GRI – The Beginning

Gregory N. Richardson
G.N. Richardson & Associates, Raleigh, NC

## ABSTRACT

Engineering development is frequently initially driven by the needs of society and not the vision of its practitioners. Such was the situation in the development of geosynthetics in the late 80's and early 90's. This paper reviews the technical and political challenges that faced the geosynthetics industry and fostered the creation of GRI during this period. The ability of Robert Koerner to anticipate and bridge the needs of a technology emerging at a pace controlled by Federal needs is highlighted.

## Pre-GRI Geosynthetics

Prior to 1986, the "geo" world was segregated with specialty conferences for geotextiles and geomembrane occurring separately. The 1984 International Conference on Geomembranes held in Denver reflected applications primarily focused on potable water retention structures. The technical highlights of this conference were papers by J.P. Giroud[i] presenting the first rational approach to evaluating liner leakage rates and R.M. Koerner[ii] on slippage between geomembranes, geotextiles, and soils. The 1986 International Conference on Geotextiles held in Vienna provides 12 paper on water retention out of 227 papers. In Vienna, Robert Koerner foreshadowed the emerging geosynthetics world with papers on asphalt-impregnated geotextiles[iii], slope stabilization using geotextiles[iv], and drainage composites[v]. It was not until the Geosynthetics '87 conference in New Orleans that the "geo" world was united.

During this same period, the need for test procedures to evaluate both index and design properties of the emerging geosynthetics was critical. In the late 70's a joint D13/D18 committee was set up in ASTM to begin the process of establishing standards for geosynthetics. In 1984, this group became the ASTM D35 Committee on Geosynthetics. Membership included practitioners, academic researchers, and manufacturers. Progress was brutally slow. Table 1 shows the limited test standards available from D35 that were used in our 1986 EPA landfill design manual[vi]. Test standards for geomembranes were missing and practitioners had to rely on index standards available from the National Sanitation Foundation (NSF) Standard 54 Flexible Membrane Liners. As the name implies, NSF54 was oriented towards water retention ponds and was not totally compatible with the landfills that would soon dominated environmental applications.

Table 1 D35 ASTM Tests in 1986

| ASTM Test | |
|---|---|
| D4491 Water Permeability of Geotextile by Permittivity | Design |
| D4595 Tensile Geotextile by Wide Width Strip | Design |
| D4545 Integrity Factory Seams Flexible Sheet Geomembranes | Index |
| D4594 Effects of Temperature on Stability of Geotextiles | Index |
| D4632 Grab Tensile Strength Geotextile | Index |

1986 was an interesting year. Koerner and I were selected by EPA to prepared a design manual[vi] oriented to the practitioner for the design of lined landfills and their final covers as required by RCRA Subtitle C covering hazardous waste disposal. This same year Koerner was completing the text that would become an industry standard: Designing with Geosynthetics. Both documents focused on identifying the important roles played by the individual geosynthetic components and then developing rational equations to allow the designer to determine required physical properties. The engineering concepts of factor of safety and design by function were being applied for the first time to geosynthetics. Repeatedly, the key properties of the geosynthetics were not known and test standards did not exist for their evaluation. This included such properties as interface friction, biaxial stress-strain, geotextile clogging/filtration, and a significant number of relevant index properties. This ignorance would be compounded by the pending development of new and important geosynthetics such as drainage composites that were not yet available.

**The Pending Crisis: Design versus Regulation**

During the preparation of the EPA landfill design manual, Robert and I had frequent meetings with our Contract Officer Bob Landreth. Bob bore the weight of EPA's move towards lined landfill solely on his shoulders. An officer in the Public Health Service assigned to EPA, Bob had the knack of finding funding for essential projects. The picture he painted was disturbing: EPA would be extending the need for liners systems being used in the hazardous waste landfills to municipal solid waste landfills in the early 90's. The number of landfills impacted would increase from less than 50 to potentially more than 3000. The number of designers involved in the design of lined landfills was about to increase several orders of magnitude. Bob had three primary goals in mind:

- Development of a design manual that would provide guidelines to civil engineers for the actual design of these landfills and support systems;

- Identification of construction quality assurance practices that would ensure the quality of landfill constructed; and
- A national training program that would present these concepts to both designers and the regulatory community.

From 1986 to 1993, implementing these goals would occupy a significant portion of many of our lives, including Koerner's. Implementing these goals would also be a significant factor in the creation of GRI.

**EPA Landfill Design Manual**

By the mid-80's, lined MSW landfills had already become a reality in several states including New York and Pennsylvania. Robert had gained the trust of many of the owners of these lined landfills and had the reputation of being a "practical" academic. During this same time, I was involved in the design of hazardous waste landfill cells in Ohio. I still remember Robert calling to ask if I would be interested in collaborating in writing this manual. EPA was soliciting for a contractor to prepare the manual with the requirement that the firm must have designed a hazardous waste cell that was in operation. My initial challenge was convincing a client that my working for EPA in this effort was in their best interests. By our own estimate, only about 5 firms would be eligible to respond to this request for proposal. I figured that they would all have the same client convincing to do. In the end, my client saw the advantage to my role in developing training documents and the addition of Robert's practical academics to my design qualifications produced a successful team.

We began the design manual by reviewing both design and construction documents from hazardous waste landfills and MSW landfills in Pennsylvania. Designer's with such firms as Golder, Fred C. Hart, GeoSyntec were very helpful in providing both design details and sample calculations. Owners including Waste Management and BFI provided their construction documents and comments. Fortunately, the lined landfill world was very small at that time and in general very cooperative. Since the design manual would be an important element in the training of regulators, all interested parties were anxious for its success and accuracy.

Before we began the EPA design manual, Robert had completed much of the initial draft of his book Designing with Geosynthetics and the "design by function" mantra was set. Individual components of the landfill were divided into those beneath the cell (liner and leachate collection), within the cell (ramps, berms), and above the cell (final cover). Each component was evaluated for primary function and the design considerations required to ensure its successful function. Numerical design examples were developed for each component

consideration. The numerical design example problems were then drafted by my wife: love does come at a price. A typical example is shown on Figure 1 and illustrates one of our dilemmas: no final testing standards existed to define many key design parameters. The design manual accommodated this shortfall by including appendices than summarized pending ASTM and other test standards. This test standards shortfall was a major concern as discussed later in this paper.

The design manual also introduced both the legal concept of and implementation details for a construction quality assurance (CQA) program. This differed from conventional civil construction in that the construction quality assurance program had to be implemented by a qualified third party firm. A facility owner was not allowed to supervise construction of a landfill cell using in-house staff. The structure of the CQA programs and documentation provided in the design manual reflected CQA programs then required by BFI and Waste Management.

**EPA Training Courses**

After completion of the EPA design manual in the fall of ’87, Robert and I were asked to prepared portions of the manual for a training course to be held in each of the ten EPA regions. These courses were free to attend and open to EPA staff, state regulators, engineers, owners, etc. The course format was quickly established: David Daniel would present clay liner design and CQA considerations, Bob Landreth would discuss chemical compatibility of liners, I would discuss liner design, final cover design, and liner CQA, while Robert discussed leachate collection and long-term considerations. During the summer of ’88, courses were held in San Francisco, Seattle, Dallas, Texas, Chicago, Denver, Kansas City, Philadelphia, Atlanta, New York, and Boston. With attendance ranging from 400 to over 600, we were overwhelmed with the response. Needless to say, the classroom teaching habit of making eye contact with the audience was abandoned.

EPA monitored the effectiveness of the courses by having the audience rate the speakers and provide comments. While Dave, Robert, and myself have comparable weighted averages for scores, I alone attracted the outliers. Each night, as we flew to the next course, Dave and Robert would read to our fellow passengers selected comments from the outliers regarding me. With such comments as “should not be allowed in public”, “a danger to the global environment”, etc. I relied on bourbon to counter the stares of fellow passengers. Comments too obscene to be read were passed from aisle to aisle; the lack of in-flight movies was not noticed by anyone but me.

Allowing two years for the dust to settle, Bob Landreth organized a second national course series focused of landfill closures. This was precipitated by the significant number of Superfund and CERCLA closures of sites contaminated by historic industrial/municipal actions. Paul Schroeder joined our team to discuss the HELP model but proved to be ineffective at deflecting the outliers from me. As we moved from Atlanta, Philadelphia, Boston, Dallas, Kansas City, Denver, Newark, Chicago, Seattle, and Oakland during the summer of 1990, Robert and Dave presented "Outliers – Part II" to the traveling public.

Approximately 10,000 people attended the two national EPA courses and for most this was their first exposure to geosynthetics and landfill design procedures. Even more than a decade latter, it is rare to meet with a regulatory group regarding a landfill that someone in the group has not attended one of these courses.

**GRI – Technical Strategy/Staff**

Robert perceived that the immediate problems facing geosynthetics applications and acceptance were beyond the training of the geotechnical engineers who dominated geosynthetics research. On of the first additions to GRI was Professor Arthur Lord of the Physics Department at Drexel. Art has a Ph.D. in metallurgy and was fascinated by both the crystalline nature of some of the plastic polymers and the use of the centrifuge to allow model tests to better replicate field conditions. More importantly, Art brought a lot of personal class to GRI that humble geotechs could never duplicate.

Robert's second key staff addition was Grace Hsuan (a.k.a. Y.H. Halse) who had just completed a Ph.D. in materials engineering. Grace quickly moved in quickly and took over the stress cracking research and set up the more sophisticated laboratory test equipment required to evaluate plastic polymers. Grace's work in stress cracking of HDPE has been critical to our ongoing success with these liners.

As with all new fields, Robert discovered that he had to train some of the staff. George Koerner, upon completion of his undergraduate degree, had moved to Cincinnati and was working for John Bove and myself in one of the few commercial geosynthetics laboratories that existed in the 80's. George was a natural in the laboratory. Unfortunately for me, this did not go unnoticed by Robert and using Paula's cooking as a bribe he seduced George into returning to Drexel. George managed the critical studies on biological clogging and geosynthetic installation damage. George's laboratory skills led to an ongoing program of training and accreditation of geosynthetic testing laboratories.

**GRI – Business Strategy**

During the fall of '86, Robert and I were completing the EPA landfill design manual. During this period, Robert had established GRI as a nonprofit organization in Pennsylvania and located potential space at Drexel. However, "build it and they will come" was not the plan. Four target member groups existed: government agencies, national landfill owners, designers, and manufacturers. During 'beverage' breaks in our writing, the needs of each group as relates to GRI were discussed. These needs were defined as follows:

- Government (EPA and FHWA): training of staff for regulatory review or actual design, standardization of geosynthetic components, development of field construction guidelines, and research where appropriate;
- National landfill owners: training of designers, standardization of components, confirmation of long-term performance, research where appropriate, and a chance to sit and drink beer with regulators;
- Designers: training of staff, geosynthetic product information, reference test standards for project specifications, and a chance to sit and drink beer with regulators and landfill owners;
- Manufacturers: data on long-term product performance, research where appropriate, and a chance to sit and drink beer with regulators, landfill owners, and designers.

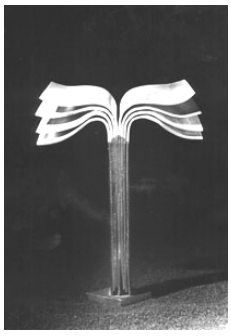
Table 2 Early GRI Membership

| Regulator | LF Owner | Designer | Manufacturer |
|---|---|---|---|
| US - EPA | Waste Management | Soils & Materials | Gundle Lining |
| US - FHWA | Browning-Ferris | Golder Associates | Polyfelt |
| | | GeoSyntec | Hoechst Celanese |
| | | GeoServices | Monsanto |
| | | | E.I. Du Pont |
| | | | Mirafi |
| | | | Tensar |
| | | | Poly-America |
| | | | Union Carbide |
| | | | Stevens Elastomerics |
| | | | Akzo |
| | | | Philips |
| | | | SLT |
| | | | National Seal |

Table 2 shows the breakdown of initial GRI members. I had the pleasure of giving Robert his second check (Gundle Lining was the first). Though industry consolidation has reduced the number of manufacturers, this same member profile exists today. In recent years, GRI began accepting associate members who are state or local government agencies with interests in geosynthetics and the membership roster now has an international flavor. But the beer (or ale) drinking pyramid continues.

**GRI – Facility History**

By November of ’86, GRI existed as a legal entity but was homeless. The following month GRI began its move into the west wing of the Rush Building. Gone were the days of the dungeon like basement of the Main building at Drexel. Also lost was the plastic ‘conditioning pond’ with its real and plastic aquatic life. Rush building offered dedicated space and distinct identity for the new institute. Originally a hospital, the new space offered a crematorium pit that became the site of Art Lord’s centrifuge and adequate heated space for Grace Hsuan’s polymer studies. Sounder minds prevailed and George Koerner’s biological clogging studies, leachate included, remained in the bowels of the Main building. The most enjoyable aspect of the new facility was, however, the addition of Paula Koerner to assist Robert.



For the next 12 years, GRI members could arrive at the Philadelphia airport, ride the rail shuttle to the 32nd Street station, and walk easily to GRI. Entering GRI through the inviting Alumni Garden, the new facilities were a dramatic improvement. Within the garden was a simple sculpture that the library science department that occupied the balance of Rush building thought was an open book. To GRI members it represented coextrusion or layered systems. Squares of geonets and GCLs were frequently found between the pages to simulate liner systems. Cultural wars are never pretty.

In 1998 GRI moved from Drexel to its current location near the airport. It maintains the GRI tradition of using ex-medical space and provided lead lined rooms! More importantly, it provides a potential for future growth, a reduced commute for the GRI staff, and greater airport convienece.

## Summary

It is difficult to picture the geosynthetic world in the absence of GRI. Rarely has such a small organization played such a critical role in key environmental and civil engineering programs. The founding of and early years of GRI represents the best memories of my 35-year career. But having known Robert Koerner for thirty of those years, I would expect no less from GRI.

## References

[i] Giroud, J.P., 1984 "Impermeability: The Myth and a Rational Approach," International Conference on Geomembranes, Denver, Colorado.

[ii] Martin, J.P., Whitty, J.E., and Koerner, R.M., 1984. "Experimental Friction Evaluation of Slippage Between Geomembranes, Geotextiles and Soils," International Conference on Geomembranes, Denver, Colorado.

[iii] Lord, A.E. and Koerner, R.M., 1986. "Diffusion of Water through Impregnated Geotextiles (MESL's), III[rd] International Conference on Geotextiles, International Geotextile Society (IGS)Vienna, Austria.

[iv] Koerner, R.M., Robins, J.C., 1986. "In-situ Stabilization of Soil Slopes Using Nailed Geosynthetics," III[rd] International Conference on Geotextiles, International Geotextile Society (IGS)Vienna, Austria.

[v] Koerner, R.M., Lucianai, V.A., Freese, J. St., Carroll, R.G. jr., 1986. "Prefabricated Drainage Composites: Evaluation and Design Guidelines," III[rd] International Conference on Geotextiles, International Geotextile Society (IGS)Vienna, Austria.

[vi] Richardson, G.N. and Koerner, R.M., 1987. *Geosynthetic Design Guidance for Hazardous Waste Landfill Cells and Surface Impoundments*, Final Report U.S. EPA Contract No. 68-03-3338, Released as EPA document EPA/600/S2-87/097 on Feb. 1988.