Evolution in the Polder


ir. Coen Boekhorst
VWS Geotechniek


ing. Erwin de Jong
Geobest BV


ing. Eelco van der Velde
BAUER Funderingstechniek BV

VolkerWessels and BAUER Funderingstechniek design and construct first Mixed-In-Place Polder in the Netherlands

Introduction

The Netherlands have a worldwide reputation in creating their own country by reclaiming land from the sea. Since the 15th century the Dutch have been creating "polders", areas of reclaimed land below sea level, surrounded by dykes and with a mechanically maintained water level. In the 20th century the use of artificial polders became an interesting construction method for creating underpasses below motorways and canals using watertight geomembranes to create an impermeable layer beneath and surrounding the polder. However these kind of structures have one big disadvantage, they need a lot of space. The main idea of such a structure is that the upward water pressures under the geomembrane have to be in balance with the remaining soil on top of it. For this reason, the geomembrane has to be placed at a depth significantly deeper than the polder surface depending on the hydraulic head in the aquifer. Slopes of 1:3 (1 vertical : 3 horizontal) are most commonly used, resulting in very large excavations and massive earthworks, even for relatively small underpasses.

VolkerWessels, the second largest contractor in the Netherlands, recently started constructing 3 underpasses in artificial polders in the province of

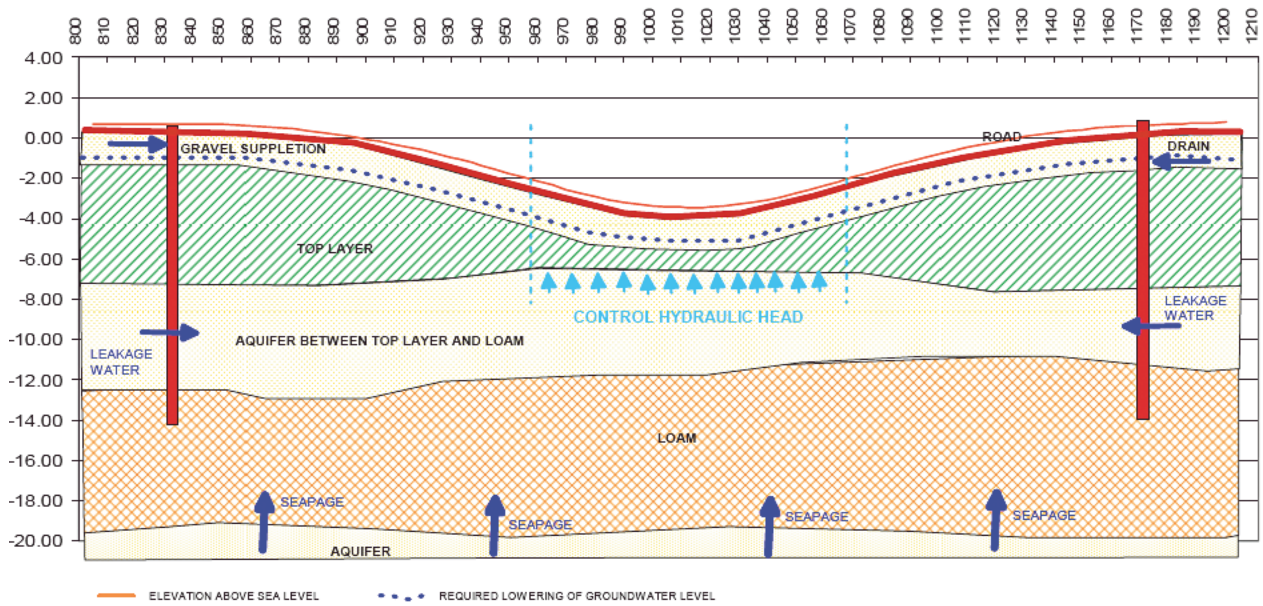

Figure 1

Summary

In recent years the market for Mixed-In-Place soil mix techniques in the Netherlands has been growing rapidly. Initially the technique was used to create cut-off walls near river dikes and as a vibration free method to create retaining walls for building pits.
Studies have been undertaken and projects are executed in order to strengthen the dike itself by the use of Mixed-In-Place technique.
In February 2012 Bauer Funderingstechniek started the construction on the first polder in the Netherlands with their approved Mixed-In-Place cut-off walls. This article explains the background of the project and describes the use of this cost-effective and durable construction method.

Friesland in the north of the Netherlands. Instead of the reference design with geomembranes that was made by the client, VolkerWessels chose to make use of the BAUER Mixed-in-Place soil mix technique to create cut-off walls with a very limited permeability. In combination with the local soil conditions, at a depth of approximately 11 to 15 meters there is a natural impermeable loam layer, "natural" polders are being constructed.

The project

In order to improve the accessibility of the northern part of Friesland, the province of Friesland commissioned the contract to design and build a 2-lane motorway with a length of approximately 7 km, a viaduct and 4 underpasses just northwest of Friesland's capital Leeuwarden. The motorway, which is also known as the NorthWest Tangent, (NWT), should be suitable for a speed of 80 km/hour and should be constructed in a safe and durable manner.

The NWT project is a Design and Construct contract. The contractor was asked to make a preliminary design based on functional requirements that were prepared by the client. For the artificial polders the most important requirement to meet is the very small amount of water that is allowed to be pumped out of the polder once the construction is completed. For the 3 main polders this amount of water is limited to 10 m^3/day per polder. The excavation for the largest underpass KW2 is 4 m below ground level and 3 m below the ground water table. A cross-section of the road and the general soil conditions is presented in figure 1.

At the locations of the 3 main underpasses a soil investigation was carried out consisting of Cone

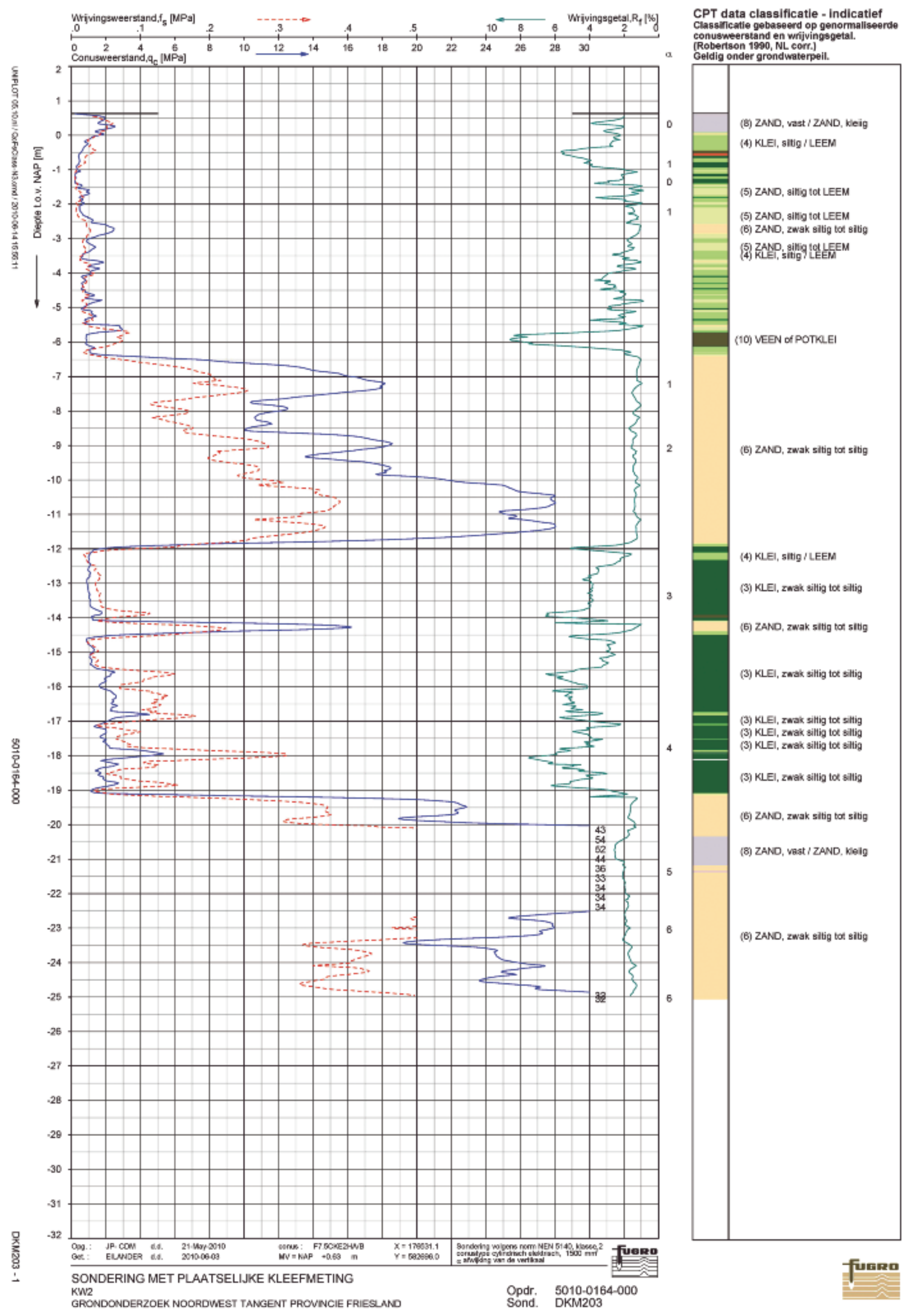

Figure 2

Figure 3

Penetration Tests (CPT), borings and laboratory tests. A typical CPT-result is presented in figure 2. The upper 7 m below ground level consists mainly of clayey and silty sand deposits with a limited permeability in vertical direction. The groundwater table varies from NAP -0,5 m to NAP -1,3 m. Between 7 m and 12,5 m below ground level, a dense silty sand layer is encountered with a high permeability in all directions. The water head in this layer varies from NAP +0,2 m to NAP -0,6 m. The partly over-consolidated loam layer between 12,5 and 19,5 m has a very limited permeability and is applied in the design as a natural barrier against groundwater flow. Below this layer a very dense, high permeable sand layer is present with a water head that varies from NAP +0,2 m to NAP -0,6 m.

In order to meet the requirements of the client, it was necessary to investigate the permeability of the loam layer in the laboratory. For KW2 a total of 8 falling head tests were carried out resulting in an average resistance against groundwater flow of 2.600 day/m for the loam layer. For a polder area of almost 6.500 m^2 the resulting water seepage is 3,5 m^3/day. Since the requirement of the client limited the total amount of water seepage to 10 m^3/day, this leaves 6,5 m^3/day of allowable seepage through the cut-off wall. Therefore the permeability requirements for this cut-off wall were set to a maximum of 1.10-9 m/s. In order to construct a permanent cut-off wall with a 80 years life-time, the minimum strength of the cut-off wall has to be at least 0,3 MPa to prevent erosion.
VolkerWessels chose the triple auger Mixed-In-Place soil mix solution of BAUER Funderingstechniek to fulfil these strict requirements and to ensure a high quality level.

Basic principle of BAUER's Mixed-In-Place

The term 'Mixed-In-Place', (MIP), describes the process of mixing soil in-situ with binder. During the MIP process, the existing pores within the soil structure are filled with the binder slurry.
The result of this process is a solidified continuous soil-cement body. The shape of the soil-cement body is defined by the geometry of the augers.

BAUER, worldwide leading foundation contractor, developed for more than 15 years their MIP soil mix techniques for walls. Construction of a MIP wall is carried out by drilling a triple parallel continuous flight auger system mounted at the front leader of a heavy duty drilling rig to the required depth. To construct the cut-off wall, the triple counter rotating augers are drilled into the ground whilst binder slurry is simultaneously injected through the hollow stem of the central auger. On reaching the final elevation, the soil-binder mixture is homogenized by alternating rotation of the individual augers and concurrent upward and downward movement of the entire auger assembly.
To ensure the construction of a continuous wall, free of joints, individual panels are constructed in an alternating sequences of overlapping primary and secondary panels, followed by a remixed panel. The width of primary panels for the 0,55 m augers, is 1,70 m, that of the secondary panels is 1,20 m.

The construction sequence is characterized by additional re-working of the overlaps between primary and secondary panels. This ensures that each

section is penetrated and reworked twice by the triple counter-rotating auger unit. Due to this "wet into wet" construction sequence the constructed wall will be virtually without gaps or joints. See figure 4.
All relevant production parameters required for Quality Assurance (QA) purposes such as drilling depth, volume of slurry placed, rate of flow, auger speed and time of installation, are automatically being recorded as time-dependent relationships with the so-called B-Tronic-System installed inside the rig operator's cabin. In addition, the position of the base of each individual panel was surveyed by an integrated verticality measuring device in both outer augers and displayed online for the rig operator.

Prior to the start of the actual works an extended feasibility study is performed with samples of the local soils. Different soil layers are put together and mixed with the cement slurry to investigate the right mixture, which is tested on permeability and compressive strength. Based on this study the site specific in-situ mix recipe is selected.

MIP in the Frisian polder

Construction of the MIP cut-off walls at the NWT project Leeuwarden is carried out with BAUER's largest rig generally used in MIP technology, a drilling rig of type LRB255 (figure 3). This rig is able to install wall depth down to 17,5 m. with a diameter of the augers of 0,55 m.

The project specific QA system consists, beside recording all relevant installation parameters, in taking samples out of the fresh soil-cement body and performing compressive strength and permeability tests after 28 and 56 days. The specific test program for this project is set at extraordinary high testing intervals to guarantee the strict permeability requirements. So far, several tests performed on MIP wall samples showed permeability and compressive strength results, which are well within the specified requirements. To obtain the required wall strength parameters, no additional reinforcement is applied in this project.

Execution at KW2 started in the beginning of February 2012 and all 3 polders will be constructed in June 2012. At that moment over 27.000 m^2 of MIP cut-off wall with an average production of 300 m^2/day, will be installed and the Netherlands will have 3 more polders.

The use of cut-off walls with the MIP soil mix techniques to create artificial polders, is being considered for several other projects in the Netherlands. The MIP technique, as patented by BAUER Spezialtiefbau GmbH., offers a technical, ecological and extremely cost-effective alternative to conventional cut-off and retaining walls.

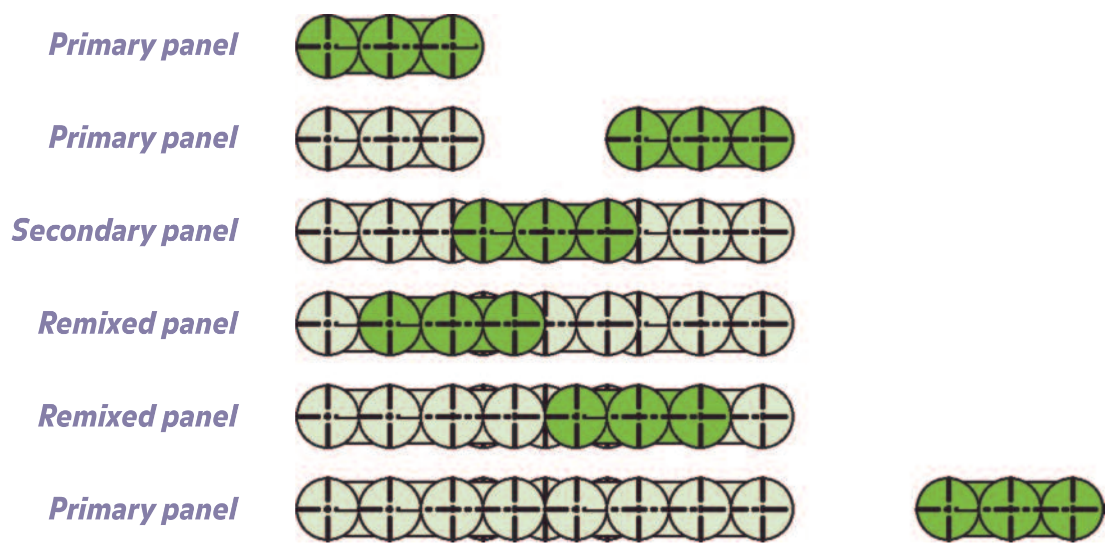

Figure 4