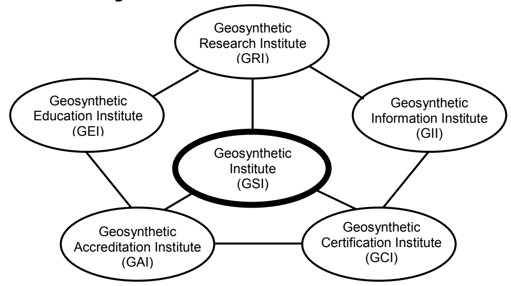
The GSI Newsletter/Report

Geosynthetic Institute



Vol. 18, No. 3 **September 2004**

This quarterly newsletter, now in its 18h year, presents the activities of GSI and its related institutes to all who are interested. It is available on the institute's home page at www.geosynthetic-institute.org. It also serves as a quarterly report to its member organizations. Details are available by contacting Robert M. Koerner or Marilyn Ashley at phone (610) 522-8440; fax (610) 522-8441 or e-mail at robert.koerner@coe.drexel.edu or mashley@dca.net.

Activities of the GSI Board of Directors & Institute Director

1. During a August 4, 2004 conference call, the board discussed the outcome of the 2004 annual member quality survey. A sincere thanks to those who responded. Follow-up calls have been made where weaknesses were expressed. Appropriate actions will be forthcoming. Future Newsletter/ Reports will carry information on GSI-Korea and GSI-Taiwan so as to gain greater visibility among the members.
2. The 2004 conference and annual meeting is taking shape with 80 papers committed and more coming. *There is still time if you have a short paper on "research-in-progress"*. Please contact us. The conference is set for Austin, Texas (with the GeoFrontiers Conference of GeoInstitute and GMA) on Wednesday, January 26, 2005.
3. GSI Focus Group Meetings are set for Thursday, January 27, 2005. See our Home Page (geosynthetic-institute.org) for details.
4. The following GRI conference and GSI annual meeting will be held in conjunction with NAGS. It is tentatively scheduled for Las Vegas, Nevada from December 14-16, 2005. More information later.
5. A relationship with GAM to provide e-mail and toll free telephone answering service is currently being setup. More information later.
6. Elections for board members whose term expires in 2004 will take place this Fall. The current members and their terms are as follows:

NOTICE: This Newsletter/Report is mailed to the contact persons of the GSI member organizations (~ 100 total). Obviously, we wish you would share it with colleagues and friends. Please recognize, however, that it is always available on our Home Page at www.geosynthetic-institute.org in the open section under the heading "Newsletter/Report".

<u>Term Ends 2004</u>
Dave Jaros - Corps of Engineers
Rex Bobsein - Chevron/Phillips Co.
Kent von Maubeuge - Naue Fasertechnik GmbH
<u>Term Ends 2005</u>
Dick Stulgis - GeoTesting Express
Jim Olsta - CETCO
Dave Suits - NY State DOT
<u>Term Ends 2006</u>
Tony Eith - Waste Management Inc.
Boyd Ramsey (Chairman) -
GSE Lining Technology, Inc.
At Large; Sam Allen - TRI/Environmental, Inc.

IN THIS ISSUE

Overview of GRI Projects (Research)

Each issue of our Newsletter/Report provides a brief glimpse and update of current GRI research projects. Details and full briefings are available to member organizations at their request. Dr. Grace Hsuan, Associate Director of GRI can be contacted for additional information as can the other project managers listed in the write-ups. Grace can be reached at (610) 522-8440 or e-mail at <grace.hsuan@coe.drexel.edu>.

1. **Stress Cracking of Geomembranes -** Dr. Grace Hsuan is project manager of our ongoing efforts to evaluate stress cracking of geomembrane resins, sheets and seams. In addition to her ongoing evaluations of HDPE geomembranes, Grace is now focusing on HDPE drainage and duct pipe. Her activity is on behalf of the Florida Department of Transportation (FL DOT). The goal for both geomembranes and geopipe is to include technically viable test methods and limiting values in generic specifications.
2. **Durability and Lifetime Prediction** - This project is based on our previous 8-year long study on the lifetime prediction of HDPE geomembranes. George Koerner has set up 20 replicate columns each of which is subjected to a compressive stress equivalent to a 50-m high landfill. In each of the columns are the following:

   (a) 1.5 mm HDPE geomembrane with no antioxidants (Stage B and C degradation will be evaluated)
   (b) 140 g/m^2 needle punched nonwoven PP geotextile
   (c) 140 g/m^2 woven slit film PP geotextile
   (d) 90 kN/m woven multifilament PP geotextile
   (e) 175 kN/m woven multifilament PP geotextile

   Temperatures are being maintained at 85, 75, 65 and 55ºC and the samples are being removed on approximate 6-mo. intervals. Grace Hsuan and George Koerner are in charge of the project.
3. **Durability of Polypropylene Geotextile Fibers and HDPE Geogrid Ribs** - Incubation at temperatures of 75, 65 and 55°C in forced air ovens is ongoing using PP-woven geotextile fibers and HDPE geogrid ribs. This 5-year study periodically measures changes in density, dimensions, mass, morphology, strength, elongation, modulus, melt index, OIT and carbonyl content. Dr. Hsuan is in charge of the project.
4. **Durability of Polyester Geotextile Fibers and Polyester Geogrid Yarns -** PET geotextile fibers and coated geogrid yarns are being incubated at temperatures of 65°C, 55°C and 45°C while being immersed in deionized water. Additional parameter variations are crystallinity, molecular weight and CEG content. This 5-year study periodically measures changes in mass, diameter, morphology, strength, elongation, modulus, molecular weight, crystallinity and CEG content. Dr. Hsuan is in charge of the project.
5. **In-Situ Temperature Monitoring of Liner and Cover Geomembranes in Dry and Wet Landfills** - Dr. George Koerner is evaluating the in-situ temperature behavior of geomembranes and has installed 20 thermocouples for long term measurements in a municipal solid waste landfill in Pennsylvania. This is a conventional "dry" landfill with no additional liquids added. Envisioned are temperature profiles of the liner and cover for up to 20 years.

   An additional effort in this regard is the monitoring of the geomembrane liner and cover temperatures in a bioreactor landfill in Pennsylvania. It happens to be at the same landfill as the previously described site which is a dry-landfill. The geomembrane beneath the waste was at an average temperature of 25°C (5°C higher than the dry landfill) at the start. It has gradually risen over the past 2.5-years to an average temperature of 40°C (approximately 10°C higher than the dry landfill). The cover geomembrane has also been instrumented and data is being generated. A technical paper is available.
6. **Bioreactor (aka, Wet) Landfill Behavior and Properties** – The above temperature monitoring has segued into a major effort under sponsorship of GSI and Waste Management, Inc. The wet cell under investigation is at field capacity, hence it is a true anaerobic bioreactor. Dr. George Koerner is in charge of considerable monitoring which includes the following:
   - waste moisture content
   - waste temperature
   - leachate chemical analysis
   - waste gas analysis
   - perched leachate within the waste

   Data is being collected on a quarterly basis. The timeline of the project calls for monitoring for 5 to 10 years. This fascinating project will be daylighted at GRI-18 in January 2005.
7. **Flow Behavior of Fully Degraded Waste** - A new field project under sponsorship of GSI and Waste Management investigates the drainage of highly degraded MSW placed directly on leachate collection systems. The leachate collection systems are both natural soils and geosynthetic drains. The project has commenced this summer at a landfill in the Philadelphia area.

8. **Hydrostatic Creep Puncture of Geomembranes** - The effect of sustained long-term hydrostatic and geostatic pressures on the puncture strength of geomembranes is an ongoing project. A series of tests using 600 g/m^2 protection geotextiles on 1.5 mm thick HDPE geomembranes is being evaluated; the time is currently 7-years. The four-test setups use truncated cone simulations of coarse subgrade stones against the geotextile protecting the underlying geomembrane. The behavior of the geomembranes under these tests is a combination of creep and stress relaxation. Results are used in a puncture design method that has been published previously. The purpose of these current tests is to better define the creep reduction factors used in the design method. It will be daylighted at GRI-18 in January, 2005.

9. **Long-Term Benefits of Geotextile Separators** - A full-scale field database of using geotextile separators on firm soil subgrades is being developed and maintained by Dr. George Koerner. Monitoring is proposed for up to 20-years. The target sites are paved highways, driveways, parking lots, etc., where control sections without geotextiles are also available for comparison purposes. This database will be national and perhaps even international in scope. Included are sites which meet the following criteria:
   - sites must have both geotextile and nongeotextile control sections
   - known type of geotextile(s)
   - known soil conditions
   - known traffic conditions
   - available hydrologic and environmental conditions
   - capability of quantifying the original condition of the pavement surface vs. the aged condition… this will be accomplished visually as well as by using falling weight deflectometers.

   There are currently 14-sites included in this program. If you have additional sites to add, please contact George at (610) 522-8440. A paper is available which outlines the procedure and field layout.

10. **UV Exposure of Geomembranes** - GSI is using its new Xenon Arc device along with its two existing UV-fluorescent devices to evaluate the simulated outdoor lifetime of seven different types of geomembranes 2 HDPEs, LLDPE, 2 fPPs and 2 PVCs). The effort is considered as part of GSI's Center for Polymers in Hydraulic Structures (CPHyS), but has relevancy in many other applications as well.

11. **High Pressure Incubation for Lifetime Prediction** - Dr. Grace Hsuan has an ongoing National Science Foundation project on this topic. Five high pressure cells are involved: four are at 2.1, 3.5, 4.9 and 6.3 MPa and one is the control at atmospheric pressure. In the cells are HDPE geogrids, needle punched nonwoven PP geotextiles, and woven slit film PP geotextiles. They will be periodically retrieved and tested for OIT and tensile strength. Comparison will then be made to nonpressure incubation to assess the acceleration factor. A paper is available.

12. **Generic Specifications** - A major effort is ongoing with respect to the development of generic geosynthetic specifications. As described at our recent annual meeting, the current status of these specifications is as follows:

    <u>Completed</u>
    GM13 – HDPE Geomembranes
    GM17 – LLDPE Geomembranes
    GM18 – fPP Geomembranes (Temporarily Suspended as of May 3, 2004)
    GM21 – EPDM Geomembranes
    GM19 – Geomembrane Seams
    GT10 – Geotextile Tubes
    GT12 – Geotextile Cushions
    GT13 – Geotextile Separators (Newly Approved)
    <u>Working Within Focus Groups</u>
    GCXX – TRMs for Erosion Control
    <u>Delayed or Off in the Distance</u>
    GGXX – Biaxial Geogrids
    GGXX – Uniaxial Geogrids
    GNXX – Biplanar Geonet Drainage Composites
    GCXX – Drainage Geocomposites
    GCLXX – Geosynthetic Clay Liners

    The completed specifications are available to everyone (members and nonmembers) on the open section of our Home Page. Please download and use them accordingly. Also, please note that this is where the latest modification will always be available.
    Also, these specifications are available on a separate power point CD which shows photos of the test methods and can be used as a presentation to clients and customers, as well as being an in-house training vehicle… don't hesitate to ask for a copy.

13. **Technical Guidance Documents on QC/QA of Waste Containment Facilities** - Drs. David Daniel and Bob Koerner have completed the Second Edition of this EPA project by greatly updating the original 1993 report. It will be published by ASCE Press, but if you want a preliminary copy on CD (~ 390 pages) contact us accordingly.

14. The 5th Edition of Designing with Geosynthetics was taken to the printers in August, 2005. It will be published in early 2005. To those who are interested, here is the track-record of this textbook over the years.

Edition	Date	Books Sold	Units
1	1984	3197	English only
2	1990	2645	English, SI in paren.
3	1994	4194	SI, English in paren.
4	1998	3500	SI only
5	2005	?	SI only

Activities within GII (Information)

We are currently supporting 2-Home Pages. The first is the GRI Home Page which is accessed as follows:

<<http://www.drexel.edu/gri>>

This home page is available to everyone (member or nonmember) and has the following menu:

- Background (including members whose home pages are linked to this home page)
- Geosynthetic Materials
- Geosynthetic Applications
- Masters Degree in Geosynthetics
- Prospectus

This home page is very introductory as far as geosynthetics knowledgeable people are concerned, and is meant to be promotional (for prospective students and potential institute members). It is probably of only nominal interest to most readers of this Newsletter/Report.

The second home page is the GSI Home Page (which is "terrific") and is accessed as follows:

<<http://www.geosynthetic-institute.org>>

It has been reconfigured through the fine efforts of Marilyn Ashley. Everyone (members and nonmembers) can access the open part, which has the following menu:

- **Introduction to GSI**
- **Prospectus**
- **Associate Membership (Agencies)**
- **Members by Focus Groups**
- **GSI Publications**
- **GRI Specifications & Guides**
- **Laboratory Accreditation**
- **CPReS & CPHyS**
- **Laboratory Accreditation**
- **Product Certification**
- **Newsletter/Reports**
- **Internet Courses**
- **Winter 2005 Courses**
- **Geosynthetics Links**
- **GSI Member Meetings**
- **Next GRI Conference**

To go further one needs a members-only password. Your contact person (see the last section of this Newsletter/Report if you do not know who it is) must get a password from Marilyn Ashley. Marilyn can be reached by e-mail at marilyn.ashley@coe.drexel.edu. When you get into this section, a treasure-trove of information is presented. This includes:

- **GRI Test Methods**
- **GRI Reports (Summaries)**
- **GRI Technical Papers (Citations)**
- **Notes of GSI Meetings**
- **Links to the GSs World**
- **Keyword Search for Literature**
- **Example Problems**
- **Frequently Asked Questions (FAQs)**

The "Links to the Geosynthetics World" is exactly that. The following is the menu in this file and by clicking on any item you will find all organizations involved in that industry segment. Selecting any one of them will give you their respective Web Site.

Regulatory Agencies
Standards Societies
Resin & Additive Producers
Geosynthetics Products
Geosynthetic Installers
Consultants in Geosynthetics
Geosynthetic Test Laboratories
Geosynthetic Organizations; Centers and Institutes
Universities with Geosynthetic Programs

Both GSI members and nonmembers are included, as are organizations on a worldwide basis. It's a super addition… try it out and advise accordingly.

Progress within GEI (Education)

The following four (each 1-day long) courses will be offered at GSI in January, 2005.

Course #1 - January 6, 2005

Geosynthetics in Reinforced Walls and Slopes incl. Computer Design

Goal: This one-day course is focused on the proper design and construction of reinforced retaining walls and steep soil slopes using geogrids or geotextiles. Included are the following:

- overview of concepts, aesthetics, costs, designs and performance,
- actual testing for tension, shear and transmissivity of geosynthetics,
- computer design using MSEWall® and ReSlope® - with Dr. Dov Leschinsky of the University of Delaware, and
- design of wall and slope drainage systems

Course #2 - January 7, 2005

Geosynthetics in Transportation/Geotechnical Applications

Goal: This one-day course is focused on the design, testing and construction of geosynthetics used in transportation and infrastructure facilities such as paved highways, unpaved roads, railroads, walls, steep slopes, embankments, filters, drains, and erosion control. The geosynthetics utilized are the following:

- geotextiles,
- geogrids,
- geonets,
- geomembranes,
- GCLs, and
- geocomposites.

Course #3 - January 13, 2005

Geosynthetics in Waste Containment Applications

Goal: This one-day course is focused on the proper design, testing, and construction of geosynthetics used in liner and cover systems for landfills, surface impoundments and waste piles. Included are the following geosynthetics:

- geomembranes,
- geotextiles,
- geonets,
- geogrids,
- geosynthetic clay liners,
- geocomposites, and
- geopipe.

Course #4 - January 14, 2005

Quality Control/Quality Assurance of Geosynthetics

Goal: This one-day course is focused on the quality control and quality assurance of geosynthetics as placed in permanent and/or critical applications. Specifications and testing are emphasized. It focuses on both the manufactured geosynthetics and on the installation processes. Applications are mainly in the waste containment area, i.e., landfills and surface impoundments, but applicability to walls, slopes, dams, canals, etc., will also be discussed. Included are the following geosynthetics:

- geomembranes,
- geosynthetic clay liners,
- geosynthetic drainage systems (geonets and geocomposites),
- vertical cutoff walls,
- ancillary materials & appurtenances.

All of these courses come with a complete set of notes, are fast-paced, extremely current, come with a great lunch, and are cheap! ($100 for GSI members; $200 for nonmembers)

Activities within GAI (Accreditation)

The Geosynthetic Accreditation Institute's (GAI) current mission is focused on a Laboratory Accreditation Program (LAP) for specific geosynthetic test methods. George Koerner is in charge of the program. The GAI-LAP was developed for accrediting geosynthetic testing laboratories on a test-by-test basis. GAI-LAP suggests that laboratories use ISO 17025 as their quality system model.

It should be made clear, however, that GAI-LAP does not profess to offer ISO certification, nor does it "certify" laboratory results. GAI-LAP provides accreditation to laboratories showing compliance with equipment and documentation for specific standard test methods, usually ASTM or ISO standards. GAI-LAP verifies that an effective quality system exists at accredited laboratories by way of proficiency testing.

As of September 2004, the following laboratories are accredited by the GAI-LAP for the number of test methods listed in parenthesis. Contact personnel and telephone numbers are also listed.

1[A] - TRI/Environmental Inc. (96 tests)
Sam Allen -- (512) 263-2101
3[A] - Golder Associates (45 tests)
Henry Mock -- (770) 496-1893
4[C] - Geosynthetic Institute (106 tests)
George Koerner -- (610) 522-8440
5[A] - NTH Consultants, Ltd. (52 tests)
Debra Klinger -- (610) 524-2300
6[A] - GeoSystems Consultants (27)
Craig Calabria -- (215) 654-9600
7[B] - Synthetic Industries Inc., Chickamauga (10 tests)
Steve Thaxton -- (800) 258-3121
8[B] - Synthetic Industries Inc., Ringgold (11 tests)
Toni Ruppert -- (706) 965-6300
9[B] - Synthetic Industries, Inc., Alto (10 tests)
Melvin Wallace -- (770) 532-9756
11[A] - STS Consultants Ltd. (13 tests)
Bill Quinn -- (847) 279-2500
13[A] - Precision Laboratories (78 tests)
Ron Belanger -- (714) 520-9631
14[A] - Geotechnics (61 tests)
Rick Lacey -- (412) 823-7600
18[A] - EMCON/OWT (51 tests)
Rasheed Ahmed -- (845) 351-5100
19[A] - HTS Inc. (42 tests)
Larry McMichael -- (713) 692-8373
20[A] - GeoTesting Express, MA (40 tests)
Gary Torosian -- (978) 635-0424
22[B] - CETCO Arlington Heights (13 tests)
Jim Olsta -- (847) 392-5800
23[B] - CETCO Fairmount (8 tests)
Derek Reece -- (706) 337-5316
24[B] - CETCO Lovell (8 tests)
Noe Garcia (307) 548-6521
25[B] - TC Nicolon (10 tests)
Melissa Medlin -- (706) 693-2226
26[B] - Agru America Inc. (16 tests)
Grant Palmer -- (843) 546-0600
27[B] - Amoco Fabrics and Fibers Co. (14 tests)
Tom Baker -- (770) 944-4718
29[C] - FITI Testing & Research Institute (70 tests)

Moon-Hyun Jeong (011-82-2-960-8034)
31[D] - NYS Dept. of Transportation (9 tests)
Dave Suits -- (518) 457-4704
32[A] - Vector Engineering (6 tests)
Ken Criley (530) 272-2448
33[D] - Arizona DOT (5 tests)
Oscar Mousaui (602) 712-8200
34[B] - GSE Richey Road (16 tests)
Jane Allen (281) 230-6726
35[B] - GSE Hardy St. (12 tests)
Nathan Ivy (281) 230-6726
37[B] - SL Limitada (16 tests)
Mauricio Ossa 56-2 6010153
38[C] - Sageos/CTT Group (54 tests)
Eric Blond (450) 771-4608
40[B] - GSE Lining Technology Inc. (14 tests)
Charles Miller (843) 382-4603
41[A] - SGI Testing Service, LLC (18 tests)
Robert Swan, Jr. (770) 931-8222
42[C] - NPUST (GSI-Taiwan) (31 tests)
Chiwan Wayne Hsieh 011-886-8-7740468
43[A] - Ardaman & Associates (18 tests)
George DeStafano (407) 855-3860
44[B] - BBA Reemay, Inc. (9 tests)
Mike Zenker (615) 847-7575
45[B] - Polyfelt Geosynthetics SDN Bhd. (23 tests)
C. P. Ng (603) 519 28568
46[B] - Bentofix Technologies (13 tests)
Pat Thiffault (705) 725-1938

[A]Third Party Independent [C]Institute
[B]Manufacturers QC [D]Government

If you are interested in this program and would like a copy of the GAI-LAP directory, please advise accordingly. A directory is published annually in December, and is also kept current on GRI's Home page at http://www.geosynthetic-institute.org. For additional information on the GAI-LAP program contact:

George R. Koerner, Ph.D., P.E., CQA
Geosynthetic Institute
475 Kedron Avenue
Folsom, PA 19033-1208
Telephone: (610) 522-8440
Fax: (610) 522-8441
E-mail: gkoerner@dca.net

Conflict Resolution

The following conflict resolution (CR) activity deserves discussion. It involves both ASTM D5994 "Test Method for Measuring the Core Thickness of Textured Geomembranes" and GRI-GM13 "Specification for HDPE Geomembranes". The CR was posed in the form of the following question:

Suppose we achieve the following results for thickness of nominal 60 mil double sided textured HDPE geomembrane when tested according to ASTM D5994. Which of the following roll(s) pass the thickness criteria set forth in the GRI-GM13 specification?

Roll and Thickness Results	Ave.	St. Dev.
Roll #1 Thickness Readings (mils): 62,54,52,60,56,54,58,51,59,62	57	4
Roll #2 Thickness Readings (mils): 60,51,62,64,54,51,55,56,54,63	57	5

First, it needs to be noted that per ASTM D5994 Section 11.1.7, one should report the individual specimen thickness measurements to the nearest 0.001 in. or 1 mil. Hence, the interpretation of the GRI-GM13 Specification for these two rolls is as follows;

Properties	Test Value 60 mils	#	Roll 1A	Roll 2A
Thickness mils (min. ave.)	nom. (-5%)	57	pass	pass
• lowest individual for 8 out of 10 values	-10%	54	pass	pass
• lowest individual for any of the 10 values	-15%	51	pass	pass

The second significant issue is the "any" in the above third criterion. This allows for two values being 53, 52, or 51 mils in the data set and is the rational for passing Roll 2; but just bearly.

Uncertainty Calculations

A major goal of the GAI-LAP program is to assure that all labs are generating repeatable and reproducible results, i.e. we want everyone to get the "same" numbers. A result is complete only when accompanied by a quantitative statement of its uncertainty. The uncertainty is required in order to decide if the result is adequate for its intended purpose and to ascertain if it is consistent with other similar results. In keeping with the ISO quality standard and in an attempt to quantity this rather complex issue we have compiled Tables 1 and 2.

Table 1, presents the accuracy of laboratory equipment found in most geosynthetic labs. This is the first component, and rather minor contributor if controlled, to variations in results. It is nevertheless necessary that we are dealing with calibrated equipment to the tolerances shown in the last column of Table 1. As you can see, accuracy's greater than 1% are uncommon. However, no discussion about uncertainty can be approached without knowing that we are dealing with well maintained and controlled equipment.

Over the years, many different approaches to evaluating and expressing the uncertainty of measurement results have been used. Because of this lack of international agreement on uncertainty measurement, there is much confusion. The uncertainty in the result generally consists of several components which may be grouped into categories according to the way in which their numerical value is estimated. Factors involved are generally considered, but not limited to, instrument differences, operator, sampling, time, and variation in the environment.

Table 1. Accuracy of Typical Geosynthetic Laboratory Equipment

Equipment	Standard Use for Verification	Accuracy
CRE Machine for load/ force	ASTM E4, Practices for Force Verification of Testing Machines	+/- 1%
CRE Machine extensometer	ASTM E83, Practice for Verification and Classification of Extensometers	+/- 0.5%
Pressure Gauge	ASTM D5720, Practice for Static Calibration of Electronic Transducer Based Pressure Measurement Systems for Geotechnical Purposes	+ 1%
Thermocouple	ASTM E77, Test Method for Inspection and Verification of Thermometers	+/- 0.5 deg C
Timer/ Stopwatch	MIL 45662A	+/- 0.25%
Volume	E694, Specification for Volumetric Ware	+/- 0.5%
Gas Flow	NIST 18010C	Class dependant
Water Flow	NIST 18020C	Class dependant
Balance	ASTM D4753, Specification for Evaluating, Selecting, and Specifying Balances and Scales for Use in Testing Soil, Rock and Related Construction Materials	0.5%
Mass	ASTM E617, Specification for Laboratory Weights and Precision Mass Standards	Class 1, 2, 3, or 4 dependant
Micrometer/ Caliper/LVDT	ASTM D6027, Practice for Calibrating Linear Variable Differential Transducers for Geotechnical Purposes	+/- 1%
Gage Block Set	NIST Traceable	+/- 0.001 in.

These factors are subsequently grouped together to establish a repeatability limit carried out by a single laboratory and a reproducibility limit attainable between determinations performed in different laboratories. In the simplest of presentations, the uncertainty is then calculated as the square root of the sum of the squares of the repeatability (Sr) and the reproducibility (SR). Table 2 presents the GAI-LAP current best estimate for the majority of the tests in the program. The uncertainties are large in some cases but typical of other construction materials.

Table 2. Uncertainty of Most GAI-LAP Tests

#	Standard	Name	Repeatability Sr	Reproducibility SR	Uncertainty %
1	ASTM D374	thickness	0.14	0.23	**27**
2	ASTM D413	adhesion	0.1	0.17	**20**
3	ASTM D471	liquid effect	0.035	0.088	**9**
4	ASTM D570	adsorption	0.057	0.108	**12**
5	ASTM D638	tensile	0.06	0.1	**12**
6	ASTM D696	coef. thermal exp.	0.03	0.05	**6**
7	ASTM D746	impact	0.1	0.2	**22**
8a	ASTM D751	thickness	0.09	0.17	**19**
8b	ASTM D751	mass/unit area	0.12	0.19	**22**
8c	ASTM D751	tear	0.11	0.19	**22**
8d	ASTM D751	grab	0.09	0.16	**18**
8e	ASTM D751	hydrostatic	0.15	0.36	**39**
9	ASTM D792	specific gravity	0.002	0.005	**1**
10	ASTM D882	strip tensile	0.03	0.08	**9**
11	ASTM D1004	90 deg. tear	0.08	0.2	**22**
12	ASTM D1149	ozone	0.3	0.4	**50**
13	ASTM D1203	volitile loss	0.09	0.23	**25**
14	ASTM D1204	dimensional change	0.25	0.17	**30**
15	ASTM D1238	melt flow index	0.03	0.095	**10**
16	ASTM D1388	stiffness	0.21	0.27	**34**
17	ASTM D1505	density	0.01	0.01	**1**
18	ASTM D1593	PVC thickness	0.07	0.1	**12**
19	ASTM D1603	CB content tube	0.01	0.01	**1**
20	ASTM D1621	compression	0.12	0.18	**22**
21	ASTM D1693	ESC bent strip	0.58	0.94	**110**
22	ASTM D1777	textile thickness	0.14	0.23	**27**
23	ASTM D1790	low temp. impact	0.04	0.15	**16**
24	ASTM D1822	impact	0.06	0.12	**13**
25	ASTM D1987	bio fouling	0.3	0.4	**50**
26	ASTM D2136	low tem. Bend	0.2	0.3	**36**
27	ASTM D2240	durometer	0.01	0.03	**3**
28	ASTM D3015	CB disp. hot plate	0.17	0.15	**23**
29	ASTM D3030	volitile matter	0.04	0.1	**11**
30a	ASTM D3083	soil burial	0.24	0.35	**42**
30b	ASTM D3083	water extraction	0.1	0.22	**24**
30c	ASTM D3083	seam strength	0.09	0.14	**17**
31	ASTM D3776	weight woven textiles	0.04	0.19	**19**
32	ASTM D3786	mullen burst	0.06	0.09	**11**
33	ASTM D3895	Std. OIT by DSC	0.05	0.13	**14**
34	ASTM D4218	CB content-muffle	0.03	0.06	**7**
35	ASTM D4355	xenon arc	0.2	0.3	**36**
36	ASTM D4437	field shear and peel	0.09	0.11	**14**
37	ASTM D4491	permittivity	0.16	0.32	**36**
38	ASTM D4533	trap. tear	0.09	0.14	**17**
39	ASTM D4545	factory shear and peel	0.09	0.11	**14**
40	ASTM D4594	GT temp. stab.	0.2	0.3	**36**
41	ASTM D4595	GT WWT	0.11	0.24	**26**
42	ASTM D4603	viscosity PET	0.1	0.15	**18**
43	ASTM D4632	GT grab	0.08	0.13	**15**
44	ASTM D4716	transmissivity	0.19	0.32	**37**
45	ASTM D4751	AOS	0.081	0.14	**16**
46	ASTM D4833	pin puncture	0.09	0.12	**15**
47	ASTM D4844	GT seam strength	0.12	0.32	**34**
48	ASTM D4885	GM wide width	0.11	0.14	**18**
49	ASTM D4886	abrasion	0.25	0.35	**43**
50	ASTM D5035	strip tensile	0.07	0.087	**11**
51	ASTM D5101	gradient ratio	0.2	0.25	**32**
52	ASTM D5141	silt fence test	0.35	0.55	**65**
53	ASTM D5199	thickness	0.018	0.045	**5**
54	ASTM D5261	mass/unit area	0.05	0.12	**13**
55	ASTM D5262	tensile creep	0.2	0.3	**36**
56	ASTM D5321	direct shear	0.2	0.22	**30**
57	ASTM D5322	9090 immersion	0.25	0.35	**43**
58	ASTM D5323	2% secant modulus	0.06	0.1	**12**
59	ASTM D5397	NCTL stress crack	.13	.16	**21**
60	ASTM D5493	perm. under load	0.1	0.15	**18**
61	ASTM D5494	pyramidal puncture	0.1	0.14	**17**
62	ASTM D5514	hydrostatic puncture	0.15	0.2	**25**
63	ASTM D5567	HCR	0.25	0.3	**39**
64	ASTM D5596	CB dist. microtome	0.11	0.15	**19**
65	ASTM D5617	multi-axial	0.15	0.2	**25**
66	ASTM D5721	oven aging	0.11	0.15	**19**
67	ASTM D5747	9090 immersion	0.25	0.35	**43**
68	ASTM D5884	tear R-GM	0.1	0.14	**17**
69	ASTM D5885	HP OIT by DSC	0.023	0.091	**9**
70	ASTM D5887	GCL flux	0.22	0.37	**43**
71	ASTM D5890	swell index	0.035	0.145	**15**
72	ASTM D5891	fluid loss	0.033	0.12	**12**
73	ASTM D5970	outdoor exposure	0.21	0.27	**34**
74	ASTM D5993	GCL mass/unit area	0.023	0.039	**5**
75	ASTM D5994	GM core thickness	0.14	0.23	**27**
76	ASTM D6140	asphalt retention	0.25	0.3	**39**
77	ASTM D6214	chem. peel and shear	0.12	0.17	**21**
78	ASTM D6241	CBR puncture	0.15	0.2	**25**
79	ASTM D6243	GCL direct shear	0.25	0.3	**39**
80	ASTM D6244	pavement comp.	0.25	0.35	**43**
81	ASTM D6364	short term comp.	0.1	0.15	**18**
82	ASTM D6392	thermo peel & shear	0.09	0.11	**14**
83	ASTM D6454	TRM compression	.13	.19	**23**
84	ASTM D6475	ECB mass/unit area	.06	.16	**17**
85	ASTM D6496	GCL peel	0.036	0.084	**9**
86	ASTM D6524	TRM resiliency	.15	.20	**25**
87	ASTM D6525	ECB thickness	0.14	0.23	**27**
88	ASTM D6566	TRM mass/unit area	.05	.18	**19**
89	ASTM D6567	TRM light penet.	.11	.17	**20**
90	ASTM D6574	radial transmissivity	.16	.19	**25**
91	ASTM D6575	TRM stiffness	.2	.25	**32**
92	ASTM D6636	GM ply adhesion	0.06	0.1	**12**
93	ASTM D6637	GG tensile	0.11	0.24	**26**
94	ASTM D6638	connection strength	.18	.21	**28**
95	ASTM D6693	GM pullout	0.06	0.1	**12**
96	ASTM D6706	pullout	.15	.24	**28**
97	ASTM D6766	9090 GCL	.2	.3	**36**
98	ASTM D6767	bubble point	.08	.12	**14**
99	ASTM D6768	GCL tensile	0.066	0.113	**13**
100	ASTM D6818	TRM tensile	.1	.17	**20**
101	ASTM D6992	TTS using SIM	.12	.20	**23**
102	ASTM E96	WVT	0.2	0.25	**32**
103	ASTM F904	ply adhesion	0.2	0.25	**32**
104	ASTM G154	UV practice	.17	.31	**35**
105	ASTM G155	xenon arc practice	.15	.22	**27**

Although preliminary, the results of Table 2 highlight the poorly behaved tests. Well behaved tests are those with uncertainties less than 10. Robert Koerner (2002) in his paper entitled "Beyond Factor of Safety : The Probability of Failure," uses Duncan's (2000) approach which requires these values for their probabilistic designs. It is imperative to tighten up on these factors affecting uncertainty. Participation in the GAI-LAP will facilitate this worthwhile aim. Thanks for working with us to assure continuous improvement in this regard.

George Koerner, Ph.D., PE, CQA
Associate Director - GSI

Activities within GCI (Certification)

We have an ongoing product certification program for all geosynthetics which have a generic specification. The program has as its target, conformance to a specific GRI specification such as GRI-GM13 for HDPE geomembranes. This specification has been in use for approximately 4 years with generally good reviews and considerable exposure. The specification is seen referenced in many project plans, specifications and quality assurance documents around the world.

The GCI certification program using this specification is based on ISO 9000 audits conducted on a 6-month cycle wherein the manufacturer's quality control plan and statistical data base are evaluated, along with sampling of the product. Upon testing by an accredited laboratory, the results are assessed and certification is granted, postponed or rejected. Certification carries with it the right to identify products as "GRI- Certified"; in this case “GRI-GM13 Certified”. We are delighted to report that SL Limitada of Chile is approved to mark its HDPE geomembrane.

GRI-GM13 Certified

Our sincere congratulations go to the following people who are the principals involved:

Enrique Saavedra	-	General Manager
Mauricio Ossa	-	Technical Manager
Michael Mathieson	-	N.A. Representative (WASEW Technologies Inc.)

The GSI Affiliate Institutes

It has long been realized that the information generated within the GSI group should have a timely outlet to all countries, and in all languages. To this end, GSI has created affiliated institutes in two countries (Korea and Taiwan), and potentially many others in the future. These affiliated institutes are full members of GSI and are empowered to translate and use all available information so as to create similar institutes and activities in their respective countries. We introduce these institutes to you in this Newsletter/Report and in future issues will present details of their respective activities.

GSI-Korea was formed on February 9, 1998 as a collaborative effort between FITI Testing and Research Institute (a quasi-government organization) and Chonnam National University (through its Department of Textile Engineering).

FITI is a 30-year old testing organization located in Seoul focusing on interlaboratory proficiency; environment protection; safety and flammability; hazardous substances; in-house quality control; consumer protection; complaint analysis; quality marking; procurement; hardlines and industrial applications; and type approval. It employs 120 people (8 with doctoral degrees) and 42 engineers. The geosynthetics testing group within FITI has 12 people (2 with doctoral degrees) and 10 engineers. The geosynthetic laboratory is GAI-LAP accredited for 70 geosynthetic test methods. Dr. Jeonghyo Kim is the general manager within FITIs geosynthetics activities.

Chonnam National University is located in Kwangju (southern Korea) and the geosynthetics laboratory within the Textile Engineering Department is led by Professor Han-Yong Jeon. Dr. Jeon has 10-students working on geosynthetic-related projects and is extremely active both nationally and internationally. The ongoing efforts of both FITI and Chonnam will be described in future Newsletter/Reports.

GSI-Taiwan was formed on August 18, 2000 and is wholly contained within the National Pingtung University of Science and Technology in Nei Pu, Pingtung (southern Taiwan). It completely parallels GSI in that it has specific units for research, education, information, accreditation and certification. The Director is Dr. Chiwan Wayne Hsieh who is a Professor in the Department of Civil Engineering and Director of the Computer Center. GSI-Taiwan has an Taiwanese consortium of geogrid/geotextile manufacturers who work toward producing quality products according to the draft GRI geogrid specification and the associated test methods. As such, GSI-Taiwan is a GAI-LAP accredited laboratory for 31 geosynthetic test methods. Dr. Hsieh has 10-students working on geosynthetic-related projects and is extremely active nationally and internationally. The ongoing efforts of GSI-Taiwan will be described in future Newsletter/Reports.

The Geosynthetic Institute Centers-of-Excellence

1. The Center for Polymeric Reinforced Structures (CPReS) was formed on Dec. 27, 2002 for the purpose of proper use of geosynthetics in walls, slopes, and foundation reinforcement. It involves Dov Leshchinsky of Delaware, Grace Hsuan of Drexel and George Koerner of GSI as Co-Directors. The mission statement and goals are available on the GSI Home Page at <geosynthetic-institute.org>. Ongoing projects are the following:

   (a) Dov Leshchinsky is modifying and incorporating two important aspects of reinforced walls into his widely-used computer program “MSEWall”. They are; design to accommodate short reinforcement lengths when full space is unavailable, and the incorporation of drainage geocomposites in accommodating low permeability backfill soils. The first topic was presented at GRI-17 in Las Vegas and a paper and report to GSI is available.

(b) Grace Hsuan is utilizing the Stepped Isothermal Method (SIM) for assessing the long-term behavior of various geosynthetic reinforcements including geofoam. Graduate student Sang-Sik Yeo, is performing the requisite research.

(c) George Koerner has supervised the construction of a segmental retaining wall at GSI which has 3-different masonry block types. He is measuring the pH-values directly between block surfaces and will do so for many years into the future… following is the "The GSI Wall". Data is currently available.

2. The Center for Polymers in Hydraulic Structures (CPHyS) was formed on June 20, 2003 for the purpose of proper use of geosynthetics in dams, canals, reservoirs, tunnels, pipes and related hydraulic systems. Jorge Zornberg of the University of Texas at Austin, Grace Hsuan of Drexel, and George Koerner of GSI are Co-Directors. The mission statement and goals are available on the GSI Home Page at <<geosynthetic-institute.org>>. Initial projects are being decided upon, but two are certain.

   (a) Grace Hsuan will focus on exposed geomembrane durability and lifetime. (See Item 10 previously). This issue is critically important to gain confidence regarding polymer lifetime in the minds of owners, regulators, designers and specifiers in the focused application areas.
   (b) Jorge Zornberg's activity, via a GSI funded graduate student, will focus on drainage behind exposed geomembranes on dams.
   (c) George Koerner's activities are within GSI and focus on the Xenon Arc and UV fluorescent devices.

3. In both CPReS and CPHyS, Bob Koerner will act in an advisory manner and as quality assurance! In both centers existing GSI Members and Associate Members are fully entitled to the information that is developed and their interaction is encouraged. No additional funding is anticipated. We will keep the membership advised as to progress in this regard. We sincerely hope that the membership is supportive of these initiatives and your comments/suggestions are always solicited.

4. There is a distinct possibility for additional centers of this type. Please contact Bob Koerner with suggestions and ideas.

Items of Interest

1. Engineering Markets Varied Last Year

The overall market for infrastructure engineering in the United States declined last year because of the lingering effects of the economic downturn in 2002 and the first half of 2003. After growth of 4 percent in 2002, the $19-billion environmental and infrastructure engineering market declined by some 2 percent last year. For the market as a whole, the power engineering sector, which suffered a 25 percent decline, was almost single-handedly responsible for the downward direction of the industry. Conversely, water quality engineering continued its strong growth, increasing by more than 10 percent. The market for transportation engineering services stalled during 2003, with a growth rate of just 3 percent, compared with 9 percent in 2002 and 19 percent in 2001. The hazardous waste management market also remained flat during 2003.

(Civil Engineering, August 2004)

2. EPA Issues Final Rule on Bioreactor RD&D Permits

EPA published the final rule for research, demonstration, and development (RD&D) permits for bioreactor landfills in the Federal Register on March 22, 2004. Under the new rule, states will have more regulatory flexibility to use new technology to manage MSW. The final rule allows the director of an approved state program to issue RD&D permits to owners and operators of MSW landfills. The permits would provide variances from certain federal regulations for new and existing MSW landfill units and lateral expansions. Variances may be provided for existing requirements for run-on control systems, liquid restrictions, and final cover requirements. EPA expects an owner/operator seeking an RD&D permit to complete an analysis demonstrating the internal and external stability of the landfill before a permit can be issued. An adequately designed leachate collection system is a prerequisite to an RD&D permit involving the addition of liquids, including the recirculation of leachate.

(MSW Management, July/August, 2004)

3. Private Toll Road is up For Auction

Texas' only private toll road, a $90 million link to Mexico that opened three years ago, has flopped financially and is up for auction after a foreclosure proceeding.

The 22-mile Camino Columbia was opened in October 2002 on the theory that it would be an alternative to clogged public roads and would speed the exchange of goods with Mexico as the North American Free Trade Agreement created more traffic across the border.

The four-lane highway connects the Columbia Solidarity Bridge to Mexico with Interstate 35 at a point 23 miles north of downtown Laredo.

However, traffic on the road -- for which the toll is $3 per car and $16 per 18-wheeler -- was only 13 percent of expectations.

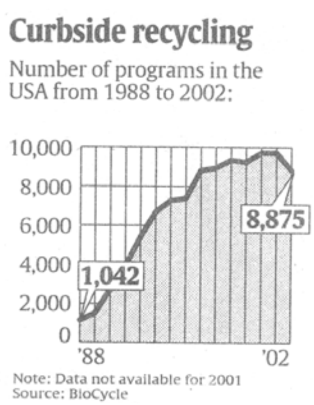
A private toll road in Virginia also has strugged financially. The owners of the Dulles Greenway borrowed millions of dollars to refinance the project in 1999, saying the traffic and toll revenue had fallen short of projections.

(Phila. Inquirer, Dec. 27, '03)

4. Recycling Efforts Dropping Off

Some of the evidence:

- Recycling has declined in many communities, including Seattle, where residents once sorted their trash with as much enthusiasm as citizens elsewhere root for the local football team.
- Americans are trashing more beverage cans and bottles (among the easiest items to recycle) into landfills. Recycling rates for both are the lowest they've been since the mid-1990s.
- The percentage of recycled material climbed dramatically in the late 1980s and 1990s. But it has not risen over the past few years.



(USA Today, July 7, 2004)

5. Growth in Hardscaping

The Interlocking Concrete Pavement Institute (ICPI) announces the release of a study that confirms continued growth of concrete pavers in North America in 2002. A survey estimated total sales for North American at 565 million ft^2 (56.5 million m^2). Approximately 19% is in Canada. Comparing results from a similar survey last year by ICPI, the amount sold represents a 17.7% increase from 2001 to 2002.

The study provides additional data on paver sales per manufacturer and average paver sales per plant location for the past three years that the survey has been conducted.

Visit www.icpi.org to order a copy.

Commentary on Geosynthetic Reduction Factors Part I - Separation and Reinforcement Applications

Introduction

It has long been practiced that the as-manufactured properties of most geosynthetics are reduced as they are used for design purposes. In so doing, one takes an ultimate test value and modifies it into an allowable, or design, test value. This practice is used in many materials and is one-half of the technique known as "load and resistance factor design", or LRFD, which is used by many highway agencies. In LRFD, loads are increased and resistances are reduced so as to arrive at a conservative and safe final design. Of course, the degree of conservatism is important and often a matter of contention between the parties involved, but that issue is not addressed at this time.

This two-part commentary is focused on the resistance aspects of geosynthetics and is presented in two board topic areas based on the primary functions that geosynthetics typically serve; they are (i) separation and reinforcement, and (ii) filtration and drainage. We will address separation and reinforcement in this first part, and then address filtration and drainage in the second part. [Containment situations using geomembranes and geosynthetic clay liners use their as-received material properties with no reduction factors and compensate in the final design with generous factor-of-safety values].

Separation and Reinforcement Reduction Factors

The usual equation for allowable strength of geosynthetics (wide-width, grab, puncture, tear, impact, etc.) is as follows.

$$T_{allow} = T_{ult}\left[\frac{1}{RF_{ID}\times RF_{CR}\times RF_{CBD}\times RF_{SM}}\right] \quad (1)$$

where

T_{allow} = allowable (or design) strength,
T_{ult} = ultimate (or as-manufactured) strength,
RF_{ID} = reduction factor for installation damage,
RF_{CR} = reduction factor for creep,
RF_{CBD} = reduction factor for chemical and biological degradation, and
RF_{SM} = reduction factor for seams (if appropriate).

The numeric values for all of the above items are both site-specific and material-specific. The latest edition of *Designing with Geosynthetics* presents Table 1 for common application areas involving geotextiles and geogrids. Note that all values are listed as ranges allowing the designer considerable latitude. Commentary on each of the reduction factors follows:

Table 1 - Recommended Strength Reduction Factor Values for Use in Equation 1.

Area	Range of Reduction Factors		
	Installation Damage	Creep*	Chemical/Biological Degradation**
Separation	1.1 to 2.5	1.5 to 2.5	1.0 to 1.5
Cushioning	1.1 to 2.0	1.2 to 1.5	1.0 to 2.0
Unpaved roads	1.1 to 2.0	1.5 to 2.5	1.0 to 1.5
Walls	1.1 to 2.0	2.0 to 4.0	1.0 to 1.5
Embankments	1.1 to 2.0	2.0 to 3.5	1.0 to 1.5
Bearing and foundations	1.1 to 2.0	2.0 to 4.0	1.0 to 1.5
Slope stabilization	1.1 to 1.5	2.0 to 3.0	1.0 to 1.5
Pavement overlays	1.1 to 1.5	1.0 to 2.0	1.0 to 1.5
Railroads	1.5 to 3.0	1.0 to 1.5	1.5 to 2.0
Flexible forms	1.1 to 1.5	1.5 to 3.0	1.0 to 1.5
Silt fences	1.1 to 1.5	1.5 to 2.5	1.0 to 1.5

*The low end of the range refers to applications which have relatively short service lifetimes and/or situations where creep deformations are not critical to the overall system performance.

**Previous editions of this book have listed biological degradation as a separate reduction factor. There is no evidence, however, of such degradation for the typical polymers used to manufacture geotextiles. Thus, it is currently included with chemical degradation as a combined reduction factor.

Installation Damage - This item has been quantified in several research projects with accompanying papers that are available in the technical literature. The nature of the subgrade, cover soil, and installation equipment counterpointed against the particular geosynthetic material gives rise to the use of the lower or upper values. The option always exists to construct a test pad in the field to determine a more project-specific and precise value.

Creep - Of all reduction factors to be discussed, creep has had the most attention given to it. This is appropriate since it is typically the largest value used in the calculation. The disadvantage of creep testing is the long testing time required. Considerable current attention is being given to time-temperature-superposition (TTS) and stepped isothermal method (SIM) testing. Both are very short in comparison to the original efforts using standard creep testing on individual test specimens. The open literature is abundant in this regard.

Chemical/Biological Degradation - These two degradation mechanisms were originally considered separately. As time progressed, it became clear that biological degradation did not occur with the high molecular weight resins used in the manufacture of geosynthetics. Thus, biological degradation should be eliminated entirely. However, if it is eliminated people will then ask where it is, and so it is currently combined with chemical degradation. Regarding the latter, one must know the site-specific environmental conditions and be aware of extremes, e.g., organic solvents, very high (or low) pH groundwater, and the like. The values listed in Table 1 are not based on research to the extent of the other values. That said, the values are the lowest and have the least impact on the allowable, or design, strength.

Seams - If seams are involved in strength related designs, a reduction factor can be added as indicated in the equation. The numeric value is very tractable. Using wide width strength test results of the unseamed material versus the seamed material (ASTM and ISO are nicely set up in this regard), the ratio is the desired reduction factor. It varies from 1.0 to 3.0 irrespective of the application area and is not included in Table 1 for this reason.

Others - Other atypical conditions, such as purposely cutting holes in a material, can be added as the site-specific conditions warrant.

Summary

It appears to the writer that the status of reduction factors in geosynthetic strength applications is in reasonable order, particularly when contrasted to the load estimation which is needed to complete a design. If we as an industry segue into LRFD methods it will be seen that much more uncertainty is associated with an estimation of both static and dynamic loads, including hydraulic loads in many cases. A recent paper on probability-of-failure calculations based on statistical variations of input values clearly shows this to be the case.

The second part of this communication (to be in the next issue) will address filtration and drainage applications and then offer concluding remarks on the two-part sequence.

Bob Koerner

Upcoming Events

- September 13, 2004 - Koerner Research Symposium at Drexel University, Philadelphia, PA
  Contact: <gkoener@dca.net>
  <www.drexel.edu/coe/conferences/Koerner/>
- One Day Courses at GSI:
  January 6, 2005 - GSs in Transportation
  January 7, 2005 - Walls and Slopes
  January 13, 2005 - GSs in Waste Containment
  January 14, 2005 - QA/QC in Waste Containment
- January 24-26, 2005 – GeoInstitute's GeoFrontiers '05 Conference in Austin, Texas
  Contact:
  <www.asce.org/confernces/geofrontiers05>
- January 26, 2005 - GRI 18 Conference at GeoFrontiers in Austin, Texas.
  Contact: <mashley@dca.net>
- January 27-29, 2005 - ASTM D-35 Meeting in Atlanta
  Contact: <csierk@astm.org>
- March 23-25, 2005 - 21st Central Pennsylvania Geotechnical Conf. at Hershey, PA
  Contact: <cbeenenga@gfnet.com>

GSI's Member Organizations

We sincerely thank all of our sponsoring organizations. Without them, GSI simply could neither happen nor exist. The current GSI member organizations and their contact members are listed below. The newest member organizations are *STS Consultants* (Mark Sieracke), *GSE Europe* (Stefan Baldauf/Mike Everest), *Precision Geosynthetics Laboratory* (Ron Belanger), *Geotechnics Inc.* (Rich Lacey), *InterGeo Geosynehtics* (Archie Filshill) and Raven Industries (Gary Kolbasuk). We welcome each of them to our growing family of geosynthetic-interested organizations.

GSE Lining Technology, Inc.
Boyd Ramsey [BoD]
Earth Tech Consultants, Inc.
Kevin McKeon/Ken Bergschultz
U.S. Environmental Protection Agency
David A. Carson
Polyfelt, GmbH
Gernot Mannsbart/Philippe Delmas
E. I. DuPont de Nemours & Co., Inc.
John L. Guglielmetti/David W. Timmons
Federal Highway Administration
Albert F. DiMillio/Jerry A. DiMaggio
Golder Associates Inc.
Daniel E. Ponder/Mark E. Case
Tensar Earth Technology, Inc.
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Poly-Flex, Inc.
James Nobert/George Yazdani
Colbond Geosynthetics
Wim Voskamp/Joseph Luna/Dennis Wedding
NOVA Chemicals Ltd.
Judy Webb-Barrett
Tenax, S.p.A.
Aigen Zhao/Caesar Baretta
Basell USA, Inc.
Robert G. Butala
TC Nicolon USA
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NTH Consultants, Ltd.
Jerome C. Neyer/Robert Sabanas
TRI/Environmental Inc.
Sam R. Allen [BoD]
U. S. Army Corps of Engineers
David L. Jaros [BoD]
Chevron Phillips Co.
Rex L. Bobsein [BoD]
Haley & Aldrich Consultants
Dave Schoenwoff
URS Corp.
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Bill Collier/Nick Tsui
Solmax Géosynthétiques
Robert Denis
Envirosource Technologies, Inc.
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CARPI, Inc.
Alberto M. Scuero/John A. Wilkes
Rumpke Waste Service, Inc.
Jay Roberts
Civil & Environmental Consultants, Inc.
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Waste Management Inc.
Anthony W. Eith [BOD]/Greg Cekander/ Charles P. Ballod
NPUST (GSI-Taiwan)
Chiwan Wayne Hsieh
GeoTesting Express
W. Allen Marr/Richard P. Stulgis [BoD]
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Michael A. Yako
SL Chile Ltda.
Mauricio Ossa/Enrique Saavedra
Atarfil, S. L.
Mario Garcia Girones/Emilio Torres
Republic Services Inc.
Clarke Lundell
Industrie Polieco – MPB
Enrico Pántano
GSE Europe
Stefan Baldauf/Mike Everest
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Environmental Agency of U. K.
Rob Marshall

IN THE NEXT ISSUE

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