IMPACTS of INDUSTRY CONSOLIDATION on GEOSYNTHETICS

Gregory N. Richardson, Ph.D., P.E.
G.N. Richardson & Associates, Inc.

Abstract

In the year 2000 and beyond, the geosynthetics industry must view consolidation as both an opportunity and natural evolution of products in the construction industry. Consolidation in this paper refers to three different and concurrent trends that will define how successful geosynthetic business is conducted in the next millennium. In this paper, consolidation of the following will be discussed:

- Market Consolidation: Is today's market penetration at a level that increased annual growth of this market is doubtful?
- Manufacturer Consolidation: Are market forces reducing the number of primary manufacturers of a given geosynthetic material?
- Product Consolidation: Will standardization of design lead to a reduced number of products required to serve the market and lead to commodity products?

This paper reviews each type of consolidation with respect to four geosynthetics: geotextiles, geomembranes, geonets, and geosynthetic clay liners.

Introduction

Popular interest in contemporary geosynthetics began with the 1977 Paris conference on fabrics, i.e. geotextiles. This was the first professional forum devoted exclusively to geotextiles. While companies such as Carthage Mills had developed limited commercial markets for geotextiles in the mid 60's, the industry did not broadly develop in the United States until the late 70's. Thus we enter the new millennium in an industry that has integrated into the vocabulary of civil engineers and yet has not gained full acceptance in typical applications. For the most part "new" applications are becoming rare and the atmosphere of technical excitement that followed early research and applications has given way to minimal market growth and limited profits. Geotextiles, for instance, are estimated to be used in less than 10% of civil applications that could benefit from their use (Willibey, 1999). The transition for innovation to commodity has occurred for all historical building products and may assumed to be the geotextile industry driver for the coming years.

This paper evaluates the impact of (1) market consolidation, (2) manufacturer consolidation, and (3) product consolidation on geosynthetics in the up-coming millennium.

GEOTEXTILES

The majority of geotextiles find application in either roadway or landfill construction applications. Market growth in the 70's and 80's focused on highway applications as subgrade separators, stabilizers, and filters. A lessor market was developed for high strength geotextiles for lagoon closures and construction of embankments over soft subgrade. Market growth in the late 80's was fueled by the increased use of geotextiles as cushions and separators in landfill liner and final cover systems.

Geotextiles – Market Consolidation

Neglecting the need to increase the market penetration of geotextiles, the next ten years appear to offer a steady increase in the potential market for geotextiles. Proposed federal highway spending is shown in Table 1 and indicates

Financing Federal-Aid Programs - Appropriations - Netscape

File Edit View Go Communicator Help

Back Forward Reload Home Search Guide Print Security Stop

Bookmarks Netsite: http://www.fhwa.dot.gov/reports/fifahiwy/fifahi04.htm

Table 1 –**Guaranteed Funding (Amounts in Millions of Dollars).**

	1998	1999	2000	2001	2002	2003	Total
Discretionary Spending "Firewalls":							
Highway Category (Sec. 8103(a)):							
FAH Obligation Limitation	21,500	25,511	26,245	26,761	27,355	27,811	155,183
Motor Carrier Safety	85	100	105	112	117	125	644
NHTSA	256	272	279	285	295	297	1,684
Subtotal	21,841	25,883	26,629	27,158	27,767	28,233	157,511
Transit Category (Sec. 8103(b)):	4,844	5,365	5,797	6,271	6,747	7,226	36,250
Total, Discretionary Firewalls	26,685	31,248	32,426	33,429	34,514	35,459	193,761
Mandatory Spending:							
Emergency Relief	100	100	100	100	100	100	600
Minimum Guarantee	639	639	639	639	639	639	3,834
Subtotal	739	739	739	739	739	739	4,434
TOTAL, Guaranteed Funding	**27,424**	**31,987**	**33,165**	**34,168**	**35,253**	**36,198**	**198,195**

Document: Done

that dollars spent for roadways will continue to grow. As explained in greater detail in the Geomembrane discussion, the market for geotextiles in landfills will also remain steady with a potential for minor growth. Clearly the real growth potential for geotextiles lies in the estimated 90% of potential highway applications that today do not use geotextiles.

Geotextiles – Manufacturer Consolidation

The late 70's and early 80's were the scene of the great "nonwoven" vs. "woven" geotextile wars with large international firms on the field. Since that time, most manufacturers have integrated their product lines across the full spectrum of geotextiles and manufacturing has become the domain of smaller domestic firms. Table 2 shows the history of the past decade relative to manufacturer's that have left and those who have entered this market. Currently, only six companies produce geotextiles. Of these only Amoco is a large international firm and it has announced an intent to divest itself of the larger fibers group within which geotextiles are made. Thus there has been a dramatic consolidation of the manufacturing of geotextiles and a move from large international producers to smaller domestic producers. This has in part been driven by higher profit margins in other civil engineering markets such as roofing materials.

Geotextiles – Product Consolidation

The next decade provides the geotextile industry important technical and business reasons to consolidate and standardize geotextile products in a process that all civil engineering products have evolved through. The basic technical outline provided by AASHTO M288-96 is a reasonable basis to examine where this consolidation must go. For roadway applications of subsurface drainage, separation, and stabilization, the critical properties of the geotextile are limited to installation survivability rating, apparent opening size (AOS), and permittivity. Figure 1 presents the range of available AOS versus permittivity for today's geotextiles. Needle punched nonwovens typically have an AOS that corresponds to that of fine sands and have permittivity values exceeding 0.6 sec^{-1}. Excepting slit film wovens, the woven geotextiles have an AOS that is equivalent to a medium sand and permittivity exceeding 0.2 sec^{-1}. Only slit-film woven and heat calendered geotextiles are found with permittivity less than 0.1 sec^{-1}. Table 3 presents the AASHTO M288-96 criteria for the major highway applications of geotextiles. The author has indicated 5 geotextile "classes" that encompass all geotextiles excepting slit-film woven and heat calendered geotextiles. Note that the full needs of highway foundation and drainage applications can be met by only 5 geotextiles. Even adding heavier weight nonwovens for environmental applications such as liner cushions, a manufacturer could satisfy the technical

Table 2 Geotextile Manufacturers to USA Last Decade
(adapted from Carthage Mills, 1999)

Company	Slit Film	Nonwoven	Mono-filament	High Strength
1) Amoco	**M**	**M**	M	
Phillips	S	M	S	
Exxon	M	S	S	S
Dupont		M		
Nicolon	M	S	M	M
Celanese/Dominion/Mirafi	M	S	S	S
2) Belton	**M**		**M**	
Polyfelt		M		
3) Evergreen Technologies		**M**		
James River		M		
Monsanto/Bidim		M		
4)American Engineering Fabr.		**M**		
Wayne Tex	M		M	
5)TNS	S	**M**		
6)Synthetic Industries		**M**	**M**	
Spartan		M		
Hoechst		M		
ICI		M		
Wellman		M		
Chicopee			M	
Welbeck (foreign)				**M**
Huesker (foreign)				**M**

M = Manufacture   S = Sell but don't manufacture
Shading indicates those manufacturers or products that are no longer in the market

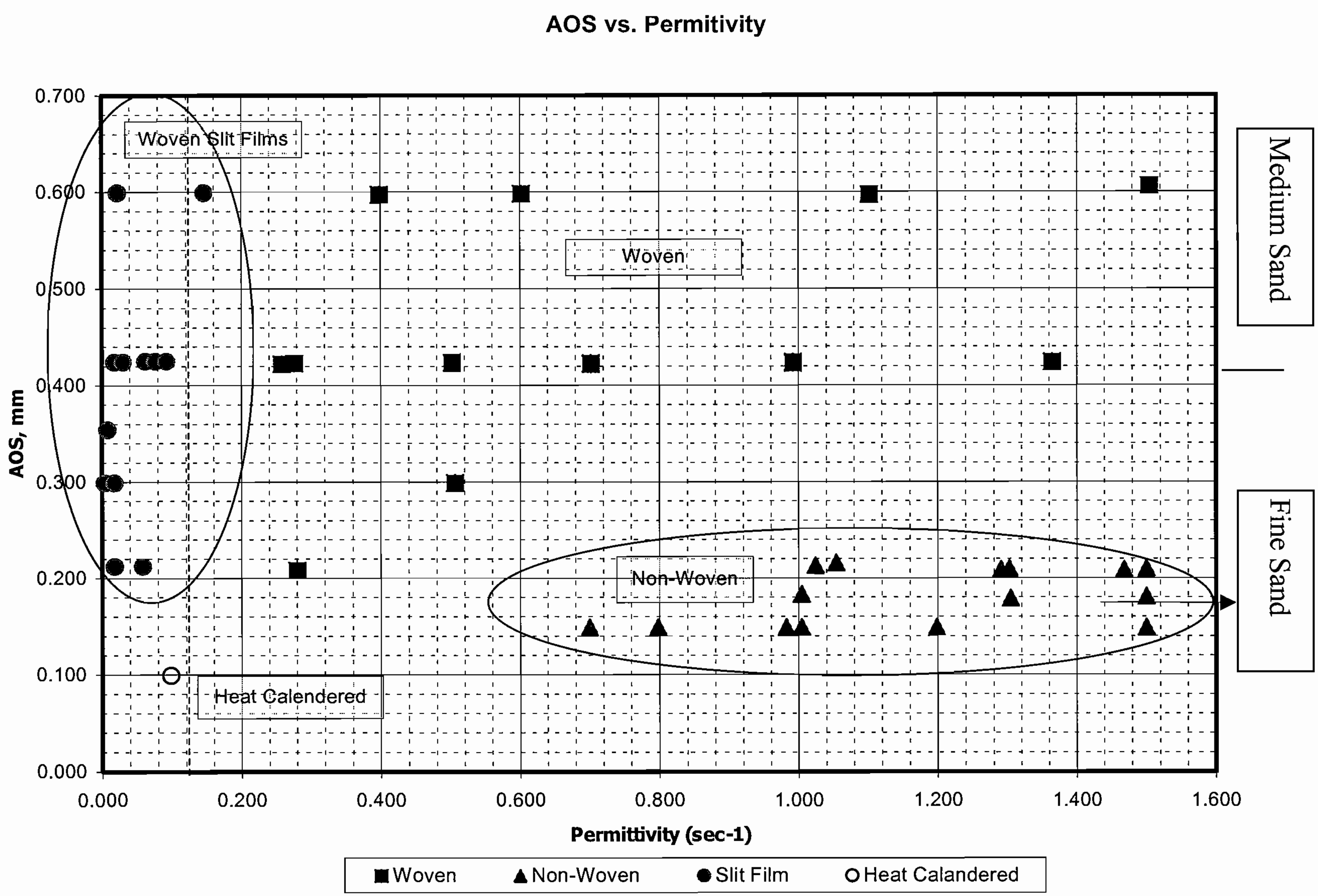

Figure 1 AOS versus Permittivity for Commercial Geotextiles

Table 3 AASHTO M288-96 Geotextile Specifications

Application	Subsurface Drainage		Erosion Control		Separation		Stabilization	
Property (MARV)	Elongation <50% Woven	Elongation >50% Nonwoven	Woven (no slit film x slit film)	Nonwoven	Woven	Nonwoven	Woven	Nonwoven
1. Strength Criteria	Survivability Class 2	Survivability Class 2	Survivability Class 1	Survivability Class 1	Survivability Class 2	Survivability Class 2	Survivability Class 1	Survivability Class 1
2. AOS, mm 3. Permittivity, θ, 1/sec	% Fines AOS θ ⑤ <15% .43 .5 NA 15-50% .25 .2 NA >50% .22 .1	 NA ② ②	% Fines AOS θ ③ <15% .43 .7 NA 15-50% .25 .2 NA >50% .22 .1	 NA ① ①	**.60 AOS(?)** .02 θ(?) ⑤	**.60 AOS(?)** .02 θ(?) ②	.43 AOS .05 θ(?) ④	.43 AOS .05 θ(?) ①

(?) suggest change in value

Nonwoven	①	**Class 1**	**AOS<0.25**	**θ >0.2**
	②	**Class 2**	**AOS<0.43**	**θ >0.2**
Woven	③	**Class 1**	**AOS<0.43**	**θ >0.7**
	④	**Class 1**	**AOS<0.43**	**θ >0.5**
	⑤	**Class 2**	**AOS<0.43**	**θ >0.5**

RECOMMENDATIONS:

- **Raise minimum permittivity to 0.1to 0.2 sec^{-1}**
- **Stop use of heat calendered and fabrics with all slit film**

needs of the engineering community with as few as 7 or 8 geotextiles. Thus a dramatic consolidation and standardization of geotextile types is possible and needed. *It is time to raise the level of performance of what we call a geotextile, standardize geotextiles, and reduce the confusion regarding the use of these materials.*

GEOMEMBRANES

The demand for geomembranes has built steadily since the 1980's with applications in mining, potable water containment, and of course landfill lining and caps. In the past decade, the implementation of RCRA Subtitle D requirements for municipal solid waste landfills added over 3000 sites for new application. Additional new applications this past decade have included lining anerobic digester vaults for the food processing industry and large scale agricultural lagoons and digesters.

<u>Geomembranes – Market Consolidation</u>

Over the next decade, domestic growth in liner sales will be marginal due a recession in the global mining industry and the dramatic consolidation now occurring within the solid waste landfill business. Figure 2, obtained from EPA's solid waste website, clearly shows that the number of solid waste landfills has declined dramatically over the past decade. The past year has seen the merger of all fist tier national solid waste companies: Allied Waste + BFI, USA Waste + WMX, Republic + Addington +.... By the year 2005 it has been forecast that 74% of municipal solid waste will be disposed of in landfills owned by publicly owned corporations. Of the remaining waste, 25% will go to publicly owned landfills and only 1% will go to privately owned facilities.

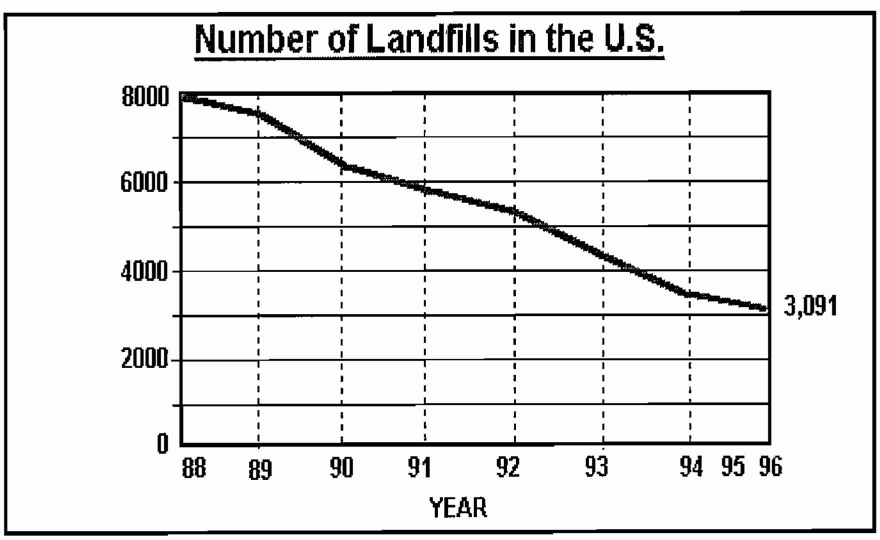

Figure 2 Number of Operating Municipal Solid Waste Landfills

One positive growth potential over the next decade will be generated by the final covers that are only now beginning to be constructed over lined solid waste landfills. While the technical design of these covers is still evolving, current experience is showing that these covers will cost from $100K to $140K per acre as compared to the $150K to $250K per acre being spent on lining systems. The annual area of cover geomembrane will increase over the next decade to that currently being required for lining systems. Thus annual volumes should increase and the number of corporate owner clients should decrease over the next decade. It will clearly be a decade when capital investment in new production lines should be minimal but may also hold out the prospect of a more efficient usage of those lines that currently exist.

Geomembranes – Manufacturer Consolidation

Not to be outdone by the mergers among their client base, the past decade has seen the merger of Gundle and SLT to form GSE Lining Technologies and the more recent merger of NSC and Serrot. Unlike geotextiles, the past decade has not seen a dramatic loss of major HDPE geomembrane producers and has seen new capacity reach the market from Solmax International and foreign suppliers such as Steel Dragon. From a user's perspective, based only on the declines in sheet pricing, it does appear that there is currently a surplus capacity for liner production.

PVC manufacturers have seen an increase in market share of approximately 20-30% in the past decade in essentially all applications other than MSW landfill liners. These applications include landfill covers, ponds, mining, water containment, and canals. This past year saw Occidental Chemical Corporation and O'Sullivan purchased by Geon; thus limited manufacturer consolidation is occurring. The establishment of the PVC Geomembrane Institute and product standards such as PGI-1197 for PVC geomembranes is an excellent beginning to establish a industry product identity that is inclusive to all manufacturers (Stark, 1999).

Geomembranes – Product Consolidation

Both HDPE and PVC geomembrane manufacturers have begun the process of standardizing their product across company boundaries. The recent GRI standards for smooth and textured HDPE geomembranes provides an example of the direction that this standardization must go. Accompanying these standards must be an aggressive educational program to both make users aware of the standards and to gain credibility for the standards. A good example of the need for standard credibility occurred on one of the author's landfills in Pennsylvania, the supplier of the HDPE geomembrane was changed by the contractor two days before installation was to commence. Both geomembranes met GRI standards, but Penn-DEP required us to verify that the new supplier met the GRI standard. This confirmation reached as far back as the polymer manufacturer. It required nearly two weeks of an engineer's time to verify that each requirement was indeed met. Two weeks late, the project began. The industry must sell the standard to all levels of users and then apply the standard to all products sold – this means actually printing the standard and a manufacturer's code on all products. Standardization, by its very nature, forces manufacturer's to consolidate their product lines across the industry.

The PVC geomembrane industry has begun an important step in this process for their geomembranes by establishing the PVC Geomembrane Institute (PGI) at the University of Illinois. PGI must both develop standards and to support these standards using a well maintained web page. This work crosses company product lines and demonstrates the direction that HDPE manufacturers must move to.

HDPE manufacturers must follow the lead of the PVC manufacturers and complete their standardization process. This work should include standards for LLPDE, and establishment of an industry web page and educational program.

GEONETS

Over the past decade, geonets have evolved from a clever means of recycling geomembrane floor scraps to an essential part of landfill leachate collection and final cover systems. Functionally, today's geonets provide a true radial planar flow in biaxial geonets to linear planar flow in triaxial geonets. Geonets are unique among geosynthetics in that they are always covered on both faces by either a geotextile or a geomembrane. *Thus geonets are the only geosynthetics that never actually come in contact with soil if they are properly installed.*

<u>Geonets – Market Consolidation</u>

The growth of geonet markets very closely parallels that of geomembranes. As previously discussed, this means that their current market growth is minor but that future growth may increase as the result of an increase in the number and area of final caps being placed on lined landfills. This growth may be less than anticipated if concerns regarding vegetative root intrusion prove true or if alternative covers that do not rely on barriers are approved for use. However, many alternative covers do rely on a capillary break layer that can be achieved using a geonet so that alternative covers may not have as large an impact on geonets as they do on geomembranes.

Geonets – Manufacturer Consolidation

The vertical integration of product lines by geomembrane manufacturers has lead to an increasingly difficult market opportunity for new geonet manufacturers. Most geonet sold today are sold as part of a "geo" package that includes geomembrane, geotextiles, and geonets. Thus, geomembrane manufacturers produce the majority of geonets. Geonet manufacturers that lack geomembrane products must generally private label for one of the geomembrane manufacturers. The recent integration of the Tenax tri-planar geonet into the GSE product lineup is a good example of the need for geonets to associate with geomembranes. Thus it is reasonable to assume that the next decade will produce no new geonet producers but will provide a further consolidation of such producers.

Geonets – Product Consolidation

The author has been very vocal regarding the need to design geonets for a unit gradient flow volume through the layer of material immediately above the geonet (Richardson and Zhao, 1998). This unit gradient assumption and the realistic assumptions regarding allowable drainage lengths in liner and final cover systems leads to a limited range of required transmissivities, Ψ. It is the author's opinion that the range of geonets currently manufactured could be replaced with the following current geonet configurations:

Final Covers

- ① Single-bonded (one geotextile attached) geonet for slopes < 10%
- ② Double-bonded (two geotextiles attached) for slopes > 10%
- $\Psi > 19$ gal/min-ft (4×10^{-3} m^3/s-m)
- Normal load capacity with minimal loss of $\Psi \approx 1000$ psf

Liners

- ③④ Single-bonded geonet for slopes less than 10%
- ⑤⑥ Double-bonded for slopes greater than 10%
- ⑦⑧ Net Alone for leak detection systems w/o composite primary liner
- $\Psi > 9$-19 gal/min-ft (2 to 4×10^{-3} m^3/s-m)
- Two normal load ranges, 15,000psf and 25,000 psf

This would cover the full gamut of landfill applications with only 8 geonet types. This could be reduced to as few as 6 geonet types by using the 15,000 psf capacity nets on cover applications. Standardization of geonets would be a considerable service to design engineers. The transmissivity test itself should be limited to gradients greater than 10% since this value can be conservatively used on flatter slopes and represents the true limit of the tests reproducibility.

Research over the next decade will need to focus on the current problem of adequately bonding geotextiles to the polyethylene ribs and means of increasing interface friction without the use of a geotextile. Bonding problems reflect themselves in poor peel strengths between the geonet and the geotextile and may impair the stability of veneer systems. If a polyester nonwoven is required to improve peel strengths, then manufacturers must search out a new source for this material. The lower geotextile in a double-bonded geonet provides an increased interface friction with the geomembrane but at the cost of a significant loss of transmissivity. Research should be started to develop a friction enhanced geonet that does do rely on a lower geotextile. Elimination of the lower geotextile and the moisture it stores may prove to be essential to limit root penetration of geonets in final cover systems. Geonet manufacturers must also increase their efforts in establishing an industry educational program, web page support, and a better understanding of their products.

GEOSYNTHETIC CLAY LINERS (GCL)

The first use of bentonite for waterproofing that the authors was exposed to was the use of Volclay panels to waterproof building basements. This application was popular in the 70's and continues today. From this beginning, contemporary GCLs have become an essential tool for the construction of alternative liner systems and caps for landfills of all types. Current regulatory hesitation in the use of GCLs appears to be limited to evidence of cracking and root penetration in final cover applications and the current Federal Regulation (40CFR258) driven restriction being enforced by EPA that prevents the use of GCL alternative liner systems in MSW landfills that recirculate leachate.

GCLs – Market Consolidation

In the author's opinion, GCLs over the next decade will continue to find increased applications in alternative liner systems and in final cover systems for waste containment applications. Recent failures of composite barriers on slopes (Richardson, 1997) has shown a potential new application for GCLs having a geomembrane component in providing a composite barrier for the slopes of final covers. Given that current technical limitations can be overcome, the next decade should be one of continued market growth for GCLs. One hopes the next decade will not provide the increasing market and decreasing profits of this past decade.

GCLs – Manufacturer Consolidation

From a designer's perspective, the two major manufacturer's of geotextile based GCLs, CETCO and NSC, appear to be locked in a price war that has certainly minimized the incentive of new manufacturer's joining this market. And with only two significant suppliers of geotextile based GCLs it is obvious that the industry cannot tolerate a consolidation of manufacturers. The author's interest is focused on whether GSE can develop an effective technical and marketing program for their geomembrane based GCL product. Can the inherent limitations of an unreinforced GCL be overcome or will geomembrane GCLs continue to live in the shadow of geotextile GCLs and eventually vanish from lack of market growth and product support?

GCLs – Product Consolidation

A review of the GFR Specifier's Guide shows that GCL manufacturers have maintained a limited variety of products types that covers a majority of potential applications. Unlike geotextiles, there does not appear to be a variety of products for variety's sake. In the author's opinion, the next decade will see a broader array of geocomposite barriers that bond the GCL directly to a geomembrane. All GCL manufacturers have initial attempts at such products but dramatic improvements will be inevitable. Composite GCL's must be developed that provide an intact geomembrane while providing adequate shear strength for slope applications. This means that either a GSE geomembrane product overcomes inherent stability problems on slopes or the geotextile reinforced GCL's will be provided with a more robust bonded and textured geomembrane. All reinforced GCLs will have to provide minimum peel strengths and hopefully the next year will find this parameter added to the annual GFR Specifier's Guide.

Summary

The next decade will hopefully see all geosynthetic products moving towards standardization and product lines based on technical needs. All segments of the industry must increase efforts to set product standards that reach across manufacturing boundaries, to increase educational efforts in support of such standards, and to begin identifying such standards directly on the products. The efforts of the Geosynthetic Materials Association (GMA), the Geosynthetic Institute (GSI), and Industrial Fabrics international (IFAI), must be better integrated to support this effort. Such integration might begin with an introspective evaluation of where "consolidation" could be applied to these organizations. At a minimum, each "Geo" product group should follow with interest the example currently being set by the newly organized PVC Geomembrane Institute.

The next decade will be the final decade of efforts by many of the "Geo" founding fathers. This transition of leadership will either be an opportunity for new ideas and growth or an opportunity for continued disintegration. On either hand, it will be an interesting decade.

References

Carthage Mills, 1999. Provided by Alan Ossage

Richardson, G.N., 1997. "Designer's Column: Fundamental Mistakes in Slope Design,", Geotechnical Fabrics Report, IFAI, St.Paul, MN., March.

Richardson, G.N., Zhao, A., 1998. "Lateral-drainage Systems Over Landfill Barrier Systems: Flat Slopes," Designers Forum, Geotechnical Fabrics Report, IFAI, St.Paul, MN., August.

Richardson, G.N., Zhao, A., 1998. "The Design of Geonets in Landfill Leak-Detection Systems," Geotechnical Fabrics Report, IFAI, St.Paul, MN., September.

Stark, Tim, 1999. Personal Communication.

Willibey, Gary, 1999. Personal Communication.