

TECHNICAL GUIDANCE ON GEOTECHNICS OF LANDFILLS AND CONTAMINATED LAND

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SYNOPSIS

This paper is based on the Technical Recommendation "Geotechnics of Landfills and Contaminated Land" prepared by the European Technical Committee No. 8 (ETC 8) of ISSMFE with the following members :
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INTRODUCTION

In recent years there has been an increasing requirement for guidelines concerning the geotechnical aspects of waste disposal sites. The reason for that development is the fact that the safety of a waste disposal site depends on the properties of the subsoil, the so-called geological barrier, and further on the sealing systems at bottom and on top. In addition, the stability analysis of landfills is based on principles which are common in geotechnical engineering.

The following geotechnical aspects are believed to be decisive :

- general design principles including multi-barrier concepts
- composite sealing systems
- suitability tests
- deformability of mineral seals
- contaminant migration
- stability and settlement analysis of the waste body
- quality assurance.

In this paper composite sealing systems and quality assurance are discussed. The basis for this are the recently published Recommendations of the Committee on Geotechnics of Landfill Design and Remedial Works of the German Geotechnical Society (GDA, 1990) and the draft version of the Technical Recommendations on Geotechnics of Landfills and Contaminated Land (ISSMFE, 1990) prepared by the European Technical Committee 8 (ETC 8) of ISSMFE. The Recommendations are prepared as supplement in to the Technical Instructions on Disposal of Hazardous Waste of the German Federal Administration (TA-Sonderabfall, 1990).

SOME PRINCIPLES OF THE GEOTECHNICAL DESIGN OF LANDFILLS

A landfill is a highly complex engineering structure. Therefore, the design which should be prepared by a geotechnical expert, must take account of all factors

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which are important to the construction, operation and closure of the landfill. Before preparing the design these factors must be clearly defined. For example, an extensive site assessment for assessing the geological, hydrological and hydrogeological conditions is an important basis for the design of a landfill. In addition to this all requirements arising from specific regulations or other concerns related to the geotechnics and management of the landfill must be given particular consideration.

Design options should be set out and evaluated. All standards and other regulations on which the design is based must be listed, together with any corresponding preliminary decrees, legal bases and the literature used. In the design and contract documentation, allowance must be made and checked either separately or in sections for convenience of construction in accordance with the principles of quality assurance.

In the geotechnical design the following design aspects or safety components have to be considered (see Fig. 1) :

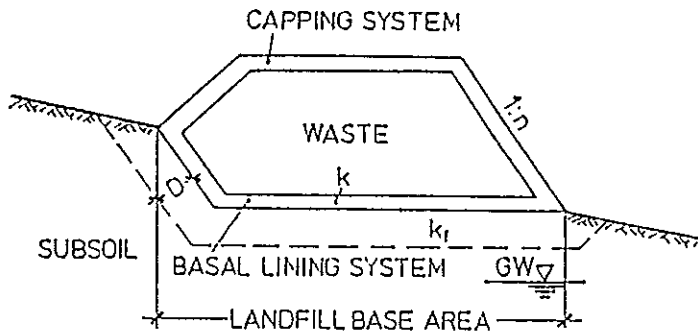


Fig. 1 Landfill with Sealing Systems

k = hydraulic conductivity of sealing layer
 k_l = hydraulic conductivity of geological barrier

- subsoil as a site barrier
- basal lining system
- waste body (including internal landfill gas and leachate management systems)
- capping system
- disposal site environment
- geotechnical aspects of operations
- geotechnical concerns regarding the removal of gas leachate from the landfill
- geotechnical aspects of restoration/recultivation
- site closure and subsequent measures
- supervision and long-term monitoring.

8	waste
7	transitional layer (if necessary)
6	drainage blanket
5	protective layer
4	geomembrane
3	mineral sealing layer 1st lift 2nd lift 3rd lift last layer in each case
2	subgrade (in the case of embankment or soil replacement)
1	subsoil

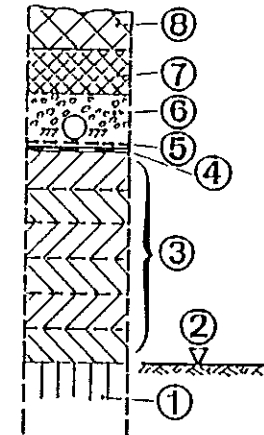


Fig. 2 Layer Zones and Relative Levels for a Composite Basal Lining System

COMPOSITE BASAL LINING SYSTEMS

A composite basal lining system (Fig. 2) may comprise a sequence of drainage blankets, transitional and sealing layers. The sealing layers may themselves be composite when a geomembrane is placed directly on a mineral sealing layer, thus minimizing the impact of local defects combining the advantages of both materials. In principle, the functions of each element as a geotechnical barrier are as follows :

Mineral sealing layer

- minimisation of seepage and diffusion, related to the choice of material, compaction and thickness of the layer;
- resistance to erosion and water penetration;
- resistance to leachate related to the swelling clay mineral content;
- heavy metal absorption capacity related to the clay mineral or organic content;
- non-susceptibility to settlement and self-healing ability related to the plasticity characteristics which are determined by the clay content and the particle size distribution;
- effects of swelling and shrinkage related to hydrogeological conditions.

Geomembrane

- non-susceptibility to settlement related to stress-strain behaviour;
- prevention of leakage;

- long-term chemical resistance depending on the material used and the thickness of the membrane in combination with the mineral sealing layer.

Interface between the sealing layers

- at perforation points in the geomembrane prevention of the lateral spread of leachate at the interface;
- prevention of any great water pressure behind the geomembrane;
- sealing effect in the interface related to :
 - a) the smooth fine-grained character of the surface of the mineral sealing layer;
 - b) the load-dependent deformation behaviour of the geomembrane and the mineral substratum;
 - c) effect of change in the gradient of the sub-grade related to the load-dependent deformation of the geomembrane.

The layers above the geomembrane, arranged one above the other, perform the following roles in the composite system :

Protective layer

- permanent distribution of concentrated stresses on the geomembrane by the angularity of the drainage blanket and the protective effect of the geotextile, if any, plus chemical resistance to leachate and resistance to slippage, if appropriate.

Drainage system

- the drainage system permits the collection and removal of leachate from the waste, thereby preventing the build-up of leachate above the sealing system.

Although there are some arguments against the use of a composite basal lining system, especially on inclined slope surfaces, today it is believed that this system should be used especially for landfills of toxic and hazardous wastes (TA-Sonderabfall, 1990). According to these technical regulations the composite lining system must be chosen as basal lining system and capping system with the following measures :

- a) basal lining system
 - mineral sealing (low permeability soil layer) $d > 1.5$ m; clay mineral content $> 10\%$, $k < 5 \times 10^{-10}$ m/s, inclination $> 3\%$
 - geomembrane $d > 2.5$ mm, specified material
- b) Capping system
 - mineral sealing $d > 0.5$ m; clay mineral content $> 10\%$, $k < 5 \times 10^{-10}$ m/s, inclination $> 5\%$
 - geomembrane $d > 2.5$ mm, specified material.

The drainage blankets with drainage pipes are placed on the top of the lining

systems with the following measures :

- drainage blanket grain size 16/32 mm, $d > 0.3$ m; $k > 1 \times 10^{-3}$ m/s, drainage pipes DN 300.

QUALITY ASSURANCE

To ensure the quality of the overall structure of a landfill, all individual components must meet the quality standard. The quality assurance must relate to both the quality of the material used and to the quality of the execution of work according to the existing state of technology. The quality assurance should comprise :

- in-house testing by the contractor
- external testing by an independent party.

If appropriate, the regulatory authority may request tests on random samples. All tests must be supervised by a qualified geotechnical expert with extensive knowledge in the field of waste disposal techniques. These tests comprise :

- initial testing of the construction materials to be processed
- test on the processing of the materials
- supervision of all work, material characteristics and functions which determine the quality.

The holder of the planning permission for a specific waste disposal site should apply to the regulatory authority for final acceptance. This should be supported by full documentation of results relating to the site, and include tests relating to :

- construction of elements of the work and the complete structure;
- adherence to the requirements of the quality plan.

The following scope of testing represents one test in the area of a sealing layer, both for the in-house test and for the external test :

- characteristics of the materials to be used, determining grain size distribution, consistency limits, water intake and water content (every 1000 square metres);
- water content on placement, homogeneity of the material placed, number of passes with the roller, quantity of water added, if any (every 1000 square metres);
- minimum clod size, cutting depth and quantity of additives or dosage in the case of multiple component mixtures in the pressure mixer (every 1000 square metres);
- thickness of the individual lifts, evenness of the lift surfaces and adherence to proposed levels and dimensions (every 500 square metres);
- degree of compaction and homogeneity achieved in the sealing layer for each lift by determination of density and water content, grain size distribution and plasticity, if appropriate, and by survey (every 1000 square metres);

- determination of the permeability of the sealing layer for each lift (per 2000 square metres).

SUMMARY

The text deals with the Technical Recommendations "Geotechnics of Landfills and Contaminated Land" prepared by the European Technical Committee No. 8 (ETC 8) of ISSMFE. The presentation of two important geotechnical aspects in the design of landfills, the composite basal lining system and quality assurance shows that a safe landfill requires careful planning and construction. All case-specific conditions in the design and construction of a landfill have to be taken into consideration seriously.

These Technical Recommendations "Geotechnics of Landfills and Contaminated Land" shall serve as an internationally accepted guidance for the application of the general geotechnical principles in the design and construction of landfills. For each specific landfill these principles apply accordingly.

REFERENCES

- GDA-Empfehlungen des Arbeitskreises (1990). "Geotechnik der Deponien und Altlasten". Deutsche Gesellschaft für Erd- und Grundbau (eds.). Verlag Ernst & Sohn, Berlin.
- ISSMFE/ETC 8 (1990) : Geotechnics of Landfills and Contaminated Land-Technical Recommendations. Verlag Ernst & Sohn, Berlin.
- TA-Sonderabfall (1990). Technical Instructions for the storage, chemical/physical and biological treatment, incineration and disposal of hazardous waste, TI Hazardous Waste, Bonn.