SUSTAINABILITY OF A SAND – BENTONITE POLYMER GEL. AN EVALUATION OF LAYERS OF TRISOPLAST EXCAVATED FROM OLD TOP BARRIERS

EFICIENȚA GELULUI POLIMERIC NISIP – BENTONITĂ. EVALUAREA STRATURILOR DE TRISOPLAST EXTRASE DIN VECHI ETANŞĂRI DE SUPRAFAȚĂ

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ABSTRACT. The water permeability of mineral barrier layers can increase in the course of time as a result of the aging process, due to dehydration and damage due to root growth for example. According to laboratory research and (digital) modelling, the Trisoplast® sand-bentonite polymer gel should be much less susceptible to these effects than traditional mineral barriers. In order to test this, excavations were carried out on barrier layers built in 1995, 1996, 1998 and 2001. The results of the tests after the excavations demonstrate that the functional properties of the layers have indeed not changed over the course of time. The material is still homogeneous, moist and typically plastic. Above all, the layer has retained its very low water permeability. This article gives a short summary of the results. The academic publications and more details about the results of the tests following excavation can be found in the reports mentioned in the list of references.

REZUMAT. Permeabilitatea la apă a barierelor minerale poate creşte în timp ca urmare a proceselor de îmbătrânire, datorită deshidratării şi deteriorării produse, de exemplu, de penetrarea rădăcinilor. În conformitate cu cercetările de laborator şi modelările numerice efectuate, gelul polimeric nisip – bentonită Trisoplast® ar trebui să fie mai puțin sensibil la aceste efecte decât barierele minerale tradiționale. Pentru a verifica acest lucru s-au realizat încercări pe bariere puse in operă în 1995, 1996, 1998 şi 2001. Rezultatele încercărilor realizate după extragere au demonstrat că proprietățile funcționale ale straturilor nu au fost modificate în timp. Materialul este încă omogen, umed şi plastic. Şi, mai presus decât orice, materialul şi-a conservat permeabilitatea scăzută. Acest articol prezintă o sinteză a rezultatelor. Publicații şi detalii despre rezultatele încercărilor pot fi găsite în rapoartele menționate în bibliografie.

1. Introduction

A mineral barrier, such as a Trisoplast®, sand-bentonite mixture or sometimes bentonite mats or clay for example, is often used to seal waste heaps, industrial estates, polluted soil and ponds. Trisoplast® is an innovative, patented insulation material for soil barriers, developed by GID Milieutechniek in Velddriel. It comprises a clay-gel mixed with a filling material (sand for instance) and is applied as an unbound, loose mixture, after which it is sealed in layers of generally between 6 to 9 cm.

The clay-gel is formed as soon as water penetrates into the mixture of clay minerals (bentonite) and polymers. A very thick gel structure with a particularly good barrier effect is formed by the network of chemical bonds between the bentonite and the polymers. The permeability of this mixture is generally less than 3×10^{-11} m/s. This means that it easily meets the Dutch and

European requirements for barrier layers. After an intensive testing procedure, the Ministry of Housing, Spatial Planning and the Environment [*Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer*] (VROM) has recognized the mineral as at least equivalent to a "standard" (3.5 to 5.5 times thicker) sand-bentonite barrier. Because of this it is to this day still the only nationally accepted alternative for the standard bottom and top barrier. In Germany too the material is recognized as a complete alternative for the clay barriers used there.

Various tests (Weitz et al, 1994; Boels and Veerman, 1996; Boels and Schreiber, 1999; Boels and Beuving, 2000; Boels and Breen, 2001; Melchior et al, 2001; Wienberg, 2005; Fugro, 2006) demonstrated, amongst other things, that Trisoplast® is resistant to percolation water, seawater, pure benzene, mineral oil, saturated phenol solution, low and high pH, variations in condensation and temperature etcetera. Even a bi-axial stretch to 10% has hardly any effect on the permeability. In addition, in the relevant tests the polymer has proven to be very sustainable.

2. Background

Following construction, a mineral barrier layer will have a long period of exposure to cycles of drying and wetting. When clay dries out there is chance of shrinkage and cracking. After excavating various top barriers, Melchior concluded that in a few years even in relatively wet climatic conditions clay-barriers lose their functionality due to the effects of cracking and root-growth penetration (Melchior et al, 2001). This same fate also applied, according to Melchior (2002), to barriers with bentonite-mats.
In comparative laboratory tests between a German clay and Trisoplast®, various wet-dry cycles were applied, under pressure and in the presence of calcium-rich percolate. From this it proved that the clay layer cracked due to dehydration after a single cycle, and lost its functionality at a water pressure of 600 hPa. Conversely, Trisoplast® maintained its plasticity, moistness and low permeability, even with multiple, long cycles (5 years and total dehydration (Melchior et al, 2001)).

Based on laboratory experiments and (theoretical/digital) model calculations the projections were favourable. However, excavations of old barrier layers provide the opportunity to re-examine the properties of the material and thereby check whether or not the aging processes have affected the quality of the Trisoplast®.

3. Locations excavated

In total, eight excavations were undertaken, at four landfills, one tank farm and one road body. The details of the locations excavated are shown in Table 1.

At two locations a combination barrier with HDPE had been constructed. The other six were chosen exactly because single barriers were involved. The effects of the aging process can be much better observed on these. In order to examine the durability of the layers, the moisture content and permeability of each layer was determined after a visual inspection. In addition, electron microscope photographs were taken in order to be able to determine the quality at a microscopic level. The results are shown below.

Table 1. Description of the locations

Location	Europort Rotterdam/VBM Maasvlakte		Vopak-Rotterdam	Almere		Soesterberg	Pritzwalk	T106
Profile	1	2	3	4	5	6	7	8
Type	Industrial waste		Oil storage	Domestic waste		Demolition waste	Domestic waste	Road body
Construction date	1995	1995	1996	1996	1996	1996	2001	1998
Excavation date	2001		2001	2001		2001	2005	2006
Vegetation	grass		gravel	grass and shrubs		grass, shrubs and trees	grass	asphalt and grass
HDPE geomembrane	yes	no	no	no	no	yes	no	no
Thickness of top layer (m)	0.55	0.60	0.30	1.40	1.20	1.25	1.00	1.30

4. Results

All eight of the layers tested had a visibly homogeneous colour, water content, density, thickness, plasticity and structure. There was no indication whatsoever of dehydration or cracks (*photograph 1*).

Moisture content and root growth

It proved that none of the layers had been damaged by root growth, while at VBM considerable root growth was present down to the trisoplast layer.
In the structures where HDPE-foil had been applied (1 and 6), the moisture content was measured in percentage by weight, 12.4% for 1 and 10.8% for 6. The moisture contents of the layers without foil (2, 3, 4, 5, 7 and 8) were up to 25% higher on average.

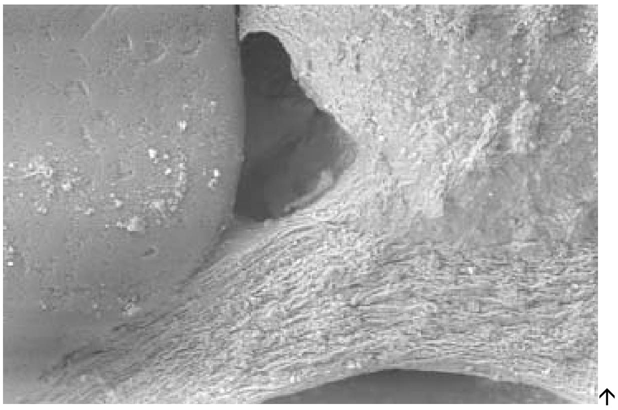
Electron microscopy

Electron microscopy demonstrated that at the microscopic level too the composition of the layer was homogeneous (*see photograph 2*). In this photograph it can clearly be seen how the polymer forms a gel with the bentonite which binds into the pores of the individual sand grains, and forms an almost impenetrable, elastic layer.

Permeability

Sample rings specially developed for the excavation (*see photographs 3 and 4*) were used, amongst other things, in order to determine the permeability. The permeability after excavation was compared with that measured during construction. From this it proved that the currently measured values do not differ from those achieved during the construction

Photograph 1. Check of layer thickness after excavation



Photograph 2. Photograph taken with electron microscope

Photograph 3. Taking a sample during excavation

Photograph 4. Sample ring developed for the excavations

5. Conclusion

The results from the excavations confirm the projections from the laboratory experiments and (theoretical/digital) model calculations. Aging processes in the period between construction and excavation have had hardly any to no effect on the quality of the sand-bentonite polymer layer. Through the excavations it was confirmed that even years after construction, Trisoplast® continues to perform much better than is required on the basis of the Dutch (Landfill Decree) and European legislation and is thus a very durable barrier.

6. References

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