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Tare #23: The Value of a Moisture Content

One evening in the cabinet
Sieve #10 woke with a start
To quiet sobs – “Come here,” he said.
“Let’s have a heart-to-heart.”

Tare 23 rolled over –
A small ceramic dish.
He’d been distraught all afternoon
Since he glimpsed the lab’s price list.

“I thought I was important,” he said,
“Tolling every day
In that inferno of an oven,
Drying endless globs of clay.

But my tests cost (sob!) twelve dollars!
Honestly, what’s the point?
Compared to a hydrometer,
I’m peanuts to this joint.

Never mind that old triaxial cell
Whose drained tests cost a grand.
A Proctor hammer’s worth trumps mine
And it just pounds on sand!”

The sieve sighed through his wire mesh.
“You have a lot to learn.
A moisture content test, you know,
Is not performed alone.

With grain sizes and limits
It tells loads about a site,
If the engineers use judgment
To correlate things right.

And when the jobs get bigger
We rely upon you still.
For consol tests with no moisture data
Would just be pointless drills.

Without you there would be no dams!
No piers or slurry walls.
Your impact runs the gamut
From pipelines to shopping malls.”

The tare gave one last sniffl e
As he pondered this address.
“I guess I’m more important
Than my listed price suggests.”

Then he drew his rim up taller
And exclaimed with renewed zeal,
“That I’m one heck of a deal!”

Mary C. Nodine, P.E., A.M.ASCE, is a geotechnical poet and a project engineer with GEI Consultants, Inc. in Woburn, MA. She can be reached at mnodine@geiconsultants.com

As I See It: Offshore Geotechnical Engineering
By Edward C. Clukey, Ph.D., P.E., F.ASCE

Lessons Learned from Geo-Legends:
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Exercise, Motivation, and Employee Performance
By Dan Kemlage, EIT
BENTLEY
I am a Registered Civil Engineer (since 1956) and have been retired since 1989, but still retain a strong interest in geophysics. The article by Bill Laprade in the Nov/Dec 2012 issue interested and disturbed me. How can a soils professional write 2600 words about Challenging Soils in Seattle, Washington and not mention the effect the Cascadia Fault’s release will have on the unstable slopes, many feet of glacial till and an abundance of colluvium?

It is fairly common knowledge that the tectonic structure of Juan DeFuco, Pacific and North American plates is very similar to the makeup of plates off the coast of Sumatra where the monstrous quake of 2004 caused devastation. The release in the Cascadia area was last experienced in January 1700 and geologists have identified a 300-year repeat cycle.

James H. Anderson, P.E., M.ASCE
Edina, MN

Author’s response.

Mr. Anderson’s comment is well-taken and valid to an extent. In addition to the Cascadia Subduction Zone (CSZ) interface mentioned, other earthquake sources that pose a significant ground shaking hazard to Seattle include the deep CSZ Benioff zone beneath the Puget Lowland and shallow crustal sources (e.g., Seattle, Tacoma and Southern Whidbey Island Faults) within the lowland. However, seismicity and seismic hazards were not the intended subjects of the article’s overview.

Topographic evidence in the ancient Puget Lowland landscape indicate that the largest landslides are associated with a large earthquake on the Seattle Fault approximately 1,100 years ago. By comparison, historic CSZ Benioff earthquakes in 1949, 1965 and 2001 have had only a minor effect on landsliding. While strong ground shaking from either of the CSZ sources (Benioff or interface) could cause significant landslides in the lowland (particularly if coupled with high winter groundwater levels), large earthquakes on the shallow crustal faults within and near the city would probably cause the largest and most wide spread landslide damage in the city.
The Value of Geo-professionals….
What Others Need to Know

Fighting commoditization today is a common refrain in the geo-professional community. We want others, particularly our clients, to value our professional engineering skills in the same way that clients value the skills of doctors and attorneys. We want others to see geo-professionals as essential to the success of projects and be willing to compensate us at a level commensurate with the risks that we help manage. These are wonderful aspirations, but how do we achieve them?

One of the key steps to attaining these goals is by educating our client base, particularly those in procurement, about how geo-professionals help them to effectively manage risks. This translates into more successful projects that are less costly, function more smoothly, and are completed expediently. The reality is that many of those procuring engineering services with geo-professional content do not have an appreciation for the competencies needed to practice effectively as a geo-professional. They don’t understand the coursework and other training needed to effectively solve geo-professional problems, and the importance of experience in dealing with geotechnical and geological conditions that can have a high level of uncertainty.

For example, most corporate executives would know to hire a litigator rather than a tax attorney to prosecute a pollution insurance claim. Most in healthcare would know to seek out a cardiologist rather than an oncologist to deal with heart complications. But do those who procure engineering services understand the difference between PEs trained as civil engineers vs. geotechnical engineers? Or structural engineers vs. geotechnical engineers? Unfortunately, those distinctions are unclear to many outside of our geo-professional community.

A recent experience made this lack of knowledge crystal clear and convinced me that we need to educate our client base about our competencies and their importance to successful execution of projects.

One of my clients is an international chemical corporation with widespread operations. I provide oversight and review of the geoenvironmental components of their projects, including procurement of geo-professional services. I am the ONLY person in their procurement and assessment chain that has a high-level understanding of geotechnics (and, I’m not an employee!) In 2010, I reviewed qualifications submittals from eight firms vying for one of my client’s high-profile projects. The project is 90 percent geotechnical engineering and is so important that a failure could disrupt the firm’s entire supply chain, permanently altering their competitiveness. Using knowledgeable geo-professionals who provide engineering services was essential. Of the eight firms that submitted a statement of qualifications, only TWO were firms that would be considered geo-professionals. The others were civil engineering or environmental science firms. All of the firms had PEs on their teams, but most of the engineers had a BS in civil engineering with no advanced training in geotechnical, geological, or geoenvironmental engineering. All of the proposals appeared impressive and each firm listed a collection of projects in their experience base. To the less familiar, all of the firms were qualified for the project and the decision could be made based on cost.

Because I know the profession, I was able to point out the differences in competencies between the firms and direct my client to the two firms that had the appropriate geo-professional competency for their project. I was able to effectively argue that geo-professional experience was essential, even though their cost proposals were higher. My client ultimately selected one of these firms, and the project has been very successful despite several unexpected complexities which have been deftly handled by the geo-professionals. My client would readily admit that she would not have been able to distinguish any of the proposals, which would have perceived all of the firms, by virtue of being staffed with PEs, as competent to provide the engineering services needed for this project. She now understands how a competent geo-professional is essential to the success of their projects.

This was an unusual case, as I had become engaged with my client by helping them right-size a previous project where lack of competency resulted in major problems. We won’t make much headway using this one-off approach to educating a client base. More proactive strategies are needed.

Providing potential clients with promotional materials that illustrate how geo-professional competencies are essential to successful completion of projects can be a successful strategy. These materials need conclusive facts and examples rather than hyperbole. The Geo-Institute is working with the GeoCoalition organizations and others to develop such collateral materials to share with your potential clients.

A means to readily distinguish geo-professionals from other PEs is also essential. The GE license would be ideal, but widespread adoption of GE licensing is a long way off. The D.GE (Diplomate of Geotechnical Engineering) credential
offered through the Academy of Geo-professionals is a great way to distinguish geo-professionals from other PEs. The D.GE demonstrates a level of personal achievement and competency in the geo-profession which includes a PE license, graduate course work in the geo-profession, at least eight years of geo-professional experience, and an oral examination. The Geo-Institute encourages geo-professionals with these qualifications to apply for the D.GE credential. For more information about the D.GE, see www.geo-professionals.org.

These are just examples of strategies we can use to educate others about our value and distinguish geo-professionals from other PEs. I am sure there are many other effective strategies. If you have a strategy that you think the G-I should pursue, please send me an email.

Craig H. Benson, Ph.D., P.E., D.GE, NAE, F.ASCE,
Geo-Institute President
chbenson@wisc.edu
As a sophomore in college, I recall understanding vividly the difference between standard and modified Proctor—those additional 4.5 lbs and extra 6-in. lifts sure made a difference in application that I had not appreciated on paper. Back then, geo-education to me meant a pile of assignments in engineering geology, foundations, geotechnical engineering, slope stability, and landslides, to name a few requirements. The term has since been modified by my 20 years 'in the force.'

Having spent the best decade of my life in college, some years in research, lecturing for over a decade in both the traditional classroom and online environment settings, and working as a full-time consultant, my definition of geo-education has evolved. It now is a mix of experiences—a combination of formal academic learning, years of research, training, and application of these lessons to practice. My geo-education experience is founded on two main supports: willingness to ‘learn to learn’ and stepping outside my comfort zone. Perseverance and a touch of insanity (late nights, weekend OT, and braving winter field work in remote, snow-packed areas with no internet—feel those shivers!) have been companions in this learning.

This issue of Geo-Strata is a collage of several authors’ experiences that endeavor to expand young and young-at-heart colleagues’ views about geo-education and the bridges that tie the academic, research, and practice aspects of our profession, and to future geo’s. Last year for the Geo-Congress 2012, Andrea Welker surveyed the state of geotechnical engineering education in the U.S. She’s updated the survey for this issue by exploring the growth of civil engineering, as measured by the number of degrees awarded over recent years, and the parameters that influence this growth: from enrollment requirements and employment opportunities to faculty preparation and the influence of professional organizations such as ASCE.

Using information from a recent survey by the G-I’s Organization Member Council, Suzanne Davenport summarizes the ‘big picture’ from a practitioner’s point of view about the current state of geo-education—some of the findings we suspected all along, others are surprising. Mark Jaksa addresses the issues surrounding geo-education online and distance learning versus more traditional formats and how geo-educators can take advantage of 21st century data-sharing. Montgomery et al. contribute the experience of the Geotechnical Graduate Student Society at the University of California at Davis and the different ways the student leaders and participants promote
scholarship, service, leadership, and social networking to add dimensionality to their academic experience.

Focusing on future geo’s, Amy Cerato and her colleagues describe their development and implementation of an educational module in an eighth-grade classroom where students learn the fundamental concepts behind soil-structure interaction, earthquakes, and geotechnical engineering. Working with second, third, and fourth graders, Eduardo Suescun-Florez and his colleagues describe how they bring geotechnical concepts to the classroom through the use of LEGO robotics to promote science, technology, engineering, and mathematics (STEM).

Oscar Wilde is credited with stating, “Education is an admirable thing, but it is well to remember from time to time that nothing that is worth knowing can be taught.” I take this to mean that we must be prepared to experience our profession to truly understand its depth and breadth and hope that our educators, mentors, and leaders incorporate hands-on experience into our geo-education. After reading this Geo-Strata issue, let us know—what do you think?

This message was prepared by Cathy Bazan-Arias, Ph.D., P.E., F.ASCE, from the Geo-Strata Editorial Board. Cathy can be reached at Cathy@DiGioiaGray.com

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Dr. James Monsees has earned an international reputation over his 52 years of experience as a leader in the design and construction of underground structures and tunnels. He has participated in many large underground projects in the U.S., including serving as the chief tunneling engineer for the Los Angeles Metropolitan Transit Authority (LA Metro) Red Line and as chief underground engineer and tunnel design manager for the Superconducting Super Collider in Texas. As technical director of underground structures for Parsons Brinkerhoff, Inc. (PB), Dr. Monsees has served as a reviewer for numerous other projects, including the deep tunnel sewage system in Singapore (named Water Project of the Year at the 2009 Global Water Awards), the Long Island Light Rail East Side Access in New York, and the LA Metro East Side Expansion, to name a few.

Dr. Monsees received his B.S. and M.S. degrees in civil engineering from the University of Missouri, where he was an Air Force ROTC student. His commission in the U.S. Air Force led him to New Mexico, where he worked on the design and construction of underground missile silos during the Cold War era. Afterward, he returned to graduate school, earning a Ph.D. in soil and rock mechanics supervised by Drs. Ralph Peck and Don Deere at the University of Illinois. Following graduation, he joined A.A. Matthews, where he designed tunnels in Mexico City, San Francisco, and Washington, D.C. before joining PB in 1983. Since 1996, Dr. Monsees has worked as technical director of underground structures and senior vice president for PB. He is a registered P.E. in seven states and the District of Columbia.

His wide array of design and construction experiences has resulted in Dr. Monsees contributing to textbooks, conferences, and technical journals. He was a principal author on the Technical Manual for the Design and Construction of Road Tunnels for the U.S. Federal Highway Administration and was selected to oversee the development of seismic design criteria for all future tunnels designed by the LA Metro.

Many organizations have honored Dr. Monsees for his leadership and innovation. He was elected to the National Academy of Engineering in 1991 and received a lifetime achievement award from the Underground Construction Association of the Society of Mining, Metallurgy, and Exploration, Inc. in 2008. He was selected as 2010’s Tunneler of the Year by the Institute of Civil Engineers in the UK, and received the 2011 Golden Beaver award. Recently he was recognized with the 2012 Lifetime Achievement Award from Tunnels and Tunneling International magazine.
What major projects shaped your engineering career after school?

I worked in Mexico City for almost a year and a half and enjoyed my time there. I worked problems on site as we encountered them in the field. Having graduated from the University of Illinois three years before, the project gave me a good preview of what I was getting into. We had some engineers doing field inspection. They were experienced tunnel engineers, but not experienced designers, and that’s what I wanted to do.

Tunneling in the soft compressible soils of Mexico City was very challenging. Decades earlier, the French had designed a sewer system for the city that worked fine for many generations, but then, with all of the settlement going on in the soil, the system began to drain backwards. On our project we drove 20-ft-diameter tunnels at a depth great enough that they wouldn’t be impacted by future settlement—and they still slope in the right direction!

How important is it for young engineers to learn from experienced workers (not necessarily engineers) in the field?

There’s nothing better. You learn so much more in the field when you have to produce, solve a problem and make it work.

Tunneling has made great technological advances over your career. How do engineers keep up with the changing technologies?

In part, by being immersed in it. On the Mexico City project, we designed an Earth Pressure Balance Machine that was built in Mexico with Mexican engineers assisting our designer. We had an engineer visit from Japan for a year to work in our office because the Japanese were so far ahead of us at that time in designing those types of machines. So we had an expert designer working side by side with our folks and the Mexicans to design the machine and to get it up and running.

Nothing beats experience in my view because a lot of the things we learn in class don’t apply in the real world. We can’t do much about it except to learn in the field and make adjustments to our design to work around it. Despite the technological advances and demand for graduates, the number of civil engineering programs teaching underground construction today is extremely limited compared to what it was 10-15 years ago. It’s a dichotomy, really. Technology is changing and we are graduating fewer engineers to do the work.

How important has mentoring been to your career?

It’s been very important. I’ve been very fortunate to work with some of the original tunneling people in the U.S. When I graduated from Illinois, I went to work for Al Mathews, who in my view is the grandfather of tunneling in the U.S. I worked with Al for three years in his office in California after I worked in Mexico City so I’d had that experience behind me, working with Al’s number one lieutenant and partner, Art Chase. But it really started at the University of Illinois with my thesis advisor, Ralph Peck, and my classwork advisor, Don Deere. They both gave me advice, were leaders of the field, and many their graduates have done well.

Why did you decide to go back to Illinois for tunneling for your Ph.D.?

I obtained a very good understanding of basic engineering principles at the University of Missouri, but the structures curriculum was short on soil and rock mechanics courses at the time and they didn’t teach tunneling, as I recall. When I graduated and went into the Air Force, I thought I would be assigned as a base engineer somewhere. My orders sent me to Kirtland Air Force Base in New Mexico which was, and still is, the leading base for Air Force activity related to underground work.

It was a fortunate assignment which my structural education qualified me for, but it forced me to learn things that were not then, and are probably not now, part of a degree program. What we were doing was top secret and would ultimately lead to the design criteria for the Minuteman missile silo system. We were doing research all over the country with just about every school that had any type of underground program.

Which project are you the most proud of in your career?

At the top is the Los Angeles subway system. We faced four problems on that project:

1. We were driving 20-ft-diameter tunnels and we were just starting to introduce earth pressure balance and slurry face machines in the U.S. so we were still using the generations-old shield-type machines. The tunnels had to go directly under downtown buildings in Los Angeles so naturally there was lots of concern about building settlement. With tight controls and a contractor willing to work with us, we drove the tunnels under the buildings. Some minor cracks had to be repaired but no problems structurally. We did it initially with a shield and good workmanship and then began to introduce the
newer machines that are now the only type of machines we would accept on a project like that.

2. At one time, parts of the LA basin produced more oil per acre than Saudi Arabia. The total acreage was relatively small, but the total production was very high. We knew the crude in the ground would release gases, primarily methane, which would explode at the proper mixture with air. Wanting to avoid that problem, we found that by taking samples we could map areas of possible concern. We were able to design a ventilation system to work our way around the issue with no major problems. Today, we are still driving tunnels in ground with oil in it. By using good inspectors and good engineering, that problem has been licked.

3. One problem we always face working underground is groundwater. Owners do not want running or dripping water in the tunnels and all of our tunnels were underneath the groundwater table. We collected information on all of the membranes that existed in the late 1980s. We settled on polyethylene, which must be welded with heat. That takes a lot of hand work when working around large objects, but we were able to use it to solve two problems at once; keeping the gas out meant the water would definitely be stopped.

4. My team was attempting to use seismic criteria that had been adopted years before for nuclear power plants. The model included surface structures as lump masses and springs and so forth to model what was going on in the underground for a tunnel. I realized that was the wrong model because a tunnel is completely buried in the surrounding soil. It has no choice but to follow the movement of the ground. The strain in the ground induced by the earthquake is basically the strain that the structure has to resist.

Of course it’s a little more involved than that, but that’s the basic concept. We realized that if we could tell the designers what the distortion is, they could superimpose it on the static load for the system to develop an acceptable final design. The design was tested by the Northridge earthquake. It hit a constructed portion of the subway that was not yet in service and amazingly, the design load was exactly what we predicted and the tunnel responded exactly like we predicted.

What advice do you have for young engineers?

It’s difficult at times to balance family and business, but life can be quite dull if you don’t do things outside of engineering. I’ve had a good life, but if you asked me when I first graduated if I would be involved in some of the things I have been, I would have probably said no. Originally, I thought I would be a master structural engineer, but when I encountered underground engineering, I saw a career I could put more of myself into. When you design a beam you can be pretty confident that you have a good design and it will work. Working underground, you can’t always be that confident. You have to be more observant and more willing to listen to someone who has done it or done something similar in the past, and then proceed to do the best possible work that you can.

Is it important to remain active in professional organizations?

Yes. I’m active in a number of organizations, but it can become difficult because you get so involved in the details of what you are working on. I think you have to pick and choose, because there are a great number of organizations out there. You can learn from every one, but you can’t learn from all of them at the same time, so you have to be careful.
GEOKON
Commentary By Edward Kavazanjian Jr., Ph.D., P.E., G.E., D.GE, M.ASCE

As I See It: Academia and Industry Working Together: A Win⁴ Solution

A recent opinion article I authored in Foundation Drilling about collaboration between academia and industry appears to have struck a receptive chord with many people in our profession. Certainly, the idea that academia and industry should collaborate for the benefit of the profession, and society, is nothing new. Engineering is an applied science, and the best engineering research is sometimes referred to as use-inspired, the user being our industry colleagues. But true collaboration among university professors and practicing engineers remains a rarity for a variety of reasons.

There are a number of barriers to academia-industry collaboration. In my opinion, two primary barriers are 1) ignorance on the part of academics of the problems industry faces and the data available to address these problems; and 2) ignorance on the part of industry on the resources available from academia to address these problems. The solution to overcoming these barriers, as is often the case, is communication. If successful, such communication can turn into a win-win-win-win (win⁴) situation:

1. Industry can benefit by engaging bright, eager and innovative young professors and students in addressing issues of significance to practice.
2. Academic professionals can benefit by becoming engaged in these practical problems, and possibly by generating practice-oriented, but still scholarly, publications.
3. Students benefit from working on practical problems and from the transfer of knowledge in the classroom from a more experienced instructor.
4. Our society, and our industry, benefits from more use-inspired research and better training of the next generation of professionals.

There is a wide variety of project types amenable to collaborative industry/academia research. The movement towards Load and Resistance Factor Design (LRFD), as mandated by the Federal Highway Administration, provides an obvious example of a situation that begs for industry/academia cooperation. Current LRFD methods have been developed such that some methods give the same answers as previous allowable stress and factor of safety design methods. But the vision for LRFD is that load and resistance factors will be developed on a statistical basis to provide safe, reliable, and economical designs.

This requires data and somewhat sophisticated statistical analysis. Industry firms often have the necessary data, such as proof loading of ground anchors, pullout tests on soil nails, and load testing of deep foundations, in their project files. University faculty have access to the necessary statistical analysis tools. Sounds like a match made in heaven! And, there are undoubtedly many more natural collaborations we could all think of if we put our minds to it.

A significant concern on the part of many potential industry partners is they will be expected to contribute funding to any collaborative project. However, many faculty members are willing to commit themselves (and their students) at no cost to work on use-inspired projects that result in publishable results. While the imperatives of our capitalistic society may dictate that the engaged faculty inquire if financial support is available, a response that no funding is available does not necessarily stop a proposed collaboration in its tracks. Collaboration comes in many forms, including services in kind and access to jobsites and data. All it may take to engage an eager young investigator in addressing a critical issue is the willingness to retrieve some boxes from storage and a little patience in explaining the nature of the problem and associated limitations.

Facilitating the necessary communication to achieve a win⁴ solution takes effort on the part of both industry and academia. The U.S. University Coalition for Geotechnical Education and Research (USUCGER) has developed one means of facilitating the necessary communication: a simple on-line form that can be used by firms interested in collaboration with university researchers at http://www.usucger.org/GeoCoalition/collab_form.html. The form asks for a brief description of the problem the firm would like to address and contact information – no commitment of funds or resources is required. USUCGER will then circulate the form among its members so that a willing faculty member can contact the firm that filled out the form.

There are undoubtedly many other solutions to the communication issue – the technical committee meetings at the annual meetings and specialty conferences of the Geo-Institute and those of our industry partners provide wonderful opportunities to exchange this type of information. So the next time you find yourself sitting next to a potential collaborator at one of these meetings, you may want to engage them in a conversation about your research needs or interests. Who knows, it could turn into a win⁴ situation.

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I thought this was going to be a snoozer, but in fact, it was pretty interesting.” This was the response from a practitioner who attended my recent talk about undergraduate education to the Delaware Valley Geo-Institute. The topic of undergraduate education may seem “academic” to many, but practitioners and academics share a deep interest in ensuring that future engineers are adequately prepared to tackle the engineering problems of today and tomorrow.

Enrollments and Graduation Rates

Of the 385 ABET-accredited engineering programs in the U.S., 224 grant ABET-accredited civil engineering degrees. Contrary to what many believe, engineering in general, and civil engineering in particular, has experienced robust growth over the past ten years, according to data from the American Society for Engineering Education. The number of civil engineering degrees awarded since 2000 has increased 34 percent while the number of engineering degrees awarded has increased 23 percent. These rates of growth in degrees granted are anticipated to continue as enrollments have also shown robust growth: 26 percent for engineering in general and 51 percent for civil engineering since 2000.

There is a disconnect between enrollment and degree attainment which is related to the relatively high rates of attrition in engineering programs; a 2004 study reported by Guilli Zhang and others that examined graduation rates at nine institutions over 15 years found that only 50 percent of students had attained their bachelor’s degree in engineering eight years after matriculation. The number of women obtaining engineering degrees has been stable over the past few years, with 20 percent of civil engineering degrees being awarded to women, as compared to 18 percent for engineering as a whole. In 2003, Jacquelynne Eccles reported that girls are drawn to technical careers that help society. Civil engineers directly improve the lives of others and this role in society must continue to be emphasized if civil engineering is to continue attracting women and other underrepresented groups.
Curriculum

My examination of the websites of the 224 accredited civil engineering programs revealed that Soil Mechanics or an equivalent, such as Geotechnical Engineering I or Introduction to Geotechnical Engineering, is a required course for 93 percent of accredited civil engineering programs. Only 37 percent of accredited programs require a second course in geotechnical engineering, while 75 percent offer a geotechnical engineering elective beyond soil mechanics. Foundation Design is the most frequently offered second geotechnical engineering course, whether it is required or an elective. Some programs allow qualified undergraduates to enroll in graduate classes, which greatly increases the number of courses a student can choose from for their electives. There has been a reduction in the number of programs requiring foundation design, which can be attributed to both a decrease in the number of credits required for a bachelor's degree and the increased flexibility many programs offer.

Professors that belong to the U.S. Universities Council on Geotechnical Engineering and Research (USUCGER) were asked which textbook they use in Soil Mechanics or its equivalent. Most professors reported using Principles of Geotechnical Engineering by Das with Geotechnical Engineering: Principles and Practices by Coduto and the second edition Coduto and others as the second most popular choice. This distribution is similar to that reported in a paper written by Mullen and others in 2005, but the gap between the most popular text and the second most popular text has narrowed.

Many professors are incorporating active learning techniques into the classroom. This form of instruction places the onus of learning onto the learner and includes such diverse practices as the inverted classroom, in which students listen to a recorded lecture before class and spend their class time solving problems based on the recorded lecture. Other active-learning teaching practices include problem-based learning, use of case histories, direct questioning, think-pair-share, and discussion.

Nearly all of the professors that responded to the USUCGER survey, 63 out of 64, believe that a laboratory is critically important or important to teaching soil mechanics; however, the website analysis revealed that only 83 percent of accredited civil engineering programs require soil mechanics laboratory. This disconnect between the significance that professors place on laboratory work and the number of programs that require a laboratory is a challenge facing geotechnical engineering education. From an administrative standpoint, laboratories are expensive because they consume large amounts of space, require maintenance and supplies, and necessitate an instructor and technicians for large amounts of time.

Involvement in research is used to retain undergraduates and entice students to continue their education in engineering by attending graduate school. Nearly 96 percent of responding professors reported that they involve undergraduates in research at least sometimes. These students are often paired with graduate students to assist with more mundane or repetitive tasks. Professors are more likely to use undergraduates if there are existing support programs which serve to reduce the costs, in terms of both time and money, of hiring the student. This indicates that if universities value this type of activity, adequate support systems must be in place.

Employment

The education of civil engineers must be responsive to the needs of the workplace. The Bureau of Labor Statistics (2011) predicts the number of civil engineering jobs will increase by 24 percent through 2018. It is anticipated that geotechnical engineering will grow at the same rate because geotechnical engineers interact with and provide support for the other civil engineering disciplines. Of notable importance, however, is that the growth in degrees awarded is currently exceeding the projected growth of jobs.

In response to ABET’s accreditation criteria, many programs have created advisory committees comprised of alumni and/or practitioners to provide input into their programs. Although these committees exist, CE News reported in June 2010 that only 36 percent of practitioners believe that entry-level civil engineers are well prepared for the workforce, compared to 70 percent of academics. Informal interviews conducted with practicing engineers for an ASEE article published in 2011, however, did not corroborate these data, as these engineers were satisfied with their more recent hires. When practitioners were asked about their expectations of new hires, some common themes emerged:

- A master’s degree or the willingness to obtain one in a timely manner.
- A solid understanding of the fundamentals and the ability to use them to obtain practical solutions.
- Solid communication skills: written, oral, and graphical.
- Professionalism. One practitioner summed this up by saying “We don’t want technicians, but people who are smart technically, can be active professionally, can build relationships, and advance in our organization."
- Work experience through co-operative education, internships, or summer employment.
Faculty

University websites were analyzed to obtain information about the number and gender of geotechnical engineering faculty at the 224 accredited civil engineering programs. This analysis revealed that about 11 percent of civil engineering faculty are geotechnical engineers and about 11 percent of geotechnical faculty are women. About 17 percent of all civil engineering programs have no geotechnical engineering faculty, and 75 percent that have geotechnical faculty have two or fewer. A majority of civil engineering departments (188) have no women faculty members, 31 have one, four have two, and one department had three. More than 80 percent of the professors that responded to the USUCGER survey are registered professional engineers and 13 percent plan on obtaining their license soon. Only 6 percent of the respondents reported that they do not have their P.E. license and do not intend to obtain one.

The Influence of ASCE

The most important way ASCE has influenced education over the past decade was the adoption of Policy Statement 465 (PS 465). This policy statement describes the preparation that will be required for future civil engineers to attain licensure and recommends that an engineer obtain an additional 30 coordinated credits beyond the bachelor's degree, along with progressive engineering experience. The path to licensure is where an individual's academic preparation and on-the-job education meet. The Body of Knowledge (BOK) details the "who, what, and where" of the path to licensure as well as describing the "knowledge, skills, and attitudes" required of a civil engineer. It provides guidelines for the individual seeking licensure, the academic teaching them in the formal academic setting, and the practitioner that is mentoring them. The BOK is important to the accreditation process; however, the current program-specific criteria for civil engineering programs are more reflective of the first edition of the BOK than the second edition.

Nearly 86 percent of the respondents to the USUCGER survey support PS 465 with either no or few reservations. Several respondents commented that the additional credits are necessary to replace the credits that have been removed from most undergraduate programs over the past 30 years. In addition, several professors responding to the USUCGER survey and several of the practitioners interviewed by the author commented that a master's degree is already the de facto entry degree for geotechnical engineering, which limits the effect that this policy will have on those pursuing a career in geotechnical engineering. Some professors voiced concern about what courses will be allowed to comprise the "30 coordinated credits."

...students listen to a recorded lecture before class and spend their class time solving problems based on the recorded lecture.
USUCGER members generally support the BOK, with nearly 80 percent answering either “Yes, it is a useful representation of what every engineer should know” or “Yes, but there are some flaws.” Although the document has support among geotechnical engineering professors, nearly 16 percent did not know what the BOK is. Several respondents commented there is too much emphasis on professional (soft) skills and not enough emphasis on technical skills at the undergraduate level. Furthermore, several commented that employers have a large responsibility in teaching young engineers professional skills.

Challenges and Changes

The national trend of falling credit requirements for the attainment of a bachelor’s degree was cited by many as a challenge facing geotechnical engineering education. On average, in 1920, 151 credit hours were required to obtain a BSCE or equivalent, compared with 130 credit hours today. This downward trend, coupled with greater emphasis being placed upon teaching professional or “soft” skills, such as the ability to work on teams and communicate orally at the undergraduate level, has placed tremendous pressure on civil engineering departments to cut credits and technical content. The result of these trends is that most students have only one required undergraduate course in soil mechanics, and geology and foundation design are often electives. Also, many professors responding to the USUCGER survey lamented limited resources to support laboratories and other hands-on experiences. These concerns were especially prominent for those facing increasing enrollments.

Professors report that attracting the best students to geotechnical engineering remains a fundamental challenge. Some tied this concern to frustrations about balancing the need to teach fundamental topics with the desire to incorporate more advanced, and perhaps more interesting, topics into their courses.

A concern voiced by one respondent was the lack of a foundation design textbook that incorporates LRFD principles: “we will never get LRFD into design practice if we don’t teach it and, of course, we need a text.” A challenge facing faculty themselves is the tension between the hands-on practical nature of geotechnical engineering and the need/desire to do research on more theoretical topics. Several provided solutions to this challenge, such as developing meaningful partnerships between academics and practitioners, elevating the status of applied research and encouraging young professors to get field experience.

Opportunities within Challenges

Geotechnical engineering education is facing challenges, but also has enormous opportunities to explore. For example, the isolation of geotechnical engineering faculty members presents both a challenge and an opportunity. Eleven percent of civil engineering faculty members are geotechnical engineers and many departments have two or fewer geotechnical engineers on faculty. To maintain graduate programs, many graduate classes appear to be taught by adjuncts, who are, presumably, practitioners.

This existing connection between academics and practitioners should be exploited to bridge the gap between the two, which was a common challenge cited by the USUCGER survey respondents, and to allow many of the geotechnical engineering educators working in isolation to form productive partnerships. In addition, the Geo Coalition, a group that includes the Geo-Institute as a member organization, and the International Society of Soil Mechanics and Geotechnical Engineering are working to form partnerships between academics and practitioners to bridge this gap.

Another challenge that also presents opportunities are the ABET and ASCE program-specific accreditation criteria. While the criteria, along with falling credit counts, has reduced the number of required geotechnical engineering classes in most
curriculums, these criteria help geotechnical educators know they are meeting their goals and that their classes are well-suited to being indispensable parts of the assessment process.

Market forces, falling undergraduate credit requirements, PS 465, and professional career advancement demands have increased the importance of a master’s degree to those wishing to practice geotechnical engineering. More than 60 percent of programs that offer an accredited civil engineering bachelor’s degree also offer graduate degrees that allow a student to specialize in geotechnical engineering. Most of these programs are taught face-to-face, rather than by distance education, because of the hands-on nature of geotechnical engineering and the desire to maintain a personal relationship with students. Every discipline of study will continue to face challenges in attracting the best and brightest. Geotechnical engineering professors routinely engage undergraduates in research as a means to encourage students to pursue advanced degrees and career opportunities.

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DYNAMIC COMPACITION

DYNAMIC COMPACITION CONTRACTORS IN GROUND IMPROVEMENT

Higher education worldwide is undergoing enormous and rapid change. Since the 1960s, universities have moved from elite to mass education with an explosion in domestic student numbers. More recently, universities around the world have experienced many common challenges in providing a quality education (Table 1). Many educators predict that the nature of universities will be vastly different in the future, with online education and distance learning becoming mainstream and replacing traditional forms of education.

### What Is the ISSMGE Doing?

The International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE) represents the interests and activities of engineers, academics and contractors all over the world that actively participate in geotechnical engineering. The ISSMGE recently re-established Technical Committee TC306 charged with the oversight of geo-engineering education. The committee recently organized a major international conference to re-exam-

### Table 1. Geo-Education Challenges

<table>
<thead>
<tr>
<th></th>
<th>Resources</th>
<th>Demographics</th>
<th>Demands</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Academic Staff</strong></td>
<td>Difficulty attracting &amp; retaining high quality staff</td>
<td>Aging workforce</td>
<td>Pressure to perform research</td>
</tr>
<tr>
<td><strong>Students</strong></td>
<td>Growing pool of international students</td>
<td>Increasing diversity</td>
<td>Changing expectations, demands &amp; diminishing prior knowledge</td>
</tr>
<tr>
<td><strong>Classroom/Environment</strong></td>
<td>Shift from classroom to distance learning</td>
<td>Increasing student/staff ratios</td>
<td>Increased use of technology in teaching and learning</td>
</tr>
<tr>
<td><strong>Outside Influence</strong></td>
<td>Diminished public funding</td>
<td>Increasing globalization of higher education</td>
<td>Greater government regulation</td>
</tr>
</tbody>
</table>
In his presentation, Prof. Paul Mayne argued that present situations enhance student engagement, stimulates critical thinking, adds variety to lectures, builds students’ confidence, develops the rapport between teacher and student and makes thinking visible. It is not particularly effective, however, as a means of assessing student learning. Prof. Ressler extensively demonstrated the use of questioning in his lecture. He also outlined several techniques to engage students with different ‘attitudes’, such as the disinterested response of “I don’t know.” Finally, Prof. Ressler suggested that, for questioning to be most effective, the instructor needs to know the students’ names and their personalities, which is obviously a challenge in large classes; be willing to take a risk; pre-plan most of the questions that will asked in class; and practice, practice, practice.

“Quandary in Geomaterial Characterization: New vs. the Old.” In his presentation, Prof. Paul Mayne argued that present curricula in introductory geotechnical engineering courses are not engaging, unrealistic and mundane and that there is an overemphasis on laboratory-based approaches to soil mechanics and geotechnics which results in missing many engaging techniques and recent developments. Prof. Mayne advocated the inclusion of geophysics, in-situ testing, sampling, drilling, lab testing and visualization.

“What Should Geotechnical Professionals Be Able to Do?” Dr. John Atkinson’s lecture examined the competencies of professional ground engineers and subdivided them into basic skills such as solving analytical problems or writing a technical report; material behavior and properties; investigations and modeling; groundwater; slopes and walls; foundations; and earthworks and materials. Dr. Atkinson also outlined several specific geotechnical engineering calculations that ground engineers should be able to perform.

“As you enter a classroom, ask yourself this question: If there were no students in the room, could I do what I am planning to do? If your answer to the question is yes, don’t do it.”

“Equilibrium, Strength, Strain, Dilation and Superposition.” Dr. Brian Simpson presented five case histories to highlight key teaching points, such as being cautious about the absence of data, checking all failure modes, not being constrained by the limitations of available software, understanding the importance of factors of safety, and that the principle of superposition is relevant only for linear systems. Dr. Simpson concluded his lecture with a very sobering quote from statistician George E. P. Box, “Essentially, all models are wrong, but some are useful.”

“Keep it Engaging, Keep it Simple, Keep it Rigorous.” Emeritus Prof. John Burland from Imperial College was honored with an award for his lifelong service to geo-engineering education and delivered the SFGE 2012 Special Invited Lecture (Editor’s
Note: Geo-Strata’s November/December 2012 issue includes a GeoLegend article about Prof. Burland. He challenged educators to think about whether “we are giving the students fish to eat so that they may live today—are we trying to make them immediately useful or are we teaching them how to fish so that they may live for the rest of their lives? Are we giving them skills that they will use for the rest of their lives?”

Prof. Burland stressed the importance of rigor and revisited the Geotechnical Triangle and the importance of physical demonstration models, such as the Base Friction model and the Sliding Beaker (cup). He concluded his presentation by giving two examples of student group work—the construction of two tunnels beneath an estate in southeast London and a leaning retaining wall with parallels with the Leaning Tower of Pisa.

ExCEEd Workshop

Another feature of SFGE 2012 was a presentation by Professors Bob O’Neill and Tanya Kunberger, of Florida Gulf Coast University, about a special workshop of the popular ASCE Excellence in Civil Engineering Education (ExCEEd) program, which explores best practices in engineering education. The half-day special ExCEEd workshop provided a taste of the complete workshop and primarily focused on creating learning objectives. A 13-year program, the ExCEEd Workshop is a six-day practicum that provides engineering educators with an opportunity to improve their teaching abilities. The workshop focuses on basic skills and includes seminars addressing:

- principles of effective teaching and learning,
- learning styles,
- communication skills,
- learning objectives,
- class organization and course organization,
- development of interpersonal rapport with students,
- teaching with technology, and
- classroom assessment techniques.

The seminars are augmented by a series of demonstration classes—models of high-quality teaching—presented by ExCEEd faculty mentors. During the latter half of the course, participants apply what they have learned by preparing and teaching three actual classes in a small-group setting to help ensure that participants make substantive improvements in their teaching skills by the end of the course.

Finally, 36 general papers were presented on the broad topics of what content should be taught, the use of case histories, laboratory work and fieldwork, computing and technology, research and teaching experiences and student-centered learning. The 105 delegates (Figure 1) from Ireland, the UK, France, Netherlands, Spain, Portugal, Italy, Hungary, Croatia, Romania, Greece, U.S., Canada, Brazil, South Africa, Australia, New Zealand, Singapore and Japan considered the conference to be extremely successful and offered high praise in their feedback to conference organizers.

Where to From Here?

Led by several of the conference’s organizers and participants, TC306 continues the momentum of SFGE 2012 through several important initiatives:

1. Dissemination of Research. A special issue of the European Journal of Engineering Education devoted to geo-engineering education is currently being developed. This issue will build on papers presented at SFGE 2012 and is expected to be published in the first half of 2013.

2. Web Portal. To facilitate the sharing of learning and teaching resources among geo-engineering educators across the globe, TC306 is developing a web-based portal. It is expected that lecture notes, PowerPoint slides, photos, videos, illustrations, case studies, e-learning resources, and examination and example questions and solutions will be hosted on
RST
To facilitate the sharing of learning and teaching resources among geo-engineering educators across the globe, TC306 is developing a web-based portal. In this way, educators will not need to ‘reinvent the wheel’ and best practices can be shared among ISSMGE member countries and their members. This tool will be particularly useful for developing countries, where such resources are limited.

3. Development and Dissemination of Resources. A project is currently underway to develop resources to improve student engagement and the learning outcomes associated with geotechnical engineering laboratory classes. Due to be completed by September 2013, the resources will be freely made available to geotechnical engineering educators worldwide via the web portal. The resources will include a series of e-learning modules for students to explore before undertaking the laboratory class, as well as a series of modules and associated computer-assisted learning tools, for use after the laboratory sessions. The modules will include embedded quizzes, videos and narration.

4. Case Studies. A template is currently being developed for case studies of real-world geotechnical projects that can be used in teaching. A summary of the information contained within the template is shown in Table 2. It is proposed that the case study template and the library of case studies will be shared via the web portal.

5. Curriculum Development. Prof. Atkinson is leading a project to define the learning competencies expected of geotechnical engineering graduates. Instead of listing topics covered in courses, TC306 defines competencies in terms of what geo-professionals can do after stages of their education and training. These include the geo-engineering content of undergraduate and postgraduate and on-the-job training by employers. For example, the committee

Table 2. Overview of Case Study Template (adapted from Pantazidou et al. 2008).

<table>
<thead>
<tr>
<th>[1] Project overview</th>
<th>Type of project (e.g. reinforced slope)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Location of project</td>
</tr>
<tr>
<td></td>
<td>Photos of the site (ideally before &amp; after construction)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>[2] Ground information</th>
<th>Borehole location plan</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Geological/soil profile</td>
</tr>
<tr>
<td></td>
<td>Details of groundwater table</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>[3] Relevant analyses</th>
<th>Typical cross section(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Types of analyses to be performed</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>[4] Geotechnical investigation and evaluation of test results</th>
<th>Details of soil tests performed and their results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Geotechnical model used in analysis</td>
</tr>
</tbody>
</table>

| [5] Construction and design considerations | Constraints and data known prior to analysis |

| [6] Geotechnical analyses performed | Basic features/步骤 of each type of analysis; Presentation of results |

| [7] Key points/messages | |
Clear patterns are emerging which highlight that higher education and the needs and demographics of students across the world are undergoing marked and rapid transformation.

suggests that civil engineering graduates would have the ability to:

- create spreadsheet calculations,
- write a technical report,
- describe soil and rock in engineering terms,
- by experiment determine the pore pressure in a sandcastle,
- estimate for sand and undrained strength of clay from soil descriptions,
- draw a simple flownet and calculate flow rate and pore pressure at any point in the flownet,
- calculate limiting undrained slope height and limiting drained slope angle,
- calculate slope stability in jointed rock,
- calculate stability of retaining walls,
- calculate bearing capacity and settlement of simple shallow foundations,
- calculate capacity of a single pile, and
- determine a compaction curve.

The Future of Geo-engineering Education

Clear patterns are emerging which highlight the facts that higher education and the needs and demographics of students across the world are undergoing marked and rapid transformation. New and emerging technologies, such as e-learning, have the potential to significantly affect the nature of universities, with some commentators suggesting that universities in their current form will cease within 30 years. Perhaps more likely is that the strengths of face-to-face and e-learning will be combined in a more systematic and educationally rigorous fashion. Just-in-time teaching (JiTT) is one such relatively recent development.

In essence, JiTT makes use of e-learning modules with embedded assessment to inform the learning process in an ‘interactive’ and engaging manner. Rather than content being delivered in the traditional face-to-face lecture format, content is presented to the student body in an online environment. This has particular value as students can access the material in their own time, at any particular location, and at their own pace. Students are then required to electronically submit responses to embedded quizzes, usually 12-24 hours before a face-to-face class. The assessment task is designed to improve students’ learning and to be a diagnostic tool for the instructor to assess the students’ level of knowledge in relation to a particular topic.

Informed by the results of this assessment, the face-to-face session is then designed to respond to the needs and strengths of the students. An important additional aspect of the assessment is that it is explicitly discussed in the lecture to further improve learning outcomes. In this way, JiTT makes use of the best aspects of both pedagogies: e-learning, which, when designed properly, is engaging and relevant and ideal for the delivery of content and the efficient compilation of assessment results; and the face-to-face classroom, where the educator is able to respond to students’ learning needs and adapt the teaching appropriately.

In many countries, higher education institutions are re-evaluating their pedagogies and the traditional forms of teacher-centered education are being replaced by student-focused learning. SFGE 2012 explored these developments and, in particular, the questions of what should be taught and how should it be taught. While focus is being directed towards student engagement and learning outcomes, it is paramount that geo-engineering education is rigorous and that students learn the fundamentals of soil mechanics and geotechnical engineering design.

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When developing this issue, the Editorial Board asked the G-I Organizational Member Council to survey select representatives of each G-I Organizational Member. Of the total 70 surveys sent, 24 were completed, yielding a 34 percent response rate. The survey was not intended to provide a complete picture of geo-education from a practitioner’s perspective, but to provide readers a snapshot of how several practitioners in several geotechnical firms view the state of geo-education today.

Who Answered the Survey?

The 24 survey respondents make up a cross-section of geo-professionals. Five have BS degrees, 11 have MS degrees and 8 are Ph.Ds. Half of the respondents work for consulting and design firms; eight work for construction firms; two work for firms that do consulting, design, and construction; one works for a materials/services supplier and one works for a firm that does consulting, design, and construction, as well as supply materials/services. None of the respondents work in education or government.

Who Do Practitioners Hire?

The respondents were asked how often they hire people with geotechnical engineering, geology, engineering geology and geologic engineering degrees. Engineering degrees were most popular, with 87 percent stating that they frequently hire engineering graduates. Only 4 percent of respondents said they rarely or never hire graduates with engineering degrees. Geology degrees represent the second-highest “frequency” rate, with 25 percent of the respondent firms frequently hiring geology graduates and 46 percent rarely or never hiring those with geology degrees. Engineering geology graduates are frequently hired by 13 percent, while geologic engineering degree graduates are frequently hired by 8 percent. Respondents reported that 50 percent of their firms rarely or never hire engineering geology graduates and 58 percent rarely or never hire those with geologic engineering degrees.

The preference to hire engineering graduates reflects two key factors. First, half of the firms responding were design/consulting firms whose focus demands more design engineers versus geologists or engineering geologists. In these firms, one geologist or engineering geologist can support several geotechnical engineers, so there is proportionately less demand for graduates with those degrees. Secondly, seven of the eight construction firms responding to the survey reported that they rarely or never hire geologists, engineering geologists or geologic engineers. One construction firm reported it rarely or never hires geologists or geologic engineers, but frequently hires engineering geologists. With one-third of the respondents in a field that rarely or never hires graduates with a geology background, the low percentage of new hires with geology degrees is not surprising.
Who’s Hiring Whom?

A master’s degree is the most desired level of education sought by employers, as reported by more than 90 percent of respondents. The desirability of bachelor’s and doctorate degrees depends on the type of firm. Graduates with bachelors’ degrees are frequently hired by construction firms and materials/service suppliers. The number of design/consulting firms “occasionally” hiring B.S. graduates was about equal to those who answered that they “frequently” hire B.S. graduates. Ph.Ds are frequently hired by 33 percent of the design/consulting firms responding, but rarely or never by 75 percent of the construction firms and materials/service suppliers.

Are The Graduates Prepared to Work?

All but one firm reported hiring graduates with less than five years of directly-relevant work experience. Seventy-one percent frequently hire less-experienced people; 25 percent occasionally hire less-experienced people, and 4 percent rarely hire less-experienced people. This practice puts firms in a position to evaluate how prepared graduates are to advance into a professional career. Two-thirds of the firms reported that their new hires are frequently prepared to do the fundamental work of the organization, while only 8 percent noted that their new hires are rarely or never adequately prepared.

Only 12 percent of the firms reported that their new hires are frequently well-prepared to understand how the business works, while 54 percent believe that their new hires are rarely or never well-prepared to understand the business. Only 17 percent believe that new hires frequently are well-prepared to understand the mission and objectives of the business, while 42 percent believe that they are rarely or never well-prepared to understand their mission and objectives. Again, these outcomes are not unexpected for entry-level persons whose education is focused on technical rather than business topics.

The Good News

Half of the respondents indicated that their new hires are frequently well-prepared to do the fundamental work based on their college education. Employers are particularly impressed by the solid fundamentals that recent graduates have attained. According to one respondent, “Our new hires are typically highly motivated and, especially the M.S. and Ph.D. hires, possess the fundamental building blocks of a consulting career. They are ready to take their classroom knowledge and apply it to solving real world problems.”

Another respondent was impressed with “the speed at which information is absorbed and ability to work independently and find answers instead of being told answers.”

Respondents were also impressed with the analytical and IT skills of the graduates. According to one firm, “The engineering degrees were most popular in this survey, with 87 percent stating that they frequently hire engineering graduates.
recent graduates are ready to take on the electronic world much easier and are easily adaptable to CADD and other electronic software. A majority of them are also trained on advanced methodologies such as FEM methods and other means for evaluation.” Another respondent added that the recent graduates were well-versed in analytical methods. “New hires tend to have excellent analysis and CAD skills that make them more ready to meet our firm’s project requirements.”

The Bad News

There are however a number of areas where new hires need improvement. The most common response was that new hires were unprepared for the business of geo-technology. This lack of preparedness seems to be broken down into two categories – what is expected of new hires in a business environment and what needs to be done to make the business run. Respondents identified such things as “working time requirement to complete the job on time,” “pace of the work,” “understanding what a client needs/values and how to operate in office environment,” and “working with a wide variety of people” as areas in which new hires were not prepared for business life.

Survey respondents also felt that new hires were not prepared for the business of being in business. Many of them noted that the graduates had little or no project management skills, little or no understanding of the workings of the business, and little or no understanding of day-to-day business operations. According to one respondent, recent hires are “unprepared for business, for example, no accounting back-

A master’s degree is by far the most desired level of education sought by employers, with over 90 percent of the respondents reporting that they frequently hire master’s degree graduates.
According to another respondent, “new hires are often lacking in most of the things you might expect for a person with such limited exposure to the working environment. These include a lack of intuitive grasp of the entire project, the important performance criteria and issues for the client, the ‘non-engineering’ factors that influence the project, the interrelationship between disciplines, the critical role of quality control and peer review, the importance of health and safety, the role of continuing education and training, and the role of contracts and risk management.”

A Rock and A Hard Place

Only three of the 24 respondents stated that universities bore no responsibility for the previously-mentioned deficiencies. They do understand, however, that universities are in a difficult spot. A bachelor’s degree requires a minimum of 120-130 hours of course work in most universities. That, combined with ABET requirements for core courses and the explosion of areas of study within the field, leaves little room for in-depth exploration of several topics. It also leaves little room for courses with a business or ‘non-technical’ focus.

One respondent clearly summarized universities’ challenges by stating, “I believe that overall, the universities are doing a good job. They have many challenges that are not always apparent to those outside the university, from meeting university, ABET, and other imposed criteria on the content of the curriculum, to facing pressure to get students through the program in four years, to having insufficient funds to create a rich ‘non-classroom’ experience for the students.”

“If I Were In Charge...”

A number of suggestions were offered when asked what changes could be
made to undergraduate and graduate engineering programs. Respondents would add more hands-on work, although this might not be applicable to undergraduate programs since not all engineering disciplines would benefit. They would also like less teacher reliance on computers and analysis, and more instruction centered on the observational method and case studies or examples of when analysis failed.

For graduate courses, respondents would like to see more detailed application of improvements in the same areas, as well as some additional areas. Some of those include more work involving practical problems and real-world applications of theory, including real-world problems that don’t have “neat” solutions. One specific improvement is the requirement for a thesis, not just an option that could be replaced with additional coursework. Respondents emphasized the positive benefits of a thesis outside actual research which include development of critical thinking, project management and technical writing skills. Another was the requirement of that more professors have backgrounds in practice rather than academia.

**Communication, Communication, Communication**

Survey responses identified a number of similarities and differences between respondents. There was one topic, however, that all respondents agreed on, several of them repeatedly, and that was the lack of communication skills, primarily poor writing skills among recent graduates. Respondents decried their new hires’ inability to write well. Virtually every open-ended question included at least one response that indicated frustration with new hires’ writing skills:

- “Writing and communication skills are often less than ideal”
- “Generally, they aren’t well prepared for project management and they lack good writing skills”
- “One area where new hires are often lacking is their relative inability to speak and write well…While there are of course exceptions, the average writing and presentation skills of many graduates are not very good.”

And, suggestions to improve this situation included:

- “Make sure to teach writing”
- “Learn to write a report!!”
- “Integrate more writing into current courses”
- “Include more writing, business, language”
- “Anything that involves writing coherently”
- “Some universities have stopped teaching technical writing, which is a fundamental mistake”
- “Learning to communicate technical ideas
Again and again, the respondents decried their new hires’ inability to write well.

In the graduates’ defense, report writing is not often taught in universities. Some of the reasons include that it is too discipline-specific, curriculum requirements limit classroom opportunities, and many academics do not have geotechnical report writing experience. Regardless, writing is an essential skill for a geo-professional, especially for those in design/consulting firms, because virtually all geo-professional service deliverables are written. Any inaccuracies or ambiguities in a proposal, report, specifications, or correspondence can have serious consequences. More fundamentally, the firms responded that the problem is not so much teaching graduates to write a proper geotechnical report, as it is in teaching them to write complete sentences that are clear, active, and engaging – basic writing skills that should be taught prior to getting a job.

Writing isn’t the only communication skill that is lacking. One respondent lamented new hires’ seeming preference for electronic communication versus personal contact. Several also identified drawing skills as an area for improvement. One claimed that recent graduates are “very weak in engineering drawing” with “limited ability to draw conceptual sketches or schematics (and this IS the language of engineering!!),” as well as being “quite poor at reading blueprints.” Another stated, “I’m amazed at how hard it is for a young engineer to make a sketch of a particular problem. Graphic skills are lacking.”

The Big Picture

Survey respondents were generally positive about the education their new hires received. There were certainly areas for improvement and discontent with some of the deficiencies they saw in geo-education, but there was also satisfaction with fundamental knowledge and analysis skills. There was also consideration of the difficult balancing act that the universities must perform in designing their programs. One respondent summarized it best:

“If I were to pick two areas where I would like to see the universities do more, they are: (1) improving the writing and speaking skills of their graduates; and (2) helping their students better understand professionalism, leadership, careers, and the concept of career progression and what is involved in achieving a rewarding career as a practicing professional.”

Organizational Members believe that there is a distinct opportunity for the geo-practitioner community to reach out and interact with their local geotechnical and engineering geology educators to stress the importance of communication, professionalism and leadership skills for students’ future professional development and career advancement.
SHAKING UP THE CLASSROOM


Students in Mr. Barry’s eighth grade Science Discovery Class at the Whittier Middle School in Norman, OK had a fun learning experience that introduced them to earthquake engineering and the role of geotechnical engineers. As part of a multifaceted earthquake engineering research project funded by the National Science Foundation’s Network for Earthquake Engineering Simulation Research (NEESR) Program, researchers at the University of Oklahoma developed a five-hour learning module for middle school students. An abbreviated module was also presented to a group of middle school science and mathematics teachers.

This NEESR project, named NEES-piles for “NEES piles in low E soils,” studies the dynamic behavior of pile foundations in soft clay and the improvement of this behavior through chemical stabilization via cement deep soil mixing (CDSM). Pile foundations and their performance in bridge systems are important for designing earthquake-resistant structures and for retrofitting existing infrastructure systems that may be inadequate for dynamic loads. The NEES-piles project consists of four major components.

Field dynamic lateral load testing of full scale instrumented piles in soft clay and soft clay improved with CDSM. This program was successfully completed in October of 2010 at a site in Miami, OK (Figure 1). The Oklahoma Department of Transportation collaborated in the project by helping to secure the site next to an existing bridge over the Neosho River and conducting extensive subsurface exploration at the test site. Field testing was led by Professor Sritharan from the Iowa State University and the equipment from NEES@UCLA was used in these tests.

Figure 1. Full-scale test pile embedded in CDSM-treated soil ready for dynamic lateral load testing at the Miami, OK field test site.

Physical modeling of pile foundation systems. Small-scale models of the unimproved and improved pile systems are constructed and tested in a geotechnical centrifuge at NEES@UC Davis under static and dynamic loading (Editor’s Note: see “Geotechnical Earthquake Engineering Research Using a Large Centrifuge” by Dan Wilson and Ross Boulanger in the September/October 2011 issue of Geo-Strata). Under centrifugal acceleration, stress conditions in the model simulate actual field conditions. Centrifuge modeling allows for close study of the behavior of different foundation system configurations without having to construct and test multiple full-scale field pile systems, which is cost prohibitive.

Numerical modeling of improved and unimproved pile foundation systems. Experimental data obtained from full-scale field and centrifuge model testing are used to validate and calibrate finite element models (FEM) developed for studying soil-structure interaction problems. Once validated, the FEM models can be used to conduct parametric analysis to...
investigate the influence of varying geometric and material properties on the performance of different pile foundation systems subjected to earthquake loading and help in developing simplified design procedures.

**Education module development** to teach middle school students about soil-structure interaction, earthquakes, and geotechnical engineering. Module development drew from the research team’s experience with actual full-scale and centrifuge modeling to create a fun classroom experience. Student teams built unimproved and improved pile-soil systems using Jell-O for soil, Slim Jims for piles, and peanut butter, marshmallows, and cheddar cheese for stabilized soil and then watched as their models were subjected to simulated earthquake loading on a portable shake table.

**Motivation**

Much of America’s existing infrastructure is old and in need of repair or replacement. To meet future engineering challenges and the demands from design and development of new infrastructure, it is important to encourage students at a young age to pursue civil engineering as a vocation. Geotechnical engineers represent a crucial sub-discipline within the civil engineering field, yet most students at the middle-school level have never even heard of a geotechnical engineer and relatively few have a clear idea of the role of civil engineers.

The NEES-piles project provided a great opportunity to engage students and demonstrate an effective way to get the word out about geotechnical engineering. Thus, the educational module was created to introduce geotechnical engineering to younger students through a fun hands-on class. Specifically, the module was developed so that participants would:

- examine geotechnical engineering to broaden career path opportunities;
- learn the importance of geotechnical engineering and foundation systems in keeping structures safe during earthquakes;
- learn to effectively improve a zone of soft soil around piles to reduce movement, minimizing earthquake-induced damage; and
- have a better perception of engineers and the engineering profession.

**Materials and Methods**

Following an introductory presentation to explain CDSM, participants were asked to design an improved pile foundation that showed smaller deflections versus an unimproved pile when subjected to a 10-second sinusoidal shake at 2 Hz. Students could choose a variety of materials, including creamy and crunchy peanut butter, block cheese, and large and small marshmallows, with differing associated properties.
costs to stabilize their pile, as well as vary the dimensions of their improvement zone around the pile.

The eighth-graders were given a large plastic tub of Jell-O and asked to experiment with different combinations of improved piles, varying the type, amount, and combinations of stabilizers (Figure 2), all of which affected the deflection and cost. Participants were charged with optimizing the decreased deflection versus increased cost using an equation they were given. They simulated several lateral and vertical improved zones around the pile that were similar to the size of the improved zones that were utilized in centrifuge and field tests (Figure 3). After being told that a larger stabilization zone would lead to less lateral deflection but at a higher cost, the students were then asked to choose their best design and build this improved pile in the middle of a new Jell-O box, where the deflection would be measured and used, along with cost, in an optimization equation to determine the winner.

Using Jell-O as soil, Slim Jims as piles, a lollipop as the seismic mass to simulate a bridge, and peanut butter, marshmallows, and/or cheese as stabilizers allowed the students to “see” into the “soil” and watch how the stabilizers reacted with the “soil” and the pile to lessen the deflections of the pile. A highly-controlled and precise shake table was used to simulate earthquakes in this module. However, a simpler, less expensive plywood shaker, toilet partition, drawer pulls, a steel rod, a ¾-in. diameter steel washer, and some nuts and bolts will suffice. A variable-speed cordless drill or a hand crank could be attached to manually shake the system. This inexpensive shaker can run continuously for as long as necessary, providing an identical output for each group, and can be constructed for under $40.

Each group’s final design was shaken at 1 Hz for 30 seconds, at 2 Hz for 10 seconds, and at 3 Hz for 10 seconds. During the competition, deflection was recorded near the end of the cyclic loading at 2 Hz frequency for consistency between the groups. Deflections of the piles were measured using a video recorder and a simple yardstick taped to the box (Figure 4). The initial position of the right side of the lollipop was recorded and then the shaking sequence was recorded. The video was then played back in slow motion, frame by frame, in order to see exactly where the lollipop moved along the ruler. The stabilized pile that exhibited the least peak-to-peak deflection, with the least associated cost, won. Each team member on the winning team was given a $15 iTunes gift card.

Assessment

The learning module was a big hit with the students and teachers and generally achieved the project objectives. All 64 participants were overwhelmingly positive in their remarks about this module and repeatedly listed “hands on” and “real-world simulations” as the most favorable aspect of this experiment. The students and the teachers enjoyed the edible facet of the activity. Knowledge of what geotechnical engineers do and what geotechnical engineering is was greatly enhanced for the students and teachers by creating a fun, hands-on, edible, well-organized educational module based solely on geotechnical engineering principles.

Some promising preliminary conclusions about engineering perceptions can be made based on “before and after” survey results, even though there have been only 64 participants thus far. In general, the students’ and teachers’ perceptions of engineers improved as a result of the module. Specifically, entrepreneurship, leadership, fun, and positive effect elicited

Student teams built unimproved and improved pile-soil systems using Jell-O for soil, Slim Jims for piles, and peanut butter, marshmallows, and cheddar cheese for stabilized soil.
higher marks after the module, while negative stereotypes of engineers, such as boring and nerdy (in the teachers’ case), significantly decreased.

In particular, this module seemed to have strongly impacted the girls in the elective science class who won the competition. The teacher recommended that the 5 girls and 27 boys who participated on the teams be delineated by gender to improve participation and provide the most benefit. The performance results indicate that, with the right experiences, girls at a relatively early age discover that they can be successful at math and engineering. This type of authentic learning engineering module can help plant the engineering seed in a group that the engineering profession needs desperately to attract for equity reasons and to help bring diversified viewpoints into any engineering project.

**Feedback**

An unsolicited “Thank you” note from one of the girls on the winning team shows how bringing a fun, hands-on educational module into the classroom can bolster a student’s interest in science and engineering:

“I was never really into science and engineering until you came and shared with us. Now I might want to be a geotechnical engineer. I was actually excited to get up and go to school for once. It was very cool how we got to make what we thought worked best and then test it.”

The overall feedback from this module is that it was great fun and the participants learned much about geotechnical engineering, earthquake engineering, and methods to make foundations stronger to withstand earthquake damage. As a result of this pilot program, the project team created five stand-alone modules directly correlated to Oklahoma Priority Academic Student Skills (PASS) requirements. The modules are housed on the NEESHub.com website and can be downloaded by any interested teacher. The modules will also be available on teachengineering.org.


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**Figure 4. The “moment of truth” when Dr. Amy Cerato measures pile deflections during shaking using an overhead digital video camera.**

All 64 participants were overwhelmingly positive in their remarks…and repeatedly listed “hands on” and “real-world simulations” as the most favorable aspect of this experiment.

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The American educational system must provide an ever-increasing number of technology workers for the U.S. to maintain its leadership position in the global economy. However, few students are attracted to engineering because they lack the required academic preparation in science, technology, engineering, and mathematics (STEM) to study engineering in college. Additionally, many lack knowledge regarding career options in engineering, or an understanding of what an engineer does. This problem is further compounded by negative stereotypes of engineering held by many Americans. Many consider engineering education to be more demanding than education in other disciplines, while perceiving engineering to be less prestigious than professions such as medicine and law.

Still others continue to view engineering as a male profession and tacitly discourage female students from becoming engineers. Finally, math and science studies are not perceived to be “fun” by many students. It is therefore essential that students develop a positive attitude towards math and science in elementary school while they are still impressionable. Early development of academic talent in science and math guarantees that students will perform better as they progress in the education system.

Exposing elementary school students to engineering through simple hands-on experiments is one of the best ways to improve student performance in math and science, and trigger their interest in pursuing engineering careers. Geotechnical engineering employs mathematics, solid mechanics, and fluid mechanics, which could be adapted in simplified form in elementary schools. Additionally, introducing students to engineering activities during their formative years stimulates creativity and invention.

Several attempts to introduce geotechnical engineering to young students have been made. Polytechnic Institute of New York University (NYU-Poly) operates the Applying Mechatronics to Promote Science Project (AMPS) under the National Science Foundation (NSF) Graduate Fellows in K-12 Education (GK-12) program. AMPS also receives funding from several philanthropic foundations joined under the Central Brooklyn STEM Initiative. The GK-12 program teams Graduate Fellows with K-12 teachers and students to improve the Graduate Fellows’ communication and teaching skills while enhancing STEM lesson content for teachers and students. AMPS emphasizes the use of LEGO robotics to promote interest in STEM.

The program’s geotechnical activities were carried out by one graduate fellow instructing in two schools with a total of about 60 second, third, and fourth graders. Each activity required 90 to 135 minutes divided over two or three 45-minute class periods. The activity was introduced during the first period, where students were challenged to identify the problem,

It is essential that students develop a positive attitude towards math and science in elementary school while they are still impressionable.
imagine possible solutions, and make a plan to implement the solution. In the second and third periods, students implemented the plan and sought to improve it.

**Soil Permeability Activity**

Soil permeability is introduced to elementary school students in many educational systems in such diverse locations such as Egypt, Iran, India, and the U.S. In New York City, soil permeability is presented as part of the water cycle unit, typically taught to third, fourth and fifth graders. However, the topic is typically introduced in a dry manner and, by middle school, few students have any recollection of the topic. AMPS uses a different approach.

For soil permeability, the role of permeability in civil engineering is first discussed and is followed by introduction of a transparent falling head permeameter made especially for this activity. Several permeameters containing gravel, sand, silt, clay, and play marbles are set up to illustrate the effect of grain size on flow rate (Figure 1). Before testing, students were challenged to predict which soil samples would have the highest and lowest permeability. After the predictions were made, the permeameters were filled and saturated to allow the students to visualize the flow of water in various soil samples, and students were asked to revise their guesses if they wanted. This process permitted the graduate fellow to discuss the experiment, the importance of soil particle size, the concept of saturation, and the need to repeat the test until the effluent volume and flow was equal between the tests.

Afterward, a falling head test was conducted in the permeameter and the students applied their math to calculate the flow rate. The rate of discharge was measured using a clock/ruler and an ultrasonic sensor that was read using a LEGO NXT controller, a device that can read electronic sensors or build robots using LEGOs. Collecting the data using two methods opened up a discussion on accuracy of measurements and the role of error in everyday measurements. This also permitted students to analyze the pros of and cons of using an automated data acquisition system.

**Contact Stress Activity**

The contact stress activity is designed for students to understand how external loads affect the stresses in a soil deposit. Because elementary school students had not been previously exposed to the concept of stress in materials, the human body was used as a simple analogy. For this example, the human body was considered to be the structure, with legs as the columns and feet as the foundation system. Based on that assumption, students were asked to find out the stress their bodies apply directly to the floor.

Students calculated the contact area of one foot by tracing their foot on grid paper, then counting the number of squares included in the trace. Partial squares were included so students could apply their addition and fractions instruction to calculate the total area of a student’s foot. Next, each student’s weight was measured, opening the topic of scales and load sensors for an introductory explanation. Because two- and three-digit division is not part of the K-4 curriculum, pennies were employed to...
Students were then asked to evenly place the number of pennies representing their weight on top of the numbered squares of their traced foot (Figure 2), and were told the number of pennies stacked on one square equals the contact stress on the floor. These activities permitted students to not only practice their math skills, but also to visualize the division operation and comprehend the concept of stress as load divided by area. Most students successfully explained how many pounds per square inch their bodies applied to the floor when they were standing on one foot. Finally, students were challenged to explain what happens to the stress when they stood on both feet. Many students found this question tricky, but they eventually answered correctly.

**Foundations in Stratified Soil Activity**

Another activity was designed to teach students the difference between shallow and deep foundations and to investigate the important role of foundations, as well as to teach students the concept of bearing capacity. The students were first introduced to natural soil profiles with a brief introduction to rock formations and their weathering into soils. Students were already familiar with the role of grain size in affecting soil properties from the permeability experiments. Various types of soils were defined according to their grain size, and then groups of five students each made their own soil profile model (Figure 3). Pictures of various natural soil profiles were shown to encourage students to come up with reasonable ideas. Students filled acrylic transparent cubes with their choice of a layered system made of any combination of gravel, play dough, natural sand, and colored sand.

The graduate fellow then introduced the concept of foundations using models made of LEGO pieces to represent shallow and deep foundations embedded in transparent soils (Figure 4). Students understood that all man-made structures are supported by foundations. They also learned that geotechnical engineers must know the properties of soil layers of a specific site to design suitable foundations. With this background, groups of students constructed their own buildings using LEGO pieces. Shallow foundations were simply made of long flat pieces placed under the structure.

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**Figure 2. Simulating stress with pennies for the contact stress activity.**

**Figure 3. Students and fellow discussing a bearing capacity test conducted using a soil model made by the students.**

**Figure 4. Elementary school students discussing the difference between shallow and deep foundations using a LEGO building and layered transparent soil model made of Aquabeads.**
Deep foundations were made using multiple small pieces stacked under each other.

Once the building units were completed, the students given a brief introduction to foundations and then were asked to carefully place them on top or in their soil profiles by using shallow and deep foundations respectively. The models were loaded and students observed that models with deep foundations are able to carry more load than those with shallow foundations. Students also observed soil settlement as the buildings were loaded. This led to a discussion on bearing capacity, complete with pictures of real bearing-capacity failures. The activity ended with a discussion of total collapse versus excessive deformation that prevents a building from meeting the needs of its occupants.

Soil Erosion Activity

An erosion table is a physical model used to demonstrate to children why mountains erode and how sediment erodes and is transported. Such a table was designed and built in a second grade classroom to support the water cycle unit of the New York City curriculum. The table was made from a hydraulic bench that pumps water in a sand bed to represent a meandering river and permit simulating erosion due to water flow in the river. The table also was used to investigate the relationship between water velocity and soil erosion.

First, the students learned why soils erode when they are in contact with water and the importance of preventing soil erosion for the safety of riverside buildings and bridges. Each student then designed a building using the Google Sketchup application, which allowed each student to express his or her imagination and to take ownership of the experiment. The teacher then made a scaled model of each student’s building using a 3-D printer donated to the class by one of AMPS’ industrial supporters.

Students then placed their buildings along the riverbank in a location that provided a nice water view and where they believed the building was safe from erosion. The hydraulic bench pump was initially operated at a small flow rate that resulted in water running under laminar flow. Some of the buildings collapsed due to soil erosion but most survived (Figure 5). The flow rate was then incrementally increased simulating larger storms and turbulent flow. This experiment permitted students to observe the increase in the rate of erosion with the increase in flow rate, which resulted in failure of many buildings.

Students worked individually so they developed a strong affinity to their designed building and its location. Because students were asked to position their buildings in areas where they believed damage would not occur, they paid special attention when the flow was increased. Afterward, the
students, graduate fellow, and several teachers engaged in a discussion of the dangers of natural disasters, occurrence rates of hurricanes, building codes, the importance of deep vs. shallow foundations, the role of sinuosity in erosion, and the rates of erosion of various soils. This activity illustrated how natural disasters are serious events that have to be designed for by experienced geotechnical professionals, stressing the importance of math and science as a foundation for the modern built environment.

**Assessing the Program’s Effectiveness**

Questionnaires conducted immediately after each activity, and in one case just before the activity, indicated that students had an increased conceptual understanding of soil mechanics and were enthusiastic about the LEGO robotics. For example, following the bearing capacity exercise students were asked, “What happens to the soil when foundations fail?” Students typically answered that the soil beneath the footing is pushed to the side and bulges up, or that the soil to the side of the foundation moves because the soil underneath pushes it.

Another question was “If a bridge was to be placed on a deep foundation, how deep would the deep foundation need to go?” An outstanding answer from a fourth grader was that the deep foundation would need to be located at the deepest place, or where soil was the strongest.

The assessment also demonstrated that physical models are helpful in elementary schools and that these students can understand somewhat complex geotechnical engineering concepts through the use of physical models. The classroom activities allowed students to use their knowledge of mathematics to a real-world application. This is important for developing an affinity to STEM subjects, and establishing a permanent connection between STEM studies and engineering at a young age.

It is difficult to assess the long-term impact of the geotechnical engineering activities on student long-term achievement because many of the main objectives need time to determine their effect. Nevertheless, all evidence suggests that the students enjoyed the interactions and it helped them to apply their math skills. Most students were motivated by the opportunity to act as geotechnical engineers. Additionally, many students affirmed that soil mechanics lessons were their favorite aspect of the science course. Teachers believed that concepts learned in hands-on soil mechanics activities were more memorable to students than those encountered in a traditional class. The AMPS team also believes that the opportunity for elementary school students to interact closely with goal-oriented role models will help them to develop academic goals for themselves.

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Five years ago, graduate students at the University of California, Davis created the Geotechnical Graduate Student Society (GGSS), a student-run organization designed to enhance and broaden their technical education through unique educational, professional, and social opportunities. The group was established after faculty and students realized that technical background is only part of what it takes to become a successful practitioner or researcher. Students felt a need to bridge the gap between academia and industry, enable peer connections within the group and contribute to local community growth. These needs led the founding members to develop an organized group focused on the enrichment of their graduate experience and preparation for their futures as professionals in practice or academia.

What is GGSS?

At its core, the goal of GGSS is to promote scholarship, service, leadership, and social networking for the geotechnical group at UC Davis with the intent of fostering collaboration throughout the group and providing opportunities to enhance the education and professional development of its members. To achieve these goals, GGSS sponsors several types of activities including seminars, field trips, outreach events, social events, and the annual Round Table event. All civil engineering graduate students at UC Davis who have an emphasis on geotechnical and pavement engineering are automatically admitted to the group.

GGSS averages 30 active members each year, in addition to several visiting scholars, post-doctoral students, select undergraduate students, and “friends” who participate as honorary members. The board of directors, consisting of five annually elected officers and a non-voting faculty advisor, makes all decisions about the group’s operations and activities and provides leadership in executing all events and activities. The board is also responsible for all GGSS finances including fundraising, preparing budgets, and managing the group’s account. The board members serve as the primary contact and host for numerous visitors throughout the year.

The core values and goals of GGSS allow and encourage all members of any background to participate and benefit from these activities. The group seeks to maximize the graduate experience in every way possible. This creates equal participation opportunities for M.S. students, Ph.D. students, post-doctoral scholars, and international visitors. The group is more well-rounded and complete with all of its members fully engaged in the activities and discussions.

Enhancing Education

GGSS helps expand the geo-education experience at UC Davis, connecting with experts in geotechnical engineering from both practice and academia to learn about current research and projects. Weekly seminars, field trips, and an annual two-day short course called an “Institute” provide
exposure and training beyond topics covered in coursework. The field trips organized by GGSS, such as those to dam construction, piling, and landfill sites, and the annual drilling and sampling class organized by a local drilling contractor, provide a hands-on experience that help students bridge classroom concepts to the field.

The weekly seminars, typically given by outside guests from academia or industry, expand the topics students are exposed to and allow for a discussion with the guest and between the group members. Recent topics have included multiphysics hillslope processes triggering landslides by Professor Ronaldo Borja, axial behavior of piled foundations in liquefiable soils by Dr. Mark Stringer, and standard of care issues surrounding the floodwall failures during Hurricane Katrina by Dr. Pat Lucia. After the seminar, the speaker is invited for lunch by two or three GGSS members, providing an opportunity for direct dialogue between students and professionals. Every quarter, current UC Davis students give a few of the seminars to share their research with the rest of the group, allowing graduate student researchers to hone their technical presentation skills while simultaneously sharing experience and knowledge.

GGSS sponsors an annual Institute to delve more deeply into a topic not explicitly covered in current course offerings. The GGSS board, in consultation with faculty, selects the topics. The Institute is given by a recognized expert and typically consists of one classroom instruction day and one field trip day. Previous Institutes have focused on rock engineering with Professor Richard Goodman, post-earthquake reconnaissance with Dr. Rob Kayen, glacial geomorphology and fault investigation with Dr. Keith Kelson (Figure 1) and geo-environmental engineering with experts Lisa Van Tassell and Drs. Pat Lucia, Chris Hunt and Jennifer Donahue. This year’s Institute will focus on underground construction and tunneling and will be taught by recognized tunneling specialist John Bischoff.

Preparing For Careers

The GGSS Round Table, a day-long open house during which invited professionals engage directly with graduate students, is the group’s annual centerpiece event (Figure 2). The Round Table brings geotechnical professionals from across the West Coast to UC Davis to interact with students presenting research through oral presentations and poster sessions. The goal of the Round Table is to foster a connection with professionals, so that UC Davis researchers gain an understanding of industry needs while informing industry professionals of ongoing research projects at UC Davis.

This event helps students polish their presentation skills and provides a forum for networking and collaboration between geotechnical professionals, faculty, and graduate students. Many students have been introduced to their future employers during this event, with about 85 percent of graduates being hired by companies/organizations who attend the Round Table, and many guests return year after year. The Round Table event uniquely bridges the academic-industry gap and opens necessary conversations with professional geotechnical engineers to help refine research goals and inspire new projects based on the current needs of the industry.

Engaging Society

Service, another important part of the GGSS mission, is supported by...
student engagement in the broader local community through outreach activities. Outreach activities are conducted through a partnership with the Center for Geotechnical Modeling at UC Davis (NEES@UC Davis), which is part of the George E. Brown, Jr. Network for Earthquake Engineering Simulation (Editor’s Note: see “Geotechnical Earthquake Engineering Research Using a Large Centrifuge” by Dan Wilson and Ross Boulanger in September/October 2011 issue of Geo-Strata for more). By combining the financial and technical resources of NEES@UC Davis with the diverse body of motivated graduates that make up GGSS, each organization can reach a broader audience than either could alone.

Outreach activities include several tours of the NEES@UC Davis facilities each year for groups including Cub Scouts, summer camps, and field trips from local elementary, middle, and high schools. These tours are customized for the audience; the time frame may range anywhere from two hours to a full day and the group may include from 8 to 60 students at a time (Figure 3). In addition to on-site activities, GGSS and NEES@UC Davis have developed and delivered interactive lesson plans in local middle school science classes (Figure 4) and taught a summer institute for earth science teachers focused on earthquake engineering in collaboration with the UC Davis School of Education. These activities are very constructive and rewarding for the graduate students and help promote earthquake engineering to the local community.

In addition to the outreach activities conducted with NEES@UC Davis, GGSS students and civil engineering faculty also assist with the local Mathematics Engineering Science Achievement (MESA) program. Each year, MESA students tour the UC Davis campus and centrifuge facility to learn about various undergraduate programs offered at UC Davis. Following the tour, a "Research Experience for Undergraduates" position is offered to one qualified student who works side-by-side with a GGSS graduate researcher at the centrifuge facility. Over the summer, this hands-on experience with geotechnical physical-modeling principles not only helps develop the academic and research interest of the undergraduate student, but also builds the mentoring and leadership skills of the GGSS researcher.

Building a Professional Family

GGSS believes that friendship and collegiality is key to a supportive, invigorating environment for research, learning, and professional development. Social activities help build relationships between students and faculty throughout the year and also help welcome new members and guests, ensuring they are fully engaged in the group. These events include semi-annual potlucks at a faculty member’s house, complete with crazy games (Figure 5), UC Davis-UC Berkeley potlucks for geotechnical graduate students and celebrations of individual milestones, such as awards, graduations, marriages, children, etc., throughout the year. GGSS also celebrates individual achievement through the annual Excellence in Geotechnical
Factors for Success

Five years ago, GGSS was formed to fill several needs within the graduate geotechnical engineering program, including a perceived disconnect between academia and industry, a lack of social opportunities to interact with fellow researchers and the desire to give back to the community through outreach and service. These needs are being fulfilled through interactions with industry during the Round Table and weekly seminars, social activities for members, and outreach with local K-12 students.

The success of GGSS in meeting these goals, while due to many factors, is primarily owed to faculty support and to the activities that make it entertaining and rewarding. Although GGSS is a student-run organization, faculty members serve as mentors and advisors to the board, facilitate connections and discussions with professionals, and encourage their students to participate in GGSS activities. GGSS board members spend about 80 hours a year on their GGSS-related duties, so the faculty’s support of this time investment is critical. Without their support and motivation, it is not likely GGSS would be as successful as it is today.

An equally important factor to the continuing success of GGSS is that students have fun! This may seem like a simple idea, but the GGSS board and faculty work hard to create an informal environment where students are comfortable interacting with their peers and guests. This fun, relaxed environment helps ensure that students stay involved in the group during their entire time in Davis and then continue as supportive alumni. The quarterly newsletter, the “GGSS Shakedown,” is another medium through which the group enhances communication and involvement between members, alumni, and professionals. The newsletter is available on the GGSS website, highlighting member achievements, and summarizing past activities, such as field trips, seminars, and other special events.

Looking to the Future

Many geo-engineering-focused graduate students attend UC Davis to obtain a high quality education. The experiences and environment provided by GGSS, along with the interactions within the group, add another dimension to the traditional, technical aspect of our education. The coursework and research at UC Davis expand students’ technical knowledge, while GGSS allows them to improve non-technical skills through leadership opportunities, community service, professional development, and social activities. Both students and alumni remain active, ensuring current and future graduate student colleagues enjoy the same opportunities. The group remains strong through the enthusiasm of its members and officers and the continued support of professional affiliates.

Jack Montgomery, A.M.ASCE, is a Ph.D. student at UC Davis, focusing on analysis of liquefaction for embankment dams. He is currently president of GGSS and worked for the U.S. Army Corps of Engineers before beginning his graduate studies. He can be reached at jmontgomery@ucdavis.edu

Katerina Ziotopoulou, S.M.ASCE, is a Ph.D. candidate at UC Davis with a research focus in constitutive and numerical modeling of liquefaction effects and direct simple shear testing of sands. She has served as the Seminar Coordinator and is currently treasurer of GGSS. She can be reached at kziotopoulou@ucdavis.edu

Manouchehr (Manny) Hakhmaneshi, A.M.ASCE, is a Ph.D. student at UC Davis. His research focus is on implementation of rocking foundations into building systems by compatibly designing the soil-structural hinging systems. In 2010-11, he served as the president of GGSS. He can be reached at mhhakhmaneshi@ucdavis.edu

Jacquelyn Allmond, S.M.ASCE, is a Ph.D. student at UC Davis with a research focus in centrifuge testing of rocking foundations in liquefiable soil. She has held officer positions of Social Coordinator and President on two previous GGSS boards. She can be reached at jallmond@ucdavis.edu

Ronnie Kamai, Ph.D., A.M.ASCE, received her doctorate from UC Davis in 2011, focused on liquefaction-related strength-loss. She is currently a post-doctoral scholar at PEER (UC Berkeley). She was one of the founding officers of the GGSS and served as president in 2009-2010. She can be reached at rkamai@ucdavis.edu
HOUSE AD?
Landslides frequently cover broad areas and span many property boundaries. To effectively control landslide movement, the input and permission of multiple property owners may be required, increasing the complexity of the resolution for a geotechnical engineer. One mitigation strategy that has been employed in California is the use of Geologic Hazard Abatement Districts (GHADs). This technique arose after roadway grading in 1956 caused approximately 270 acres of the massive Portuguese Bend Landslide Complex, located on the Palos Verdes Peninsula southwest of Los Angeles, to begin large-scale movements. By 1970, only 29 of the original 156 homes within the moving landslide area were still occupied.

Continued movement of this landslide and adjacent landslide areas resulted in the construction of various control measures at very high costs in an attempt to reduce the slope movements. The associated difficulties led California to pass the Beverly Act in 1979, which enabled the creation of GHADs. A GHAD is a local assessment district for the purpose of preventing, mitigating, abating, and/or controlling geologic hazards. The Beverly Act defines “geologic hazard” fairly broadly as “an actual or threatened landslide, land subsidence, soil erosion, earthquake or any other natural or unnatural movement of land or earth.”

The first two GHADs formed were for the Abalone Cove Landslide and the Klondike Canyon Landslide, adjacent to and influenced by the Portuguese Bend Landslide (Figure 1). The Abalone Cove Landslide Abatement District was formed in 1981 after the 60-acre slide began moving in 1978 and threatened 100 homes. In 1980, movement of the 50-acre Klondike Canyon Landslide threatened 36 homes, leading to the creation of the Klondike Canyon Landslide Abatement District in 1982. Since that time, about 50 GHADs have been formed under the California Public Resources Code sections created by the Beverly Act.

**A GHAD Success Story**

The Abalone Cove Landslide Abatement District (ACLAD) was the first district formed in the state and serves as a good example of GHAD effectiveness. Studies have indicated the landslide mass is complex and is moving on slip zones at depths of about 100, 130, and 170 ft. The shallower movements are typically related to annual rainfall while the

![Figure 1. Palos Verdes Peninsula Landslides.](image-url)
deeper movements are generally controlled by groundwater. Studies for the ACLAD have concluded that 50-75 percent of the rainfall in the canyons uphill of the slide infiltrate through the fractured ground surface, recharging the groundwater throughout the area. In the slide area itself, the surface consists largely of open fields and only 15 percent of the rainwater infiltrates into the groundwater.

ACLAD has funded the installation of both monitoring and dewatering wells within and upslope of the landslide complex because lowering of the groundwater levels is the most cost-effective means to reduce the rate of landslide movement over such a broad slide complex. Figure 2 shows data illustrating the pumping rates for the wells. These wells currently remove about 200,000 gallons per day and have lowered the groundwater level about 25-60 ft within the slide area and up to 8-10 ft in the upslope area. A water budget analysis indicates the wells remove between 78 and 92 percent of the annual groundwater recharge. Slow creep of several tenths of an inch still occurs when the annual rainfall exceeds about 22 in. per year, but the wells have been very effective. Maintenance and periodic replacement of the wells is performed by ACLAD, and surface GPS stations and leveloggers in monitoring wells are providing detailed monitoring data to guide on-going efforts.

Forming a GHAD

The California GHAD approach provides a mechanism by which a broad group of property owners can pool resources and jointly fund preventative maintenance and remedial measures. The process is initiated by a group of landowners or by the legislative body of a local government agency. If started by the landowners, it must include a petition signed by at least 10 percent of the owners within the proposed district boundary. In addition, a Plan of Control (Plan) prepared by a state-certified engineering geologist must be included with the filing; the Plan is generally developed jointly with a geotechnical engineer so both geologic and geotechnical engineering input is provided.

The Plan must “describe in detail a geologic hazard, its location and the area affected, and a plan for the prevention, mitigation, abatement or control thereof.” The Plan must project a reserve level of funds to address probable future geologic events. This funding must include monitoring geologic conditions, identifying geologic hazards, constructing needed improvements and maintaining, repairing, and replacing facilities. Following a public hearing and endorsement of the district formation by the local agency, landowners within the proposed district vote. If the owners of more than 50 percent of the assessed valuation of the properties do not object, a GHAD board is formed and the district can be established.

Comparison to Other District Forms in California

A GHAD is only one form of a district that may be used to control or repair geologic hazards. In California, the two most common alternatives are Drainage Benefit Assessment Areas (DBAAs) and Community Facility Districts (CFDs). Nearly all of the DBAAs are located in Southern California and each was created by a local governmental entity. DBAAs own, operate, and maintain surface and subsurface drainage facilities in many cases where landslide movements can be controlled by such operations. A CFD, also known as a Mello-Roos District, can be created to fund a much broader range of improvements and services. A CFD is normally operated by the local government and is commonly used to fund infrastructure needs and emergency services, but is seldom used solely for geological hazard concerns.

In contrast to other types of assessment districts, GHADs can help the District geologist or geotechnical engineer focus on prevention and early control of hazards. The process to create a GHAD is much simpler than the process needed for other
district forms because the process is exempt from the California Environmental Quality Act (CEQA) and does not need approval from the Local Agency Formation Commission (LAFCO). Also, on-going management by a local independent board can often be more responsive to new circumstances that may develop.

**Application of GHADs to New Subdivisions**

In 1985, the Blackhawk and Canyon Lakes GHADs were formed in the San Francisco East Bay, near Danville and San Ramon. Whereas the initial GHADs responded to impacts of landslide movements on developed properties, the Blackhawk and Canyon Lakes GHADs were created for new subdivisions prior to the sale of individual lots. The purpose of these GHADs was for the subdivision geologist and geotechnical engineer to respond to geologic hazards in the common land areas and/or hazards impacting multiple private lots that could occur in the future but had not yet taken place. This type of pre-failure GHAD creation is much simpler than the formation of a GHAD with multiple developed lots because it involves approval of only one owner, the developer, along with the local government agency. This type of GHAD is most commonly used in Northern California.

The GHADs monitor and maintain surface drainage features, repair slope failures, stabilize creek banks, control eroding areas, and help educate homeowners. With a primary focus on the broad swaths of common areas, they generally do not perform work on private lots unless damage results from hazards on the open space areas or numerous private lots are involved. The effectiveness of the Blackhawk GHAD was demonstrated following a major rainstorm on December 15, 2002 when over 60 shallow landslides began moving on open space slopes. This led to the development of the Plate pile method to control shallow depth landslide and creeping slope failures.
movements. This technique was developed by the geotechnical engineer working for the GHAD as a cost-effective technique to manage the large number of failure areas, some on slopes greater than 300 ft high immediately adjacent to developed yard areas. The Plate pile slope stabilization method consists of installing vertical steel reinforcing elements in natural or man-made slopes to increasing the factor of safety against a landslide failure (Figure 3).

Coastal Retreat

On average, California coastal bluffs retreat at a rate of about one foot per year. Given the valuable properties along the coastline, bluff retreat and beach erosion pose a very serious risk. An increasing number of GHADs have been formed to respond to these hazards and construct new improvements that address the hazard, as well as repair or replace past failed or unpermitted work. This process can be very complex because it requires approval from the State of California and typically involves comprehensive submittals along with high funding levels. An example of a recent approval of an emergency seawall and rip-rap mitigation scheme is for the Oceanus GHAD in San Diego (Figure 4).

GHADs or Similar Districts in the Future

For over 30 years, GHADs have provided an effective and flexible mechanism to deal with geologic hazards that have or could impact multiple properties in California. The adaption of GHADs to other landslide hazards as well as other geologic hazard situations is now underway in the state. GHADs have an inherent flexibility that allows them to be adapted to a number of geologic concerns. New possibilities now being considered include adaptive management of levee maintenance and rehabilitation, consequences of sea level rise and flood-prone and protected areas in the Central Valley.

Elsewhere, the idea of a district providing landslide controls covering multiple properties that is guided by a geotechnical engineer and/or geologist has considerable merit. The use of this type of district in areas of rockfall hazard, sinkhole development, mine subsidence, levee failure or other geologic hazards could provide a reasonable resolution to situations that previously seemed to have no solution because of the lack of a trained, independent board of oversight, inadequate funding mechanisms, or political restraints. Because so many of the unique features of GHADs are the result of the Beverly Act, it may require legislation for a GHAD-like district to have the full legal and political powers needed to be effective, but the benefits seen in California GHADs may create the public will for such legislation to be passed.

In contrast to other types of assessment districts, GHADs can help the District geologist or geotechnical engineer focus on prevention and early control of hazards.
For most of my career as a geologist, I have practiced in the area of environmental assessment and remediation of hazardous substances. In 2007, I became CEO of GeoEngineers, Inc., an employee-owned firm that originated as a geotechnical engineering practice and has grown to embrace a broad definition of what constitutes a geoprofessional. As a result, we have acted to reduce the boundaries that often form around single-specialty silos and to nurture collaboration between diverse technical disciplines. Deconstructing these boundaries has led us to places, markets, clients, and solutions that we never thought possible when we began our journey. Companies that focus on building bridges between technical specialties and reducing barriers to collaboration can capitalize on the opportunities that lie ahead. Competitive advantages await those willing to break down old barriers and expand their self-definition.

A New Model Emerges

Today, our clients’ business problems are increasingly connected to multifaceted aspects of the earth, particularly when considered through the lenses of sustainable development and our crumbling infrastructure. Geo-professional firms that view themselves as business consultants that help reduce risk where the natural environment and human needs intersect are in a better position to create value and differentiate themselves in a crowded market. By seeing beyond traditional practice boundaries, these forward-thinking firms can help solve new environmental practice, and clients found it convenient to have this range of services under one umbrella. If silos hadn’t already formed around geotechnical engineers and other scientists, the emergence of environmental practice—a distinctly different market heavily dominated by geologists—promoted silo construction. Few firms avoided these barriers during this expansion of the geoprosessions.

As other market opportunities have emerged, some geoprofessional firms have further expanded their service offerings to include a wider variety of engineering and scientific components, including construction materials engineering and testing, hydrology, ecology, wetlands science, toxicology, oceanography, atmospheric science, and archaeology. Add geographic information systems and other applied computer-based technologies to the mix, and geoprosessional organizations can either feel threatened by the proliferation of new service elements or in awe of the potential of these elements. How many questioned whether the first wave of environmental opportunity was for them?
and increasingly complex problems. As our self-definition broadens, so do our opportunities.

The connected and collaborative world with few boundaries described in Thomas L. Friedman’s great book, *The World Is Flat, A Brief History of the Twenty-First Century*, has emerged as a dominant consideration for businesses today. Climbing out of our single-specialty silos and embracing creative multidisciplinary solutions is an effective way to avoid being marginalized and falling into commodity traps in this environment. Firms that have embraced this view proactively encourage and reward employees for achieving collaboration and leveraging connections between technical specialties. They are more flexible, adaptive and attractive to early-career geoprofessionals who value teamwork over competition. These are critical attributes in the more uncertain world that is our new normal.

**Where to Begin?**

It’s fair to say that you can find evidence of technical silos in all our organizations. Many scientists and engineers are most comfortable, and derive benefit from, working in groups of colleagues with similar expertise. However, it is common for leaders within our organizations to say that they desire more collaboration and connection between technical groups. Many are frustrated by how difficult that is to achieve. It takes a cultural shift—the hardest change of all. So where to begin?

**Step 1: Start with a strong balance sheet.** If you are struggling financially, you likely have bigger issues to tackle that may create barriers to effective change.

**Step 2: Adopt a single profit center approach.** The more you compartmentalize performance metrics, particularly by

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If silos hadn’t already formed around geotechnical engineers and other scientists, the emergence of environmental practice—a distinctly different market heavily dominated by geologists—promoted silo construction.
Keep in mind that not all silos that are created in organizations are technical. The most prominent silos often are between office locations. If you encourage teamwork between technical disciplines and office locations, it becomes very difficult to fairly proportion credit for profit realized. Establishing personalized performance metrics and individual annual goals, independent of location and technical discipline, are reasonable alternatives. It also helps to practice decision-making that demonstrates a single-profit-center philosophy. It is not enough to say you operate as a single profit center; your staff must believe that such a philosophy truly drives decision-making and financial compensation.

Step 3: Make multidisciplinary pursuits strategic. Celebrate and reward success. Look at various combinations of services and how to bundle them for a particular market. Select strategic initiatives for combined-service teams to pursue and practice working together. Set goals, track progress, learn and teach from experiences. Make adjustments. Highlight successes through communications, spontaneous celebrations, awards, and bonuses. At our annual shareholders meetings, we offer a half-day of technical presentations highlighting our top project achievements. A panel judges the entries and gives an award for the project of the year. Multidisciplinary collaboration and value creation on the project are strongly weighted criteria of the selection.

Step 4: Develop market intelligence, don’t lead with selling services. Some of the barriers we erect between technical disciplines have their origins in the sales process. Early in my career, I hated doing business development. I suspect I was not alone. The problem was that I was selling the service that my technical expertise supported. “Hello, I’m Kurt, would you like to buy a soil cleanup?” The only thing worse was trying to sell other services where I lacked expertise.

Firms that adopt a market-oriented approach to business development find that it can go a long way towards building business-development skills in staff, particularly in improving the ability to land multidisciplinary projects. This is because most market-oriented approaches start with listening and learning from clients and the communities they serve. The problems they face surface and almost always involve more than just one technical component. This approach promotes learning and is a much better fit for scientists and engineers, who are quite comfortable with seeking knowledge. What they will discover is that when they see the world through the client’s eyes and the complexity of their markets, it is a lot easier to see opportunities to bundle services and find solutions. Market strategies will emerge that necessitate collaboration between technical services.

Step 5: Make the project manager primary. Some firms structure their projects with a principal (or similar titles related to contractual authority and quality control) above the project manager in the project hierarchy. This approach can work just fine if the project involves a single technical discipline and location. However, firms with this project structure that are taking on more multidiscipline and/or multi-office work may inadvertently fall into the trap of the client having to assume too much of the project management role. There may be clear internal leadership structure for the individual areas of expertise, but the absence of a single point of contact for the overall project may inadvertently contribute to confusion in client communication.

Climbing out of our single-specialty silos and embracing creative multidisciplinary solutions is an effective way to avoid being marginalized and falling into commodity traps.
Breaking down technical-discipline silos involves strengthening the project manager role within the firm. If you have the "Project Manager" title as part of your promotional track, remove it and use the title only to describe the role for the primary position on a specific project. Encourage and teach staff to view project management skills as independent from specific technical expertise. Train and empower project managers to oversee multiple technical disciplines on projects that involve more senior principals.

**Step 6: Employ the catalyst of project planning.** Cultures that promote inclusion in the project-planning process often have fewer barriers to overcome in breaking down their silos. Start early and include representatives from multiple disciplines in proposal preparation and project kick-off meetings. Contingencies often include the potential need for additional services. Just because the original scope may not include the service, that doesn’t mean that the project won’t benefit from the perspectives of other technical disciplines being represented in an internal kick-off meeting. At the very least, as you encourage staff to take an active interest in what others are doing, they will become more comfortable and effective in working with other disciplines when needed.

**Step 7: Invest in training and technology.** Open up technical-training events to anyone who is interested. Consider cross-training programs to increase understanding of capabilities and interest in skills the firm offers. Use video conferencing and other electronic means to overcome physical separations often have the most attention from leadership and stand to benefit from efforts to integrate services.

**Step 8: Examine your office structure.** How many of your offices are structured with specific technical groups occupying the same area? A powerful tool in promoting cross-discipline work is restructuring the office layout to mix the groups. Many find that an even more powerful step to encourage cross-discipline synergies is to tear down the walls and share more space to promote spontaneous learning, collaboration and open exchanges of information. We did this last year in our Seattle headquarters, and the effect has been remarkably positive in drawing our various practices much closer.

**Step 9: Model the behavior.** Senior leaders must model effective cross-disciplinary behaviors. Nothing will stop an effort to break down silos faster than lack of buy-in at the top. Integrating multiple services must be seen as an advantage and means of creating value for individuals, the firm, and clients. Those who effectively cross-sell or manage multiple services should be visible and promoted. Share client testimonials regarding the broad capabilities of the firm.

Leaders should act to flatten hierarchies of expertise. Most of us understand that it is important to have depth in each technical service we offer to provide for backup, flexibility, and transition. Some do not recognize that certain service groups that have not achieved a critical mass may feel that they lack support. These situations often need the most attention from leadership and stand to benefit from efforts to integrate services.

**Step 10: Develop external partnerships.** Corporate cultures that embrace multi-discipline teamwork within their organizations find it easier to find value in teaming with other organizations. By keeping an open mind, being creative, and resisting the urge to say, “We can’t, or don’t, do that,” companies can find outside services that combine with their own in powerful ways and result in exciting project opportunities. Another benefit of developing external partnerships is that they enable you to be more nimble in customizing combinations of services to meet the specific needs of the project. Assembling and then disassembling various combinations of expertise—without hesitation or disruption—is an art form in itself. Strong external partnerships provide options and are essential to this process.

**Embrace the Journey, Enjoy the Rewards**

It is much easier to preach these steps than it is to accomplish them. The cultural change represented by silo deconstruction doesn’t happen overnight and the process is evolutionary, if not revolutionary. Despite some setbacks, for many years our firm has made it a priority to break down barriers between communities of practice in as many ways as we can. I invite you to join us in this endeavor. I am confident that you will find, as we have, that when those barriers are not present:

- you will be viewed by your clients more as a valuable resource and not a bit player;
- you will be invited to the client table earlier and more often;
- your clients will take a broader view of your capabilities;
your clients will share a wider range of potentially useful information with you;

- your clients will view you as in their corner, no matter what the problem;
- your staff will realize more career opportunities;
- you will improve your ability to adapt to market forces beyond your control;
- you will enjoy increased professional freedom;
- you will become more vital; and
- you will find each day will be more interesting.

Now is the time for geoprofessionals to broaden their view of what constitutes our services and how those services interact. In doing so, we have an opportunity to elevate how others see us and the value we provide. The disruption of the economy has opened the door for doing things differently.

Breaking down technical-discipline silos involves strengthening the project manager role within the firm.
MONOTUBE
Looking Out for You from the G-I Organizational Member Council

Join us in standing behind the Geo-Institute. Become an Organizational Member. Download the application at http://www.asce.org/uploadedFiles/geo/About_GeoInstitute/Organizational_Member/Organizational%20brochure%205.16.12(1).pdf

Two Executives Join the OMC

Jay Beech, Ph.D., P.E., M.ASCE, is a principal with Geosyntec Consultants. Based in Atlanta, GA, Jay manages the firm’s engineering groups in Georgia and the Carolinas. His area of practice is in the area of waste containment including landfills, in-situ barriers, and sediment capping. He is looking forward to serving on the OMC to help foster a better understanding of the value geotechnical engineers can bring to projects.

James D. Hussin, P.E., M.ASCE. Following seven years with a national geotechnical consulting firm, Jim has worked for Hayward Baker since 1984 as a chief engineer designing and managing projects involving most geotechnical construction technologies. A director of the company since 2002, he is a member of the company’s Technical and Risk Oversight Committee, as well as oversees national business development and marketing. He is a past president of the South Carolina Eastern Branch and has been active in the G-I, where he served as the past chair of the National Soil Improvement Committee and past member of the G-I Technical Coordination Council.

The OMC Welcomes the G-I’s Newest OM

Shannon & Wilson, founded in 1954 as a geotechnical engineering firm, offers a complete staff of professional geotechnical engineers, geologists, technicinans, and support personnel. The firm’s expertise includes development of project scope and planning exploration programs, directing field drilling and sampling operations, completion of laboratory testing and performing engineering analysis. Sustainability is incorporated into the firm’s geotechnical design through the reuse of materials and the implementation of well-designed erosion and sedimentation control programs.

OM Activities at 2013 Geo-Congress

The OMC has news to share with you regarding the outcomes of the various OM events during the Congress. Watch for its special report and selected photos in the May June 2013 Geo-Strata.

Free Publicity for Your Organization

One of your OM benefits is the publicizing of your company's non-sales-related information in these pages of Geo-Strata. Send award news, new staff member notices, company project news, upcoming meetings, etc., plus high-resolution photos to lbayer@asce.org.

ORGANIZATIONAL MEMBERS

"Thank you for supporting students and the geo-profession."

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ECS Corporate Services
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Things You Should Know as an OM

1. Let the G-I know about your recent Facebook and Twitter business posts so we can help you publicize your information. "Like" us on the G-I Facebook page at facebook.com/GeoInstitute and follow us on Twitter at twitter.com/GeoInstitute.

2. OMs receive a 5 percent discount for advertising in Geo-Strata magazine. Be sure to mention this to your advertising representative.

3. Is your logo posted on the G-I website at www.asce.org/geo/About-GeoInstitute/Organizational-Members/Organizational-Members-of-the-Geo-Institute/? If not, send your logo in a png, jpg, or gif format to lbayer@asce.org.

4. Maximize your professional commitment to the Geo-Institute by displaying the G-I logo on your website and on printed materials. Request a logo and preferred format at lbayer@asce.org.

The G-I Follows Its Organizational Members

The G-I not only follows its Organizational Members on Twitter, but retweets news and lists it at @GeoInstitute/GIOrgMembers. We also follow OMs who are on Facebook. E-mail us at ecuscino@asce.org when you join Facebook and Twitter so we can follow you and add your name to our list.

Schnabel Staffing News

Schnabel’s Board of Directors and has been with the firm for more than 11 years, serving as branch leader for the Sterling, VA office for the past ten years. Additionally, Rabe has been instrumental in growing and maintaining Schnabel’s federal and international work.

In other staff news, David Ebinger joined Schnabel as a senior staff geologist. Ebinger has more than five years of experience as a hydrogeologist with the South Carolina Department of Health & Environmental Control, where he provided project supervision of corrective action and groundwater monitoring for more than 140 underground storage tank release sites; technical review of potential and existing groundwater impacts in support of NPDES I Land Application permitting program; evaluation of site hydrogeology and application of regulatory requirements with regard to risks associated with permitted activities; and data mining of public drinking water compliance data and private well geochemical data for spatial representation of groundwater contaminant impacts. Ebinger has approximately 10 years of experience as a mineral exploration field technician in ME and NH, where he worked on a contract basis.

Anthony Grubbs and Jonathan Pittman were promoted to associates. With more than nine years of experience, Grubbs serves as Schnabel’s Hydrology and Hydraulics/Geographic Information Systems (GIS) Team Leader for the Greensboro, NC office. He and his team are vital contributors to projects that include alternatives analyses, inundation studies, Emergency Action Plans, and Operation and Maintenance Manuals. Grubbs earned his Bachelor of...
Jonathan Pittman has 11 years of experience in dam and geotechnical engineering and construction administration and monitoring. He specializes in water resources and electric utility projects, including the evaluation and design of earthfill, conventional concrete, and roller compacted concrete (RCC) dams; ash ponds; and levees. Pittman also has experience in geotechnical engineering and construction monitoring for commercial, industrial, warehouse, apartment, and municipal structures. He holds a P.E. in KY, NC, and VA. Mr. Pittman received his Bachelor of Science in civil engineering from the University of Virginia.

Gannett Fleming Names Zink Stockholder

Thomas G. Zink, P.E., M.ASCE, was named a stockholder of Gannett Fleming. Based in the firm’s Mt. Laurel, N.J., office, Zink has 19 years of experience with the company. He is the bridge practice manager for the firm’s Northeast Region, in addition to serving as the deputy director of transportation for its New Jersey operations. Zink provides direct oversight of the Bridge, Highway, and Geotechnical Design Units in the Mt. Laurel office.

Zink served as Gannett Fleming’s lead structural engineer for the design and engineering of the reconstruction of New Jersey Route 18 in New Brunswick, NJ. This award-winning project transformed a congested, failing roadway with more than 85,000 motorists daily to an efficient regional thoroughfare. At its groundbreaking, this complex $215 million project...
LEED® Certification for Pile Dynamics and GRL Engineers Building

The building that houses the headquarters of Pile Dynamics, Inc. (PDI) and GRL Engineers, Inc. (GRL) in Solon, OH, is now LEED® Certified. The LEED program, established by the U.S. Green Building Council (USGBC) and verified by the Green Building Certification Institute (GBCI), is the U.S. preeminent program for the design, construction and operation of high performance green buildings. PDI and GRL are proud to be housed in the first - and so far only - certified LEED Green Building in the New Construction and Major Renovations category in the City of Solon.

The building achieved LEED certification for the efficient use of energy, lighting and water and for incorporating a variety of other sustainable strategies. "Most of all, we are proud that we could preserve valuable resources by adaptively reusing an existing building," said Yolita Rausche, who served as LEED project administrator for the renovation. The original building housed a packaged nuts plant; renovation was accomplished with minimal construction material waste and reusing 96% of the existing structure.

"The green building movement offers an unprecedented opportunity to respond to the most important challenges of our time, including global climate change, dependence on non-sustainable and expensive sources of energy and threats to human health," said Rick Fedrizzi, president, CEO & founding chair, USGBC. "The work of innovative building projects such as the PDI and GRL headquarters is a fundamental driving force in the green building movement."

A Certification Ceremony conducted by Michele Kilroy, LEED AP, Executive Director of the Northeast Ohio Chapter of the USGBC, took place on January 29. Present at the ceremony were Solon Mayor Susan Drucker and U.S. Congressman David Joyce, who presented PDI and GRL with a Certificate of Congressional Recognition and Achievement. State Senator Thomas F. Patton and Ohio Representative Marlene Anielski could not attend the ceremony, but also acknowledged its significance with tributes to the companies and the renovation team. "PDI is honored to be part of a movement towards greater building efficiency, which, according to USGBC, has the potential to reduce the future U.S. demand for energy and generate 2.5 million jobs", said Garland Likins, P.E., M.ASCE, PDI president.

Terracon and Liesch Join Together to Expand and Enhance Services

Terracon Consultants, Inc. recently announced the acquisition of The Liesch Companies - Environmental Consultants & Engineers, based in Minneapolis, MN.

Founded in 1968, Liesch provides a full range of environmental services including industrial hygiene, industrial water and wastewater, air quality, acquisition due diligence, environmental compliance, environmental engineering, solid waste and Brownfield services. Client sectors include agribusiness, airports, alternative energy, commercial real estate, facilities, government, healthcare, industrial, infrastructure, legal, mining and waste. Liesch has additional offices in St. Paul and Phoenix.

“We are excited to be joining forces with Liesch to expand our environmental services to clients,” said David Gaboury, P.E., president and CEO of Terracon. “Their employees deliver expertise and service that is responsive and thorough with successful results. Their track record speaks for itself.”

Terracon is retaining Liesch’s 50 employees. Liesch will continue operating under the same name.

“Over the last 44 years, we have built our reputation on providing quality environmental engineering and consulting services,” said Brian Liesch, CEO and managing principal of Liesch. “As we extend the same quality services to a larger market, merging with Terracon will allow us to continue to meet the diverse needs of our clients.”

Goharioon Joins Terracon

Alex Goharioon joined Terracon as a senior vice president and senior principal. He will be the division manager for the Gulf Coast region, including Atlanta, and will also serve national clients. He brings more than 28 years of experience in geotechnical engineering and construction materials testing services. His project experience includes sport facilities, transportation, airports, medical and healthcare facilities, high-rise office buildings, retail, correctional facilities, industrial and higher education.

He has a master's degree in technology and a bachelor of engineering technology in mechanical engineering technology and civil engineering technology from Georgia Southern University.

“We are delighted to have Alex join the Terracon senior management team,” said David Gaboury, P.E., president and CEO of Terracon. "His many years of proven leadership success and service to clients will be a great addition to the firm.”
Frank Pita has been a principal and senior project manager with Jacobs Associates in Seattle, WA for the last 5 years. He holds professional civil and/or geotechnical engineering licenses in AK, NY, ID, MT, UT, WA and OR and is a licensed hydrogeologist in Washington. He is a fellow of ASCE and became a diplomate in the Academy of Geo-Professionals in 2009. Mr. Pita holds two MS degrees, one in civil engineering from Oregon State University and another in geology from the University of Tulsa, OK.

Pita is an active member of several national engineering organizations, where he has participated locally as an officer and on national committees working on engineering business issues. He chaired the ASCE Geotechnical Committee in Seattle for its first two active years in the late 1970s and then became an officer in the local Seattle ASCE section and eventually became president. He also participated on a ASCE national committee. Mr. Pita has also been an active member of ASFE, chairing and participating on several business-oriented committees and was on its Board of Directors.

What was the most fun project you worked on?

My first design projects where I had a major role in design and construction are very memorable to me. These were the design and construction of Terminal 46 for the Port of Seattle and the Cedar Street Wall Project in Port Angeles, WA. The wall project had an error in the local town surveyor’s work, which was not caught till the initial staking was taking place. The result was that design would not fit the site conditions. I learned all about small town politics and how a quick redesign can be done while being a young resident engineer.

How early did you know that you wanted to study civil engineering? What were the key factors in your decision to be a civil engineer?

I went to college to be a history teacher and a football coach. I switched to geology (there was no engineering program) and gave up the teaching/coaching idea. When my undergraduate studies ended, I took a job for an oil company in Tulsa, OK, where I used geology to look for oil drilling sites. It was interesting to learn about electric logs and large-scale drilling. The oil company also paid for me to obtain my graduate degree in geology. While doing that, I took civil engineering elective courses. I loved them, and was hooked. After receiving my Master’s in geology, I went back to school to obtain a Master’s in civil engineering. My wife was still willing to help support me, and it was the best move we ever made. My CE Master's was in geotechnical engineering, and my engineering career started from there.

Did you have other aspirations of going into another discipline or field, other than civil engineering at any point?

I thought I wanted to be a geologist, but I much prefer the design aspects of civil/geotechnical engineering. The technical knowledge of geology does help a lot in predicting and understanding the subsurface parameters needed for engineering design. It is a great combination of skills for this profession.

What is your message to professional engineers regarding specialty certification?

We need certification so that our civil engineering clients know that they are getting a person with extensive knowledge in that facet of engineering. However, the profession and the individual expert must also realize that their particular area of knowledge may NOT be the key element of a particular project.

Why are you certified as a D.GE and what made you choose to become a Diplomat in the Academy?

It is an honor to be a Diplomate. When my peers called and said I should apply, I did not hesitate.

How do you feel about the state of civil engineering and the profession as it is today?

It is changing. Much of the so-called uncertainty or risk in the subsurface is being shifted by contract from the A/E firms to the contractors. This means that many of the subsurface issues are not designed by A/E firms anymore. Some of this work comes back to specialty engineering firms, but our client is now the contractor.

What do you feel are the biggest challenges for the profession?

Finding good people to go into the field, training them in technical and business aspects of engineering, getting them experience on construction sites, and in estimating and making it fun. Also, we must keep their pay up while doing all the above.
SCHNABEL
A Complete Geoprofessional Service

An individual who prefers to remain anonymous has sent you, Mr. Government Official, this photocopy of an article that appeared in the March/April 2013 issue of Geo-Strata magazine.

You are a government official who believes geotechnical engineers of record should not be permitted to observe excavation on the sites of projects for which they have been engaged. You maintain this belief because you fear that these geoprofessionals will fraudulently alter their instruments of professional service to hide their negligent performance.

You need to learn something about geotechnical engineering, because – if you don’t – you could seriously damage those you serve.

The site-specific nature of geotechnical engineering is just one of the discipline’s aspects that make it unique. Other forms of engineering tend to be location-independent; i.e., given the same subsurface conditions and building-code requirements, the civil, structural, mechanical, electrical, and plumbing design of almost any project would be the same no matter its location. By contrast, geotechnical engineering deals with site-specific, natural conditions that can differ significantly from conditions typical of the area’s geology. This potential seemingly would necessitate extensive subsurface exploration before initiating foundation design. It doesn’t.

Because extensive subsurface exploration is expensive, proper geotechnical-engineering practice has always incorporated “the observational method,” another unique aspect of the discipline that skilled practitioners apply to optimize cost-effectiveness. It’s implemented by sampling and testing just a tiny portion of a site’s subsurface, then applying local experience and seasoned judgment to formulate the provisional foundation-design recommendations included in a geotechnical engineer of record’s final report. The recommendations are provisional because, given the limited sampling involved, they can be responsibly finalized only in the field, during excavation, when actual subsurface conditions are exposed, permitting geotechnical engineers of record to evaluate and adjust their recommendations if and as necessary.

Please get it! Geotechnical engineers cannot use on-site geotechnical observation to fraudulently modify their final recommendations because they don’t take their final recommendations into the field. They take the provisional recommendations that they rightfully assume will need some post-excavation fine-tuning, because no one can see what’s hidden by earth, rock, and time. In other words, your policy prevents a problem that doesn’t exist, while creating a problem that’s all too real, because it prevents geotechnical engineers from completing their service and shifts reliance to replacement firms whose unfamiliarity with key issues could compromise the success of the entire project.

And it gets even worse, because – despite their serious information deficits – replacement firms seldom ask questions of the one person who knows more about the project’s geotechnical issues than anyone else – the original firm’s project manager – because the replacement firm’s personnel regard the project manager as a competitor; i.e., the enemy. By contrast, when the original firm is retained to complete its service, the project manager briefs field representatives before they depart for a project site, so they know what to look for. And while on site, the field representatives stay in close contact with the project manager, using smartphones to communicate by voice, e-mail, texts, photos, and videos.

The communications breakdown that occurs when a replacement firm is retained to perform field services increases the risk of unanticipated conditions, delays, extras, claims, and disputes. It also increases the risk of far more serious problems, such as those investigated by the Subcommittee on In-
vestigations and Oversight of the House Committee on Science and Technology in 1983, following a series of alarming construction failures that included the Kansas City Hyatt failure that killed 114. The Subcommittee’s conclusion? The engineer of record needs to be engaged during the construction phase to help ensure specifications are being met.

The problems become still worse because of liability issues.

Geotechnical engineers obviously cannot be held liable for site problems they ordinarily would have prevented had you not prevented them from performing a complete geotechnical-engineering service. Supplanting firms cannot be held liable for preventing those problems either, because their job is to evaluate what they find, not second-guess the engineer of record. In other words, you and your employer may be held solely responsible for all the problems, because you’re the ones who created them! That can be a particularly onerous burden when it comes to geotechnical engineering, because subsurface issues comprise the number-one source of construction-industry claims and disputes.

And, finally, this point: Those who believe the geotechnical engineer of record should be prevented from performing geotechnical field services cannot cite even one instance where the problem they are trying to prevent has ever occurred. By contrast, just a 60-second Internet search will identify dozens of instances where the problems you would create have resulted in hundreds of deaths.

The position you advocate is dangerous and, if you choose to maintain it, you are, too.

**AUTHOR**

John P. Bachner is the executive vice president of ASFE/The Geoprofessional Business Association, a not-for-profit association of geoprofessional firms, i.e., firms that provide geotechnical, geologic, environmental, construction materials engineering and testing (CoMET), and related professional services (en.wikipedia.org/wiki/Geoprofessions). ASFE develops programs, services, and materials that its members apply to achieve excellence in their business and professional practices. Contact john@asfe.org
This issue of CoreBits brings you news of only its Geo-Institute members. CoreBits will return in its entirety in the May/June 2013 issue. Until then, check these sources for breaking G-I news:

- The G-I webpage at [www.asce.org/geo](http://www.asce.org/geo)
- The G-I April eUpdate sent on April 8, 2013.
- Twitter at [http://twitter.com/GeoInstitute](http://twitter.com/GeoInstitute)
- Facebook at [www.facebook.com/GeoInstitute](http://www.facebook.com/GeoInstitute)
- G-I LinkedIn at [http://www.linkedin.com](http://www.linkedin.com)

MEMBERS

Kavazanjian Elected to National Academy of Engineering

The National Academy of Engineering’s (NAE) President Charles Vest announced the election of 69 new members and 11 foreign associates on February 7, 2013. One of those was G-I Past President, Edward Kavazanjian Jr., Ph.D., NAE, D.GE.

Kavazanjian Jr., Edward, senior sustainability scientist, Global Institute of Sustainability, and professor, School of Sustainable Engineering and the Built Environment, Ira A. Fulton School of Engineering, Arizona State University, Tempe. For geotechnical engineering for municipal solid-waste management, earthquake hazard mitigation, and safety of transportation facilities.

McCartney Wins 2012 Prize for Excellence in Teaching

John S. McCartney, Ph.D., P.E., M.ASCE, an assistant professor in the Department of Civil, Environmental, and Architectural Engineering at the University of Colorado Boulder (UC Boulder), won the 2012 Shamsher Prakash Foundation’s Excellence in Teaching Award. The award, given to teachers younger than 40, recognizes a candidate’s record of significant teaching excellence and the promise of continued excellence.

McCartney received B.S. and M.S. degrees in civil engineering from UC Boulder and his Ph.D. in civil engineering from the University of Texas at Austin. McCartney’s research interests include unsaturated soil mechanics, geosynthetics, centrifuge modeling, and thermally-active geotechnical systems. He has taught courses about an introduction to geotechnical engineering, engineering properties of soils, foundation engineering, and geoenvironmental engineering. He is a recipient of the NSF Faculty Early Development (CAREER) Award in 2011, which is focused on the thermal improvement of unsaturated soils. This project also involves development of a communication-training program for geotechnical engineers. He currently advises the research of seven Ph.D. and three MS students, and has graduated three PhD students and 15 MS students. McCartney is passionate about using centrifuge modeling for educational purposes, and developed a new educational module on stress distribution and bearing capacity of shallow foundations.

Bumpas Presented $200 Starbucks Card

Though the January/February 2013 Geo-Strata announced Kristi Bumpas, P.E., M.ASCE as the winner of the $200 Starbucks gift card for being selected from all those who registered for the 2013 Geo-Congress by January 3, 2013, we wanted to include her smiling face as she received her award.

Bumpas is president of Red Rock Consulting, an Oklahoma-based, woman-owned engineering firm specializing in geotechnical engineering in Oklahoma, north Texas and southern Kansas. The firm’s experience includes ODOT, USACE, FAA, university, medical, municipal, commercial, airport, private and residential projects. Kristi is the current founder and President of the Geo-Institute’s Oklahoma Chapter.
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BAKER