THE USE OF GEOSYNTHETICS FOR WASTE STORAGE CONTAINMENT ; TECHNICAL ASPECTS AND RECOMMANDATIONS.

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ABSTRACT

A waste storage landfill can be realized in security conditions if some principles are respected, by means of technics for etancheification. A lot of experiences are realized in U.S.A., CANADA and GERMANY. Wallonia, the south region of Belgium, has also a lot of sites, that are able to receive wastes. But it can produce a lot of problems - pollutions of underground, contamination of phreatic water - if technical and engineering solutions are not adopted.For many types of landfills, the use of geosynthetics can give an adapted response to these problems and give a guarantee for a normal service-life of the structure.

1. INTRODUCTION

The purpose of lining of hazardous waste surface impoundment and landfills is to reduce the risk that polluting fluids will migrate away from the site and contaminate surface and ground water resources. The use of impoundments and landfills to store, treat and/or dispose of unwanted materials has been common practice for industry and municipalities.
Since these types of facilities often prove to be cost effective solutions to hazardous waste handling requirements, their use will continue.

As defined earlier (SCHULTS (1984), the proper planning, design, and construction of lined containment facilities involve numerous steps including the following :
- defining facility function, location and geometry;
- designing a liner system that is compatible with the substances to be stored or treated;
- planning suitable subgrade preparation, seepage monitoring and collection systems (if appropriate);
- planning proper liner installation;
- developing appropriate post-installation operation, maintenance, use and closure plans.

Quality assurance and control are developped, due to the fact that :

- once it has been realized and covered by waste, a lining system may not be repaired in case of damage (valid for bottom and slope linings);
- the latest permeability requirements request global k values 10^{-11} m/sec for the whole lining which may be obtained by very complex barrier systems combining mineral (clay, sand, gravels) and synthetic (geotextiles, geomembrane,...)materials;
- waste potential activity or danger may be 30, 50, 100 years long or more;

- such long term service life must be insured in spite of the fact that some uncertainties remain concerning the long term behavior of the barrier constitutive materials like clay dessication, geomembranes behavior, seams behavior,...;
- human life has no price.

2. GEOSYNTHETICS USED IN LANDFILLS

Geosynthetics are materials used in soil and are synthetic products. The specific families of geosynthetics are :

- geotextiles;
- geomembranes;
- geogrids;
- geocomposites;
- geonets.

2.1. Geotextiles

The are a permeable polymeric material which may be woven, non woven or knitted. The fibers are made into a flexible, porous fabric - essentially polypropylene, nylon nd polyester -by standard weaving machinery or are matted together in a random or a non woven manner. Some of them are also knitted. The major point is that they are porous to water flow accross their manufactured plane and also within their plane, but to a widely varying degree. The fabrics always performs at least one of the five discrete functions

1. Separation;
2. Reinforcement;
3. Filtration;
4. Drainage;
5. Moisture barrier.

2.2. Geogrids and geonets

They are plastics formed into a very open netlike configuration. Often they are streched in one or two directions for improved mechanical properties. Their function are in two ways :

1. Separation (occasionnaly);
2. Reinforcement (usualy);

2.3. Geomembranes

Geomembranes are "impervious" thin sheets of rubber or plastic material used primarily for linings and cover of liquid - or solid-storage impoundments. So their primary function is always as a liquid or vapour barrier.

2.4. Geocomposites

A geocomposite consists of a combination of geotextile and geogrid, or geogrid and geomembrne, or geotextile, geogrid and geomembrane, or any one of these three materials with another one (e.g.with soil, steel cables, steel anchorages,...).

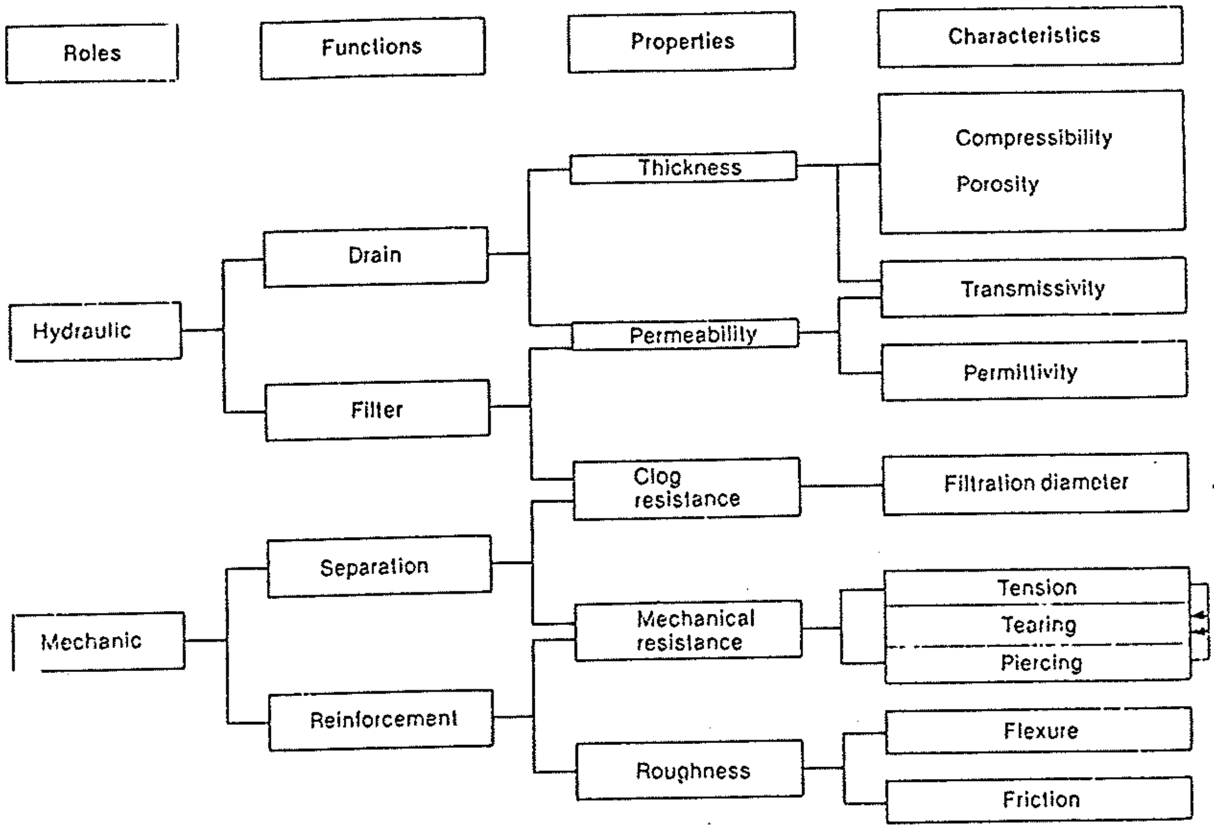
3. CHARACTERISTICS OF THE GEOTEXTILES AND GEOMEMBRANES

3.1. Geotextiles

The evaluation of the characteristics of a geotextile is necessary for calculation but also to choice the best product. In landfill applications, the main properties of interest are the mechanical, physical, chemical and hydraulical properties. These will be largely a function of the polymers used and of the manufacturing process which creates the structure of the geotextile.
The principal hydraulical and mechanical properties are :

- thickness;
- permeability;
- diameter of filtration;
- traction;
- tear propagation;
- puncture;
- flexibility.

They are related to the function played by the following shemes :



The table hereafter gives some values for the principal characteristics of different types of geotextiles.

Characteristics	Non-woven thermobonded	Non-woven needle-punched	Woven	Grids
Surfacic massa (gr/m²)	100-400	100-600	100-300	200-800
Thickness (mm)	0,2-2	0,2-5	0,2-1,5	2-6
Tensile test (KN/m)	4-30	4-50	20-80	2-79
Deformation (%)	20-70	50-150	10-35	10-40
Pores size (mm)	0,06-0,15	0,06-15	0,05-1,5	30-110
Permittivity (sec^{-1})	0,2-2	0,2-2,5	0,05-0,5	-

3.2. Geomembranes

The success in the use of a geomembrane to form a waterproofing membrane will depend of the following factors

- the conception of the project;
- the quality of the materials;
- the quality of the placement of the system;
- the use of the structure.

The principal types of membranes are :

Thermoplastic polymers
- Polyvinyl chloride (PVC)
- Polyethylene (VLDPE, LDPE, LLDPE, MDPE, HDPE, referring to very low, low, linear low, medium and high density)
- Chlorinated polyethylene (CPE)
- Elastiezd polyolefin
- Ethylene interpolymer alloy (EIA)
- Polyamid (PA)

Thermoset polymers
- Isoprene - isobutylene (IIR)
- Epichlorohydrin rubber
- Ethylene propylene diene monomer (EPDM)
- Ethylene propylene terpolymer (EPT)
- Polychloroprene (neoprene)
- Ethylene vinyl acetate (EVA)

Combination
- PVC - nitrile rubber
- PE-EPDM
- PVC-ethyl vinyl acetate
- Cross-linked CPE
- Chlorosulfonatedpolyethylene (CSPE)

Generally the choice of the chemical properties of the material will depend to the environment agressivity.
From the intrinsec characteristics of the chosen membrane, we shall be able to know what are the mechanical properties of the membrane.

The chemical nature can definite exactly :

- the resistance to ageing;
- the thermal stability;
- the thermal dilatation;
- the chemical resistance;
- the mechanical resistance (if the membrane is not reinforced);
- the welding in the factory and in site.

About the mechanical properties, we must say that some sollicitations can be applied in stresses and other in deformations. For example, for the storage of liquids, the sollicitations are acting on deformations when the deepness is more than 5 m.
But to definite some criteria for the use of geomembranes, it is fundamental to point out what are the external stresses :

a. Mechanical actions of gas and liquids

- Wind
- Gas below the membrane
- Liquids ont he membrane
- Liquids below the membrane

b. Strains of geotechnical origins

- Slope stability
- Local settlements and cracks
- Settlements
- Differential movements

c. Agression on the geomembrane

- Agregates and angular objects
- Construction elements
- Vegetation
- Chocs

d. Fabrication and installation of geomembranes

- Bungles during manufacturing
- Accidents during transportation
- Errors during installation
- Errors during welding
- Connections to the constructions
- Accident during installation of materials on the membrane

e. Membrane evolution

- Ageing
- Physical evolution of the membrane
- Chemical reaction with the contained liquids
- Mechanical evolution of the membrane

4. RECOMMANDATIONS FOR THE USE OF GEOTEXTILES AND GEOMEMBRANES IN WASTE STORAGES

4.1. Solid material (landfill) liners

The amount of solid waste generated in the world is enormous by any standard of measure. The waste materials are grouped into the following categories :

- municipal waste, i.e., waste generated by domestic households;
- industrial waste, i.e., waste generated by industry (and comprising subcategories);
- hazardous waste, which is a specific term (and includes toxic waste) for wastes having higher than regulated quantities of priority pollutants;
- low-level radioactive waste, which includes hospital waste, clothing, equipment and machinery that has been exposed to radioactivity.

4.2. Overview

As a groundwater pollution control mechanism, the use of a liner on the bottom and sides of a landfill has been considered as necessary for many years. This necessity is created by the moisture in the landfill materials (increased by rainfall and snowmelt) interacting with the contaiend waste, forming a liquid called "leachate". Although both the quantity and quality of leachate are of concerne, it is the quality that can have horrendous characteristics while at the same time being extremely variable in its compositions. The predominant liner material until recently has been clay. When of the proper type, clay liners can achieve hydraulic conductivity (or permeability) values in the range 0.5×10^{-7} to 0.5×10^{-9} cm/s and perform very satisfactorily.

But prevention (via flexible membrane liners), rather than minimization (via clay liners), of leachate migration similarly produces better environmental results in the case of surface impoundments used to dispose of hazardous wastes. A liner that prevents rather than minimizes leachate migration provides added assurance that environmental contamination will not occur.

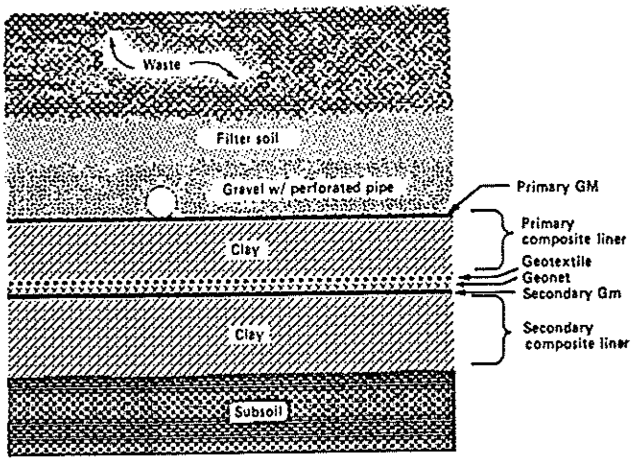
4.3. Siting considerations

Regarding siting considerations, the following list of items are important to consider :

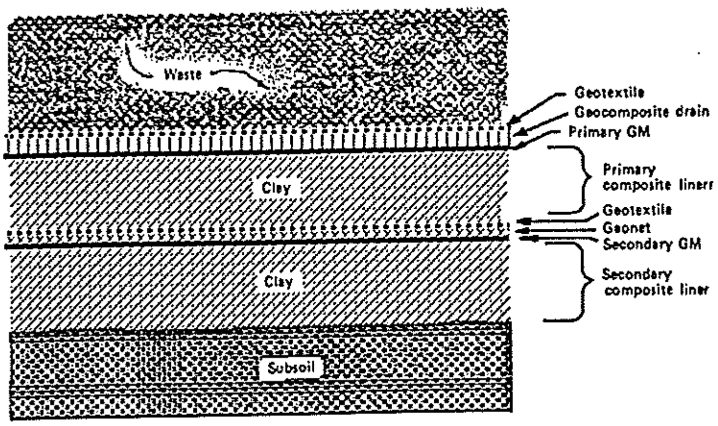
- stratigraphy and geoloy of site;
- depth to water table;
- quality and significance of subsurface water;
- use of down-gradient water;
- population density;
- weather conditions, particularly precipitation;
- seismicity of region;
- other concerns unique to the particular site.

4.4. Typical cross-sections

A critical element in the proper functioning of a landfill containment system is the liner, or liners. For solid waste landfills there must be integrated into the system a leachate collection (and removal) system and in some cases a leak detection system as well. The leachate collection and removal system is located above the uppermost, or primary, liner. Regarding leak detection for many solid waste landfills, the quality of the groundwater is required to be continuously assured. This has traditionally necessitated downstream monitoring wells and, for comparative purposes, upstream wells. If the wells are properly sited, the difference in water quality between downstream up upstream wells is indicative of the functioning of the landfill liner. If the quality is the same, the lined landfill is functioning as intended.
If not, a leak is suggested. Considerably better than such a hit-or-miss leak detection approach is to construct a doubly lined landfill liner with a gravel and perforated pipe system or geonet drain system between them. When graded to a low spot beneath the landfill, any leachate getting through the primary (upper) liner indicates a leak. Corrective measures and downstream monitoring wells should then (but only then) be instituted immediately.



Double composite liner with geonet



Double composite liner with geonet and geocomposite

5. CONCLUSIONS

The design of waste storage landfills needs a good knowledge of the synthetic products used to insure a good impermeability or a good transfer of loads during the service life of the structure.
A geosynthetic will be selected on the base of the security coefficient that it can offer about the value of the characteristics selected.
In any case, landfills are engineering structures and are to be considered as these : so it is necessary that, in all cases, a study is done to define the minimum characteristics of the materials-natural or synthetic - used.

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