ENVIRONMENTAL PROTECTION INCL. WASTE CONTAINMENT

gigsa Established 1994

The South African Chapter of the International Geosynthetics Society

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Geosynthetic Clay Liners

Geotextiles Africa

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Developed over 20 years ago, Geosynthetic Clay liners (GCLs) according to ISO definition (also called geosynthetic barrier-clay (GBR-C) bentonite liners or bentonite mats) are defined as a manufactured hydraulic barrier consisting of bentonite clay bonded to a layer or layers of geosynthetic materials. The main purpose of a GCL is to reduce the flow of liquid through a barrier system. They work by utilising the properties of sodium bentonite, which swells when hydrated with water and forms an impermeable gel-like structure. In landfill applications GCLs are commonly used in combination with HDPE geomembranes in the base and in capping systems. However in caps, GCLs are also used as the sole barrier. In both cases the GCL replaces a compacted clay liner thereby saving airspace (in landfills), and the system is able to reduce the overall construction costs.

Reinforced GCLs are the most common type and the reinforcement of the majority of GCLs is by needlepunching.

Design Considerations

In recent years some concern has been raised regarding an issue known as ion exchange. This occurs when a sodium cation of the clay is preferentially exchanged with a cation of an electrolyte such as calcium, potassium or magnesium. When this occurs, the swelling of the bentonite is reduced and the hydraulic conductivity of the bentonite is increased. It has been found that polyvalent cations such as calcium or magnesium are the most problematic in this regard.

Whilst an issue, this ion exchange can be mitigated if the entire system around the GCL is designed properly to begin with. It is known that by using a high enough overburden stress, an increase in the confining stress of the GCL occurs which decreases the hydraulic

Applications

Application	Function	Typical Confining Pressure
Landfill Capping	To inhibit the ingress of liquids and the uncontrolled escape of gases	10 — 50 kN/m²
Landfill Lining	Typically in combination with a geomembrane to prevent the uncontrolled leakage of leachate and gasses.	50 to 1000 kN/m²
Canals, Rivers and Surface Impoundments	In areas where the water level is constant they can be used as the single barrier, in most cases replacing a compacted natural clay liner	Less than 50 kN/m² Hydraulic gradient *i* of over 100
Environmental Protection	To stop hazardous liquids from transport vehicles entering sensitive locations, mainly in the infrastructural environment such as roads, railways & airports	Less than 50 kN/m²

As can be seen the areas where GCL's are used are wide and varied. As with all geosynthetic products, they will only perform according to expectations if they are properly designed for their intended application.

continued...

conductivity. This could help mitigate the effects of ion exchange. However the conditions are in relation to each other so that it is not possible to give specific values. For low confining stress applications such as water impoundments, an investigation should be done on the cover soil that is going to be used, and an increase in cover soil depth is valuable to improve the long-term performance of the GCL.

In any case if there is any doubt then the free swell test (ASTM D5890) and the fluid loss test (ASTM D5891) are a very nice compatibility test to investigate whether there is a possibility of an effect on the bentonite. Having a chemical analysis as well as the pH value and electrical conductivity of the site leachate also helps experienced engineers to indicate if an influence on the long-term permeability value could occur. Hydraulic conductivity tests allow a longer term investigation.

For applications where the GCL is going to be placed on a slope, the internal shear strength of the GCL is very important. Bentonite alone or unreinforced GCLs have an internal residual friction angle when hydrated of approx 4-5 degrees. Needlepunched reinforced GCLs show significantly better performance, having a higher peak shear strength. It has been suggested by the GRI that a minimum peel value of 360N/m tested according to ASTM D6768 should be accepted. Various Bentofix¤ publications show a correlation between the 'Peel Strength' of needlepunched GCLs and the internal shear value. However, it is recommended that these are verified to site-specific conditions in direct shear tests.

Bentofix NSP recently being installed at Lufhereng Attenuation Ponds, Soweto.

Research study

To summarise the efficiency and long-term performance of Bentofix¤ GCLs, NAUE carried out long-term in-situ tests and came to the following conclusions after the first 10 years of the study. Some conclusions and consequences for landfill engineering can be drawn from these investigations of cover systems with GCLs installed in lysimeters and exposed to mid-European climate conditions (Editor's note: mid European climatic conditions vary significantly from South African climatic conditions, and indeed, our climate varies considerably within South Africa itself. Please use your discretion in the application of this information):

- Large scale testing in lysimeters under in-situ conditions is an effective and economic way to prove the long-term permeation behaviour of cover systems with GCLs.

- High-quality-GCLs, filled with 4,500 to 5,500 g/m^2 of high premium grade powder sodium bentonite covered by soil layers of more than one meter in thickness and exposed to humid climate conditions show a very high sealing efficiency. During ten years of investigation, only 0.5 to 1.4 % of the rainfall permeated through the GCLs.

- A replacement of silty cover soil with a water permeability of 10^{-7} m/s by sand with a water permeability of about 10^{-3} m/s leads to a decrease of permeation, due to a steadier water supply and therefore less desiccation of the GCL during the summer periods.

- The sealing efficiency of the GCL depends on the amount of drainage water supplying the bentonite with water. After a temporary increase of permeation due to lower water content, GCLs regained full sealing efficiency in the following winter period. This may be called reversible material behaviour or self-healing capacity.

- GCL sealing systems with a thin cover and a small overburden load show a decrease in sealing efficiency after some years. Lower overburden and therefore small confining pressures against swelling pressure obviously leads to an increase in permeability and to a reduced self-healing capacity.

- For landfill engineering, the positive effects of sufficient and steady drainage water supply above GCLs on their sealing capacity must be taken into consideration when drainage layers on GCL liners have to be designed. The thickness of the overburden on caps is dependent on climate conditions and the type of cover soil, and should be selected in such a way as to create a steady wet "local climate" in the soil pores above the GCL.

Prez Sez

Sadness and relief are some of the emotions that were felt post-GeoAfrica 2009.

Sadness, because a very successful conference that brought together old and new friends from the international geosynthetics community, has been and gone.

Relief, because all that hard work, anxiety, excitement, sleepless nights, preparation has passed and one can breathe again. However one is left to pick up the pieces, so to speak, of one's former life with family, jobs, friends and hobbies. Restful weekends are now a reality again.

There is indeed life after GeoAfrica!

Unfortunately the work load had not marked time in anticipation of our return to the office it had marched on greeting us with a plethora of tasks to do in as little time as possible.

I would like to convey my heartiest congratulations and thanks to Peter Legg and his Organizing Committee for the supreme effort that made GeoAfrica such a success. Peter Davies deserves much credit for his efforts in putting together a great technical programme.

My sincere thanks go to Lesley Ferreira and her Cebisa Conference staff for an extremely well co-ordinated conference. I was most proud to be President of GIGSA witnessing the culmination of many months of sheer hard graft on the part of our GIGSA committee and members.

We used this unique opportunity of international exposure to make our GIGSA Awards to include the President's Award, Development in Technology Award, Construction Award and Honorary Life Membership Awards.

The final report from Lesley confirmed that the conference was a resounding success and the evaluation forms collected from the delegates were all complimentary. The remarks about certain operational issues at the conference were highlighted and we were well aware of some of these shortcomings during the conference.

We are very grateful to our key note speakers, special speakers, presenters, sponsors, exhibitors and delegates for their contribution toward a wonderful conference.

One big disappointment to the Organizing Committee was the relatively poor turn out from our local consulting fraternity. This was through no lack of trying on the part of GIGSA and I can safely say that those who did not attend have missed out on a unique opportunity which turned out to be the gain of 40 of their colleagues. I understand that most of those people reason that geosynthetics do not play a huge part in their daily design work and they tend to refer such speciality work to those more in the know.

However Geosynthetics are established engineering expedients worldwide and cannot be ignored by our engineers. Those who have chosen to keep pace with the developments in geosynthetics have certainly gained the advantage.

South Africa is not likely to see such a gathering of world geosynthetics experts in a hurry again although 2013 is mooted to be the year for the next IGS African Regional Conference.

At this suggestion, by the IGS Council, we were quick to selfishly propose our North African neighbours, like Algeria, so that we would be free from organizing another colossal event, certainly not on my watch! Maybe the young and energetic members of GIGSA have other ideas!

In my previous Prez Sez I was at pains to avoid too much doom and gloom about the prospects for the civil engineering industry looking ahead yet I was encouraged to see the comments made at an economic workshop recently held in Johannesburg hosted by Consulting Engineers South Africa (CESA) at which three leading experts in their fields gave their opinions on the Impact of the Global Economic Crisis on the Consulting Engineering Industry.

In his welcoming address Felix Fongoqa, President of CESA, stated that the workshop was important in order for consultants to look at strategies for a sustainable future for business in South Africa and the African continent. He posed the question as to whether the economy was heading for a cliff or just going to experience slight turbulence. He also referred to the planned Government spend of nearly R 800 billion on infrastructure development over the next three years.

One of the experts, Iraj Abedian, CEO of Pan African Investment and Research Services and Chairperson of Bigen Africa, pointed out that over the past 14 years the ratio of the construction sector as a contributor to GDP has been rising and therefore the relative growth in this sector of the economy has been above average. He pointed out that — not only was construction booming in South Africa — but also China, Dubai and Sydney. And, in fact, worldwide leading to a shortage of skills and capacity issues.

He said that "Government will channel a great deal of resources to improve urban infrastructure. South Africa s construction industry is unlikely to be hit as hard as some other countries."

He concluded with "Times are tough but opportunities have not dried up and cost consciousness is bound to rise rapidly".

(Business Report, Tuesday, September 29, 2009)

There is hope after all!

Geosynthetic Greetings,

Garth James

President

garth@kaytech.co.za

This page is dedicated in memory of

Alan Lever

(14 September 1924 - 8 July 2009)

Note from the Editor

Another year has come to an end and there is so much that GIGSA has accomplished this year that we can be proud of, not least of which was the hosting of the first African regional conference on geosynthetics, GeoAfrica 2009. A special mention is due to Peter Legg, chairman of the GeoAfrica 2009 organising committee, and Peter Davies, chairman of the technical committee, for their exceptional personal contributions to organising such a successful conference. To Peter L and Peter D, we thank you and wish you a happy return to normality after GeoAfrica!

To all the GIGSA newsletter readers, I wish you a very auspicious festive season. Take care till next year.

Shakira Sattar
GIGSA Newsletter Editor

Send your comments and suggestions for the GIGSA newsletter to the Editor at: shakira@sattarconsulting.co.za

Welcome to our new GIGSA members

Individual Members:

Peter Dimaio (Anchor Lining Systems)

Honorary Life Members:

Clifford Gundle
Du Toit Viljoen
Ronnie Scheurenberg
Rod Drayton
Peter Davies
Falk Hedrich

Student Members:

Tasneem Vawda
Kenneth Moya
Keoagile Kerileng
Yoosuf Essopjee
Jabulani Makafane
Brenden Jordaan
Bernita Kalan
Melamy Moipone
Tal Bugai
Adelle van Staden
Thulani Ngwawba
Werner van den Berg
Joanne Muller
Joanne Muller
Corne Els
Wessel Swart
Kayakazi Mafuta
Abdul Magimbi
Calvin Langley
Whitney Pailman
Mandla Dyodo
Shaym Natha
Sameer Suliman
Byron Hendrickse
Dillon Swanepoel
Reynier van Rooyen
Jacobus Pretorius
Annemarie De Lange
Tshepo Sathekge
Nhlanhla Tshabalala
Chris Berry
Phathamandla Sithole
Phetile Nkosi
Mpho Shikwambana
Tsanwani Maluma
Thabo Gopane
Lucky Molefe
Awelani Ramadwa
Nkosinathi Dube
Kagiso Letlala
Mosa Tsoai
David Mphafudi
Giancarlo Wingrave
Samuel Ditsele
Karabo Kgaphole
Quinton Botha
Tshidiso Selemela
Moretsi Seratlelo
Duma Senzo
Katlego Pico
Thabani Molalose
Fannie Nkuna

New members will get a special mention in each edition of the GIGSA newsletter so watch this space!

GIGSA Membership Fees 2010

We are pleased to inform you that there will be no increase in the membership fees for 2010.

GIGSA AWARDS 2009

Photo Gallery

The GIGSA awardees were nominated by the members of GIGSA and after adjudication of the submissions by the Awards Committee the awards were presented at the GeoAfrica 2009 conference in Cape Town.

The GIGSA 2009 awards are as follows:

GIGSA President's Award 2009

The Kelly Nicole Legge Floating Trophy awarded to:

Peter Legg

In honour of his excellence and dedication to GIGSA in his capacity as Immediate Past President of GIGSA, Conference Chairman for GeoAfrica 2009 and IGS Council Member

The GIGSA Development in Technology Award

Awarded to:

Moore Spence and Jones (Malcolm Jaros)

Bombela Civils JV (Pty) Ltd

Kaytech Engineered Fabrics

For the Multiple Layered Geosynthetic Reinforced Embankment over Sinkhole Area, Snake Valley, Gauteng Rapid Rail Link

The GIGSA Construction Award

Awarded to:

Aquatan

For the Buzwagi Gold Mine Water Harvesting and Floating Cover Reservoir, Tanzania

Commendation — GIGSA Construction Award

Awarded to:

Dept. of Water Affairs (Engineering Services)

Iliso Consulting Engineers

Kaytech Engineered Fabrics

Usutu River Emergency Works, RSA-Mozambique Border

Honorary Life Membership Awards

Clifford Gundle

Rod Drayton

Du Toit Viljoen

Peter Davies

Ronnie Scheurenberg

Falk Hedrich

For outstanding service to GIGSA and the geosynthetic industry in South Africa.

Report GeoAfrica 2009

The first African Regional Conference on Geosynthetics, GeoAfrica 2009, was held at the Cape Sun Hotel in Cape Town from 2 to 5 September 2009, and was organized by GIGSA, the South African Chapter of IGS. After months of planning for such an event, it is difficult to know how to report on GeoAfrica 2009. The most important point is that the conference was undoubtedly a technical, social and financial success, much to the relief of the organizers. It was also a great opportunity to catch up with old friends and industry legends, as well as to meet a new generation of up-and-coming professionals in the geosynthetics industry.

The conference covered four broad themes in geosynthetics applications: barriers, erosion protection and separation, soil reinforcement, and filtration and drainage. There were three excellent keynote addresses by Kerry Rowe, Kelvin Legge and Jorge Zornberg; three highly informative special lectures by Sam Allen, Richard Bathurst, and Malek Bouazza; and 65 technical papers were presented, which were generally of a high standard. The exhibition hall was lively too, with 31 stands, many taken by international vendors. In total, 177 delegates attended, with good international representation.

GeoAfrica 2009 was a world-class conference, and allowed a vast body of information to be assimilated by delegates in a matter of days. There was informed debate on currently contentious issues, such as the testing and appropriate use of GCLs. Of particular benefit were presentations of state-of-the-art practice, such as in Kerry Rowe's keynote address on the long-term performance of leachate collection systems and geomembrane liners for MSW landfills, Richard Bathurst's special lecture on recent developments in reinforced soil wall testing, analysis and design, and Sam Allen's special lecture on laboratory testing for geosynthetic durability and reinforcement design. Kelvin Legge's keynote presentation on Geosynthetics for Africa highlighted the extensive and varied use of geosynthetics on the African continent. This was supplemented by Malek Bouazza's interesting paper on case histories of geosynthetic applications in North Africa, while Jorge Zornberg's keynote explored the potential for the use of geosynthetic capillary barriers in alternative landfill capping systems.

An award for the paper considered to have made the best contribution at the conference was made to Nathalie Touze-Foltz, for her paper on the effects of premature hydration on the hydraulic performance of geosynthetic clay liners.

On day two of the conference GIGSA made six honorary life membership awards, as well as awards for development in technology, construction, and the president's award. The IGS also used the opportunity to make 20 year corporate membership awards to Tensar International UK, Tensar International Corporation USA, and The Reinforced Earth Company International.

The conference social events included a welcome function with entertaining talks by two of the 'grand old men' of geosynthetics in South Africa, Glen Lawson and Clifford Gundle. The conference dinner on the Friday evening had a Cape Malay theme, and the entertainment was memorable, particularly the dancing of Loke and his lovely wife with the Cape Malay choir. The trip to Spier wine estate was also a highlight, with many delegates interacting with cheetahs, tasting home grown South African wines, and enjoying a sumptuous meal at Moyo African restaurant . Other social activities around the conference included an anchor sponsor evening at a German brewery at the Victoria & Alfred Waterfront, where some of the ladies enjoyed being served drinks by Clifford Gundle himself! The IGS Council members also ventured to try African cuisine at a traditional restaurant in Cape Town. I am sure that Russell Jones' introduction to a "smiley" (sheep's head) will remain with him for many years to come!

GeoAfrica 2009 would not have been a success without our sponsors Aquatan, CETCO and GSE (anchor sponsors); Golder Associates, Huitex Geosynthetics, Jones & Wagener, PD Naidoo & Associates and Geosynthetica.net (chain sponsors) and Gast, BKS, Enviro-Fill, EnviroServ, Geotextiles Africa, KV3 Engineers, SRK Consulting and Steffanuti Stocks (link sponsors). Kaytech sponsored the proceedings and provided the hall monitors, Gast sponsored the conference folders, and Nampak Recycling sponsored the refuse bins. Thank you for making GeoAfrica 2009 possible, particularly in a tough economic climate.

As with any large event of this nature, there are many people to thank. The members of the organizing committee, as well as the past and present GIGSA committees, all deserve thanks. A few deserve special mention: Peter Davies for organizing the technical aspects of the conference, from reviewing abstracts and papers, liaising with the scientific committee and paper authors and developing the proceedings, to coping with a number of last-minute paper retractions; Kelvin Legge for doing an excellent job of attracting sponsorship during tough economic times; and Mike Wittmann for managing the finances and providing a wise sounding board when tempers flared. Lesley Ferreira of Cebisa Conferences was the conference organizer, and went above and beyond the call of duty for GeoAfrica 2009. She and her team ensured the smooth-running of the conference itself, and her experience proved its worth over and over again.

I need to thank the IGS council and the executive officers in particular who encouraged and advised us throughout the planning and preparation leading up to the conference.

Lastly, I would like to thank all the international delegates who travelled great distances to participate in GeoAfrica 2009. We were honoured by your presence and we thoroughly enjoyed showing off our beautiful country and its people to you.

I look forward to seeing you all at the next GeoAfrica conference in 2013, probably in North Africa!

Peter Legg
Conference Chairman

Photo Gallery

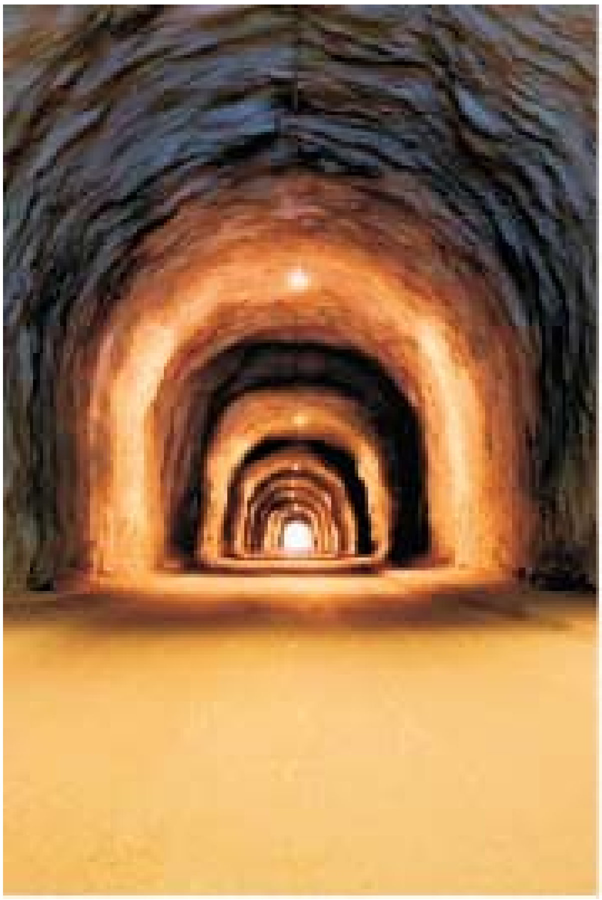
GeoAfrica 2009

Liquid Geosynthetics

The Way of the Future?

By: Dr. Kevin Gast
Gast Press Office

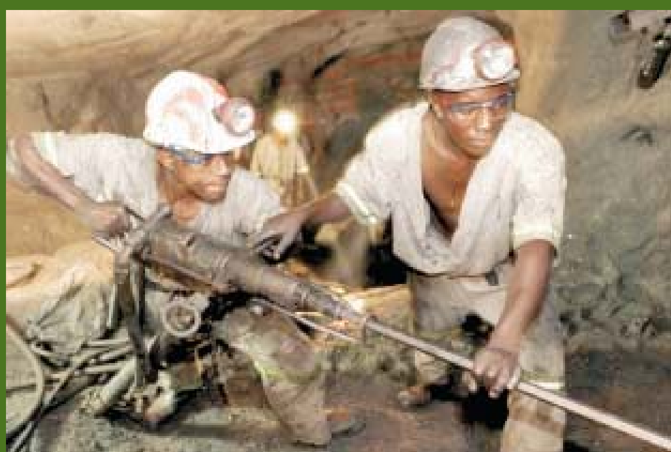
The uncontrolled penetration or leaking of water into or through building structures, underground excavations, dam walls, foundations and mine tunnels is one of the most difficult, dangerous and costly problems faced by engineers, owners and operators. A company dedicated to finding solutions for these types of problems is GAST which has been working in this industry for over 40 years. The development of the Sovereign product was primarily focused on finding a solution for water ingress where accessibility is restricted or denied. Typical examples of these would be water retaining concrete structures such as dams, reservoirs or retainer walls. Another application would be water ingress in geological formations as often encountered in mining activity. Water has the uncanny ability of making an appearance in the most unwanted places.



The Gast Sovereign system can be implemented wherever leakages occur where the source point is unknown or not easily identifiable. The system is unique and rather simplistic in application in that reverse water pressure is applied so as to determine the hydrostatic index of the leak, water is then reverse pumped through the leak containing a particular isotope or marker.

An investigation then takes place to determine if the leak is an accomplice to other related water problems or not.

The same water is then used as a carrier so as to enable liquidated rubber to be pumped in until this corresponds with the isotope marker and the existing hydrostatic head. Once this is achieved the entire "plug" is then activated by a unique catalyst, bringing about homogenization and solidification of all the rubber particles held in suspension. Once this has been achieved, the more hydrostatic pressure increases the more firmly the "plug" is forced against the apertures. This then creates a mechanical seal with a success ratio of up to 80% on first injection. The "plug" itself remains flexible, is non-toxic and non-hazardous. Success has also been achieved on suspended concrete structures such as parking decks, roof decks and other construction areas post initial construction. Founded in 1961 GAST has expanded into various different industries such as civil engineering, commodities brokerage, construction and development.



Performance of GCL in Landfill Applications

Case Study

By:
R.C.Emery. Jeffares & Green (Pty) Ltd
B. Makgekgenene. Jeffares & Green (Pty) Ltd

INTRODUCTION

This article is an extract from a paper presented at the GeoAfrica Conference in 2009. It documents a study that was undertaken to examine the medium-to-long term performance of a particular GCL in a landfill basin lining system and in a landfill cap system installed at Bellville South Landfill Site, Cape Town. The study determined certain parameters in exhumed GCL samples.

Samples were taken from Cells 1 and 4 at Bellville South Landfill site and from the capping face on the western side of the landfill. Cell 1 has a composite primary lining system using HDPE and GCL and was installed approximately six years ago. Cell 4 has a composite primary lining system using HDPE and GCL and was installed approximately three years ago. The GCL and soil cap on the western embankment was installed approximately six years ago. The samples were removed by hand and were tested in commercial and institutional laboratories. The results are presented together with the method of sampling and the method of testing.

The research does not consider the chemistry of the results or the reasons for any change in character of the GCL. The primary objective of the research was to determine, at an engineering level, whether there has been a change in the primary function of the GCL at Bellville South Landfill, this being the "permeability" and "swell-ability" irrespective of ion exchange.

The information presented here is from a case study done on a specific GCL installed in a particular environment and application from a specific position at one site and thus does not necessarily reflect the performance of GCLs in general.

TEST RESULTS

Table 1 below lists the geotechnical test results from the four selected GCL samples.

Table 1: Summary of results and comparisons thereof

Sample	Property	Units	Test Method	GRI-GCL3 Specifications	Min Requ.[1]	Results for GCL samples
GCL 1 from the capping system, top of embankment.	Hydraulic conductivity at 35kPa	m/sec	ASTM D5887	Max 5E-11	1.6E-08 (cap, G:L+)	1.7E-11
	Hydraulic conductivity at 70kPa	m/sec	ASTM D5887	Max 5E-11	1.6E-08 (cap, G:L+)	1.7E-11
	Index flux at 35kPa	$(m^3/m^2)/s$	ASTM D5887	Max 1E-08		3.9E-09
	Index flux at 70kPa	$(m^3/m^2)/s$	ASTM D5887	Max 1E-08		3.5E-09
	Atterberg liquid limit		ASTM D4318			105
	Free swell	ml	ASTM D5890	Min 24		7.0
GCL 2 from the capping system, mid reach up embankment.	Hydraulic conductivity at 35kPa	m/sec	ASTM D5887	Max 5E-11	1.6E-08 (cap, G:L+)	1.6E-09
	Hydraulic conductivity	m/sec	ASTM D5887	Max 5E-11	1.6E-08 (cap, G:L+)	5.1E-11

continued... **Performance of GCL in Landfill Applications**

Sample	Property	Units	Test Method	GRI-GCL3 Specifications	Min Requ.[1]	Results for GCL samples
	at 70kPa					
	Index flux at 35kPa	$(m^3/m^2)/s$	ASTM D5887	Max 1E-08		4.1E-08
	Index flux at 70kPa	$(m^3/m^2)/s$	ASTM D5887	Max 1E-08		9.6E-09
	Atterberg liquid limit		ASTM D4318			108
	Free swell	ml	ASTM D5890	Min 24		6.0
GCL 3 from the basal lining system in Cell 1.	Hydraulic conductivity at 35kPa	m/sec	ASTM D5887	Max 5E-11	1E-08 (liner, G:L+)	2.0E-11
	Hydraulic conductivity at 70kPa	m/sec	ASTM D5887	Max 5E-11	1E-08 (liner, G:L+)	1.1E-11
	Hydraulic conductivity at 140kPa	m/sec	ASTM D5887	Max 5E-11	1E-08 (liner, G:L+)	6.2E-12
	Index flux at 35kPa	$(m^3/m^2)/s$	ASTM D5887	Max 1E-08		4.1E-09
	Index flux at 70kPa	$(m^3/m^2)/s$	ASTM D5887	Max 1E-08		2.4E-09
	Index flux at 140kPa	$(m^3/m^2)/s$	ASTM D5887	Max 1E-08		1.0E-09
	Atterberg liquid limit		ASTM D4318			177
	Free swell	ml	ASTM D5890	Min 24		13.5
GCL 4 from the basal lining system in Cell 4.	Hydraulic conductivity at 35kPa	m/sec	ASTM D5887	Max 5E-11	1E-08 (liner, G:L+)	1.6E-11
	Hydraulic conductivity at 70kPa	m/sec	ASTM D5887	Max 5E-11	1E-08 (liner, G:L+)	9.5E-12
	Hydraulic conductivity at 140kPa	m/sec	ASTM D5887	Max 5E-11	1E-08 (liner, G:L+)	5.3E-12
	Index flux at 35kPa	$(m^3/m^2)/s$	ASTM D5887	Max 1E-08		3.8E-09
	Index flux at 70kPa	$(m^3/m^2)/s$	ASTM D5887	Max 1E-08		2.4E-09
	Index flux at 140kPa	$(m^3/m^2)/s$	ASTM D5887	Max 1E-08		1.4E-09
	Atterberg liquid limit		ASTM D4318			227
	Free swell	ml	ASTM D5890	Min 24		13.0

1. Minimum Requirements for Waste Disposal By Landfill

The GCL samples for the capping and basal linings systems were at least six years old when tested.

*continued...***Performance of GCL in Landfill Applications**

The GCL taken from the capping system, as described above, appear to still have sufficient hydraulic integrity to serve as a barrier for such an application, compared to the Minimum Requirements of the Department of Water Affairs and Forestry (1998.)

The GCL taken from the top of the embankment appears to have maintained its original installed state of hydraulic integrity whilst the GCL sampled from mid-reach (of the embankment) has reduced.

Most manufactured GCLs today achieve a maximum hydraulic conductivity of 1E-11 m/s. This said, the GCL samples taken from the basal lining system and the top of the embankment still maintain this conductivity, whilst the GCL sample taken from mid-reach of the embankment has dropped below the as-manufactured conductivity.

The free swell index for all GCL samples taken from the cap has reduced significantly, yet not in relation to its hydraulic performance. This could be due to chemical change in the bentonite.

The GCL taken from basal lining system also appears to have maintained its original installed state of hydraulic integrity. The free swell of the bentonite has reduced, yet not as significantly as the GCL samples taken from the capping system.

SOIL ANALYSIS

The soil adjacent to the GCL was sampled at the same point as the GCL. The soil in the capping system had a pH ranging from 7.4 to 7.5. The pH of the soil in the basal lining system in "Cell 1 "had a pH ranging from 7.7 to 8.3. The conductivity of the soil in the capping system ranged from 30 mS/m to 60 mS/m.

The results of Atomic Absorption Spectrometry identified the presence of Calcium (Ca^{+}), Potassium (K^{+}), and Magnesium (Mg^{2+}) cations within a Sodium rich Clay Mineral, indicating possible isomorphic substitution of cations and cationic exchanges within the tetra octahedral layers of the Bentonite.

CONCLUSION

There has been a deterioration of the GCLs hydraulic conductivity in the capping system (mid-reach of embankment only) and essentially no loss in the basal lining system. All tested GCL samples still meet the minimum hydraulic conductivities required by Minimum Requirements for Waste Disposal by Landfill, after approximately six years of service.

This study supports further investigation of soils used in conjunction with GCLs for each site-specific condition.

*end...***Performance of GCL in Landfill Applications**

R.C.Emery. Jeffares & Green (Pty) Ltd
B. Makgekgenene. Jeffares & Green (Pty) Ltd

What Not to do with GCLs

By Ian Peggs, Ph.D., P.E., P.Eng., DABFET
President, I-CORP INTERNATIONAL, Inc.
8 September 2009

Geosynthetic Clay Liners work extremely well when installed properly but I have seen many installation mistakes. The main one is correctly recognizing that all single liners leak to some degree and attempting to put a coarse subgrade drainage layer immediately underneath the GCL. Thus a GCL may be correctly covered with soil/sand ballast layer to provide the required confining pressure but it will be underlain by a drainage layer of 19 or 25 mm angular aggregate. Consequently the GCL is punctured, bentonite is laterally displaced and unacceptable leakage occurs. Thus there can be two conflicting requirements —imposing a uniform confining pressure on the GCL, and providing a drainage medium (with void spaces) underneath it. The two are often achieved in an incompatible way. Let's look at two case histories.

Case 1 Decorative pond

An 800 m^2 1 m deep pond with a GCL liner was leaking about 150,000 litres of water per day. When investigated the GCL was found to be placed on a 150 mm drainage layer of slatey stone with particle size ~20 mm. There was a monolayer of pebbles on top of the liner since the designer did not appreciate the need for a confining pressure.
In addition there were many limestone rocks in and around the pond. The subgrade punctured the lower geotextile in many places and the bentonite eroded away. There was no chance for the bentonite to seal any holes since it was already fully hydrated and expanded. Although not tested ion exchange of sodium ions in the bentonite by calcium ions from the limestone was a given. Even if there had been a uniform compacted subgrade under the GCL sealing would still not have occurred, due to the lack of confining pressure. Conversely to what many people think, the hydrostatic pressure on the GCL does not provide the required confining pressure.

Figure 1. Hole in GCL with bentonite eroded away

Case 2 Waste Water Treatment Plant

A 6 ha WWTP lagoon used an unreinforced GCL on the floor and a reinforced GCL on the slopes. Both had membrane films laminated to them. When the lagoon was filled it started leaking about 2.3 Ml per day. It was emptied and some repairs made but the leakage did not stop. It was emptied and investigated 2 years after first filling. When litigation was initiated it was thoroughly investigated another 2 years later.

There was about 300 mm of clayey sand on top of the GCL and 150 mm of 19 mm crushed aggregate under the GCL. Both GCLs had been placed with the membrane film down. The membrane had been punctured, the GCL had been punctured, and the bentonite laterally displaced. Not unexpectedly damage was more prevalent in the unreinforced GCL on the floor.

The situation would have been better had the GCLs been placed with the film up, as is the case with most composite liners — geomembrane on top, GCL or compacted clay liner underneath. This way the more impermeable component, the film, would not have been punctured first. The GCL would have cushioned the membrane and the geomembrane could have imparted the full hydrostatic head (~4 m) to the confining pressure of the GCL, had the subgrade not been so rough with aggregate peaks and void space between them.

Figure 2. Subgrade aggregate and punctures in floor membrane.

When the water and soils were analyzed it was clear that significant cation exchange of sodium for calcium had occurred (after 4 years) but this was not considered to be a major contribution to the initial leakage since such exchange does not occur immediately.

Summary

For a GCL to act as an impermeable barrier it must be installed with a uniform confining pressure. That means no angular particles and significant void spaces on either side. This is the primary objective. Leak drainage capability must be considered to be secondary and must not compromise the primary function. When a composite GCL is used, unless there are other good reasons, it should be deployed with the membrane uppermost.

Index testing : a designer's tool

By: David Johns
Jones & Wagener

Geosynthetic clay liners (GCLs) achieve their low permeabilities by virtue of their ability to undergo swelling of the bentonite clay when wetted, thus restricting pore spaces and limiting the flow of water. However, the swelling capacity of the bentonite clay may be adversely affected by contact with the leachate intended to be retained. Leachates with high concentrations of cations, particularly multi-valent cations such as Ca^{2+}, Mg^{2+} and Fe^{3+}, may, by the process of cation exchange, result in clay particles with significantly reduced hydrated radii. This manifests on the macroscopic scale as reduced swell. The pH of the leachate also plays a role in affecting swell and therefore in the hydraulic conductivity of the bentonite.

It is imperative that designers check compatibility of the bentonite component of any GCL with the site specific leachate. This can be done by several methods: the most obvious of which is a permeameter test (ASTM methods D 5887 and D 6766). However, these tests are often terminated too early, resulting in un-conservative estimates (up to one and a half orders of magnitude) of long-term hydraulic conductivity being made. On the other hand, reliable results from tests conducted with appropriate termination criteria can take impractically lengthy periods of time to complete. More rapid, although only qualitative, methods to assess compatibility of GCL bentonites with leachates are by index tests, for example the swell index test (see Figure 1), and the fluid loss test, as prescribed by ASTM D 5890 and ASTM D 5891 respectively. The test results may be compared to correlations of the index in question and long-term hydraulic conductivity, providing a rapid and cheap method to assess compatibility and possibly exclude the use of GCLs with aggressive leachates.

Site specific leachates will not necessarily be available at design stage, except in the case where design is for extensions to, or replacements for, existing landfill sites. In the case of a new site where leachate has not yet been generated, designers are cautioned that bentonite compatibility testing with synthetic leachates may be an un-conservative approach, or may even be overly conservative. In addition, making judgements of compatibility based purely on chemical composition of the leachates should be avoided, as experience has shown apparently similar leachates to produce significantly different swell indices with different bentonites.

Figure 1 - Swell index test, target swell 24ml/2g.

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