Both economy and ecology speak in favour of geosynthetics

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Introduction

Geosynthetics are planar synthetic materials, such as geotextiles, geosynthetic clay liners, geogrids or geomembranes, which are used in contact with soil/rock and/or other geotechnical materials in filtration, drainage, separation, reinforcement, sealing protection, packing, erosion control and applications. They are typically used in landfills, civil engineering, infrastructure, tunnel, mining, hydraulic engineering, waterproofing and environmental projects. Further information on geosynthetics are available under: http://www.naue.com/english/lexikon/frame/index.html (or see glossary)
Geosynthetics are used to improve soil conditions or allow the soil to perform in a better manner, similar to steel in concrete, where the steel gives the concrete the necessary strength e.g. to withstand bending. Additionally geosynthetics can improve the lifetime of a certain application and therefore save short-term maintenance costs.

Increased awareness of our environment leads to "ecology" being taken more seriously in civil engineering. But in continuing changing economic conditions, ecological aspects should not be ignored. On the other hand, economy and ecology aspects should not be allowed to mutually exclude each other. They have to be considered together. This is possible if the two aspects are balanced against each other. It is achieved by analysing the entire lifetime of a product and its effects on the environment and the extent to which the materials and energy are consumed throughout its product lifetime.

The benefits

The benefits of geosynthetics, such as needlepunched geosynthetic clay liners (GCLs), geosynthetic drainage systems or filter geotextiles in comparison to conventional soil solutions, such as clay, gravel or sand, taking into account both economy and ecology are:

- less air space and therefore less excavation material during construction
- transport costs to the site are far lower due to the lower transport volumes of geosynthetics, even if the distances are greater
- installation requires only light-weight equipment, which saves costs and time
- valuable resources are protected

Facts & figures

The key benefits discussed previously are very much in evidence in the following comparison of energy costs for the landfill site at Hillern in the Soltau-Fallingbostel district of Germany. For a temporary landfill cover over domestic waste, a Bentofix® geosynthetic clay liner (GCL) and Secudrän® geosynthetic drainage system from Naue Fasertechnik, Germany was used. The comparison in table 1 shows the differences between Bentofix® /Secudrän® on the one side and mineral-based barriers and gravel rainwater collection systems on the other. Over the project a surface area of 32,853 m², the use of Bentofix® geosynthetic clay barriers in conjunction with Secudrän® drainage systems resulted in total energy cost savings of 70%. Additional information on this topic is available from the publication entitled "Ecology and energy comparison for geosynthetics and collection mineral barrier and collection systems for landfill cover systems" by Dr. Thomas Egloffstein, Gerd Burkhardt and Phillip Franz (SKZ 2001 congress in Würzburg; Germany; in German).

Dr. Robert Koerner of Drexel University, Philadelphia, presented a further cost-saving (table 2) comparison during the 14th GRI Conference in Las Vegas 2000. He concluded that geogrid reinforced veneer walls can save up to 403 US$ / m² compared to gravity walls.

	GCL	Geosynthetic Drainage System	Compacted Clay Liner	Gravel Collection System
Mining	3.40E-03	-	0.68	2.60
Transport	4.25	-	-	-
Feedstock	6.47	15.53	-	-
Manufacturing	0.95	1.96	-	-
Transportation	0.47	0.51	23.83	14.30
Installation	0.89	0.63	6.19	5.69
Total	13.03	18.63	30.70	22.59
Total for landfill (A=32,853m²)	428,065	612,073	1,008,598	742,149

Tab 1: Tab 1: Comparison of energy consumption per square meter between a GCL/ geosynthetic drainage system and compacted clay liner / gravel collection system using the Hillern landfill as an example (Values are in kWh).

	Wall height	1973	1981	1988	1998
Gravity wall (concrete cast in situ)	H ≥ 9 m	300	570	570	760
	4.5 < H < 9 m	190	344	344	573
	H ≤ 4.5	190	344	344	455
Gravity wall (prefabricated elements) gabions	H ≥ 9 m	245	377	377	---
	4.5 < H < 9 m	230	280	280	390
	H ≤ 4.5	225	183	183	272
Reinforced walls (steel)	H ≥ 9 m	140	300	300	358
	4.5 < H < 9 m	100	280	280	381
	H ≤ 4.5	70	172	172	341
Reinforced walls (geosynthetics)	H ≥ 9 m	---	---	250	357
	4.5 < H < 9 m	---	---	180	279
	H ≤ 4.5	---	---	130	223

Tab 2: Comparative costing of veneer walls in US$ / m² (from the Proceedings of the 14th GRI Conference, December 2000).

Cost Saving References

Example 1: Landfill New Wulmstorf, Germany

The original design required a composite lining system comprising a 50 cm thick compacted clay liner and an HDPE geomembrane. After reconsidering technical and economical aspects, the owner decided to allow the proposed geosynthetic alternative with a Secudrän® rain water collection system, BAM (Federal Institute for Materials Research and Testing) certified HDPE geomembrane and needlepunched Bentofix® geosynthetic clay liner (GCL) (figure 1). With the use of a geosynthetic system as an alternative to the German TASi regulation (Environmental Policy in Germany-Technical Instructions on Waste from Human Settlements - and Supplementary Recommendations and Information) the total cost savings were: 11 Mio. Euros (approximately 11 Mio. US$).

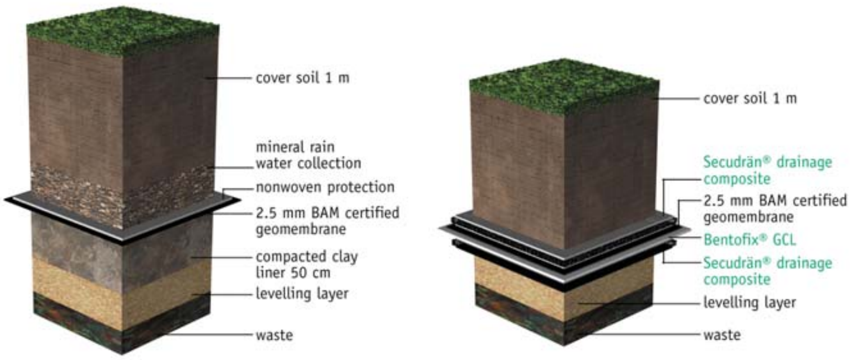

Figure 1:
Cross-section of the final landfill cover system New Wulmstorf, Germany

Example 2:
Temporary Construction Road in Espelkamp, Germany

A temporary roadway had to be built over a length of 1 km over a very soft soil with an CBR 3 %. The design asked for a CBR for the top level of the road of CBR 24 %. The first approach therefore requested a minimum of 70 cm of crushed material 0/80 mm (figure 2) to allow this value and ensure that a permanent traffic during the construction phase is possible, without any damage to the temporary road. An alternative solution from the awarded contractor suggested a Secugrid® geogrid and only 45 cm of fill material (figure 2) and saved the owner roughly 10,000 Euros.

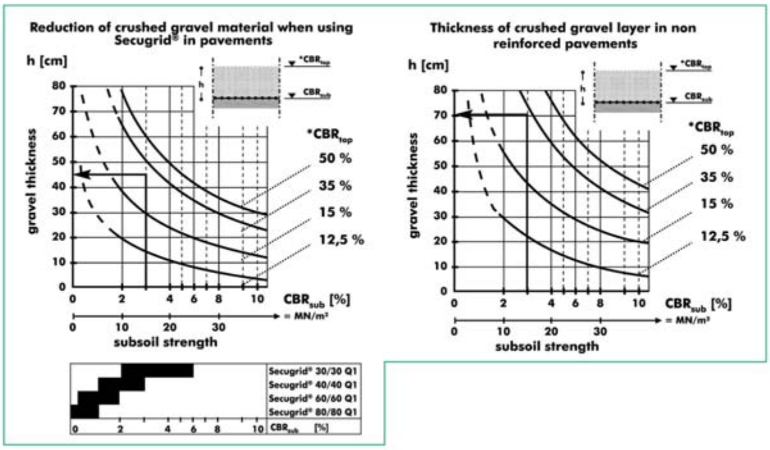

Figure 2:
Calculation diagram for crushed gravel and gravel subbase ($E_{V2, top}$ = 120 MN/m², resp. CBR_{top} = 24 %)

Summary

Geosynthetics, such as geotextiles, geosynthetic clay liners, geomembranes, geogrids are durable synthetic products which allow most demanding design for soil improvement. They are also able to give the soil performances which it originally does not have and therefore it is able to design and build long lasting structures with geosynthetics. Geosynthetics are installed in landfills, civil engineering, infrastructure, tunnel, mining, hydraulic engineering, waterproofing and environmental projects. Further benefits of geosynthetics are economic and ecologic aspects. Due to the ease of design and installation it is possible to have an immense cost saving in projects where geosynthetics are used without suffering the technical performance of the design. Considering ecological aspects geosynthetics consume far less energy during the manufacturing process compared to traditional mineral based solutions. One further ecological aspect is the transportation. A truck load with geosynthetics can replace – material depending - 50 to 200 truck loads of soil material, such as gravel for drainage or clay for sealing applications and therefore not only reduce transportation costs but also reduce environmental pollution.

Glossary

bentonite
A fine-grained swellable clay with montmorillonite as the predominant material with very low hydraulic conductivities (approx. 1 x 10^{-9} up to 5 x 10^{-12} m/s). Through the relatively large negatively charged surface (approx. up to 800 m²/g), e. g. natural sodium bentonite has a high cation exchange capacity (approx. 80 up to 120 mval/100 g) and hence a high contaminant adsorption capacity. In geosynthetic clay liners nearly exclusively natural sodium bentonite is used, occasionally activated sodium bentonite.

geosynthetic
A planar synthetic material used in contact with soil/rock and/or other geotechnical material in filtration, drainage, separation, reinforcement, protection, packing, erosion control and sealing applications.

geogrid
A planar synthetic structure consisting of a regular open network of integrally connected tensile elements, which may be linked by extrusion, bonding or interlacing (e.g. knitted), used in contact with soil/rock and/or other geotechnical material in reinforcement applications. It is i.e. differentiated between junction stiff (welded bars) and flexible (e.g. PVC coated) geogrids.

geomembrane
A very low permeable material in the form of a manufactured sheet, used in geotechnical and civil engineering applications with the purpose of reducing or preventing the flow of fluid and/or vapour through the construction (see sealing). It is differentiated between homogeneous and heterogeneous geomembranes (geomembranes are; 1.0 mm; less than 1.0 mm are foils).

geosynthetic drainage system
Three-dimensional prefabricated product manufactured from synthetic raw materials, consisting of a drainage layer (core) which is in most cases covered with at least one geotextile filter, for liquid and/or vapour transportation

geotextile
A planar, permeable, synthetic textile material, which may be nonwoven, knitted or woven, used in contact with soil and/or other materials in geotechnical and civil engineering applications. Geotextiles can fulfil one or more functions (filtration, separation, drainage, reinforcement, protection, packing, erosion control). Wovens, geogrids (geotextile-related product) and knitted products are usually used for reinforcement, nonwovens for filtration, separation, drainage, protection, packing, erosion control applications.

geosynthetic clay liner
A factory assembled product of geosynthetic materials and low hydraulic conductivity clay materials (e.g. bentonite) in the form of a sheet for sealing applications, in which the clay layer is encapsulated between geosynthetics (cover and carrier geotextile), or connected with a geosynthetic. Shear force transmitting geosynthetic clay liners are needle-punched (directional independent) or stitch-bonded (directional dependent).

needle-punched geosynthetic clay liner
An arrangement of barbed needles creates by punching through the encapsulating cover and carrier geotextiles and the bentonite core an over the entire area direction independent shear strength transmitting geosynthetic clay liner in order to increase the low internal friction angle of the bentonite and also to encapsulate the bentonite erosion safely.