Innovative, Protective Mattresses for Landfill Geomembranes

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ABSTRACT: Protective layers have to protect the synthetic lining membrane of a landfill from damage caused by loads in the long term. The requirements for protective layers with regard to mechanical protective capacity and durability will be explained. Both concrete and sand mattresses fulfil these requirements. A report will be given on a landfill project with concrete mattresses. Sand mattresses protect liners efficiently even if heavy loads are present.

1 INTRODUCTION

The Third General Administrative Regulations under the Waste Act (TA Siedlungsabfall, 1993) of 14 May 1993 laid down that the "combination sealing" is to be used in Germany as the base sealing system for landfills of class II (Fig. 1). This combination sealing consists of a 75 cm thick three-layered mineral liner with a permeability of $k \leq 5 \cdot 10^{-10}$ m/s and a 2.5 mm thick HDPE synthetic liner.

A further important element of this sealing system is the protective layer which has to protect the synthetic lining membrane from damage caused by loads, e.g. by the grains of the gravel drainage layer with a gradation of 16/32 mm.

Plans often provide for protective layers made of 1200 g/m^2 nonwoven and a 15 cm thick layer of 0/8 mm crushed aggregate. For reasons to do with costs, but also because of the difficult installation work involved with the relatively thin crushed aggregate layer, as well as erosion and stability problems in the area of the slopes, this type of protective system is seldom installed. Pure geotextile protective layers made of up to 3000 g/m^2 reinforced nonwoven, which are economic and easy to lay, are used more often.

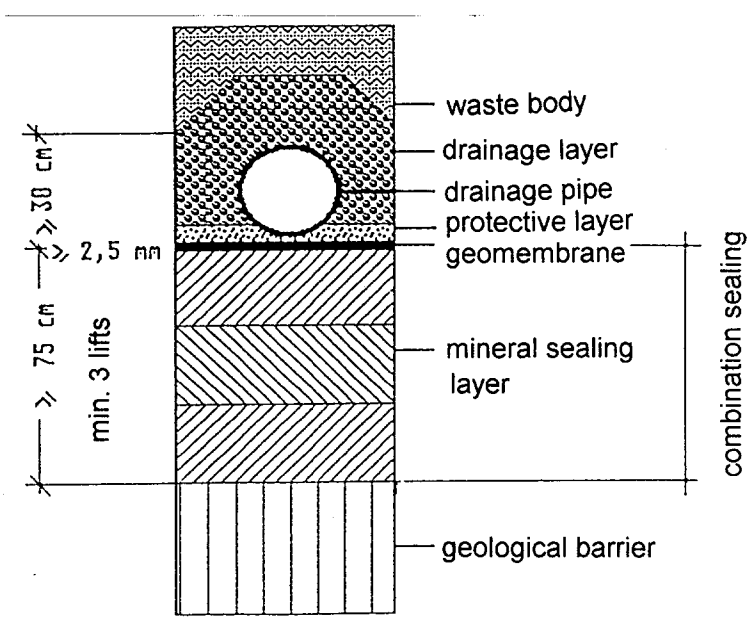

Fig. 1 Base sealing system for landfills of class II according to TA Siedlungsabfall, 1993

At the same time, possible high impacts caused by chemicals mean that these systems are not regarded as possessing sufficient permanent chemical resistance. For this reason, in the recent past composite protective systems consisting of synthetic and mineral components have been preferred. This is a report on two such systems.

2 REQUIREMENTS FOR PROTECTIVE LAYERS

Proof must be shown of the mechanical protective capacity of the mineral components of a protective layer. Moreover, in the case of non-mineral components durability must also be given. Proof of durability covers tests of chemical resistance to highly concentrated liquid media, a weathering test, a test of the thermal-oxidative decomposition and a soil burial test for resistance to micro-organisms. Details of durability testing can be seen in (August and Müller, 1993).

Proof of suitability with regard to mechanical protective capacity is shown by means of a modified plate loading test which is carried out over a 1000 hours test period (Bundesanstalt für Materialforschung und - prüfung, 1992). The following are additional important test conditions:

- diameter of the pressure cell min. 300 mm
- layer construction as shown in Fig. 2
- test temperature approx. 40°C
- test pressure corresponding to 1.5 times the load from the maximum height of the landfill and the mean density of the landfill body.

A protective layer is deemed to be suitable if after the 1000 hours trial the depressions measured in the synthetic liner correspond at the most to maximum strain of 0.25 %. Strain is determined in the experiment by means of a tin foil arranged under the liner

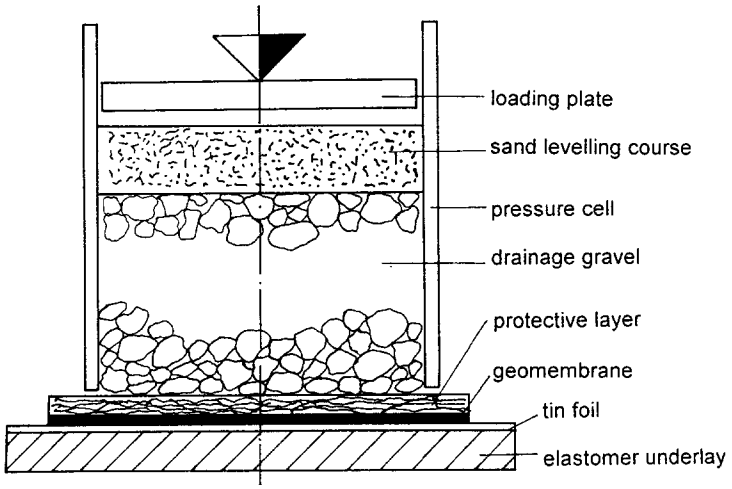

Fig. 2 Test device for modified plate loading test

which "stores" the deformations of the synthetic layer (Kirschner and Witte, 1991). Under certain conditions, higher maximum strain in the liner up to 1 % is permitted. Notches, cracks and perforations in the liner are not permitted at all.

A complete quality assurance plan from the moulding material through the granules to the finished product is required for the certification of a protective layer system by the Federal Agency for Material Research and Testing (Bundesanstalt für Materialforschung und -prüfung).

3 PROTECTIVE MATTRESSES

Concrete mattresses have been used for some time in hydraulic engineering. These consist of two layers of woven specially linked with spacer threads and filled with concrete (Fig. 3). These mattresses are usually used to protect against erosion on the banks or beds of rivers and canals or as breakwaters in coastal protection systems.

Concrete mattresses are also suitable for use as protective layers in landfill construction if the requirements referred to in Section 2 are fulfilled. This is the case where the synthetic components consist of HDPE and the concrete does not experience any cement corrosion through the

landfill leachate. This is achieved when calcium and sulphate of the concrete is prevented from leaching out (N.N., 1991) by

- use of sulphate-resistant cement
- a low water-cement ratio of roughly 0.35
- achievement of a high hydratation degree (through long, wet treatment after casting).

The problem of cement corrosion resp. chemical resistance can be avoided in principle if the two layers of woven are filled with sand instead of concrete. Sand is an inert material which can be pumped and can flow in a mixture with water and clay minerals. This type of sand mattress for landfill construction has been tested since 1992.

Proof of the mechanical protection capacity not only of concrete mattresses but also of sand mattresses must be shown in relation to each project.

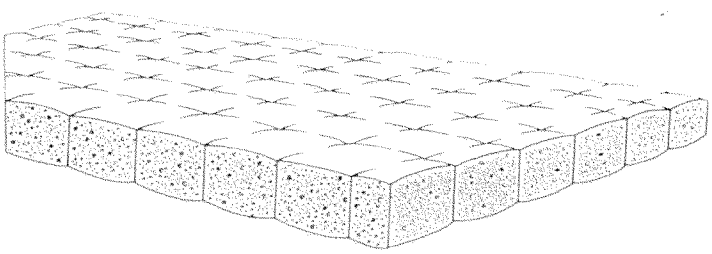

Fig. 3 Standard concrete mattress

4 DAMSDORF LANDFILL

In 1992 the concept of a concrete mattress to protect the synthetic liner was realized over an area of 60,000 m^2 for the Damsdorf landfill in Northern Germany (Fig. 4).

The landfill, which is in a 16 m deep former sand quarry, was given a combination sealing at the base consisting of a 60 cm thick clay liner and a 2.5 mm thick HDPE synthetic liner. On top of this there is a an HDPE nonwoven, 500 g/m^2, and 15 cm thick hydraulically bound base course to protect the liner. A drainage layer was not installed; instead of this, generously dimensioned coarse (16/32 and 32/64) gravel drains were placed at distances of 40 m.

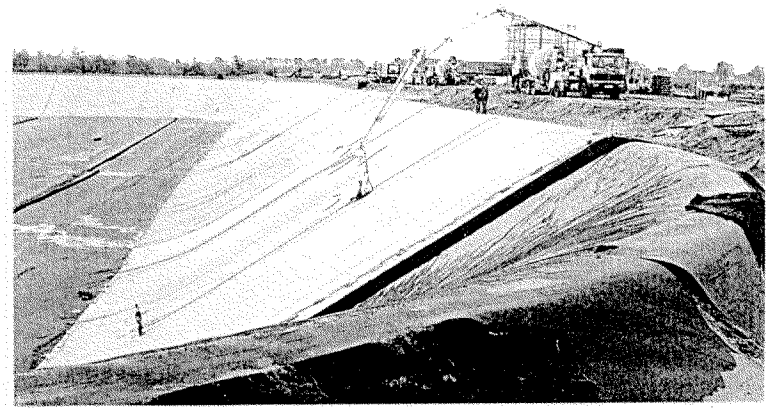

Fig. 4 Damsdorf landfill site

A mineral liner was not chosen for the slopes because of the extreme inclination of 34° and instead a synthetic liner alone was used. The protective layer consisted of a 10 cm thick Incomat(R) concrete mattress (N.N., 1992).

During the concrete filling process, the tensionproof two-layer woven takes over the sliding forces which are absorbed on the crown of the slope through a temporary anchoring with soil nails. After the concrete has set, this "concrete plate" is supported at the base on the hydraulically bound base course which serves as an abutment. For this reason the concrete must have a compressive strength of $\beta_{c28} \geq 10$ N/mm^2 and a bending tension strength of $\beta_{bt28} \geq 3$ N/mm^2.

Along with effective protection against mechanical damage to the liner during and after filling the landfill with waste, the concrete mattress offers further advantages: as soon as the concrete has been cast the relatively heavy weight of the concrete mattress prevents corrugations forming in the liner due to temperature changes. A good bonding between the syn-

thetic liner and the mineral layer is guaranteed in this way. In addition, thanks to its good heat insulation properties the concrete mattress protects the landfill slope in winter from the effects of frost. There is also a relatively low water permeability.

5 SAND MATTRESSES

The sand mattress, type Incomat(R) as well, is prefabricated with a maximum size of 40 x 25 m. On site, several of these panels can be joined together by means of double zips or by being sewn together and then filled with a sand-water-clay minerals mixture with a weight ratio of 72:25:3. Mixing is done in a standard concrete mixer. The sand mattress is filled to 5 cm thickness by means of a concrete pump.

The protective capacity is excellent. With a temperature of 40 °C, a test pressure of 1500 kPa and a 16/32 gravel, after 1000 hours duration a maximum strain of approx. 0.03 % in the area of the zips was determined (Amtliche Materialprüfanstalt, 1992).

Up the present it has been possible to test and optimize the installation technique in smaller test areas with a total of 600 m^2. The use of about 90,000 m^2 sand mattresses is planned for early 1994.

6 CONCLUSIONS

Proof of the durability and the mechanical protective capacity of both the sand mattress and the concrete mattress has been shown. The concrete mattress is particularly suitable for use on steep slopes. The sand mattress is to be recommended for extremely heavy loads because of its good protective capacity.

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