June July 2006
Volume 24 Number 3

Geosynthetics

formerly GFR

Yucatan: Shoreline restored with geotextile tubes

TRM triumphs in California

Examine full-scale MSE test walls

An update from Korea

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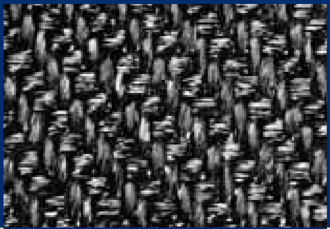

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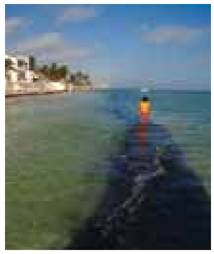

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Good engineers are worriers

| Ron Bygness, Editor
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That was a quote from Bob Bea in an April 13 report on National Public Radio's *Morning Edition*.

He should know. Robert G. Bea is an engineering professor at the University of California–Berkeley with five decades of geotechnical engineering experience. Since last autumn, he's served as one of the lead investigators in the National Science Foundation's study of the New Orleans levee failures during Hurricane Katrina.

In January, after Bea pointed out what he said was the use of substandard soils (too much sand) to reconstruct the levees, he was rebuffed by the U.S. Army Corps of Engineers. But in early April, during a follow-up inspection, Bea said he was greatly reassured with the quality of the materials and also the diligence of the Corps and the contractors on the job.

But Bea maintained that he was right to raise the alarm in January. "Good engineers," he said, "are worriers."

Contributions from around the world

We are delighted to welcome our friends, Enrique Álvarez del Rio from Mexico and Han-Yong Jeon from Korea, back to the pages of *Geosynthetics* (formerly *GFR*) in this issue.

Enrique presents a great follow-up to his article from the September 2005 issue of *GFR* about the beach restoration efforts on the north coast of Yucatan. His paper was a keynote at the proceedings of the international symposium, "Tsunami Reconstruction with Geosynthetics—Protection, Mitigation, and Rehabilitation of Coastal and Waterway Erosion Control" held in Bangkok, Thailand last December.

Dr. Jeon's article offers a timely update on the status of geosynthetics in Korea.

Welcome back, gentlemen—this is excellent information for our readers. Please see page 20 for "Back to the beach in Mexico" and page 32 for "Geosynthetics: Update from Korea."

Pack your bags

Let's go!

Let's go to Japan, to Yokohama. 8-ICG, the 8th International Conference on Geosynthetics, is Sept. 18-22 at the Pacifico Yokohama on Tokyo Bay.

Let's go to Washington, D.C. Geosynthetics 2007 is at the Hilton Washington Jan. 16-19, 2007.

Are you registered and all set to go?

Please visit *www.8icg-yokohama.org* or *www.geoshow.info*

Make your plans now if you haven't already. I'll see you there!

Ronald W. Bygness

***Geosynthetics* (formerly *GFR*) is an international, bi-monthly publication for civil engineers, contractors and government agencies in need of expert information on geosynthetic engineering solutions. *Geosynthetics* presents articles from field professionals for innovative, exemplary practice.**

| *Geosynthetics* encourages your contributions of case histories, photos, and field tips. For submittal guidelines, contact Ron Bygness at 800 225 4324 or +1 651 225 6988; e-mail: rwbygness@ifai.com.

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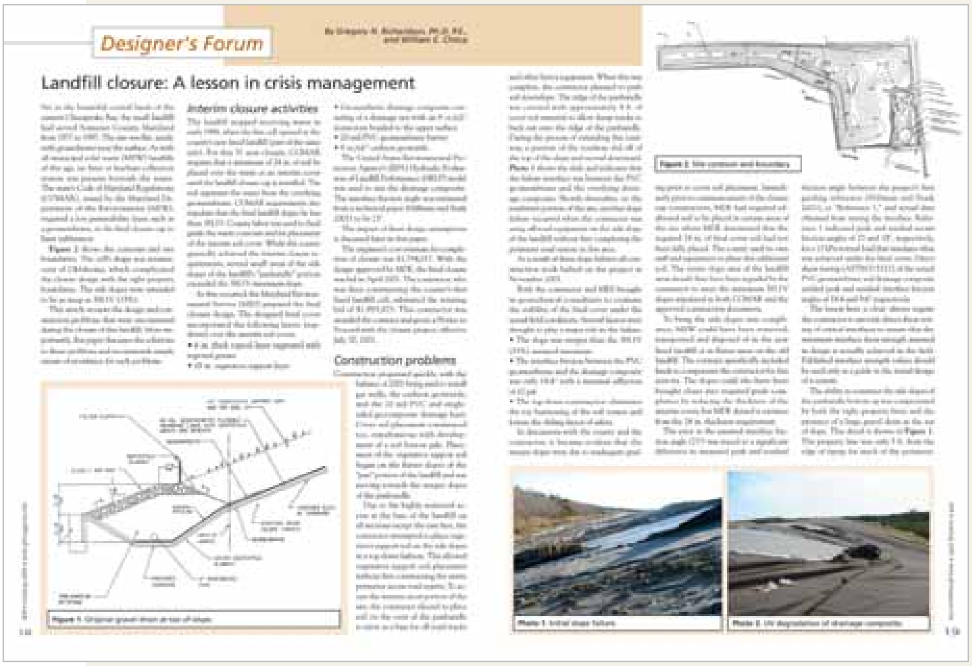
Further comment on ‘Landfill closure’ column

To the editor:

I want to express further thoughts on the Designer’s Forum column in the June/July 2005 issue of *GFR* (now *Geosynthetics*), titled “Landfill closure: A lesson in crisis management” by Gregory Richardson and William Chicca. This article is interesting but does not present the real reason for implementing the crisis management procedures described therein, namely the problematic design and lack of testing to confirm the design of the cover system.

The initial geosynthetic cover specifies a single-sided drainage composite with the geonet in contact with the underlying 20-mil PVC geomembrane on slopes that were designed to be 3H:1V (18.4°) but ended up to be as steep as 2.5H:1V (21.8°) after cover soil placement by the county. Because of the low normal stress present during cover soil placement, the geonet did not develop enough friction with the underlying geomembrane to produce a stable slope.


Designer's Forum

By Gregory N. Richardson, Ph.D., P.E., and William C. Chicca

Landfill closure: A lesson in crisis management

Interim closure activities

Construction problems

Figure 1: Original gravel drain at toe of slope

Figure 2: Site contours and boundary

Photo 1: Initial slope failure

Photo 2: UV degradation of drainage composite

Besides the inclusion of the weak geonet/PVC geomembrane interface, other troubling aspects of the design were the stability analyses being conducted after the construction drawings were distributed for bid purposes. However, stability analyses were prepared prior to issuance of the Permit-to-Construct.

Second, the interface strength parameters used in the stability analyses were obtained from a geosynthetics seminar instead of site-specific interface testing. In addition, the assumed interface strength parameters were not verified prior to bid or construction. In fact, no interface testing was conducted until after slope instability developed.

Richardson and Chicca (2005) suggest that the designer used data from Stark and Hillman (2001) to develop the design interface friction angle of 23° but this paper was not published until after the date of the stability calculations. Even if the designer somehow obtained an “advanced copy” of the paper, it is recommended that designers not use information until it is published or contact the author to assess the status/usefulness of the data. For example, Hillman and Stark (2001) present interface data for a 30-mil PVC geomembrane and not a 20-mil PVC geomembrane as was used in this case. Hillman and Stark (2001) clearly show PVC geomembrane interface strength is a function of thickness and surface texture.

The selection of interface strength is especially critical in the cited case because the regulatory agency only required a state factor of safety of 1.3 for final cover slopes instead of the typical value of 1.5. Thus, the calculations performed using the “seminar” strength parameters only achieved a factor of safety of 1.3.

In conclusion, I recommend that: (1) design entities not “recycle” designs from prior sites and assume that the design will be suitable for another site; (2) slope inclinations are verified to match design assumptions before allowing bid and/or construction to proceed so oversteepened slopes are not encountered; (3) stability analyses be conducted before requesting bids; (4) site-specific interface testing be conducted to verify the design strength parameters prior to bid and construction; and (5) Maryland raise the required static factor of safety for landfill covers from 1.3 to 1.5 to prevent future landfill cover problems.

Timothy D. Stark
Professor of Civil and Environmental Engineering,
University of Illinois

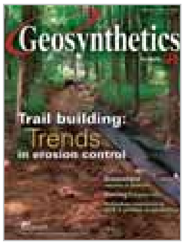
Sources

Hillman, R.P. and Stark, T.D., 2001, “Shear Behavior of PVC Geomembrane/Geosynthetic Interfaces,” Geosynthetics International Journal, Industrial Fabrics Association International (IFAI), Vol. 8, No. 2, June, pp. 135–162.

A most-interesting article…with one correction

To the editor:

I really enjoyed reading the article on the use of synthetic and/or manufactured soil stabilization materials in World War II by Mr. Gregory Richardson (*Geosynthetics*, February-March, pp. 14-20, "Lost in history: Geo-Airdromes").



I am very much an amateur historian on WW II and have quite a collection of books on the subject. I am also a collector of model airplanes and vehicles of the period, as well as also collecting the real things. I have two military jeeps, a trailer, and other items.

My first hands-on experience with the "pierced steel planks" (PSP) came back in 1974 when I worked with the Metzgers at

Terrace Gardens in Youngstown, Ohio. Both served in WW II and they had acquired some surplus PSP that we used to support tractors and tree movers in soft soil conditions.

I did, however, find one error in the article. On page 20, where the references are made to the aircraft that were using the newly created airstrip on the bluffs overlooking Omaha Beach, the fighter planes mentioned are [incorrect]. There was never a P-30 serving in WW II in the European Theater of Operations (ETO). That plane was the P-38 "Lightning" manufactured by Lockheed.

The P-38 was credited with more "kills" than any other fighter plane in our service in WW II. It was also the most-feared by the Axis forces, as mentioned by Gen. Fritz Bayerlein who was [German Field Marshal Erwin] Rommel's Chief of Staff in North Africa, and later during the Normandy invasion and the ensuing ETO battles, when he commanded the elite German Panzer Lehr Division.

The ability of our Allied forces to quickly and effectively create forward airstrips in direct support of our ground troops was a major factor in defeating the Axis forces. This article certainly illustrates how critical it was to have the materials that allowed our forces to do what needed to be done—a most-interesting article and thoroughly enjoyed by this reader.

Respectfully submitted,

G.M. "Skip" McCullough
APLD #156
Certified Professional Landscape Designer
Meadowbrook Nursery and The Landscape Co.
Lisbon, Ohio

Ecosystems, soil present challenges for levees

There is no shortage of challenges to building hurricane protection in Gulf Coast USA.

Soils are so soft that it's difficult to get the land to support massive levees. The landscape itself continues to sink through natural and man-made processes. And a fragile ecosystem of coastal marshland likely will be affected by whatever is built.

Federal, state, and private engineers and designers have been meeting and tussling with such concerns, often through sessions such as workshops sponsored by the U.S. Army Corps of Engineers. Congress has mandated that the Corps come up with plans for a comprehensive system to protect against a Category 5 storm. One portion of this comprehensive plan will include the entire Louisiana coast. An initial report is to be issued to Congress this summer.

Corps officials said they want to come up with new ways to build strong, durable, stable levees. Peter Cali, an engineer with the Corps, said soft soils mean that earthen levees would need to be built much wider at the bottom to more evenly distribute weight. Such levees would sink more slowly than conventional ones, but would need to be very wide, he said.

A levee built to a 40-ft. elevation with a 10-ft.-wide crown would end up measuring 930 ft. wide at the base. If a levee was built by digging a "borrow pit" next to it—a standard practice—the entire "footprint" of the levee would be 3,500 feet across.

"You can see the magnitude of what you'd [need to] build in soft soil conditions," Cali said.

Then there's the issue of what materials to use to construct new levees, since digging a "borrow pit" often means using soft marsh soils. "One of our biggest challenges will be to find suitable building material," Cali said.

Builders must consider many other factors. Among the issues: Every pipeline the system crosses will need to be relocated; the levees will affect how protected areas drain; and digging channels to build the levees will have an impact on coastal-restoration efforts.

Obviously, the construction itself comes with complications, Cali said. He described how levees are typically built by packing the dirt and adding additional layers after the structure sinks, often using geotextiles to help support some of the weight, plus metal sheet piles to stabilize the structures.

"This is what we do now, but we may need to do something different," Cali said.

One option is to use concrete within earthen levees to strengthen weak soils. Another suggestion is using a soft-fill interior covered with tougher soil. A soft fill, which could be sand or even a type of geofoam, would allow the levee structure to be lighter than a conventional one. Another idea is using tubes filled with water or air—inflated on their own or on top of an earthen levee—to provide additional storm-surge protection, Cali said.

Testing would be required to see if those types of levees would be sturdy enough to withstand a hurricane's storm surge, he said.

One complication in complying with the congressional mandate is determining exactly what "protect from a Category 5 storm" means. Category 5 describes a storm only in terms of wind speed, but that does not directly translate into how high or strong a levee needs to be.

"[There] could be a 10-ft. surge with a Category 2, or a 15-ft. storm surge with a Category 2," said Nancy Powell, chief of the Corps' hydrologic engineering section.

The strength of a surge depends on many factors, including the central intensity, the size and scope of a hurricane, wind speeds, what inland waters the storm crosses, the slope of the Continental Shelf in the area, and the temperature of waters in the Gulf of Mexico.

| *The Advocate* of Baton Rouge, La., and Ron Bygness, editor of *Geosynthetics* (formerly *GFR*), contributed to this article.

Geofoam used in Kentucky road rehab

An innovative highway rehabilitation project in northern Kentucky has utilized a geofoam fill system to stabilize the roadbed. The project was unusual because of a new approach to stopping chronic road slippage.

A 1-mile stretch of Kentucky Highway 8 in Campbell County was bolstered with geofoam instead of infill dirt to prevent slippage. Geofoam, used in place of soil and rock, took the weight off the top of the slide to prevent future movement, according to the Kentucky transportation officials.

The roadbed was filled with huge blocks of geofoam, a sturdy geosynthetic compound similar in consistency to a foam drinking cup. The technique has been used successfully elsewhere across the U.S. but is being tried in northern Kentucky for the first time.

The soil beneath the road is subject to flood damage, though the Ohio River has never risen to the road level in modern times. Harsh weather interrupted the project last winter. But after hot asphalt plants reopened in Kentucky this spring, the contractor finished pouring asphalt, and plans to complete all grading, seeding, striping, and shoulder work this summer.

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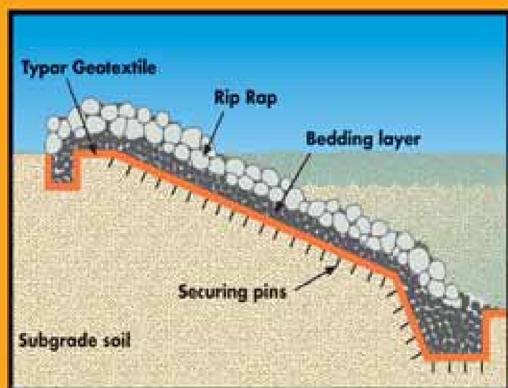

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GMA Geosynthetic Materials Association

Sand-confinement grids from Geocell Systems

In the wake of the floods following Hurricane Katrina, officials are working to figure out how to prepare and respond to other natural disasters involving flooding, and the need for improved water barriers. The U.S. Army Corps of Engineers (USACE) is now in the process of testing new, so-called "super-levees."

The first series of modular sand-confinement grid systems by Geocell Systems is called the Rapid Deployment Flood Wall (RDFW), and is designed to supplement existing earthen water barriers. The strength of an RDFW is much greater than that of a sandbag structure, and its construction requires much less labor. RDFW is made of an environmentally friendly, recyclable plastic from Eastman Chemical Co. of Kingsport, Tenn. The material is resistant to vermin and mildew, and is convenient to store, repair, and reuse.

| The geogrid walls are assembled and then filled with sand. The walls can be assembled and installed by only two people. Tests have demonstrated that the construction of floodwalls with RDFW is much faster than with traditional sandbags.

| In the same amount of time it would take a crew of sandbaggers to build a 4-ft. water barrier the length of a football field, a work crew using RDFW can build one that is 5.5 miles long.

| According to the official USACE report, a 50-ft.-long, 4-ft.-high section of RDFW was subjected to 40 hours of wave action. Wave height was varied between 0.42 ft. and 1.52 ft. The RDFW withstood the testing with minimal, easily repairable, damage.

| When assembled, an RDFW is quickly expanded into place and then filled from the top with a loader, excavator, bottom-dump, or other earth-moving equipment.

| RDFW is reusable, making it cost-effective. The grid folds compactly, can be stored for 10 years or more, and is resistant to vermin and mildew.

Propex names Dana new CEO

Joseph F. Dana was named president and CEO of Propex Fabrics Inc., effective March 20, 2006. He was also appointed a director of the company. Dana, who was previously vice president and chief of North American operations, joined Propex when it acquired SI Concrete Systems Corp. and SI Geosolutions Corp. on Jan. 31, 2006.

Dana, 58, was president and CEO of SI Concrete and SI Geosolutions, which were formed in October 2005 as part of the reorganization of the former SI Corp. He had joined SI Corp. as COO in June 1997 and was promoted to president in August 1999. He assumed the role of CEO in January 2001.

Dana served as SI's external general counsel from 1986 to 1997 and was a member of SI's board of directors since 1993. He earned a bachelor's degree and a law degree from the University of Georgia.

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Geosynthetics: U.S. demand will continue to grow

U.S. demand for geosynthetics is forecast to advance 4.1% per year to 865 million yd.^{2} in 2006, according to The Freedonia Group Inc. Demand will be driven by growing consumer awareness of the benefits of geosynthetics in various applications, fueled by an ongoing consumer education effort on the part of manufacturers and industry organizations.

The result will be greater penetration of geosynthetics in a broader array of applications. Further gains will be restrained somewhat by the projected deceleration of nonbuilding expenditures through 2006.

In value terms, growth will lag somewhat because of overcapacity and the resulting difficult pricing environment for certain geosynthetic products, the report stated.

Geotextiles to remain dominant

Geotextiles accounted for the largest share of demand for geosynthetics in 2001, with roughly 75% of volume sales. However, geosynthetic sales in value terms is led by geomembranes, which cost more than geotextiles on a dollars per sy basis. Smaller volume geosynthetic products, such as geogrids, are expected to achieve stronger demand growth through 2006, albeit from a small base.

Gains for these smaller volume products will be driven by the ongoing development of new applications as well as the growth of pre-fabricated geocomposite products.

Solid-waste disposal, erosion-control markets are fastest growing

Among the various markets for geosynthetics, ground stabilization and reinforcement continues to lead demand, accounting for 29% of sales in volume terms in 2001. Part of the reason is this is one area where consumers are fairly familiar with geosynthetics.

Though growth for the ground stabilization and reinforcement market will remain healthy, stronger annual gains are projected for markets such as solid-waste disposal and erosion control, where geosynthetics benefit from the performance advantages of the materials relative to competing products.

The South was the largest geographic market for geosynthetics in the U.S. in 2001, but the West is expected to experience faster growth through 2006. Advances in these census regions will be driven by strong growth in nonbuilding expenditures, as well as the most rapid gains in population and overall economic activity.

Biodegradable staple system introduced

American Excelsior Co. and Uzet World Dublin have partnered to introduce e-Staple to the erosion-control industry. The devices offer an option in biodegradation from cold to warm conditions and will not soften during storage through humidity pickup.

The e–Staple product can also be used on coastal erosion installation projects and for sod as well, and disappears in 8 to 24 months. The material is waterproof and has been approved by the Irish Department of Communications, Marine and Natural Resources.

The material characteristics and the e-Staple design provide high holding and tensile strength. A manual applicator system is available now; a pneumatic hand-held and automated applicator is planned for future release.

For more information: 888 352 9582; www.sales@AmericanExcelsior.com.

GMA offers new level of membership

The Geosynthetic Materials Association (GMA) is now offering a new level of membership for distributors of geosynthetics. The GMA Executive Council recently approved a measure that opened the door for membership to distributors of geosynthetic materials.

"Distributors play a vital role in the geosynthetics industry," said Ernie English, chairman of the GMA Executive Council. "Their expertise in this marketplace will add to the dialogue, programs, and promotion of geosynthetics by GMA.

"GMA membership will also provide distributors with a venue to network with geotechnical engineers and manufacturers of geosynthetics. Bringing distributors into GMA will make the organization an even stronger voice for the geosynthetics industry," English said.

The organization is currently undertaking lobbying efforts intended to enhance the value of GMA membership and build the market for both manufacturers and distributors. (See page 52.)

If your company partners with distributors who would benefit from membership in GMA, please contact Andrew Aho at +1 651 225 6907; amaho@ifai.com. G

Project Showcase

| Turf reinforcement mat to the rescue in Riverside County. Geosynthetic clay liners now working at an airport in France and a gold mine in Saudi Arabia.

| December 2004: Torrential rain left MDP-Line E in questionable condition.

| After the initial storms: Slope and riprap failures in the Line E channel.

TRM triumphs in California water-harvesting project

Master Drainage Plan, Line E, San Jacinto Basin

This project had been planned to capture stormwater and excess agricultural flows during the Southern California rainy season, then reuse this water to replenish the area's groundwater basin during times of drought.

The 50-ft.-wide x 8,000-ft.-long, 12-ft.-deep channel was constructed under the guidance of the owner, the Riverside County Flood Control and Water Conservation District (RCFCWCD). The initial design used the available sandy soil, reinforced with a hydroseeded native grass and plant mix on the slopes and floor of the channel.

In November 2004, a superintendent for the general contractor was in the process of closing out the contract on the project, when a single torrential storm severely eroded many of the 2:1 slopes (particularly the radii) and scoured the floor of the channel, leaving the functionality of the channel in question.

Concrete, rock, and grout were the initial methods considered to repair the damaged channel. But time and budget

| The Line E low-flow reservoir channel prior to TRM installation.

constraints forced the lead engineer, Clyde Johnson of the RCFCWCD, to search for other protection options for the Line E channel.

RCFCWCD contacted Triumph Geo-Synthetics of Anaheim, Calif., which suggested a turf reinforcement mat (TRM) as a potential solution for this situation. A comprehensive turf-reinforcement assessment was scheduled immediately and within days a composite turf reinforcement mat from North American Green was selected to address the channel-erosion problem. This

| Forrest Pharaoh, regional manager with Triumph Geo-Synthetics Inc. in Fullerton, Calif., and Ron Bygness, editor of *Geosynthetics* (formerly *GFR*), contributed to this article.

MDP-Line E during TRM installation: Note protected and unprotected slope conditions.

The Line E channel radius after another deluge: Note unvegetated TRM in place.

January 2005: More rain: Note rock in place failure, with intact TRM.

March 2005: And still more rain. Note TRM channel floor integrity.

TRM installation at MDP-Line E reservoir channel.

TRM (C350) was cited for: high tensile strength, permanent netting, a three-year protection period provided by the coconut fibers for the drought-tolerant seed mix, ease of installation, and the substantial time and money savings associated with the product compared to other options for this project.

The first delivery of the matting, 50,000 yd.^{2}, arrived on the job site the first week of December 2004, just prior to the record-setting Southern California rainfall that would soon be on the way. Because of the sandy, non-cohesive soil composition, extra long 12-in., 9-gauge staples were used to anchor the mat to both the side slopes as well as the channel floor.

The slopes were hydroseeded with a drought-tolerant native grass and flower mix, and then the TRM installation commenced. After approximately 20,000 yd.^{2}

MDP-Line E in March 2005, approximately 90 days after installation.

April 2005: Survival! The reinforced matting for this project performed far beyond expectations.

of installation, the record-breaking storms of December 2004/January 2005 sloshed Southern California. The weather would momentarily clear, the crews would rush out and continue installation of the matting, only to have the job site subsequently at a standstill for days at a time because of the torrents of rain.

Although designed as a low- to medium-flow channel (1,350 cfs), the MDP-Line E channel was often subjected to amounts of water far beyond its designed hydraulic capacity due to the relentless rainfall and reservoir breaches throughout the entire San Jacinto Basin.

The unvegetated installation area was closely monitored for failures by RCFCWCD, KEC Engineering, and Triumph Geo-Synthetics during this period. Much to the satisfaction (and relief!) of all concerned, there were no slope or channel-bottom failures where the matting had been installed; however, the areas that did not have any TRM protection did sustain damage.

The final installation segments were slated for completion by March 15, 2005, and by that time, much of the channel already had a strong stand of vegetation. The seed mix was kept in place despite months of unusually heavy rainfall.

Having overcome all of these obstacles—a major change order, a redesign, poor soils, and extremely inclement weather—the reinforced matting for this project performed far beyond expectations.

"Incredibly, much better than I ever thought it would," said Mike Luna of the RCFCWCD.

Project Highlights

Owner: Riverside County (Calif.) Flood Control and Water Conservation District

General contractor: KEC Engineering, Corona, Calif.

Geosynthetics supplier: Triumph Geo-Synthetics Inc.

Turf reinforcement mat (TRM): North American Green C350

Native grass and flower mix: formulated and supplied by Stover Seeds of Los Angeles, Calif.

Hydroseeding and TRM installation: Reyco, Smith and Reynolds Erosion Control of Corona, Calif.

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Runway widening construction at the Toulouse-Blagnac Airport in France.

GCLs used for airport runways in France, containment at gold mine in Saudi Arabia

Toulouse-Blagnac Airport Toulouse, France

One of the largest infrastructure projects in Europe in recent years has been in Toulouse, France, at the Toulouse-Blagnac Airport and the adjacent Airbus-France facility where the new Airbus A-380s are built.

During the course of this construction project, hangars were built to house the wide-bodied A-380 planes. But in addition, the entire infrastructure of the complex was also realigned to accommodate the dimensions of the redesigned aircraft.

Runway No. 2, built originally as a test track for the supersonic Concorde, now serves the newest Airbus A-380s, currently in production. The necessary construction work included widening the 4-km runway by 2m to accommodate the 700-ton “silver bird” with its 80m wingspan.

The conceptual design and advisory services for this construction project were completed in cooperation with the airport’s operating company, ADP Aeroport de Paris, and consulting engineers, including the decision to use geosynthetic clay liners (GCLs) to seal the runway.

The entire system prevents any drainage water, contaminated by air and traffic, from polluting the groundwater. The project—from earthmoving activities; installation of sewer pipes, service lines and pipelines; and construction of roads and approach runways—had to be completed within two months … all without disruption to air traffic!

The liner installation, and all of the associated construction work, proceeded smoothly. In fact, the installation portion of the project was completed ahead of schedule.

All told, 40,000m^2 of GCL and 24,000m^2 of separation nonwoven geotextile were installed within two weeks.

The capital expenditure for the total extension work was €13 million ($15.78 million U.S.) and was borne by the Toulouse Chamber of Commerce and Industry, and Airbus-France.

Project Highlights

Title: Toulouse-Blagnac Airport
Consulting engineers: Sceauroute
Liner material: Bentofix® Type NSP 4900 geosynthetic clay liner
Geotextile: nonwoven Secutex® 201 GRK-3
Geosynthetics supplier: Naue Applications S.A.R.L.

Containment liner installation at the Sukhaybarat Gold Mine in Saudi Arabia.

Sukhaybarat Gold Mine
Qaseem, Saudia Arabia

The Saudi Company for Precious Metals (SCPM) made provisions for a new tailing facility at the Sukhaybarat Gold Mine in Qaseem province for the containment of the tailing from the gold ore mining process, in accordance with a technical specification drawn up by engineering consultants.

SCPM is a limited-liability company of Saudi Arabia and is wholly owned by Saudi Arabian Mining Co., a state-owned company.

To cope with the harsh chemical conditions of the containment and to ensure an environmentally safe solution, the designer specified a double-lined system that included a primary HDPE geomembrane and a needle-punched geosynthetic clay liner (GCL). The new tailing facility is approximately 580m x 380m surrounded by an embankment 7m high.

The total area, including the slopes of the embankments, was lined with 222.100m^2 of a double-lined HDPE above the geosynthetic clay liner. The primary liner system was protected on the base area with nonwoven geotextile before placement of a 30cm-thick protective layer of heap-leach gravel. The gravel did not contain stones greater than 15mm in diameter.

A protective embankment and a layer of rockfill were created at one end of the tailing facility to slow the flow of tailing sand pouring into the tailing pond. The embankment and the protective layer were made of rockfill and a separation layer of geotextile was specified for this area prior to the positioning of the rockfill and also below the drain material and the drainage pipes. The project was completed in 13 weeks.

Project Highlights
Title: Sukhaybarat Gold Mine, Saudi Arabia
Engineering consultant: TS Markteknik AB
Liner material: Carbofol® HDPE 406 (2mm) above Bentofix® NSP 4900 GCL
Geotextile: nonwoven Secutex® R504
Geosynthetics supplier: Naue Applications S.A.R.L.
Liner installation: Trading and Development Partnership G

Shoreline restored with geotextile tubes as submerged breakwaters

Back to the beach in Mexico

By Enrique Álvarez, Ramiro Rubio, Herbert Ricalde

Abstract

The beaches of the northern coast of Yucatan in Mexico have been in an erosion process that has dramatically increased in the past 15 years. Changes in the littoral dynamics, mainly due to human action, have generated a coastline regression rate, estimated at 1m per year and more.

In addition, this region is affected by all hurricanes that follow a path through the Gulf of Mexico. Risk of destruction due to extraordinary wave conditions is a permanent threat. Coastline stabilization required a carefully designed project for controlling beach erosion, reducing as much as possible any changes to littoral dynamics that would have negative consequences in the long term.

This paper describes the technical solution adopted using geotextile tubes, as low-crested structures, along 4km of beach. Proposed actions for improving knowledge of this application are also discussed.

Introduction

In 2001, federal authorities from the Ministry of the Environment in Yucatan initiated a Beach Rehabilitation Program. For a long-term solution, it was imperative that any restorative actions not affect the natural dynamic process that relates wave climate/bathymetry/sediments. The philosophy behind the solution was to generate a sand accumulation process without interrupting alongshore sediment transport. Also, the solution had to be as flexible as possible, avoiding any rigid structures, so it would easily absorb any physical media modification.

Under these conditions and for critical points, geosynthetics were considered optimal for the beach-restoration project. Woven polypropylene geotextile tubes were designed to work as low-crested submerged structures. Their main function was to reduce the incident wave energy on the beach, by controlling the wave-breaking process, to the required level that maintains the dynamic balance on the shoreline **(Figure 1)**.

Based on these criteria and using a maritime field database processed by federal and state authorities, geotextile tubes were designed according to coastal engineering theories regarding wave propagation, the breaking process, and their relation

Editor's Note:
This follow-up story is a sequel to an article published in the September 2005 issue of *GFR* (now *Geosynthetics*), "Saving Yucatan's coast." It is based on the paper by Messrs. Álvarez, Rubio, and Ricalde presented at the proceedings of the international symposium, "Tsunami Reconstruction with Geosynthetics—Protection, Mitigation, and Rehabilitation of Coastal and Waterway Erosion Control" in Bangkok, Thailand in December 2005.

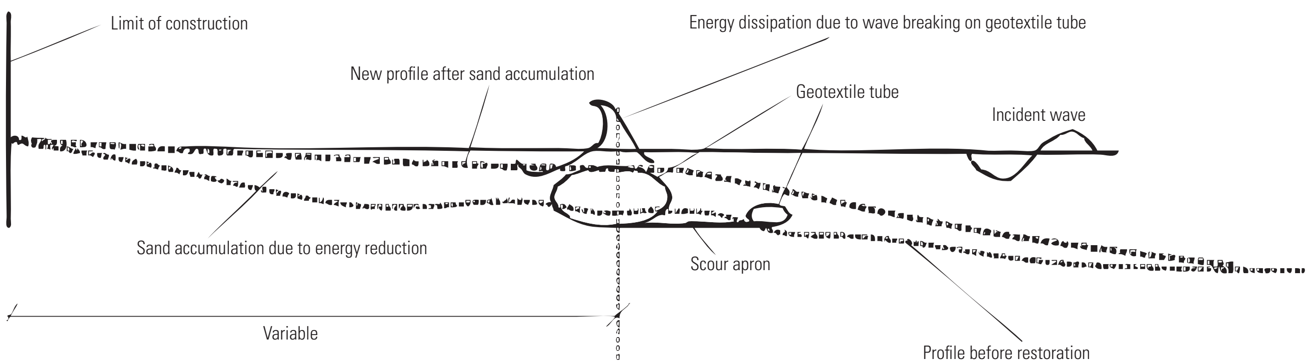


Figure 1 | Schematic section of wave energy reduction.

| Ing. Enrique Álvarez del Rio, Axis Ingenieria S.A. de C.V.; www.axisingenieria.com
Ramiro Rubio and Herbert Ricalde, Ministry of the Environment of Mexico, Yucatan Office

to sediment transport. The main goal was to generate a balanced beach profile integrated to natural littoral dynamics. By September 2005, 4km of geotextile tubes were installed.

Initial situation

The case discussed in this paper refers to a beach system defined as Barrier Island, formed by alongshore transport of sediments running parallel to the coast. The most-developed zone, near the city of Progreso, was originally limited by a vigorous and balanced beach 30m to 100m wide. However, as a particularity of this beach system, there are not many natural sediment sources such as river discharges, so littoral balance may be easily broken by infrastructure such as small harbors, piers, and groins. The first attempts to control beach erosion were individual actions undertaken to retain sediment for beach stabilization without considering other consequences along the coast. By the end of 2002 the situation was critical, since many beaches were almost fully eroded **(Photo 1)** and many faced the risk of permanent destruction due to extreme waves induced by any hurricane with a path through the Gulf of Mexico.

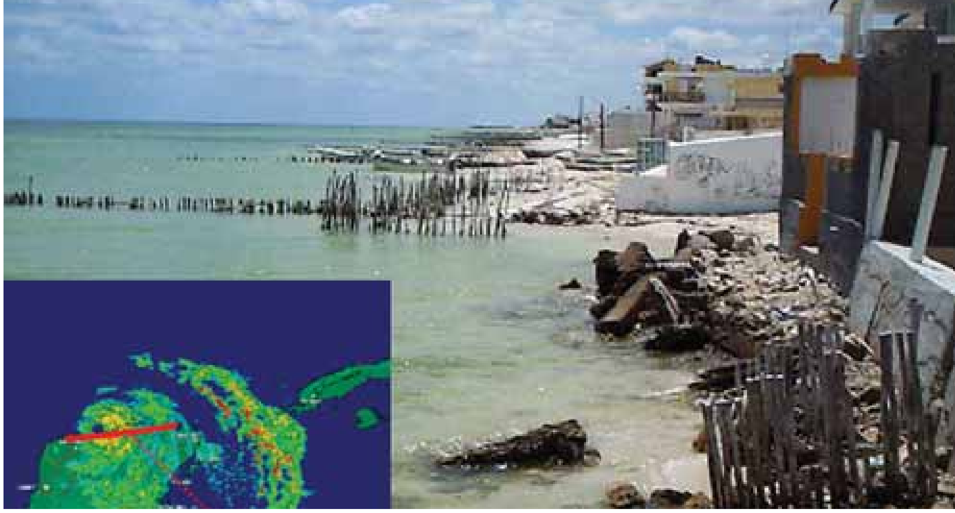


Photo 1 | Initial situation: Many beaches were almost fully eroded.

Proposed solution

The combination of wave climate, currents, tides, and storm surges is the main cause of beach erosion. Based on local experience in the past 20 years, any beach restoration action has to be environmentally friendly, reducing as much as possible any changes to littoral dynamics and it also needs to consider possible negative impacts on adjacent beaches. Under these requirements, the final objective of the beach restoration project was to re-establish the natural conditions that govern the littoral drift.

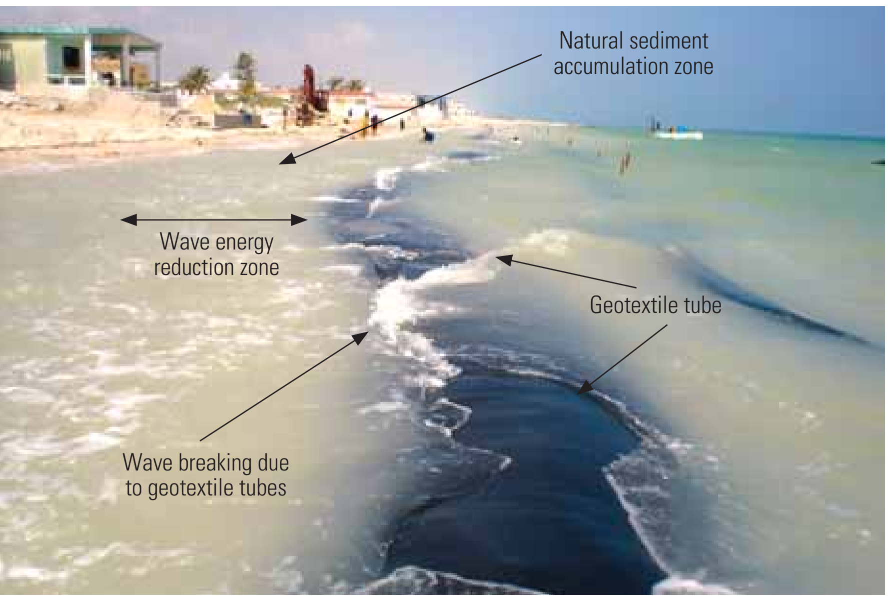


Photo 2 | Geotextile tube inducing wave breaking for energy attenuation.

Originally, the solution consisted of: (1) the elimination of structures perpendicular to shoreline (groins); (2) beach nourishment from inland material banks, so actions in the seabed were fully avoided; and (3) implementation of sediment bypass techniques for the various harbors along the coast.

With these actions, alongshore sediment transport was partially recovered to natural conditions. Evidently, the beaches never recovered their original dimensions but in some segments, they were naturally stabilized solely by the free sediment motion. In critical segments, free sediment motion was not enough.

The hydraulic load on the coast governs morphological response to wave climate and shoreline control. When it is too high, related to the littoral drift, the erosion process causes shoreline regression. In these cases, incident wave energy may be reduced to conditions that generate a balanced beach profile by submerged structures, so sand accumulates without interrupting alongshore transport. According to the U.S. Army Corps of Engineers (1984), wave energy reduction is defined in terms of the energy transmission coefficient:

$$Kt = Ht \big/ Hi$$

Where Kt is the wave transmission coefficient, Ht is the transmitted wave height shoreward side of the submerged structure, and Hi is the incident wave height on seaward side of the submerged structure. Full description of wave reduction by submerged structures can be found also in Pilarczyk (2003).

Among the various alternatives for submerged structures, geotextile tubes where chosen for their viability to cause wave dissipation and thus reduce energy, in a flexible adaptation to a media as dynamic as the maritime media. The possibility of quick modification of structures according to morphological response to structures, and low costs for initial installation and maintenance, were also considered.

Design parameters

A precise analysis of wave climate currents and tides, and its interaction with bathymetry and sediment characteristics, controls the littoral drift. Once all these parameters are evaluated and their interaction with littoral drift is estimated, the cross section of the balanced beach profile, including the geotextile tubes, may be defined. At the end, the main interest is to control sediment transport since this will govern the erosion/accretion processes. Another important cause of erosion processes are storm surges. As discussed later, the behavior of geotextile tubes for major storm

Restored shoreline

Photos 3a–b | (a) Natural sediment accumulation zone showing sand gained shoreward of geotextile tubes. (b) Geotextile tubes working with mean tide level.

surges generated by hurricanes is out of the scope of this paper. However, in a full evaluation of shore erosion mechanics, they must be considered.

The basic parameters for designing the cross section that maintains the dynamic balance of the shoreline were defined from database information provided by the Ministry of the Environment:

- Breaking wave height *Hb*: Hb<1.0m (93% occurrence)
- Wave period *Tz:* 4 seg <Tz<8 seg (93% occurrence)
- Bathymetric profile slope $\tan\theta$: 0.1%<$\tan\theta$<0.5%
- Tides range: 0.90m
- Net alongshore current direction: E – W
- Littoral drift *Sl:* 60,000m^3/yr
- Sediment diameter D_{50}: 0.30mm

One of the primary requirements for an efficient submerged tube cross-section design is to define the crest high, in relation to the still water level (SWL) for all the tide ranges, since this will govern the wave breaking mechanism that controls wave energy reduction. **Photo 2** shows this concept.

By evaluating the dimensionless surf similarity parameter, also known as Iribarren number, the breaker type may be defined, and then, energy reduction mechanism estimated:

$$\xi = \frac{\tan\theta}{\sqrt{H/Lo}}$$

Where ξ is the Iribarren number, $\tan\theta$ is the slope of the seabed, H is the incident wave high, and Lo is the deep-water wave length.

When computing the Iribarren number for different site conditions in terms of $\tan\theta$, H, and Lo, it is verified that the breaker type in this case is basically the one called "spilling" that is associated with smooth slopes and distributed wave reduction along space. This is usually positive for a beach restoration design since sand is carried in a shoreline direction. Then, the accumulation of sand at the shoreward of the tube becomes a viable task.

Full information of wave-breaking processes may be found in the U.S. Army Corps of Engineers (1984).

An important issue is to avoid wave reflection in all types of tide conditions. This phenomenon may cause major changes to current patterns that govern alongshore transport. As mentioned before, Yucatan beaches are all connected to the same littoral dynamics. Changes in current patterns may cause negative effects to littoral drift at adjacent beaches.

Based on these criteria, three important considerations were verified permanently:

1) Breaking on bathymetric profiles at low tide conditions where a "spilling" type in relation to Iribarren number analysis.
2) A scour apron had to be engineered to work as a first wave breaking at low tide conditions to avoid direct impact of waves on main tube so that reflection could be eliminated as much as possible.
3) Tubes must be engineered crested at high tide conditions in such a way that they generate a smooth dissipation of wave energy. Designing the structure too high would lead to a sure wave reflection; and if too low, the effect of the tubes would disappear **(see Photos 2, 3a, 3b)**.

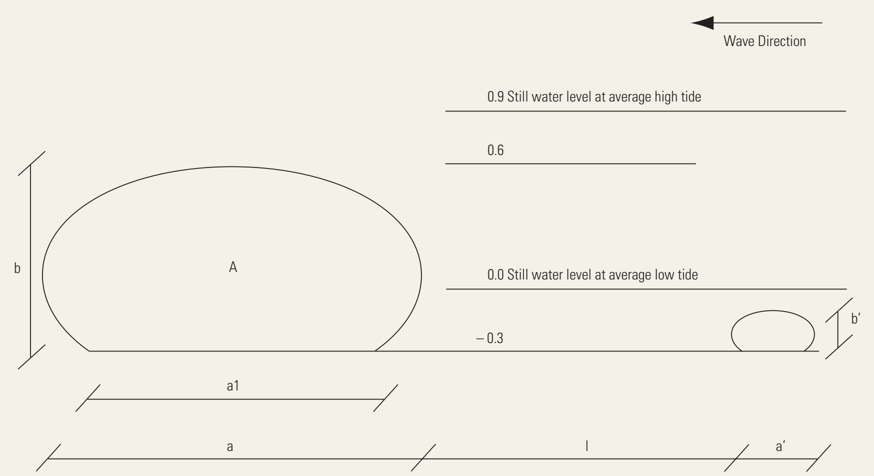
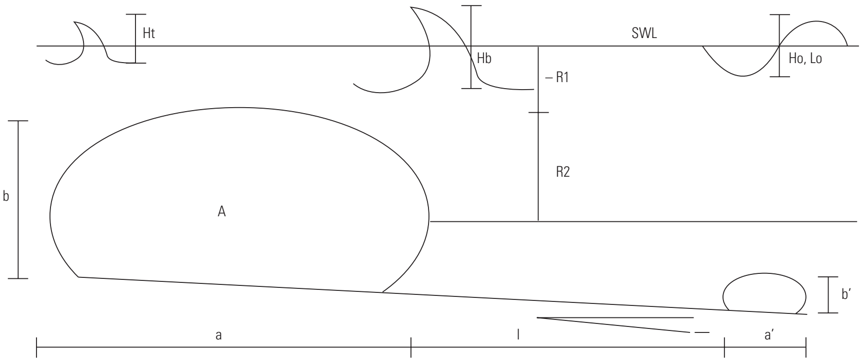


Figure 2 | Geotextile tube cross section



Where:			
Ho, Lo:	Deep water wave height and length	Hb:	Wave height at breaking
SWL:	Still water level	Ht:	Transmitted wave high
Ri:	Freeboard for average high and low tide (R2-R1=tidal range)	θ:	Sea bed slope

Figure 3 | Parameters involved in wave transmission due to breaking-wave process on geotextile tubes.

Geotextile tubes cross section

Once the littoral process was evaluated, a tube cross section was designed and geosynthetic materials were defined in terms of their mechanical properties. The following considerations were mandatory:

1) Stresses on geosynthetics are very sensitive to the slurry pumping pressure when the tubes are filled. This pressure governs the criteria design for defining the estimated force of the required geosynthetics, working under load conditions.
2) Slurry pumping pressure does not have a significant influence on the final sectional area of the tubes.
3) The apparent opening size of the geotextile is conditioned by sediment diameter *D50*.
4) Inlets separations are defined in terms also of *D50*. The larger sediment diameter *D50*, the closer the inlets are.
5) The ultimate strength of required geosynthetics must consider (Leshchinsky 1996), reduction factors for installation damage, chemical and biological degradation, treachery creep, and seam strength:

$$T_{ult} = T_{work}(RF_{id} \bullet RF_d \bullet RF_c \bullet RF_{ss})$$

Where *Tult* is the ultimate strength of the required geosynthetic, *Twork* is the calculated tensile force under load conditions and *RFid*, *RFd*, *RFc*, and *RFss* are the reduction factors for installation damage, chemical and biological degradation, creep, and seam strength.

Another important consideration with a complex evaluation is the behavior of the tubes under permanent contact with wave action, UV exposition, and frictional effects of littoral drift while the tubes are covered by sand. These topics require special attention and development based mainly on site monitoring.

Restored shoreline

Restored shoreline

During the installation of the 4km of geotextile tubes in Yucatan, mechanical and geometrical parameters for geosynthetics were permanently modified. Up to September 2005, parameters considered best according to design theories applied and local observation are referred to in **Figure 2** and have the following values:

Mechanical parameters:

- *Tult* circumferential direction: 90 Kn/m
- *Tult* axial direction: 70 Kn/m
- *AOS*: 0.35–0.425mm
- Factory seam strength: 50 Kn/m

Geometrical parameters:

- *a:* 1.85m
- *a1*: 1.25m
- *b:* 0.90m
- *A:* 1.4m^2 (70% full)
- *l:* 2.0m
- *a':* 0.40m
- *b':* 0.20m
- Seams orientation: Axial–Not exposed to wave attack.
- Inlet separation: 15m

Construction procedure

As discussed, stresses in the encapsulating geosynthetics due to slurry pumping pressure, makes the installation procedure a task that must be carried out under extremely controlled conditions. Overpressure during filling of tubes may produce failure of geotextile. Most of the job was carried out with slurry pumps with 4-in. and 6-in. discharge diameters with volume discharge rates up to 1000 gpm of slurry with 10–30% of solids. **Photo 4b** shows slurry-pumping operations.

A very significant topic is that, since the philosophy behind the beach restoration project is to reestablish natural conditions for littoral drift, and even that volume to fill geotextile tubes is not significant in comparison to sediment transport rates, the use of offshore sand banks was reduced as much as possible. In the case of Yucatan, some tubes were filled with offshore banks, but whenever it was possible, inland sand was carried to the job site before pumping it into the tubes **(Photo 4a)**. In the case of beach nourishment, when required, in critical segments because of damaged conditions, no offshore sand banks were allowed.

Photos 4a–b | Filling tubes procedure by: (a) hopper method; and (b) offshore sand-pumping method.

Solution performance, monitoring, and maintenance

By September 2005, nearly one year of monitoring had passed since the first geotextile tube was installed. Performance of the tubes is evaluated basically from two perspectives: marine processes response and geosynthetics materials behavior.

Marine processes response:

Geotextile tubes have been performing satisfactorily, working as parallel submerged breakwaters. As expected, energy dissipation is generated by wave breaking due to the presence of the tubes. Turbulence generated shoreward induces sand accumulation without interrupting littoral drift. Meanwhile, there are no changes of natural current patterns seaward of tubes **(Photos 5a, 5b,** and **Photo 6)**.

Restored shoreline

Efficiency of design depends highly on how precise is the evaluation of wave transmission at the geotextile tubes. However, there is not much literature on this topic and the existing literature refers basically to studies made of submerged rubble-mound breakwaters that evaluate wave transmission in terms of deep water wave height (*Ho*), wave length (*Lo*), structure geometry, and freeboard between crest and still water level.

These studies only give a qualitative first approach. However, results may be out of reality when applied to geosynthetic materials and tubes geometry. For design techniques development, wave breaking and energy dissipation/reflection, must be studied, monitored and tested on geotextile tubes, considering all the parameters involved and referred to in **Figure 3**. Detailed information on wave transmission research may be found in Daemrich (2002) and Wamsley (2002).

For a shoreline response evaluation, the data that resulted from wave transmission analysis must interact with distance offshore, orientation angle and length of tubes, beach slope shoreward of tubes, wave direction distribution, littoral drift, and grain size.

Storm surges have an important influence on shore stabilization, especially in regions such as Yucatan where hurricane risk is permanent. Predicting sea level rise due to storm surge is a complex task. The effect of geotextile tubes as submerged structures on storm surge must be neglected, since the energy dissipation is reduced as sea level rises.

Finally, the geotextile tube is designed to be part of the elements that generate a balanced beach profile. Once the shore has been stabilized, a vegetated dune must be developed that works as a natural defense for extreme conditions. Vegetated dune formation must be considered a goal when designing any beach restoration project on eroded shores **(Photos 8a-b)**.

Behavior of the geosynthetics materials:

As discussed, tensile strength for geosynthetics is conditioned mainly by

Restored shoreline

Photos 5a–b, 6 | (a) Geotextile tube installation in October 2004. (b) Sand accumulation process, comparison view: Stabilized shoreline in June 2005, eight months after geotextile tube installation. (6) Natural sand accumulation is restoring the eroded beach.

slurry pumping pressure. Most of the tubes were filled with pumping equipment from inland and offshore sediments banks, with no overstressed geotextiles detected. However, the question when designing is also the long-term behavior to UV exposition while tubes are covered by littoral drift.

Many times, there is an unpredictable period for having tubes full confined by sand since it depends on external factors to the job site, mainly related to the alongshore sediment transport. This topic requires full discussion with manufacturers because, originally, geosynthetics were not designed to work exposed to UV action. As in the case of the Yucatan project, during the littoral process, tubes may be naturally covered by seaweed and marine flora, which are very welcome since they provide additional UV protection.

Finally, there are many questions around long-term behavior of seams. In the case of the Yucatan beaches, transversal seams have been avoided when a permanent interaction with wave action is expected. They seem to develop a premature lost of mechanical properties. Anyway, this is just a primary conclusion coming from one year of observation. Engineering for seaming conditions requires a precise analysis in conjunction with manufacturers.

Conclusions

Geotextile tubes performing as shore-parallel, low-crested structures have shown that they are an effective and environmentally friendly alternative for shore stabilization.

Among many variables, wave transmission at geotextile tubes is the leading parameter that controls shore response. The existing literature and studies on this topic basically refer to rubble-mound breakwaters, and provide only qualitative information when applied to geotextile tubes design. Future designing techniques of geotextile tubes, as submerged breakwaters, will require development on predicting models for wave energy transmission, as a function of wave parameters, tubes geometry, and relative submergence.

As in all human coastal actions, it is extremely important to control negative effects in adjacent beaches when a shore protection project is executed. Geotextile tubes offer an effective alternative when modifications to installed breakwaters, due to marine media response, are required in the shortest time and at the lowest cost.

In a physical media as dynamic as the maritime media, there are many questions about the behavior of geotextile tubes in the mid- and long-term. Basically, the questions deal with durability against unpredictable UV exposure periods, as well as behavior against direct interaction with stresses generated by continuous wave action and sediment motion. Full research on this topic is required.

In this paper, the intention is to show the great potential of these promising shore protection alternatives. Extensive monitoring and research must be stimulated among public and private organizations to create permanent improvement on designing techniques.

Photos 8a–b | (a) Before the beach restoration. (b) Once the shore has been restored and stabilized, a vegetated dune will help work as a natural defense.

| Before and After: On the left, a portion of Yucatan beach in 2004. On the right, the same section about two years later.

Acknowledgements
The supplier of the geotextile tubes for the 2005 Beach Restoring Program was Ten Cate Nicolon. The authors wish to thank the Ministry of the Environment, Yucatan Office, for all the field information supplied and support during development of the 2001–2005 Beach Restoration Program; and special thanks to the government of the state of Yucatan for permanent support and investment on innovative techniques for coastal rehabilitation. We also want to thank the private investors who promoted the application of new technologies for protection of their coastal properties.

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Selecting reinforced fill soil for MSE retaining walls

A full-scale field test is currently being conducted to establish properties for "high fines" reinforced soils and associated design controls that give acceptable MSE wall performance.

By Richard P. Stulgis

Mechanically Stabilized Earth (MSE) retaining walls on public sector transportation projects are generally conservatively designed with "low fines" reinforced soils. Private MSE walls are less conservatively designed, and use a variety of reinforced soils (NCMA recommends 35% < 0.075mm or greater). It is also clear from the literature that the combination of reinforced soil consisting of fine-grained soils (either "high" fines or "high" plasticity) and water in the reinforced zone were the principal reasons for serviceability problems (excessive deformation) or failure (collapse).

However, a higher quantity of fines can be safely allowed in the reinforced fill, provided the properties of the materials are well-defined and controls are established to address the design issues. The potential savings from replacing AASHTO reinforced fill materials with marginal reinforced fill materials could be in the range of 20% to 30% of current MSE wall costs.

Terms used in this article

AASHTO: American Association of State Highway and Transportation Officials

Automated robotic total station technology: Robotic Total Stations (RTSs) were first developed in the early 1990s and were soon incorporated into construction efficiencies. RTSs with automatic searching and tracking offer the possibility to track and order cinematic processes such as movement and deformations of structures.

FHWA: Federal Highway Administration

MSE: mechanically stabilized earth (as in walls, MSE retaining walls)

NCHRP: National Cooperative Highway Research Project

NCMA: National Concrete Masonry Association

TRB: Transportation Research Board

Figures and Photos courtesy of R. Stulgis

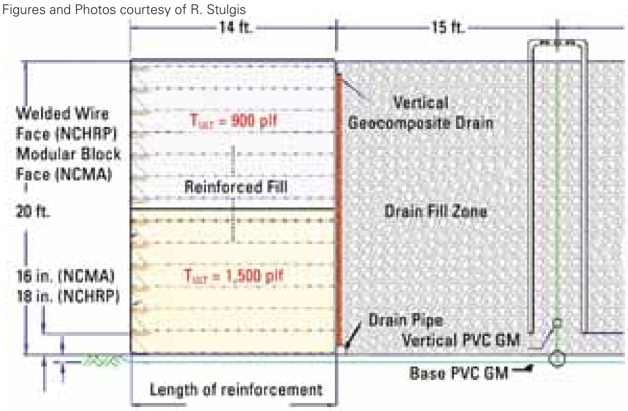

Figure 1 | Cross section of typical full-scale test wall.

A full-scale field test is currently being conducted in order to establish properties for "high fines" reinforced soils and associated design controls that give acceptable MSE wall performance. The field test includes provisions to demonstrate the role of porewater pressure in the reinforced fill and the importance of including a positive drainage system to obtain good wall performance. Based on the survey of the literature, to date, full-scale test or experimental MSE walls have not rigorously evaluated this important aspect.

The full-scale field test is primarily funded by the Transportation Research Board, under the National Cooperative Highway Research Project (NCHRP) 24-22, with a portion funded by the National Concrete Masonry Association (NCMA). The objective of NCHRP Project 24-22 is to develop selection guidelines, soil parameters, testing methods, and construction specifications that will allow the use of a wider range of reinforced fill materials within the reinforced zone of mechanically stabilized earth (MSE) walls.

NCHRP Project 24-22 includes four sections:

1) One section with an AASHTO A-1-a reinforced fill to provide a baseline of performance for current AASHTO and FHWA standards.

2) A second section with an AASHTO A-2-4 reinforced fill to demonstrate that non-plastic, silty sand materials with up to 35% fines (of no plasticity) can provide suitable reinforced fill for MSE walls.

| Dick Stulgis, P.E., is currently a senior consultant at Geocomp Corp. in Boxborough, Mass.

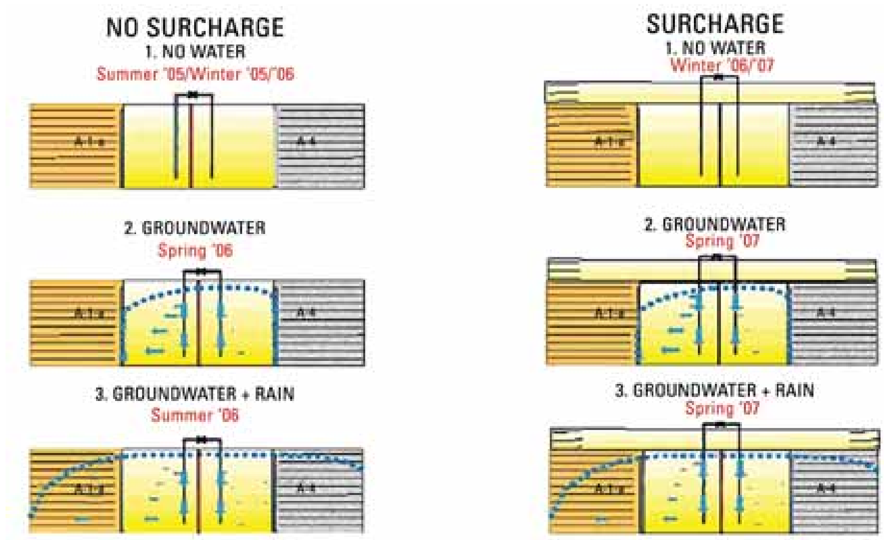

Figure 2 | Test sequence

3 & 4) The third and fourth sections with an AASHTO A-4 material to demonstrate that silty soils (50% fines) of low to moderate plasticity can provide suitable reinforced fill for MSE walls.

Welded wire was used for the wall face system. NCMA sponsored two additional sections utilizing dry-cast concrete modular block for the wall face. The two NCMA sections consist of the AASHTO A-1-a and A-4 reinforced fill soils used in the NCHRP sections.

Polyester geogrid is being used for the reinforcement in all sections, with the exception of one NCHRP section where nonwoven geotextile reinforcement with in-plane drainage capability was used.

A geocomposite drainage material has been placed at the back of the reinforcement in each test section.

An essential component of an MSE retaining wall that uses reinforced fill with "high fines" soil is aggressive drainage to prevent the buildup of porewater pressure in the reinforced zone. Porewater pressure produces an additional outward force that the wall must resist, and it reduces the strength of the soil that holds the wall in place. Therefore, the field test includes provisions to demonstrate the role of porewater pressure in the reinforced fill and the importance of including a positive drainage system to obtain good wall performance.

Figure 1 shows how this will be accomplished. A geocomposite drainage material has been placed at the back of the reinforcement in each test section. It was wrapped around a slotted drain pipe at the bottom of the reinforced fill that will remove water from the drain.

To simulate groundwater, water is pumped to a feed line at the top of the test sections. A system of valves will control the introduction of water from the feed line into the individual drainage soil zones of each test section via slotted, vertical fill pipes. This will initiate horizontal flow towards the wall and into the geocomposite drain for the wall. By controlling the head in the drainage soil (with the drain pipe open), the effect of rising groundwater level on the performance of the wall can be simulated. We would expect little, if any, effect on the test sections as long as the geocomposite drains function as designed.

This phase of the test is intended to demonstrate that various reinforced fill materials will provide suitable performance, even in areas with high groundwater conditions, as long as they are properly drained.

By closing a valve on the drain pipe and spraying water on top of the reinforced fill, the effects of poor drainage and heavy rainfall on the performance of MSE walls with the various reinforced fills can be simulated. The porewater pressure in the reinforced fill can be increased until the wall experiences noticeable distress. This phase will provide valuable information to evaluate the ability of the numerical models to consider the effects of pore pressure.

Finally, the test areas can be drained, a surcharge added and the test sequence repeated to measure the effects of groundwater and rainfall. The walls have been designed so that they should experience considerable distress when subjected to a surcharge and high porewater pressures (i.e., the factor of safety is essentially 1.0, based on numerical model and limit equilibrium analyses).

Figure 2 illustrates the proposed test sequence:

Each test section is fully instrumented to record data that will be used to evaluate a number of technical questions. Instrumentation consists of strain gages mounted on the

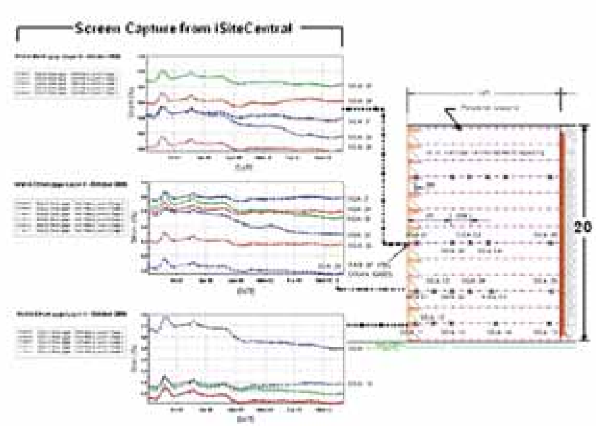

Figure 3 | Sample of real-time, Web-based monitoring; Strain gages; Wall Section A

geosynthetic reinforcement; piezometers, thermistors, multiple position horizontal extensometers, and vertical extensometers positioned throughout the reinforced fill; vertical inclinometers; and an array of high-precision prisms mounted on the face of the test walls where optical survey readings are being obtained using automated robotic total station technology.

Most instruments are electronic and connected to automatic data logging equipment using the iSite™ system. This system has been programmed for each instrument to have a warning level at which an electronic notice is sent to key personnel indicating that some activity is occurring at that instrument. Instruments are being read four times each day and stored in the on-site data loggers. These data loggers are connected by cell phone modem to our Web server, which periodically contacts the site and updates its database with the latest readings on all instruments.

Figure 4 | Photos of completed full-scale test walls

The database is accessible with a Web browser and provides up-to-date process readings plotted in engineering units at any time from any location with Web access. This allows the field tests to be carried out with far more extensive monitoring than typically possible. The benefit of this extensive monitoring is to identify the effects of environmental changes, such as temperature and rainfall on the performance of the wall to a degree of detail not previously possible. **Figure 3** presents a "sample screen capture" from real-time processed strain gage data for Test Section A, for a one-week period in October 2005.

Construction of the full-scale test walls began in summer 2005 and was completed in November 2005 **(Figure 4)**. The test sequence indicated in **Figure 3** is under way and monitoring will continue through spring 2007. Guidelines for selecting MSE reinforced fill soils, representative soil parameters, appropriate testing methods, and construction specifications for a wide variety of reinforced fill soils will then be prepared. G

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NAUE

Geosynthetics: Update from Korea

The infusion of geosynthetics in Korea has been accomplished in a relatively short time. A look at potential growth, research, and markets.

By Han-Yong Jeon

1. Introduction

The geosynthetics industry in Korea is a promising field for investment and development. Many types of domestic geosynthetic products are produced and their applications and end uses are widely enlarged every year. Although the geosynthetics-related history in Korea is not long, the infusion has been accomplished in a relatively short period, particularly as far as geosynthetic usage and applications are concerned.

The types of geosynthetics produced and used in the domestic market include: geotextiles, geomembranes, geogrids, PBD (prefabricated board drain), and GCLs (geosynthetic clay liners). The application fields for these products are mainly in the areas of soft soil reinforcement, soil retaining walls, waste landfills, road and subway construction, tunnel and earth dam construction (Korea Nonwoven Industry Association, 2004). The technologies relating to Korean geosynthetics (raw materials, manufacturing processes, testing and evaluation, design and installation, etc.) come mainly from the United States, Europe, and Japan.

In this manuscript, I would like to simply introduce and review the overall and current situation of geosynthetics in Korea, based on the recent technology circumstances of Korean geosynthetics to consider the principle of international geosynthetics technology transfer.

2. Potential growth of geosynthetics

2.1 History of geosynthetics applications

Traditional geotechnical and civil engineering structures have long histories in Korea but there is no evidence that geosynthetics were used until recently. It was suggested that the Japanese used geosynthetics, in this case woven geotextiles, as reinforcement materials in the fields of roads and runways, earth dams, etc. in the 1920s, but we cannot confirm this officially.

It is known that the Korean government used woven geotextiles as protection materials in the breakwater construction on A-San and Nam-Yang areas for the first time in 1971. In 1979 and again in 1983, geotextiles were used as asphalt overlay materials in the fields of highway construction between Seoul and Pusan, and between Sunchun and Pusan. After this, many types of geosynthetics were used in the fields of soft soil reinforcement, waste landfill construction, road pavements and construction, breakwater construction, embankments, beach protection, retaining walls, stabilization of steep soil slopes, erosion control, and tunnel construction.

The amount of geosynthetics used in Korea has increased every year and new materials have been developed consistently since 1996. Despite this situation, geosynthetics-related construction is not as widespread as traditional civil engineering materials such as concrete, steel, etc. Many engineers and design firms are simply unaware of geosynthetics and their potential for lower costs or completely new applications.

Geosynthetic	Raw Material	Number of Manufacturers
Geotextile (Woven)	PP, PET	6
Geotextile (Nonwoven)	PP, PET	8
Geogrid (GG)	Polyester, Glass Fiber	6
Geomembrane (GM)	HDPE, EVA	5
GCLs	GT/Bentonite/GT or GM	5
PBD	GT/PP Core	6
Geonet Composite (GC)	GT/GN/GT	2
Geopipe (GP)	HDPE	3
Geofoam	PS	4
Sheet Drain (SD)	GT/PE Core	2
Miscellaneous	Various	6

Table 1 | Current state of geosynthetic products in Korea

| Han-Yong Jeon, Ph.D., GSRL (Geosynthetics Research Laboratory), Division of Nano-Systems Engineering, INHA University, Incheon, Korea.

The Korean economy is recovering since the second half of 1999 and the demands for geosynthetics are increasing gradually with the stability of the economy. Imported geosynthetics from the U.S. and Europe are increasing slightly at a uniform rate. The paper of Lawson and Cowland illustrates that the position of Korea is in the middle level of the geosynthetics developing Asian countries.

Typical products and manufacturing processes of domestic geosynthetics are itemized in **Table 1**. There are no significant differences from the kinds of products among Korea and other advanced countries of North America and Europe in this regard. The types of geosynthetics currently produced in Korea include: geotextiles, geomembranes, geogrids, GCLs (geosynthetic clay liners), PBD, geofoam (EPS expanded polystyrene), geopipe, geonets, and geocomposites. **Table 1** represents the current state of domestic geosynthetic products.

From **Table 1**, it is seen that the order of numbers of manufacturing companies is geotextiles > geogrids > GCLs > geomembranes. Unfortunately, the corresponding statistical data of manufacturing and installation amounts in domestic vs. imported amounts of geosynthetic products are not available from the respective companies. In general, both U.S. and European manufacturers influenced the manufacturing technologies for geotextiles, GCLs, and flexible geogrids. Mainly U.S. manufacturers influenced the manufacturing technologies for geomembranes and geocomposites. Conversely, the technologies of design, installation, and administration of geosynthetics were influenced by those in Japan. Some original technologies for geosynthetic manufacturing, design and installation were adjusted to take into account typical Korean circumstances.

The amount of geosynthetics used in Korea has increased every year and new materials have been developed consistently since 1996.

2.2 Developments of geosynthetic products

(1) Geotextiles

Nonwoven geotextiles of staple fibers having width: ~8.6m, weight per m^2: ~3500g/m^2 are produced by needle-punching methods and spunbonded nonwovens of filament fibers with ~600g/m^2 are produced by spunbonding method. Woven geotextiles of split polyester and polypropylene yarns having length ~3m are produced by weaving. The range of their design strength is 4~50 ton/m.

For woven geotextiles, high drawn split yarns (; ~3,000 denier) are used as warp and weft yarns and rapier or air-jet weaving machines are used to make woven geotextiles. Recently, the requirement of low elongation (~10%) woven geotextiles are increased to improve the resistance against fracture in installation fields. The smart polymer resins for this purpose are developing and modifying the manufacturing process of woven geotextiles to give the low elongation. For nonwoven geotextiles, staple fibers and filaments of polypropylene, polyester or recycled polyester with/without carbon black are used as raw fibers and needle punching and spunbonding methods are used to make nonwoven geotextiles. Specially designed manufacturing lines were established to produce 8.5m width, 3,500g/m^2 needle-punched nonwovens.

Photos, Figures, and Charts courtesy of Dr. Han-Yong Jeon

Photo 1 | Photographs of waste landfill construction in Korea.

(2) Geomembranes

HDPE smooth type geomembranes are widely used in Korea. Also, small amounts of EVA geomembrane are used in special-end usages as water-barrier materials. Recently, textured geomembranes were developed and currently tests are in progress. The main end use of HDPE geomembranes is as liners for waste landfills. The range of thickness is 1.0~2.0mm. HDPE is also used as a waterproofing sheet in the fields of tunnel and subway construction.

For smooth type, HDPE geomembranes with UV stabilizers and antioxidants are the main geomembranes in Korea. Extrusion type with T-die and blown type with circular-die manufacturing processes are used to produce geomembranes. Thickness of at least 2mm must be used for waste landfills, based on revised regulations by the Ministry of Environment in 1999. Therefore, research on geomembranes to improve the seam properties is currently ongoing. For textured type, spray-on (impingement) type textured geomembranes to improve the frictional properties between soil and geomembrane have been developed and the testing of their frictional properties is ongoing.

(3) Geogrids

Fabric-type geogrids (aka, soft geogrids) of high-tenacity polyester yarns are the types mainly produced. Either PVC or acrylic resin is used as a coating agent. In 1999, glass fiber geogrids were developed and currently tests are in progress. The fabric type geogrids are used in the fields of soil retaining walls and steep slope soil retention. The glass fiber geogrids are used as reinforcement materials in road construction. Fabric type geogrids, by using high-tenacity polyester yarns and glass fibers, are produced domestically with PVC and acrylic resin used as coating resins.

(4) GCLs

GCLs are generally geotextile-type with staple fiber needle-punched nonwoven, bentonite/woven, or nonwoven geotextile, and—to a lesser extent—bentonite+adhesive/HDPE geomembrane type. Specially designed GCLs are produced to prevent the bentonite loss. Both powder and granular type bentonites are used. The bentonite is imported from the United States, Russia, China, or Australia.

GCLs are mainly used as a composite liner with geomembranes for slopes of waste landfills. They are also used as waterproofing materials in tunnels and subway construction. GCLs are produced by the needle punching method and bentonite mixed with adhesive/HDPE geomembrane type GCLs are produced by calendaring. Special composition of GCL layers and binder are used to prevent the fluid loss of bentonite.

(5) PBD

Prefabricated board drains (wick drains or plastic drain boards) are routine products produced in Korea and also imported. They are used to rapidly consolidate soft soil materials. Nonwoven heat-bonded geotextiles are used as filters. The plastic cores are manufactured domestically using polypropylene. PBD is very common since more than 60% of the west and south areas of Korea consist of soft soils. Many industrial complexes will be constructed in these areas. To strengthen these soils, a large amount of PBD will be used for many years into the future.

(6) Geonet composites

For geonet composites, non-woven geotextiles are used on both surfaces. They are used for drainage in waste landfills.

(7) Miscellaneous

Some geosynthetics, such as geofoam, geopipe, and geosynthetic sheet drains, are used for special end uses in various types of construction. Nonwoven geotextiles used as filters along with polypropylene cores are bonded by heat bonding methods. Currently, research on biodegradable filters and plastic cores is ongoing to prevent soil and surrounding environmental pollution. Biodegradable, smart PBDs with excellent drainage performance are being developed.

3. Regulations, specifications, and standardization

Currently, regulations, specifications, and standard testing methods of geosynthetics are the hottest issues in Korea because some specifications for designing with geosynthetics are confusing to set the minimum values of geosynthetic performances. This situation must be clearly solved, to adopt the international standard test method to be considered for Korean special-installation circumstances.

Photo 2 | Photographs of segmental retaining walls in Korea.

Different ministries of the government supervise regulations of geosynthetics. For example, the following ministries are involved in the regulations for geosynthetics:

- Ministry of Environment—geosynthetics for waste landfills
- Ministry of Construction and Transportation—geosynthetics for general construction
- Korea Highway Corporation—geosynthetics for transportation

The Korean government is adopting similar standards as Korean industry. They use both ISO and ASTM International standard test methods involving different types of materials. For geosynthetics, specific properties and circumstances of geosynthetics have been taken into consideration beginning in 1998.

Most standardized geosynthetic-related test methods were adopted from JIS (Japan Industry Standard). However, a new standardization project by the Korea Industry Standards group (including geosynthetics) is ongoing from 1998, in accordance with international standards such as ISO and ASTM International. But between two international standards, ISO standard test methods, regulation of geosynthetics in Korea is strongly influenced by special task forces in different installation fields. Therefore, many regulatory standards are adopted for different installation fields on a project-specific basis.

Currently there are no specific organizations to develop specifications, accreditation, or certification of geosynthetics in Korea except the Agency for Technology and Standards. This agency is undertaking the preparation and organization of these geosynthetic activities. The following organizations are related to specifications, accreditation, and certification of geosynthetics in Korea:

(1) Specifications

- Agency for Technology and Standards
- Ministry of Environment
- Ministry of Construction and Transportation
- Korean Standards Association

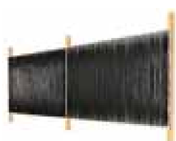
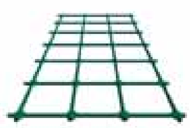
(2) Accreditation

The Korea Laboratory Accreditation Scheme (KOLAS) is the governmental accreditation body established Dec. 8, 1992, and administered by the Korean Agency of Technology and Standards(KATS). KOLAS has been actively participating in the international activities relating to testing, calibration, and inspection in conjunction with the Asia-Pacific Laboratory Cooperation (APLAC) and the International Laboratory Accreditation Cooperation (ILAC).

KOLAS signed Asia-Pacific Laboratory Cooperation Mutual Recognition Arrangement (APLAC MRA) in Sydney on Oct. 23, 1998 for testing, and May 22, 2001 for calibration. Since then, members of the APLAC MRA have expanded to 20 bodies from 15 economies.

KOLAS is also a signatory to the International Laboratory Accreditation




Update from Korea

Cooperation Mutual Recognition Arrangement (ILAC MRA) which was signed in Washington, D.C., on Nov. 2, 2000. It now involves 46 member bodies from 37 economies. The ILAC arrangement will provide technical underpinning to international trade by promoting cross-border stakeholder's confidence and acceptance of accredited testing and calibration results.

KOLAS operates in accordance with the requirements of ISO/IEC 17025, calibration and testing laboratory accreditation system/general requirements for operation and recognition, and is providing accreditation service for testing and calibration laboratories as well as inspection bodies.

The mission of KOLAS:

- Provide national accreditation for competent laboratories and inspection bodies.
- Encourage establishment and development of laboratories, inspection bodies and related facilities in Korea.
- Promote mutual recognition with other accreditation bodies.
- Promote international acceptance of test results and inspection reports produced by accredited organizations to facilitate trade.
- Cooperate and collaborate with other accreditation bodies.

In addition to KOLAS accreditation, FITI/GSI Korea obtained GAI-LAP accreditation in 1999.

There are also numerous geosynthetics accreditation tests available in Korea on behalf of FITI/GSI-Korea, including 66 ASTM International, 8 ISO, and 3 GRI.

(3) Certification

Currently, there is no organization or institute giving geosynthetic certification in Korea. Private certification reports by Korean consultants, professors, researchers from private or public institutes, geotechnical consultants—or test reports from foreign geosynthetic laboratories—provide a part of geosynthetic certification. In the future, FITI/GSI-Korea should undertake a more significant role of certification of geosynthetics in Korea. FITI/GSI-Korea conducted a pilot certification project of uni-axial

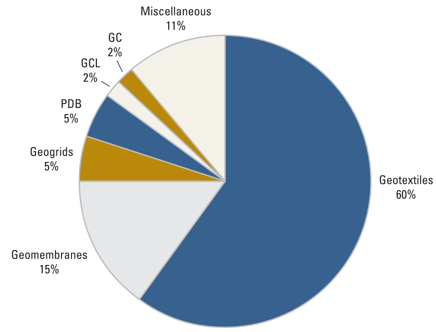


Chart 1 | Production ratios of geosynthetics in Korea (2004).

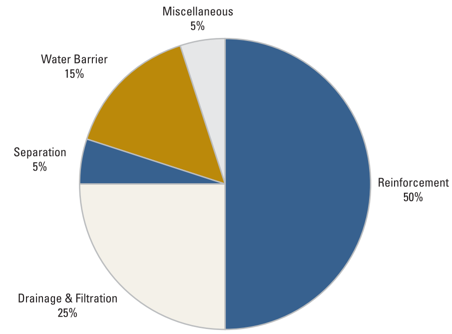


Chart 2 | End uses of geosynthetics in Korea (2004).

geogrids of Samyang Co.(Korea), in accordance with GCI-PCP of the Geosynthetic Institute (USA) during 2004–2005. The results were reasonable and future efforts are envisioned.

4. Korean research and development vs. international needs

Training and education programs in geosynthetics have been supervised by the Korean Geotechnical Society (KGS) from 1987 to 2000. Since 2001, the KGS has supervised most of academic programs of geosynthetic related conferences in Korea. These programs present geosynthetic types and manufacturing, testing methods, applications, and case histories. The focus of these programs is usually on design and installation rather than manufacturing and testing of geosynthetics. Three to four seminars and conferences on geosynthetics are held in Korea per year. For seminars, the special title is selected to be related in geosynthetic installation and some presentations and discussions are available.

Recently, Korean Geosynthetic Society–IGS Korean Chapter held the Asian Regional Conference for geosynthetics, GeoAsia 2004, and this successful conference motivated more geosynthetics activity in Korea. For conferences, special divisions are selected, such as: geosynthetics manufacturing, testing and evaluation, case histories, etc. Many papers are presented in each session. The supervising organizations for geosynthetic related seminars and conferences in Korea are as follows:

- Korean Geotechnical Society–Division of Geosynthetics
- Korean Society of Civil Engineers
- Korean Geosynthetic Society–IGS Korean Chapter
- Korean Fiber Society
- FITI GSI-Korea/GSRL (INHA University)
- GS-ATRA (GeoSynthetic Application Technology Association)
- Geosynthetics Research Committee of KOSEF (Korea Science and Engineering Foundation)

Research topics and interests regarding geosynthetics in Korea are the same as those in the United States, Europe, and Japan. Most of the geosynthetic related geotechnical and environmental engineers, professors, and researchers undertake similar research. Also, worldwide information, data, and technical papers on geosynthetics are available in Korea. The main research fields involving geosynthetics are the application, design and assessment of soil retaining walls, waste landfills, roads, railroads, and runway construction, as well as soft soil reinforcement.

Research on geosynthetic regulations and standardization is ongoing by GSRL (Geosynthetic Research Laboratory), Division of Nano-Systems Engineering, INHA University, and testing methods is ongoing by FITI/GSI-Korea. Research on design, installation, and assessment of geosynthetics is under the Korea Institute of Construction Technology and Highway Research Center of the Korea Highway Department.

5. Lessons learned from forensic analysis of case histories applicable to specific areas

There are several areas presenting problems for geosynthetics in Korea. Some typical case histories include:

5.1 Environmental fields

Most waste landfills are constructed between valleys because of limited area. Therefore, they have steep slopes and many rough stones, and are in the category of canyon landfills **(Photo 1)**. The problems that have occurred with this application include:

- Failure of geomembranes due to imperfect seaming
  –Destruction of waste-landfill system and pollution of surrounded soils
- Degradation of polypropylene nonwoven geotextiles due to UV attack
  –Decrease of tensile strength and elongation
- Bentonite loss from GCLs
  –Decrease of water-barrier properties

5.2 Geotechnical fields

Application examples of geogrids to the geotechnical field are the case of segmental retaining wall **(Photo 2)**. For this case, many reduction factors influencing the long-term strength of geogrids must be considered, but specifically high reduction factors were adopted in Korea because of installation concerns. Therefore, high factors of safety must be reflected in design using geogrids and relatively high costs will be incurred even though the system is quite stable. There are no considerations of reduction factors for high rainfalls and drainage systems in design. Situations of inadequate drainage are very dangerous in rainfall seasons.

Photo 3 | Photographs of railroad construction procedure using geosynthetics in Korea.

5.3 Transportation fields

For the application of geosynthetics to soft-soil reinforcement, road and railroad construction, geotextiles are used as reinforcement but they are subjected to high tensile stresses **(Photo 3)**. This is the cause of failure of woven geotextiles by differential settlement and thus attempts to use glass fiber geogrids are ongoing.

6. Market analysis of geosynthetics

Production of domestic geosynthetics in Korea is represented in **Chart 1**. Here it is seen that the order of production is geotextiles > geomembranes > PDB > geogrids. **Chart 2** shows geosynthetic end uses, and illustrates that the order of geosynthetic end uses is reinforcement > drainage/filtration > water barrier > separation.

Geosynthetics design aids in Korea are highly oriented to the geosynthetic properties of task forces that are required for installation rather than the suitability of geosynthetic application. It is not felt to be reasonable for geosynthetic development and advancement to do this. It is clearly recognized that standardization, regulations, and certification of geosynthetics must be developed to improve the situation in Korea.

Both domestic and imported geosynthetics are used in many geotechnical and environmental fields. For domestic geosynthetics, the large companies make use of their own trade routes from manufacturing to marketing. Most middle and small companies make an alliance (a kind of consortium) to supply and sell the required geosynthetics as necessary. On the other hand, imported geosynthetics are supplied through distributors and representatives located in Korea.

There are two types of purchasing and contracting agreements using geosynthetics in Korea. One is government supply and the other is individual supply. The former is an undertaking of the Supply Administration for the Republic of Korea and it occupies the largest portion. The latter is controlled by individual companies and occupies a relatively smaller portion. The final type of government supply is determined by turnkey type organizations. The results of this situation affect all kinds of contracting. The domestic construction fields utilizing geosynthetics are as follows:

- Soft soil reinforcement—Nonwoven and woven geotextiles, PDBs, etc.
- Soil retaining walls—Nonwoven geotextiles, geogrids, etc.
- Waste landfills—Nonwoven geotextiles, HDPE geomembranes, GCLs, geonet composites etc.
- Tunnel construction—Bentonite mixed with adhesive/HDPE geomembrane type
- Subway construction—Bentonite mixed with adhesive/HDPE geomembrane type
- Road and railroad construction—Nonwoven and woven geotextiles, geogrids etc.
- Miscellaneous—many types of geosynthetics associated with various end uses

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SUPER GLUE

Ground rules

| The imagination of the designer and the skills of the engineer combine for unique geosynthetics applications, from subsurface to rooftop.

By Andrew Aho

Photos courtesy North American Green

| White River project: Referred to as a "composite turf reinforcement mat" or C-TRM, this permanent geosynthetic mat controls soil erosion by itself as vegetation grows. Once vegetation is established, the mat reinforces the vegetation for permanent erosion control.

Geosynthetic materials entered the marketplace during the last third of the 20th century, and since then have increasingly become a staple for landscape architects and designers. By incorporating the creative use of geosynthetics, landscape projects are limited only by the imagination of the designer and the application skills of the engineer. Gravity and other physical laws notwithstanding, the designer's scope has expanded greatly through the use of geosynthetics.

Whether the project involves the simple elegance of a sculpted river bank or the attractive, but highly functional, aesthetics of natural barriers of protection for federal buildings … from the hobbit village-like effect of a green roof to cleverly constructed temporary parking facilities, geosynthetic materials allow engineers, designers, and landscape architects to do things that would simply not be possible using only natural materials.

Geosynthetics and landscape design

Geosynthetics are made of the same synthetic polymers that are so much a part of our everyday consumption and comfort—in fact, the general public may refer to them as plastics. But when these polymers are combined with the imagination of a designer and the skills of an engineer, we can literally reshape the earth to accommodate our needs. Generally, the function of geosynthetic materials is to separate, reinforce, filter, drain, and contain earth and water.

More than $4 billion were spent on geosynthetics worldwide in 2003, according to Robert M. Koerner in *Designing with Geosynthetics* (Prentice-Hall, 2005). He estimated that geosynthetics are growing at a rate of 5% annually when used in transportation and environmental applications. Use in the geotechnical sector is growing by 10% per year, and by 15% per year in hydraulics and private development. It is also estimated that only 20% of the marketplace has been tapped for geosynthetics applications, Koerner noted.

That sculptured river bank, the building protection barriers, a temporary parking facility, and a green roof were all projects that were expertly presented at the 2005 IFAI Expo Educational Track, "Geosynthetic Materials for Landscape Architecture." The eclectic collection of presentations and wide variety of applications represented just a small slice of the market potential for the use of geosynthetics in the landscaping and construction industries.

Creative applications

Todd Croke of North American Green in Evansville, Ind., highlighted the use of geosynthetic reinforcement materials in erosion-control projects. The aesthetically acclaimed White River project in Indiana included ero-

| Andrew Aho is managing director of the Geosynthetic Materials Association, a division of the Industrial Fabrics Association International.

Photos courtesy Gale-Tec Engineering Inc.

| Minneapolis Federal Building project: These geosynthetics-reinforced barrier mounds are part of the security set-back built into the design of federal buildings since the Oklahoma City bombing in 1995.

sion-control mats that combine natural fibers and a geonet that allows vegetation to be established on the relatively steep slope. The geonet keeps that vegetation in place; the roots grow through the geonet and form a stabilized erosion-control blanket. The reinforcement was needed because of hydraulic pressures from both runoff into the river and the occasional flooding onto its banks.

After three months of duty, the "parking lot" was rolled up, transported, and installed in a field by another Ford plant near Chicago.

According to Croke, the geonet helps keep the vegetation root system in place and also creates a green, park-like appearance along the riverbank.

The casual observer is not generally aware of the presence of geosynthetics because they are usually buried in the earth. We simply see a grassy hillside next to the walking path by the river. Or, in the case of the Federal Building and U.S. Courthouse in Minneapolis, we observe some curious green mounds in front of the building.

The mounds in front of the Federal Building in downtown Minneapolis were put in place in response to new security measures required in the design of federal buildings since the bombing of the Oklahoma City Federal Building in 1995. Steve Gale of Gale-Tec Engineering Inc., Wayzata, Minn., was the engineer on this novel design that used geosynthetic material as part of a project aimed at helping to protect a building from a possible terrorist act. Gale noted that the intent of this project was to create a visual obstacle and security barrier to the front of the building. The mounds appear to be solid, grassy knobs protruding from the concrete deck. They are, however, actually made with a core of geofoam, a lightweight geosynthetic material, with a sand fill held in place with geogrids. The sod is attached to the geosynthetic materials with wire, and small trees are set in a planter in the 5- to 8-ft. mounds to create a visual impression of a tree-studded hillside.

Photos courtesy I-Corp International Inc.

| Ford-Canada parking lot: A temporary parking lot near the Ford plant in Oakville, Ontario, was actually rolled up and reused at another Ford location. The geocomposite sandwich provided a surface that was clean, fire-retardant, and water-permeable to allow natural runoff.

Ground rules

Green roofs can extend the service life of a roof as well as providing energy savings and a pleasing natural aesthetic.

Another project presents a less natural finished appearance but addresses a growing problem: Imagine having 9,000 new cars and no place to park them. This was the challenge that Ford Motor Co.-Canada presented to Ian Peggs of I-Corp International of Ocean Ridge, Fla.

Dr. Peggs came up with a productive, reuseable, geosynthetic answer for Ford's situation: Instead of paving paradise and putting up a parking lot, his solution was to roll out 57 acres of geosynthetics to produce a temporary parking site. He chose a geocomposite, a geosynthetic material of more than one component; in this case, a biaxial geonet sandwiched between polypropylene geotextiles. This material provided one large, clean, stable, fire-retardant surface that was UV-resistant and also permeable, so there was no change in the natural water runoff.

After minor scraping of topsoil in a field near the Ford plant in Oakville, Ontario, lengths of the geocomposites were welded, stretched, and anchored. Parking stalls and traffic lines were painted on the surface, and Ford had its 9,000-vehicle, temporary parking facility. After three months of duty in Canada, the "parking lot" was rolled up, transported, and installed in a field by another Ford plant near Chicago.

Moving from bottom to top, one of the more unusual applications of geosynthetics is in the building of green roofs for residential and commercial structures. A green roof is planted with vegetation to increase the value of a structure by extending the service life of the roof; not only do green roofs produce energy savings, they can mitigate stormwater damage by serving as a natural barrier that allows rainwater to percolate through the vegetation, much as it does on the ground.

Charlie Miller of Roofscapes Inc. in Philadelphia explained that geosynthetics are an important component of green-roof construction. Geonets are used as drainage devices on green roofs; geomembranes serve as waterproofing liners and barriers to contain plant roots; geotextiles are used for separation of soil materials and for water transmission; geogrids provide support and reinforcement on green roofs with slopes. Geocomposites are also used, and provide multiple functions, including drainage, separation and protection.

Although relatively common in Europe, green roofs have yet to gain much popularity in the North American marketplace. However, some successful North American green-roof projects include Chicago City Hall, the World Trade Center in Boston, the Heinz 57 Center in Pittsburgh, and the Central Library in Kansas City, Mo.

From riverbank to rooftop, homeland security to portable parking lots, geosynthetics are providing 21st century answers.

Sources

Gale-Tec Engineering Inc., Wayzata, Minn., +1 952 473 7193, fax +1 952 473 1492, E-mail: smg@gale-tec.com, Web site: www.gale-tec.com

I-Corp International Inc., Ocean Ridge, Fla., +1 561 369 0795, fax +1 561 369 0895, E-mail: icorp@geosynthetic.com, Web site: www.geosynthetic.com

North American Green Inc., Evansville, Ind., +1 812 867 6632, 800 772 2040; fax +1 812 867 0247, Web site: www.nagreen.com

Roofscapes Inc., Philadelphia, Pa., +1 215 247 8784, fax +1 215 247 4659 Web site: www.roofscapes.com

Initial feedback from CQA-ICP testing

By George R. Koerner and Robert M. Koerner

During the course of three summers (1988, 1990, and 1992) a team of speakers was put together by Bob Landreth of the U.S. Environmental Protection Agency to travel to each of the EPA's 10 regions to teach and to explain the agency's regulations on landfill design.

The core group included Landreth, who opened the day-and-a-half-long sessions, followed by Dave Daniel on compacted clay liners (CCLs), Bob Koerner on geosynthetic materials, Greg Richardson on system design, and Paul Schroeder on HELP modeling. Each event concluded with a panel session consisting of all of the speakers. An issue that frequently arose was essentially a challenge to the credibility and expertise of both construction quality control (CQC) and construction quality assurance (CQA) personnel.

With this in mind, the group subsequently explored existing certification institutes and eventually went with the National Institute for Certification of Engineering Technologists (NICET), a well-established group certifying engineering technologists in approximately 30 different application areas. We worked with them forming advisory experts in geosynthetics and they started with examinations and the granting of certifications in about 1994 at three different levels for geosynthetic materials. (CCLs never were developed under NICET auspices.)

During the subsequent few years, progress was made; however, it became apparent that the CQC personnel did not fit the mold of taking written examinations. For example, some excellent installers don't speak English. To compensate for this unfulfilled need, the International Association of Geosynthetics Installers (IAGI) was formed. This "hands-on" testing organization is functioning well and certainly filling the need for certified installation personnel. For further information see their Web site: www.iagi.org.

Editor's note:
Please see the Geosynthetic Institute column in the April-May issue of ***Geosynthetics***, pp. 46-49, for an introduction to this program, described in "GRI White Paper #8."

In the decade since the NICET-CQA examinations were first crafted, little has been done in upgrading and updating the exams; and the "fit" for geosynthetics CQA inspectors was thought marginal, at best. The suggestion was made in 2005 that GSI might provide such a service since we are currently doing both laboratory accreditation (the GAI-LAP program) and product certification (the GCI-PCP program). Furthermore, GSI has a vested interest in geosynthetics, per se, and thus program maintenance is assured.

The GSI Board of Directors gave the green light and we formed an ad-hoc steering committee: Sam Allen of TRI, Jeff Blum of STS, Jeff Fassett of Golder, Jim Goddard of ADS, Jim Olsta of CETCO, Boyd Ramsey of GSE, Dan Rohe of EPI, Mark Sieracke of Weaver Boos, Maria Tanase of Earth Tech, Rick Thiel of Vector, and Steve Wintheiser of CTI.

This group has worked efficiently to establish the following basic criteria:

(a) His/her supervisor, preferably a professional engineer, must recommend the candidate.

(b) The candidate's resume must be submitted and it must include at least 6 months of experience in CQA of like materials.

(c) The fee was established at $400 for a 5-year certification for geosynthetics materials. (Subsequently it was modified to $500 for 5 years of certification for both geosynthetic materials and CCLs.)

(d) The candidate must pass a multiple-choice geosynthetics examination of 140 questions with a grade of 70%, or higher. (The CCL examination is an additional 55 questions, with 70% again the passing grade.)

The Steering Committee then crafted the geosynthetics examination,

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which is currently 20 questions on geosynthetics, 20 questions on geotextiles, 10 questions on geogrids, 20 questions on geonets, 35 questions on geomembranes, 20 questions on GCLs, and 15 questions on geopipe.

The first examination was held at GSI on Jan. 28, 2006, with 11 people taking (and all passing) the examination.

The first examination was held at GSI on Jan. 28, 2006, with 11 people taking (and all passing) the examination. There were subsequent modifications made to the exam, however, and some poorly worded or possible multiple-answer questions were revised.

Following these first exams, Sam Allen suggested adding CCLs to the program. Of course, soils are beyond the mandate of GSI, so our Board of Directors was brought back into the discussion and eventually approved the idea. The logic of this decision is that CCLs have no "home" and that for liner systems, geosynthetics and CCLs truly go together and are often inspected by the same CQA personnel. Fortunately, Sam with the aid of John Allen and Bob Gilbert (who had now joined the Steering Committee), had a set of questions and answers, and offered them to us for the purpose of the certification examination in CCLs. There are 55 questions in this particular test. Testing times are 2 hours for geosynthetic materials and 1 hour for CCLs, with a 30-minute break between the two exams.

The first offering of both exams was in Richmond, Va. at Golder Associates on March 1, 2006, with an independent proctor overseeing the exams. GSI did all of the grading. Nine candidates took the two examinations and they all passed with scores of 70% or higher, and all were certified accordingly.

This year, both examinations have been offered in: Fairmount, WV on March 17; Austin, Texas, March 24; Richmond, Va., April 1; Lansing, Mich., April 3; Grass Valley, Calif., April 7; Folsom, Pa., April 22; Irvine, Calif., May 3; and Pittsburgh, Pa., May 13.

From the number of sites and the nice geographic distribution of locations, the program has started out well beyond our expectations. Landfill owners, particularly Waste Management Inc., are firmly behind the program and we sense that the regulatory community is as well.

George Koerner is the project manager, Jamie Koerner is handling the considerable bookkeeping involved, and Bob Koerner is providing oversight. Please visit our Web site at: www.geosynthetic-institue.org under "Inspector Certification—GCI-ICP" for information on application forms, proctor details, and other scheduled examination dates and locations. Also, please don't hesitate to give us feedback and your ideas regarding ongoing improvement in the examinations or the program's organization. G

8th International Conference on Geosynthetics

18–22 September: Yokohama, Japan

Reported by Fumio Tatsuoka, IGS vice president and chair of the 8ICG Organizing Committee

2006 YOKOHAMA

The International Geosynthetics Society's (IGS) showcase conference offers an exceptional opportunity for dialogue among the various disciplines related to geosynthetics (e.g., geotechnical, environmental, and civil engineering; hydraulics; geology). It will provide perspectives on and overview of technical innovations by offering forums for engineers and researchers, and by welcoming papers devoted to new techniques and applications.

More than 400 paper abstracts have been accepted for the 8ICG, the most in the history of the ICG. The final papers have been peer reviewed by the International Paper Selection Committee (IPSC) and a number of international reviewers appointed by the IPSC.

The IPSC members are: Jiro Kuwano, chair (Japan), Richard Bathurst (Canada), Heinz Brandl (Austria), Daniele Cazzuffi (Italy), Jean-Pierre Gourc (France), Robert Holtz (United States), Chris Lawson (Malaysia), Masashi Kamon, Junichi Koseki, and Fumio Tatsuoka (all of Japan).

8ICG conference topics include: transportation, hydraulic structures, erosion control and coastal works, soil improvement and reinforcement, mining, waste landfills, remediation of contaminated sites, landscaping and environmental mitigation, prevention of natural and technological risks, agriculture and forests, innovative geo-materials and construction methods, and education and technology transfer.

New conference features at 8ICG

Practitioners and Academics Forum. A Special Plenary Session will be held during the 8ICG to help facilitate a dialogue between geosynthetics researchers and practitioners, which will be moderated by Richard J. Bathurst, IGS past-president. The goal is to have areas of research identified by academics that have potential applications to practitioners and have potential geosynthetics research opportunities identified by practitioners.

Case Histories. A new and unique feature of the 8ICG will be presentation sessions organized for about 100 papers on geosynthetics engineering case histories, submitted from IGS chapters and individual authors all over the world.

Special and Keynote Lectures

Giroud Lecture by Lawson, C.R. (Malaysia) on "Geotextile containment for hydraulic and environmental engineering"

Keynote Lectures:

- Heibaum, M. (Germany), Fourie, A. (Australia), Girard, H. (France), Karunaratne, G.P. (Singapore), Lafleur, J. (Canada), Palmeira, E.M. (Brazil) on "Hydraulic Applications of Geosynthetics"
- Koseki, J. (Japan), Bathurst, R.J. (Canada), Guler, E. (Turkey), Kuwano, J. (Japan), Maugeri, M. (Italy) on "Seismic Stability of Reinforced Soil Walls"
- Kavazanjian, E. (USA), Dixon, N. (UK), Katsumi, T. (Japan), Kortegast, A. (New Zealand), Legg, P. (South Africa), Zanzinger, H. (Germany) on "Landfill and Environmental Issues"
- "IGS History" by Giroud, J.P.
- Training Course on Geosynthetics (9 a.m.–5 p.m. on 18 September (¥3,000/U.S.$25) for materials and lunch), organized by the IGS Education Committee. The topics and lecturers are: Geosynthetics Types and Functions (Palmeira, E.), Geosynthetics in Drainage and Filtration (Gourc, J. P.), Geosynthetics in Hydraulic Applications (Zornberg, J.), Geosynthetics in Reinforced Walls and Steep Slopes (Bathurst, R.), Geosynthetics in Unpaved Roads (Shin, E. C.), Geosynthetics in Embankment on Soft Soils (Otani, J.), and Geosynthetics in Waste Disposal (Bouazza, M.).
- Pre-8ICG Special Lectures (5:30 p.m., 18 September, free) will be hosted by the IGS Japanese Chapter and the Japanese Geotechnical Society. The two special lectures are: Geosynthetics Engineering: Successes, Failures and Lessons Learned (the Vienna Terzaghi Lecture) by J. P. Giroud; and Long-Term Performance of Contaminant Barrier Systems (2005 Rankine Lecture) by R. Kerry Rowe. For reservations, please contact Mrs. Nohara (nohara@rs.noda.tus.ac.jp.) and provide name, affiliation, and country.

Other activities and events

Exhibits will be held and will be open to any individuals free of charge.

Excursions to various attractions in Kyoto and the surrounding area are planned, which will provide conference participants and accompanying persons an opportunity to enjoy Japanese culture, e.g., visits to modern and historical cities and a cruise on Tokyo Bay. A number of post-conference technical tours to unique and interesting construction sites and structures are also being organized.

Conference fees

IGS and ISSMGE members, before the end of May 2006: ¥70,000/U.S.$600 for full participation (¥30,000/

U.S.$260 for one day); after 1 June 2006: ¥80,000/U.S.$685 for full participation (¥36,000/U.S.$308 for one day).

For others, before the end of May 2006: ¥80,000 for full participation (¥36,000/U.S.$308 for one day); after 1 June 2006: ¥90,000/U.S.$770 for full participation (¥42,000/U.S.$360 for one day).

Organized by the Japan chapter of the IGS, under the auspices of the IGS, with the support of the International Society for Soil Mechanics and Geotechnical Engineering, and the Japanese Geotechnical Society.

Are you an "IGS Pioneer"? If you have attended all seven previous international conferences dedicated to geosynthetics, and you plan to attend the 8ICG in Yokohama, please contact the IGS Secretary at IGSsec@aol.com.

Visit the conference Web site at: www.8icg-yokohama.org/ for information on transportation, accommodation, registration, and exhibitor applications, or contact:

Mr. Noboru Kiyokawa
Conference Secretary
Tel: 81/3 3837 2503
Fax: 81/3 3837 5818
E-mail: info@8icg-yokohama.org

10–13 September
2006 APWA International Public Works Congress & Exposition, Kansas City, Mo.

The American Public Works Association's annual event gives visitors an excellent opportunity to network with and learn from leaders in the public works field. Thousands of officials and professionals attend, sharing their infrastructure planning, design, maintenance, and management experience.

NOTE: APWA 2006 was scheduled originally for New Orleans. Due to Hurricane Katrina's damage, the event has been moved to Kansas City during the same dates.

For more information, contact Dana Priddy, American Public Works Association, 2345 Grand Blvd., Ste. 500, Kansas City, MO 64108-2641, USA; +1 816 595 5241; fax +1 816 472 1610; e-mail: dpriddy@apwa.net; Web site: www.apwa.net.

10–14 September
Dam Safety 2006, Boston

The dam safety exhibit and show will be held in conjunction with the 23rd annual Association of State Dam Safety Officials conference at the Seaport Hotel and World Trade Center in Boston.

Contact ASDSO for more information: +1 859 257 5140; info@damsafety.org

Contact the Seaport Hotel for reservations: 877 732 7678.

19–22 September
Pan American Convention of Engineers, Atlanta

The Georgia Institute of Technology (Georgia Tech) is hosting the 30th biannual Pan American Convention of

Engineers/Union Pan Americana de Asociaciones de Ingenieria (UPADI), Sept. 19-22. This is the first time the conference has been hosted in Georgia and by Georgia Tech. The convention will be held at the Westin Peachtree Plaza in downtown Atlanta.

The theme of the bilingual conference is "Building a Sustainable Infrastructure: Education, Technology Innovation, and Economic Development." Features of the four-day meeting include a series of technical congresses and presentations, along with five plenary sessions focusing on transparency and global ethics, economic development, free trade, sustainability, and education.

Georgia Tech president, Wayne Clough, will be one of the keynote speakers during the event. Plenary session speakers include: Ciro de Falco, executive vice president, Inter-American Development Bank; Raquel Alfaro, Fund for Fostering Scientific and Technological Research; Carlos Braga, senior advisor, International Trade Department, The World Bank; and Alberto Alemán Zubieta, chief executive officer, Panama Canal Authority. Registration and conference details for UPADI can be found at: http://www.upadi2006.com/english/index.shtml or contact Diana Turner at +1 404 385 3510 for additional information.

1–4 October

Geotechnique 2006, Vancouver

The Canadian and Vancouver Geotechnical Societies (CGS/VGS) and the Canadian National Chapter of the International Association of Hydrogeologists (IAH-CNC) welcome you to Sea to Sky Geotechnique 2006, the 59th Canadian Geotechnical Conference and the 7th Joint CGS/IAH-CNC Groundwater Specialty Conference. The conference will be held at the Fairmont Hotel in Vancouver, British Columbia, Oct. 1-4, 2006.

The Sea to Sky Geotechnique 2006 organizing committee invites members of the Canadian and international geotechnical communities to contribute to and to learn about recent research and developments that affect all sectors of geotechnical engineering, applied geology, and hydrogeology. The conference will cover a wide range of topics, including special sessions on Infrastructure and Mining Geotechnique that are of specific local or national relevance to the fields of geotechnical and groundwater engineering.

Vancouver is the host city for the 2010 Winter Olympics. Numerous facilities are being constructed along BC's Sea to Sky corridor linking Vancouver with Whistler, BC, site of the Olympic alpine events. Geotechnical engineering will play a key role in the upgrading and building of infrastructure between now and 2010. Sea to Sky Geotechnique 2006 will focus on many themes associated with these major civil engineering works.

Sea to Sky Geotechnique 2006 will offer a complete conference experience, including social events, an accompanying guest program, short courses, and technical tours. For more information: 604 473 5343; peter.lighthall@amec.com

31 October–3 November
IFAI Expo 2006/MEGATEX, Atlanta
The Trade Show for the Global Specialty Fabrics Marketplace

Industrial Fabrics Association International (IFAI) is pleased to announce that MEGATEX, an event featuring the co-location of IFAI Expo 2006 and ATME-I 2006, has been selected by the U.S. Department of Commerce for the prestigious International Buyer Program (IBP) designation in 2006.

"We are very excited about being awarded the International Buyer Program designation," said IFAI president Steve Warner. "The IFAI Expo is always the largest show in the Americas for the technical textiles industry. The IBP recognition by the Department of Commerce will now help us bring in thousands of new buyers from around the world through the active promotion of the more than 150 U.S. Foreign and Commercial Services offices located in 70 countries."

MEGATEX will be held at the Georgia World Congress Center in Atlanta, and is anchored by the IFAI Expo 2006 (Oct. 31–Nov. 2) and the ATME-I 2006 (Oct. 31–Nov. 3) shows. Together the shows are expected to have more than 1,000 exhibitors and attract as many as 20,000 visitors.

The U.S. Department of Commerce, through the IBP program, promotes key U.S. trade shows that will bring international business buyers. MEGATEX was one of only 50 trade shows in the U.S. to receive the coveted IBP designation for 2006. A survey of U.S. Commercial Service offices around the world concluded that MEGATEX will generate significant interest in numerous overseas markets that justify the IBP selection.

"If you are interested in selling your products to the overseas markets, the IFAI Expo 2006 will definitely be the place to exhibit," said Bob Smith, IFAI Expo 2006 exhibit sales manager.

In addition to ATME-I 2006 and IFAI Expo 2006, the American Association of Textile Chemists and Colorists (AATCC) will be co-locating its AATCC 2006 International Conference & Exhibition within MEGATEX.

Several other organizations have already announced support for MEGATEX, including the National Council of Textile Organizations (NCTO), the National Textile Association (NTA), the American Fiber Manufacturing Association (AFMA), the Carpet and Rug Institute (CRI) and the Secondary Materials and Recycled Textiles Association (SMART).

For information about exhibiting at the IFAI Expo 2006, visit the tab marked "Exhibitors" at www.ifai.com, or contact Bob Smith or Chris Kohn, Exhibit Sales, IFAI, 1801 County Road-B W., Roseville, MN 55113, USA; phone: +1 651 222 2508 or 800 225 4324 (USA and Canada only); fax: +1 651 631 9334; e-mail: confmgmt@ifai.com.

Geosynthetics 2007

January 16–19 • Washington D.C.

16–19 January 2007

Geosynthetics 2007, Washington, D.C. Geosynthetics 2007: Geo Solutions for the Environment, Transportation, and Homeland Security

Geosynthetics 2007 will be held at the Hilton Washington in Washington, D.C., Jan. 16-19, 2007, immediately preceding the Transportation Research Board's 86th Annual Meeting.

The conference and exhibition, themed Geo Solutions for the Environment, Transportation, and Homeland Security will provide a platform for the discussion of practices, applications, regulatory issues, and the construction outlook shaping the future of the geosynthetics community.

More than 1,200 professionals representing regulatory and government agencies, research, design, engineering, manufacturing, construction and installation fields of geosynthetic materials and products are expected to attend the multitude of educational offerings at this event.

The exhibition features more than 100 companies showcasing their latest fabrics, technologies, services, and equipment. A value-added bonus for participants includes the opportunity to attend the Geosynthetics Research Institute 20th Anniversary Conference focusing on Geosynthetics in Homeland Security held in conjunction with Geosynthetics 2007.

Geosynthetics 2007 is organized by the Industrial Fabrics Association International (IFAI) and Geosynthetic Materials Association (GMA). The event is held in cooperation with the North American Geosynthetic Society (NAGS) under the auspices of the International Geosynthetics Society (IGS) and the Geosynthetics Research Institute (GRI).

To subscribe to Geosynthetics 2007 E-News Bulletins, visit www.geoshow.info or contact: Jill M. Rutledge, Secretary-General, IFAI, 1801 County Road B. West, Roseville, MN 55113-4061; + 1 651 225 6981; fax: + 1 651-631-9334; e-mail: jmrutledge@ifai.com.

Schedule-at-a-Glance

Tuesday, Jan. 16, 2007

8 a.m.–5 p.m.
Environmental Short Courses

6–8:30 p.m.
Trade Show Open/ Welcome Party

Wednesday, Jan. 17

8 a.m.–5 p.m.
Environmental Keynote & Technical Sessions

11:30 a.m.–6:30 p.m.
Trade Show Open/VIP Admittance/Lunch & Reception

Thursday, Jan. 18

7:30–10 a.m.
Trade Show Open/Breakfast

10 a.m.–6 p.m.
GRI 20th Anniversary Conference

10 a.m.–6 p.m.
Transportation Short Courses

6:30–7:30 p.m.
Reception

Friday, Jan. 19

8 a.m.–5 p.m.
Transportation Keynote & Technical Sessions

5:30–7 p.m.
Closing Reception

Registration materials are available now: www.geoshow.info

GMA Geosynthetic Materials Association · nags · IFAI Industrial Fabrics Association International · igs

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Geosynthetic Materials Association

The Geosynthetic Materials Association is directed by the needs of the North American geosynthetics industry. It serves as the central resource for information regarding geosynthetics and provides a forum for consistent and accurate information to increase the acceptance and to promote the correct use of geosynthetics.

Visit www.gmanow.com, Contact: Andrew Aho amaho@ifai.com, 800 636 5042.

A great story to tell

By Andrew Aho

| Andrew Aho
Managing Director, GMA
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"You have a wonderful story to tell."

Those words came from a Washington, D.C. lobbyist after a meeting where I had presented an overview of the geosynthetics industry, the benefits of geosynthetic products, and the variety of geosynthetics applications.

"And the timing couldn't be better to tell it," he added, given the "build it right" rhetoric coming from Washington for Gulf coast rebuilding, the passage of a federal highway bill and its "Highways for Life" program, and the likely movement of the Water Resources Development Act this year in Congress also, to mention just a few major infrastructure proposals.

The timing is absolutely right.

To measure and act upon current opportunities, the Geosynthetic Materials Association (GMA) engaged Whitmer & Worrall, and Kemp Partners, both lobbying firms in Washington, D.C., to develop a comprehensive government marketplace opportunity report for the geosynthetics industry.

The team that produced the report included a recent senior official in the Department of Transportation, a former congressman, a former CEO of a Washington, D.C. think tank, an elite fundraiser for the president, and the COO of a strategic consulting firm.

And they produced some pretty good stuff, actually an overwhelming amount of good stuff. The GMA report shows that the opportunities are vast, the processes sometimes complicated, the competition keen, the work hard, and … *it is very expensive.*

But we do have a wonderful story to tell. The industry has matured, research has been completed, the materials are standardized, the applications are common, and the savings are real. It is time to bring geosynthetics to the political forefront and present its best practices to Capitol Hill and federal agencies as they address this country's needs in transportation, public works, water resources, and the environment.

The GMA government relations vision is one of spreading the geosynthetics story far and wide. GMA's government marketplace opportunity report identifies seven key U.S. Senate committees and a dozen subcommittees that are relevant to the growth of the geosynthetics industry.

There are an equal number in the House of Representatives. We envision establishing relationships with the congressional chairs and staffers of all these congressional committees. What's more, we plan to promote the establishment of a Congressional Caucus on Geosynthetic Materials, formed by members of Congress who have a specific interest in geosynthetics because they have constituents who work in, and benefit from, our industry.

Our plan includes demonstrating our products and their benefits to the White House and to federal agencies. Through the Domestic Policy Council, the policy-making arm of the White House, we will seek support and recommendations regarding our issues to nine federal departments that have been identified as influential to the interests of the geosynthetics industry.

In addition to federal advocacy, our plan includes encouraging state governors to support our efforts at the state and federal level. And, of course, our plan includes Katrina rebuilding and the U.S. Army Corps of Engineers.

Our plans are ambitious but our goals are simple—to grow the geosynthetics industry.

Our success will be ensured through the dedication and help of all companies and individuals touched by our industry. GMA will be looking to the readers of this magazine to provide expertise, and the time and resources to make our vision happen. In the future we will be issuing calls to action asking for your intellectual and financial support.

We do have a wonderful story. Let's go tell it.

***Geosynthetics* (formerly *GFR*) is an international, bi-monthly publication for civil engineers, contractors and government agencies in need of expert information on geosynthetic engineering solutions. *Geosynthetics* presents articles from field professionals for innovative, exemplary practice.**

| Andrew Aho is the managing director of the Geosynthetics Materials Association (GMA), a division of the Industrial Fabrics Association International (IFAI) based in Roseville, Minn.