with a layer of fill. Two pile-founded apartment blocks were then built and the site landscaped.

Remediation of the former landfill is now underway and consists of measures to prevent the horizontal and vertical spread of gas and leachate. For this purpose, a barrier wall is placed around the location extending to the clay under the so-called Holocene sand layer. Within the barrier wall, the level of the groundwater in this Holocene sand layer is permanently lowered to below the level of the deep Pleistocene sand.
The largest part of the barrier wall consists of the composite wall. However, because of the need for a cantilever bulkhead along the Dr. Albert Schweitzer dreef, special steel sheet piling with watertight interlocks were installed.

SOIL COMPOSITION AND GEOHYDROLOGY

The soil composition at the site of the landfill is shown in figure 2 as a longitudinal profile over the traced out display. This profile is derived from boring logs and can roughly be described as follows:

- Top layer, consisting of alternate layers of sand and clay.
- On the northern side mainly clay was found.
- On average, the ground surface is at NAP +4.00 m (NAP = Normal Amsterdam Level).
- At the site itself, the upper layer consists of the landfill, with a ground surface level of between NAP +4.00 m and +4.30 m.
- The original ground surface is varies from NAP +0.20 m to NAP -0.50 m, with an underlying clay layer 0.70 m to 1.40 m thick.
- A Holocene sand layer consisting of alternate layers of sand and sandy clay. The bottom of this layer is at NAP -3.50 m to NAP -4.50 m.
- Holocene clay between NAP -4.00 m and NAP -

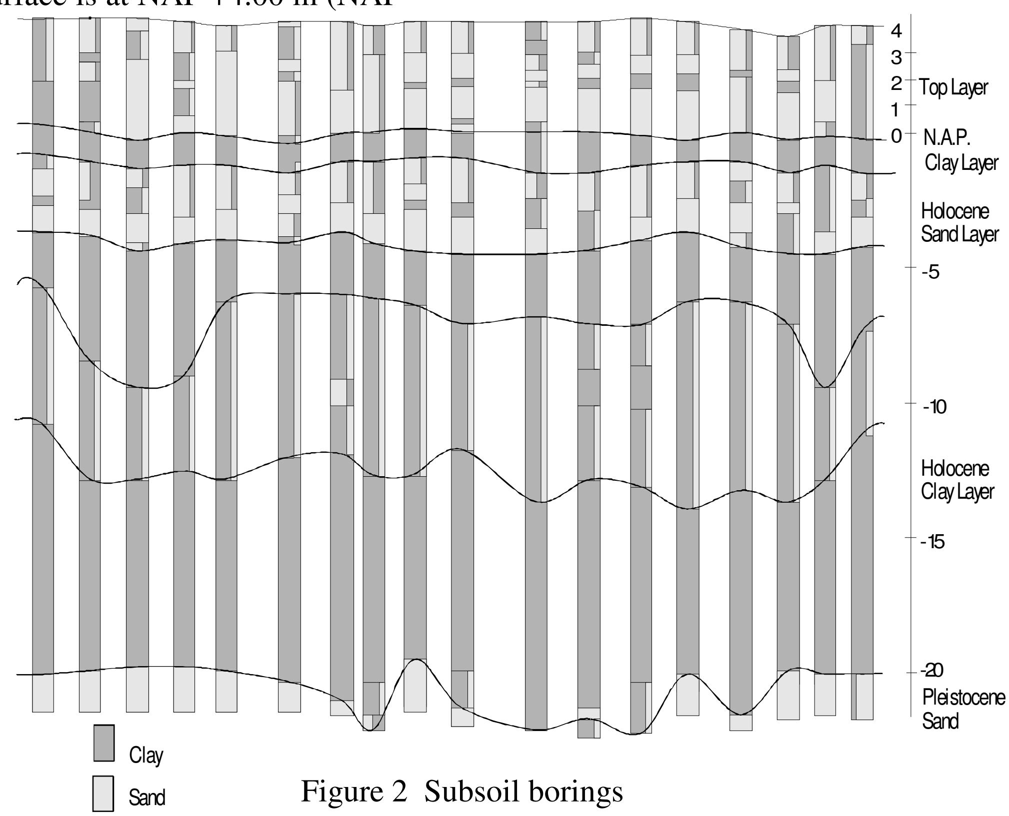

Figure 2 Subsoil borings

22.00 m, with an intermediate layer of sandy clay between NAP -6.00 m and NAP -13.50 m.

In the original situation, there is vertical infiltration of the groundwater from the cover layer in the direction of the deep Pleistocene sand;

- Phreatic groundwater level in cover layer: NAP +1.90 m to NAP +2.80 m
- Rise in Holocene sand layer: NAP +1.10 m to +2.20 m
- Rise in Pleistocene sand layer: approx. NAP +0.25 m

The flow of the groundwater in the cover layer and in the Holocene sand layer is mainly in a northern direction.

To prevent the vertical migration of the leachate, the groundwater level in the Holocene sand layer has to be lowered to approx. NAP, i.e. by an average of 1.70 m. The horizontal permeability in this layer is between 5 to 7 m per 24 hours.

CONSEQUENCES OF THE REMEDIATION

The lowering of the groundwater level within the barrier wall is expected to cause additional 150 mm of ground surface settlement. As ground surface settlements have already occurred within the site, both previous to and after construction of the apartment blocks, the additional settlement can be expected to cause no significant additional negative adhesion ("down drag") to the apartments foundation piles.

The impact on the standing water level outside the barrier wall depends on the hydraulic resistance of the barrier wall. Any drop in the level to be kept to a minimum in order to limit settlement effects in the adjoining residential area. As a consequence of this, the specifications required an average hydraulic resistance of >1,700 days (k value of approximately $7x10^{-9}$ cm/sec) for the barrier wall. Additionally, the bottom of the barrier wall was to be keyed 2 m into the aquitard under the Holocene sand layer.

THE COMPOSITE WALL

In accordance with the specifications, the wall had to reach from top NAP +3.00 m down to a depth of NAP -6.50 m; total wall surface area was approximately 7,000 m.

The 100 mm thick bentonite/cement slurry wall had to be installed using a soil displacement method of the contractor's choice, the generation of spoils not being allowed. The Geolock panels were to be centred in the bentonite/cement wall and the average hydraulic resistance of the composite wall was to exceed 1700 natural days (k = $7x10^{-9}$ cm/sec). For the wall alignment see figure 1.

With the rather stringent specification requirements in mind, the Geolock HDPE vertical barrier system was used as part of the long-term remediation of this site. Geolock is a water and gas impermeable barrier wall, developed by Cofra BV/Geotechnics Holland BV, for use as a vertical cut-off wall. While it has mainly been used in conjunction with environmental remediation projects, it has also been used in civil engineering projects such as dike repairs, building excavations, below-grade motorways and other civil related projects.

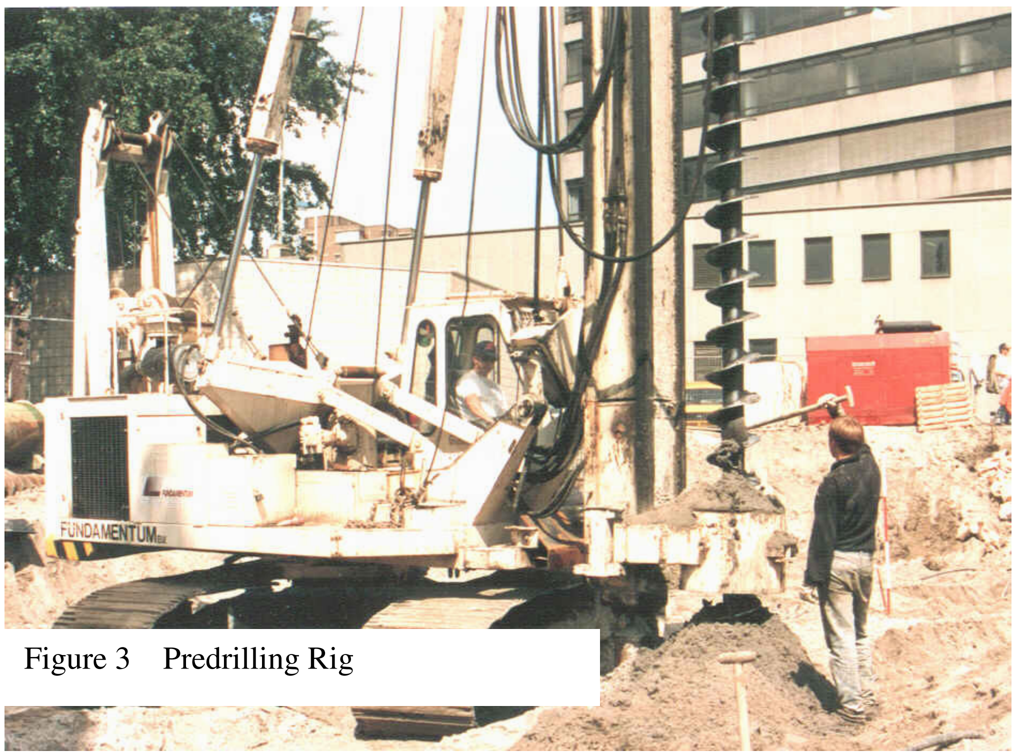

Figure 3 Predrilling Rig

Geolock is a system in which High Density Polyethylene (HDPE) panels are interlocked by means of welded HDPE lock profiles. This flexible, chemically resistant material possesses excellent stress-crack resistance and its service life when buried is measured in the hundreds of years. This highly adaptable material, combined with the well-designed interlocks, allows for installations to depths up to 40 m.

Geolock panels are made to measure and, depending on project requirements, are 1.5 to 2.5mm thick. The lock profiles are approximately 5 mm thick and when interlocked have a tensile strength that is greater than the connecting membrane. This is important if the barrier experiences settlement or other movement in the sub-soils. The Geolock panels will bend, deflect, and even yield but the interlocks will not release. To ensure that the interlocks are water- tight, a hydrophilic, neoprene based rubber, seal is used. The seal fits into a specially designed groove in the female lock profile and is installed as the Geolock panel is installed. Checking the lock connection is possible by using a so-called "fore planer" during installation or by means of an electronic control system.

Specially developed welding and installation methods, suitable for use in practically all soils, guarantees the water and gas tightness of the barrier.

Figure 4 Drilling, bentonite trenching and Geolock installation rig on a row Rig

EXECUTION

The construction of the barrier wall, started in October 1993 and completed that November, was accomplished using 2 cranes (see photographs). Per project procedures, the exact work methods and contingency plans were extensively discussed with management and laid down in advance. This proactive approach resulted in completion of the project with no significant problems.

Because of the presence of rubble and broken concrete in the landfill, it was necessary to prebored pilot holes under a bentonite / cement slurry. The bentonite suspension was prepared in a hydration tank then pumped to the mixer in which the required amount of cement was added. The bentonite/cement mixture was then held in a storage vessel until it was pumped to the point of installation. The level of the bentonite/cement slurry was constantly monitored to ensure that it remained flush with the ground surface. After approximately 2 linear meters of wall was opened, the Geolock panels were immediately installed so as to prevent any damage by the rubble.

The actual installation of the 2 m wide Geolock panels was accomplished using a steel framework especially designed for this purpose. The framework was lowered between 2 ground-mounted guide beams that insured positive control of the installation. An indicator system used during installation of the Geolock panels guarantees that all interlocks are fully connected.

Figure 5 Installed Geolock panels

CONCLUDING REMARKS

Now that a number of these projects have been carried out, it is expected that installations to depths up to 20 m are feasible using this technique. Product improvement is on going and methods to make Geolock panels fully watertight after installation are currently being developed using a special welding device within the interlock.

However, it is our firm belief that for this type of environmental project, it will always be necessary to maintain the groundwater level within the encircled area at a level below that of the surrounding environment. This will insure that any possible groundwater flow will be into the isolated area and not out of it. The use of a long lasting, high quality barrier wall assures that the amount of contaminated groundwater that must be removed and treated to maintain this hydraulic differential is minimised.

The method of construction described in this article shows great promise for use in future projects in that it allows for the construction of a high quality barrier wall, in an economical manner, over a wide variety of site requirements.