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ON THE COVER
Clockwise from top left corner: Stabilization of loess bluff using soil nail, anchored, and MSE walls along Mississippi River in Natchez, MS (courtesy of Hayward Baker, Inc.); Permanent soil nail wall in the mid-western U.S. (courtesy of GEI Consultants, Inc.); Braced excavation during construction of Transbay Transit Center in San Francisco, CA (courtesy of Brian Haux – SkyHawk Photography, skyhawkphoto.com); Anchored soldier beam and lagging excavation support at “The Shell” in Arlington, VA (courtesy of Steele Foundation, LLC).
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SiteMaster Inclinometer Software

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Simon Miles, Principal Geotechnical Engineer
Technical Authority for Geotechnical Data Management
ATKINS
Walking with Terzaghi

We all know Karl Terzaghi as the founder of our profession – an inescapable reference to nearly every one of our technical disciplines. But why Terzaghi? And why did all of this discovery occur in the last 100 years? Was there no need for soil mechanics before then?

In his seminal biography Karl Terzaghi, the Engineer as Artist, Dick Goodman teaches us that after the completion of his studies at the Technical University in Graz in Austria, Terzaghi spent much time examining geologic conditions for large dams in Austria, Eastern Europe, and even the western United States. This was well before conducting his experiments at Robert College. He immersed himself into experiencing construction-related design issues not readily addressed by known approaches — approaches that he later became uniquely adept at solving.

Progress is driven by people who first recognize the need, even when the need is not readily apparent to others, and then find creative bridges to get there. Nobody knew that the world needed a better search engine until Google gave us theirs. We were all quite pleased with our paper atlases before Garmin unveiled its GPS. And our Garmins were the “cat’s meow” until Google upended it all again. The world did not need music players, telephones, or tablets when Apple unveiled its iPod, iPhone, and iPads – but Steve Jobs recognized that the world needed devices that are more readily manageable. Everybody thought concrete retaining walls did the trick, but it was Henri Vidal who saw the need and followed through with the opportunity to connect the wall with the soil, turning the latter driving force into one that provided resistance as well.

All developments, great and small, start with people. People who somehow see the need that others don’t and then have the knowledge, wits, creativity, imagination, and courage to bring a new twist to the package. That’s nice, but how does this affect the rest of us geo-mortals working earnestly to serve our clients, students, and research sponsors? We are not Karl Terzaghi – heck, many (most!) of us don’t even read the ‘Journal’ anymore! We are working hard in a world full of many like-minded and like-skilled, equivalently educated, great people who are solving similar problems and serving similar customers in an increasingly competitive and non-differentiated world. And that’s just the point. Karl Terzaghi moved the profession because he saw the unmet needs that others didn’t know existed. And so can we all. Each of us in our own way. We do this simply by stopping to think and consider, “What can we do here to better reach a preferred construction outcome
for our customers?” Consider, if you will, a whimsical list of some of our modern methods we might do better.

- We characterize sites by making discrete boreholes, then banging on steel rods at 5-ft intervals to get design values for strength, stiffness, compressibility... Really?
- We estimate the liquefaction of silt by pretending it’s sand.
- We estimate 2D deformations using a groovy, complicated, and insanely detailed grid of little colored squares assembled mathematically with an elegant system of linear equations, the accuracy of which is all based on material properties that stem (largely) from speculation.
- We write our geo reports just like we did in 1970 (same format and all), but have become really good at updating how we deliver them (first by mail, then fax... now via PDF through email).
- Our reports are stuffed with data — moisture contents, Atterberg limits, strength, stiffness, layer contact information — yet we never bother to integrate our data with its neighbors, cousins, or extended family. All of this in a “big data,” BIM-filled world.
- We say we want more integration with the project team so that our work might better benefit the project... then communicate our recommendations via email. Or, if we are feeling especially up to it, we make the effort to “drop off” our soil reports on the desks of our clients.
- Construction observation via the “observational method” consists largely of moisture-density readings with comparisons to backbone curves first developed by R.R. Proctor in 1933. This is our “state of the art?”
- We put lots of great (and expensive) things into the ground to bypass that bad stuff or maybe make it better. And we test it how and for what?

Why Terzaghi? A great question. But a better question is, “Why not us, too?” Like Terzaghi, we exist in a frontier-filled world replete with unmet needs, great and small, just waiting to be discovered, uncovered, and explored. It’s up to all of us to do something, to act on these needs (and what better home than the G-I to work with like-minded people to learn about and tackle the challenges still with us?) We reinvent our value to our customers by finding creative, imaginative, and knowledge-based solutions that make a difference to the preferred outcome. By doing this, we enhance our world, whether it be great or small, walking with Terzaghi — and not just in his footsteps.

Kord Wissmann, PhD, PE, D.GE, M.ASCE
Geo-Institute President
kwissmann@geopier.com

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**GEOSTRATA Seeks New Editors**

GEOSTRATA has achieved its success by publishing great content from many of the world’s leading geoprofessionals. We have been blessed with a loyal core of sustaining advertisers and the ever-encouraging support of the magazine’s nearly 12,000 readers from near and far. But each issue is also the result of much behind-the-scenes work by a small, energetic group of geoprofessional editors who work with authors and the magazine’s publisher to bring each issue to press.

During 2016, we seek 1-2 new editors to replace retirees and augment the magazine’s current Editorial Board.

An editor’s general responsibilities include:

- 3-4 assignments each year — coordinating with authors to edit and help enhance article quality and working with them to ensure that editorial deadlines are met.
- Participating on a monthly conference call.
- Occasional authoring of an editor’s message for an issue.
- Contributing article ideas and suggestions for potential authors.
- Attending the annual GEOSTRATA Editorial Board meeting, held during the annual G-I meeting, to plan issue themes and ideas for the coming year.

While GEOSTRATA’s editors are not professional writers, most have had experience writing and/or editing journal papers, magazine articles, or newsletters. If this seems like an opportunity that interests you, please submit a short letter of interest and a 2-3 page resume describing your geoprofessional experience to geostrata@asce.org.
Earth retention and retaining wall systems have a long and rich history in civil works. For centuries they have been used for land development, and integrated into transportation and water resource projects. Of course, newer systems have evolved over the past half century, mainly due to the advancement of construction techniques, equipment, and improvements in construction materials. Thus, today’s geotechnical engineers are interested in not only the past and future performance of older, more traditional systems, but also in the complex relationships between design, construction, and performance of newer systems. Articles in this issue cover a wide spectrum of wall types and ages, installation systems, and performance monitoring. We also dive into the legal and regulatory issues pertaining to design responsibility of retaining walls and earth retention systems.

Not all retaining walls have performed as intended. Older retaining walls may deteriorate, rendering decreased capacity, structural distress, and vulnerability from future extreme events. Even the performance of newer types of retaining walls may be affected by unknown subsurface conditions, misunderstandings relative to the response of the wall system, or from the selection of construction techniques and changes that are ordered during construction without the benefit of a design review. Retaining wall failures can be expensive and can affect other nearby facilities and infrastructure components. Three articles in this issue address retaining wall performance and problems surrounding failure of retaining walls and earth retention systems.

James Niehoff describes common causes for failures of retaining wall systems in his article “Nature Sides with the Hidden Flaw,” while Joseph J. Cavey, James A. Guinther, and Anthony Passaro describe the challenges of replacing a century-old retaining wall that failed during a storm event in their article, “Emergency Retaining Wall Replacement.” Unfortunately, the problems described by these authors were not anticipated, leading to expensive repairs or replacement of retaining wall systems. Methods for tracking the existing condition, sources of distress, and documenting performance for existing retaining walls are necessary to help identify potential failures before they occur. Mo Gabr, Cedrick Butler, William Rasdorf, Daniel Findley, and Steven Bert offer “Highway Retaining Walls Are Assets,” which describes a program to rate the conditions of existing retaining walls and to plan for system-wide maintenance, retrofits, and replacements.

Two more articles address innovations in the design and implementation of earth retention systems. Soil nailing is a relatively new earth retention system for temporary and permanent support of excavations. Carlos Lazarte, Helen Robinson, and Allen Cadden describe innovations and recent advances in the art of soil nailing in their article, “Soil Nailing in the 2010s.” As the authors describe, today’s use of soil nails in conjunction with other systems provides a broadened range of design alternatives. Mark Seel and Luis Berroteran describe such a system and the benefits of a flexible implementation plan to deal with uncertain subsurface conditions in their article, “Stabilizing Variable and Sloping Ground.”

Design and construction of retaining walls and earth structures requires significant input from geotechnical engineers, despite the fact that some aspects of the design involve structural engineering. Although structural engineers may understand this, the challenge is to ensure that licensing authorities also understand the geotechnical elements inherent to the design and construction of earth structures and retaining walls. In his As I See It commentary, “SE Licensure and Partial Practice Laws – Their Potential Impacts on the Geotechnical Profession,” Richard Finno describes these issues and ongoing activities in response to the perceived threats to geotechnical engineering practice.

In a related topic, Martin Walker describes the use of the geotechnical engineering reports during preparation of contract documents in his As I See It article, “Geotechnical Reports in the Hands of Others.” I think we all can agree with Martin that geotechnical engineers need to participate with the design...
Letters

Client Expectations Come Into Play

I’m writing to let you know that I enjoyed Gary Brierley’s commentary, “Geotechnical Risk Management,” in the September/October 2015 issue of GEOSTRATA. Geotechnical risk management has been an important aspect of my 50-year engineering consulting career. Brierley summarized the main aspects quite well. However, one statement could be taken out of context. On page 63, Brierley states, “Owners and other project participants have a right to expect that the geotechnical professional’s design will result in a completed facility that is adequate for its intended purpose...” Remember that many factors come into play when it comes to achieving such a broad goal. First of all, the geotechnical engineer typically serves as part of a design team including structural engineers, civil engineers, and others sharing the responsibility. Secondly, the constructor bears major responsibility for quality control. Lastly, the owner is responsible for providing adequate funding to complete the work. Often, these important aspects are largely beyond the control of the geotechnical professional.

John Bachner, GEOSTRATA’s GeoCurmudgeon, often emphasizes that, when consulting engineers are sued, it is typically by their clients and project owners as a result of unmet expectations. The “Negotiations” section of the commentary correctly highlights the well-established responsibility of the geotechnical professional to abide by the governing standard of care and avoid errors and omissions. These, however, are narrower definitions of responsibility than the statement above that was made on page 63 of the commentary.

Howard Thomas, PE, P.Eng, F.ASCE Geotechnical Lead, CH2M Portland, OR howard.thomas@ch2m.com

Author Response

I appreciate the positive comments made about my commentary, “Geotechnical Risk Management,” and am very sympathetic to the issue raised by Howard Thomas. He is correct in stating that foundation design is a team effort and that many things can go wrong during the process of foundation design and construction. But — and this is a big “but” — if the subsurface structures do not perform “as anticipated” for any reason, then there can be little doubt that the geotechnical engineer will become enmeshed in the resolution of that issue, whatever that may entail. Hence, the primary purpose of my commentary was to make certain that the geotechnical engineer’s role on a project is adequately defined by clearly stating what services have and have not been authorized under the contract and by the proposed scope of services. “Standard of Care” is an elastic concept that the geotechnical engineer cannot simply assume will work in his or her favor. If the geotechnical engineer’s scope of services within the team structure is limited, as suggested by Mr. Thomas, then those “limitations” should be adequately described in the agreement to perform the services. A few short, pertinent clauses in the agreement with the client can have an enormous, positive impact on the outcome of any form of dispute resolution relating to problem projects.

Gary S. Brierley, PhD, PE, F.ASCE President, Doctor Mole, Inc. Denver, CO gbrierley@drmoleinc.com

GEOSTRATA welcomes letters to the editor. Some letters may be edited to suit style and space guidelines. Please send them to us at geostrata@asce.org.

This message was prepared by KENNETH L. FISHMAN, PhD, PE, M.ASCE. He can be reached at kfishman@mmce.net.
The G-I has 20 technical committees focused on unique subjects that encompass all major technical disciplines within geotechnical engineering and the geoprofession. The committees are the gateway to the G-I’s core value of technical excellence. Committee members have a high level of technical expertise and make the G-I a primary source of knowledge for our community. We’re always looking for new members interested in actively participating in and helping drive committee work. Personal experience and ability are the most important criteria for membership. For more information about a specific committee, please contact the committee chair. To apply to join a committee, complete the online form at: committees.geoinstitute.org/how-to-join-a-committee.

Technical committee proposals recently approved for G-I funding by the G-I include:

**Earth Retaining Structures Committee**
The committee is engaging in two activities that touch academia and vital practice issues: 1) developing the inaugural full-day Web Conference on Earth Retaining Structures (ERS); and 2) researching the state of U.S. graduate education in ERS. Both activities will improve our understanding of current educational efforts in ERS design, but also help our community of practicing engineers.

**Earthquake Engineering and Soil Dynamics Committee**
A Geotechnical Earthquake Engineering Pilot Speakers Bureau will be developed to fund travel by national experts in earthquake engineering to local G-I or ASCE chapters and civil engineering conferences to give seminars. The benefits of this activity include the dissemination of state-of-the-art knowledge to local practitioners, as well as raising the awareness of seismic hazards in areas where such awareness may only be at the nascent state.

"Participation in a technical committee gives members a voice in the development of design guidelines and other technical publications. Committee membership also provides the opportunity to network with experts in a given field practicing throughout the country and the world."

Daniel J. Rich, PhD, PE, M.ASCE, President & Chief Engineer, Rich Engineering; Chair, Shallow Foundations Committee
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Technical Activities Update

**Geoenvironmental Engineering Committee**
With the growth of the geoenvironmental engineering industry, there is a growing need for a review of the state of the art and practice. To address this need, a "Manual on Geoenvironmental Engineering Practice" will be developed to "consolidate" the state of the practice and art in this area. The manual will be geared toward practitioners and will consist of short, straight-to-the-point sections or chapters on "what we know" and "what to do."

**Pavements Committee**
The 5th Monismith Lecture will be recorded and uploaded to the Geo-Institute YouTube channel for public viewing.

**Underground Engineering and Construction Committee**
To foster student interest and engagement in the field of underground engineering and construction, two educational initiatives are planned: 1) an Underground Engineering Speakers Program to link potential speakers from industry with student chapters of G-I or ASCE and the Underground Construction Association of the Society for Mining, Metallurgy and Exploration (UCA of SME), and 2) an annual Student Tunnel Tour Program, in which student chapters receive travel grants for a tour of a major underground construction project.
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Cross-USA Lectures:
The G-I provides the Cross-USA Lecture Tour to local G-I Chapters and Graduate Student Organizations as an ongoing program to enhance the prestige of the geoprofession. Although a lecturer typically presents at a minimum of five locations, our 2015-2016 lecturer, Jean-Louis Briaud, PhD, PE, D.GE, Dist.M.ASCE, received a large number of requests for his lecture and has agreed to speak at more than 20 locations. His upcoming lecture schedule is shown below. For more information on specific topics, times, and locations for these events, please email the contact name below.

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<td>Univ. of WA</td>
<td>Seattle, WA</td>
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<td>Alex Grant <a href="mailto:agrant3@uw.edu">agrant3@uw.edu</a></td>
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<td>Pressuremeter and Foundation Design</td>
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<td>4/29/16</td>
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<td>Raising the Bar in Geotechnical Engineering</td>
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ASCE and Geo-Institute Awards

Through the Awards Program, ASCE and the Geo-Institute recognize colleagues who have contributed to civil engineering through outstanding leadership, research, or substantial career accomplishments. A number of these Awards were presented at the 2016 Geotechnical & Structural Engineering Congress:

Karl Terzaghi Lecture
Thomas D. O’Rourke, PhD, Hon.D.GE, NAE, FREng, Dist.M.ASCE
For more than 50 years, the Karl Terzaghi Lecture has been given by an individual honored for their exemplary contributions to the field of geotechnical engineering. The 2016 Terzaghi Lecture, “Ground Deformation Effects on Subsurface Pipelines and Infrastructure Systems,” was presented by Dr. Thomas D. O’Rourke at the Congress.

Dr. O’Rourke, the Thomas R. Briggs Professor in Engineering at Cornell University, is an expert on natural disasters and their impact on the infrastructure supporting civil society, pipelines, and underground construction. He has authored or co-authored over 360 publications on various geotechnical topics and has served on several teams reviewing and reporting on significant disasters such as Hurricane Katrina and earthquakes around the world. O’Rourke also headed a team that analyzed the impact on infrastructure systems of the attack against New York City on September 11, 2001. He served as chair or member of the consulting boards and peer review of many large infrastructure projects.

Throughout his career, Dr. O’Rourke received many honors, including ASCE’s Stephen D. Bechtel Pipeline Engineering Award and the Ralph B. Peck, C. Martin Duke, and LeVal Lund awards. He is a member of the National Academy of Engineering and an International Fellow of the Royal Academy of Engineering.

Arthur Casagrande Professional Development Award
Brina M. Montoya, PhD, PE, M.ASCE
The Arthur Casagrande Professional Development Award is bestowed to recognize the outstanding accomplishments of young practitioners, researchers, and teachers of geotechnical engineering, as evidenced by completed works, reports, or papers. The 2016 winner is Dr. Brina M. Montoya, for innovative research in the application of biologically-induced carbonate precipitation to address geotechnical problems of critical importance.

H. Bolton Seed Medal
Ricardo Dobry, Sc.D, M.ASCE
The H. Bolton Seed Medal is awarded for outstanding contributions to teaching, research, and/or practice in geotechnical engineering. The 2016 recipient is Ricardo Dobry of the Rensselaer Polytechnic Institute. Dr. Dobry presented the Seed Memorial Lecture on “New Findings on Liquefaction Triggering of Sands During Earthquakes” at the Congress.

Dobry studied at the University of Chile, UNAM in Mexico City, and MIT. He is an institute professor at Rensselaer Polytechnic Institute in Troy, NY, where he is also director of the Geotechnical Centrifuge Research Center. His research interests include soil dynamics, geotechnical earthquake engineering, and centrifuge testing. Dr. Dobry participated in the 1990s group that wrote the new seismic provisions on local site amplification, which are now incorporated in the U.S. building codes. He has written more than 200 technical papers and research reports and has directed 40 PhD and master’s theses. Dobry has been an invited
keynote speaker at many international meetings, and delivered the Third Ishihara Lecture in 2011 and the Carrillo Lecture in 2012. He earned the Croes Medal of ASCE in 1985, and was elected member of the National Academy of Engineering in 2004 for his fundamental contributions to geotechnical earthquake engineering.

Ralph B. Peck Award

Ross Boulanger, PhD, PE, F.ASCE

The 2016 Ralph B. Peck Award was presented to Dr. Ross W. Boulanger for his outstanding contributions to soil liquefaction assessment methodologies, including liquefaction effects on buildings, pile foundations, and earth dams, as well as the seismic response of organic and fine-grained soils.

Dr. Boulanger is the director of the Center for Geotechnical Modeling in the Department of Civil and Environmental Engineering at the University of California, Davis. He received his PhD and master’s degrees in civil engineering from the University of California at Berkeley, and his B.A.Sc. degree in civil engineering from the University of British Columbia. His research and professional practice are primarily related to liquefaction and its remediation, seismic soil-pile-structure interaction, and seismic performance of dams and levees. Over the past 25 years, he has produced over 230 publications and served as a technical specialist on over 40 seismic remediation and dam safety projects. His prior honors include the Institution of Civil Engineers’ TK Hsieh

IN MEMORIAM

Elio D’Appolonia, PhD, PE, NAE, Hon.M.ASCE (1918-2015)

Surrounded by his family, Elio “D’App” D’Appolonia, died peacefully on December 30, 2015. D’App was known around the world for his pioneering work in the areas of dams and tailings disposal, and heavily-load foundations for industrial facilities. Upon learning of his passing, Bill Marcuson, former ASCE president, said, “May we all have such a long, significant, and impactful life.”

D’App was born the son of Italian immigrants in Crow’s Nest Pass near Coleman, Alberta, Canada. As a young man, D’App developed a passion for hockey and hoped to play professionally, but his father wisely put him to work in his construction company and then encouraged him to enter college. D’App received a bachelor’s degree (1942) and a master’s in civil engineering (1946), both from the University of Alberta. During the summers between 1942 and 1946, D’App worked for the U.S. Corps of Engineers on engineering and construction of foundations, airfields, and highways placed on permafrost in northern Canada and Alaska. In the summer of 1946, D’App moved his family to Illinois, where he completed his doctorate (1948) at the University of Illinois, working with an early version of the finite element analysis method.

After his PhD studies, D’App moved his family to Pittsburgh and devoted the next eight years to teaching and research at the Carnegie Institute of Technology, now Carnegie Mellon University. At that time, his interests and training were primarily in structural engineering and applied mechanics, but he was asked to fill a void in the curriculum by teaching soil mechanics and foundations, which ultimately dominated his professional interest for the remainder of his life. From 1950 to 1956, he was a part-time consultant on projects involving structural and soil mechanics (now geotechnical engineering).

In 1956, D’App stepped down as a full-time professor to start a consulting engineering practice that later became D’Appolonia Consulting Engineers (EDCE), an internationally renowned leader in geotechnical engineering. Under his leadership, D’Appolonia grew and flourished to become a multi-faceted group of companies providing geotechnical engineering, construction, and related environmental and earth science services to both private industry and government agencies. As a consultant, D’App embraced challenging and difficult client projects, and finding creative solutions for them. Among his most challenging projects was foundation design and construction for the new Bethlehem Steel manufacturing facility in Burns Harbor, IN; construction of a nuclear power plant on a deep fill in Italy for ENEL; resolution of unexpected foundation movements that affected construction of the Velodrome for the 1976 Olympics in Montreal; and serving as a member of the board of consultants during construction of Merrill Creek Dam in northwestern New Jersey.

D’App made seminal contributions to the fields of geotechnical and foundation engineering. He authored numerous technical papers, served on various committees of professional societies, and received countless accolades for his significant contributions to the profession. Over the years, he has received numerous awards, including the Thomas A. Middlebrooks Award and 24th Terzaghi Lecturer from ASCE, election into the National Academy of Engineering, and honorary doctorates from CMU and the University of Genoa, Italy. He was also a founding member of ASFE (now the Geoprofessional Business Association).
Award and ASCE’s Norman Medal, Walter L. Huber Civil Engineering Research Prize, and Arthur Casagrande Professional Development Award.

Wallace Hayward Baker Award
George Filz, PhD, PE, F.ASCE
The 2016 Wallace Hayward Baker Award winner is Professor George Filz, assistant head of the Civil and Environmental Engineering Department at Virginia Tech. He was presented with the award in recognition of his contributions to the development of new ground technologies, specifically to the fundamental understanding of slurry walls, column-supported embankments, and QA/QC of deep-soil mixing.

Harry Schnabel Jr. Award for Career Excellence in Earth Retaining Structures
Ronald W. Steele, PE, M.ASCE
Ronald W. Steele was awarded the 2016 Harry Schnabel Jr. Award for providing over 50 years of design and construction of earth-retaining structures, including excavation support, façade preservation, and structural modification shoring systems. A registered professional engineer in DC, MD, and VA, Steele holds a bachelor’s degree in civil engineering from Purdue University. In 2011, he received that institution’s Civil Engineering Alumni Achievement Award.

Since 1968, Steele has been integral to the geotechnical construction community in the mid-Atlantic region and has established a firm well-respected for its employees’ experience, knowledge, and contributions to the industry.

Carl L. Monismith Lecture Award
Dallas N. Little, PhD, PE, Dist.M.ASCE
In recognition of Professor Carl L. Monismith’s teaching and research career contributions to pavement technology, which spanned more than 50 years, the C. L. Monismith Lecture Award is presented annually for outstanding research contributions in pavement engineering. This year’s winner is Dallas N. Little, a regents’ professor and E. B. Sneed Endowed Chair Professor of Civil Engineering at Texas A&M University. Dr. Little is also the first person at the Texas A&M Transportation Institute to hold the title of senior research fellow. Dr. Little’s unique contributions to our industry include three decades of leadership in pavement engineering, including groundbreaking research on soil stabilization, aggregates, aggregate-binder adhesion and surface chemistry, and asphalt mixture constitutive behavior.

OPAL Awards
ASCE’s Outstanding Projects and Leaders (OPAL) Leadership Awards honor outstanding civil engineering leaders whose significant accomplishments across their careers have contributed to construction, design, education, government, or management. The 2016 class of OPAL winners includes two Geo-Institute members: Rudolph Bonaparte and Jerry A. DiMaggio. The Awards were presented on March 17 in Arlington, VA.

Rudolph Bonaparte, PhD, PE, D.GE, NAE, F.ASCE, is the recipient of the 2016 OPAL Award for design. He is the president, CEO, and principal for Geosyntec Consultants in Atlanta, GA. Bonaparte has extensive experience in the siting, design, permitting, construction, and closure of municipal, industrial, and hazardous-waste landfills and liquid impoundments. He is widely regarded as a national leader in the design and performance evaluation of waste-containment systems for all types of solid-waste landfills and liquid impoundments.

DiMaggio is a principal engineer at Applied Research Associates Inc., working in the research and technology deployment group. Previously, he served as the implementation coordinator for the Second Strategic Highway Research Program at the National Academies in Washington, DC, and as national program manager for geotechnical engineering at the Federal Highway Administration, U.S. Department of Transportation. He has significantly contributed to the development of the American Association of State Highway and Transportation Officials’ Load Resistance Factor Design specifications for more than 20 years.

He also has been a member of the adjunct faculty at the University of Delaware, John Hopkins University, the University of Akron, and Columbia University. His many other honors include ASCE’s Martin S. Kapp Foundation Engineering Award, the U.S. DOT Administrator’s Award, and the International Geosynthetics Society Achievement Medal.

Thomas A. Middlebrooks Award
Adda Athanasopoulos-Zekkos, PhD, A.M.ASCE, and Raymond B. Seed, PhD
The 2015 Thomas A. Middlebrooks Award was presented to professors Adda Athanasopoulos-Zekkos and Raymond Seed for the paper titled, “Simplified Methodology for Consideration of Two-Dimensional Dynamic Response of Levees in Liquefaction-Triggering

The paper makes several important contributions to the state of knowledge, and to the state of practice, with regard to the seismic response and performance of flood protection systems. This is a subject of increasing importance, both in the U.S. and abroad, as both the U.S. and Japan are making unprecedented efforts to better address the issue of seismic levee performance. The procedures presented in the paper form the critical underlying basis for both local- and regional-scale evaluations currently underway for more than 1,050 miles of levees in California’s Central Valley regional flood protection systems, a joint effort by the California Department of Water Resources and the U.S. Army Corps of Engineers that is establishing important national precedents. The paper also makes important contributions to the recommended procedures in the recently developed (and first ever) “Guidelines for Seismic Evaluation of Levees” (ETL 1110-2-580), a draft national guideline (currently under review) by the U.S. Army Corps of Engineers.

Walter L. Huber Research Award
Scott J. Brandenberg, PhD, M.ASCE
Scott J. Brandenberg was named the winner of the 2016 Walter L. Huber Research Award. He received the award for outstanding contributions to characterization of lateral spreading effects on pile foundations, development of design guidelines and fragility functions for pile foundations embedded in liquefiable soil profiles, and evaluation of the seismic response of levees by field testing and case history evaluation.

Dr. Brandenberg completed his PhD in 2005 at the University of California, Davis, and is currently associate professor and vice chair for undergraduate studies in the Civil & Environmental Engineering Department at the University of California, Los Angeles (UCLA).
As I See It

SE Licensure and Partial Practice Laws – Their Potential Impacts on the Geotechnical Profession

By Richard J. Finno, PhD, PE, D.GE, M.ASCE

Over the past few years, I have served on a Geo-Institute (G-I) task force charged to work with a similar group from the Structural Engineering Institute (SEI). The purpose of the task force is to address the G-I’s concerns regarding the Structural Engineering Licensing Coalition’s (SELC) efforts to have states require structural engineering licensure to provide engineering services for certain designated structures. (SELC is comprised of the SEI, the National Council of Structural Engineers Association, the Structural Engineering Certification Board, and the Council of American Structural Engineers.) SELC further recommends that each licensing board adopt rules to define appropriate thresholds for the designated structures, but does not provide guidance for what constitutes a designated structure. The reasoning behind this strategy is to allow each jurisdiction latitude to address the problems that arise locally. For example, California has a clear need to address earthquake hazards in a way that other states may not.
SELC’s efforts are not inconsistent with the goals of ASCE to “raise the bar” for all civil engineers. However, the obvious question is what constitutes a designated structure within each jurisdiction? What happens when a shallow or deep foundation, or an earth retention system, is part of a designated structure? By not providing a model that can be endorsed by the SEI and G-I, uncertainty exists about how geotechnical engineering design would be included within a designated structure if the SELC effort is successful. How large might this impact be on the geotechnical engineering profession? The SELC estimates that about 10 percent of all structures would become a “designated structure” if such a law is enacted in a state.

**Full- and Partial-Practice Laws**

A handful of states already have such laws in place. Furthermore, there are two kinds of laws: full- and partial-practice laws. Full-practice laws require that all structures be designed by a licensed structural engineer (SE). Partial-practice laws require that only designated structures be designed by a licensed SE. Illinois and Hawaii are the only states with full-practice laws. The SE law in Illinois was promulgated in 1915 and predates the state’s PE licensure requirements. The current efforts of the SELC are focused solely on partial-practice laws. States with such laws include California, Nevada, Utah, and Washington.

There are considerable differences and specificity in what constitutes a designated structure in each state. For example, Washington requires an SE license for hazardous facilities, special occupancy structures, essential facilities over 5,000 ft² in plan area or 20 ft in height, structures with irregular features, and buildings over 5 stories or 100 ft in height, bridges with spans over 200 ft, piers with surface area greater than 10,000 ft², and structures where 300 people or more congregate. In contrast, Utah requires an SE license for buildings and other structures representing a substantial hazard to human life, essential facilities, and buildings requiring special consideration. In states with partial-practice laws, a PE license is sufficient for responsible charge when a structure is not designated.

Connecticut has taken another approach. It requires an SE to conduct an independent review of the plans and specifications for structures beyond certain thresholds related to the size and occupancy of structures. The review is paid for by the owner, and the local building official decides who qualifies as a competent structural engineer.

Independent of any post-PE licensure, the code of ethics of a professional engineer dictates that no licensed professional should practice outside their area of competence. So if this simple dictate was followed, there would be no need for partial-practice laws. Unfortunately, these laws were not promulgated without cause.

Regardless, it’s easy to imagine how the practice of geotechnical engineering could be adversely affected by passage of these partial practice laws without special consideration for geo-structures. Having practiced in Illinois for more years than I care to admit, I’ve seen how geotechnical engineering in that state occasionally is relegated to providing drilling services and logs of borings to A/E firms or contractors for a structure that would certainly be considered a “designated structure.” Let’s just say that, in a number of cases, the public welfare was not well served.

**Going Forward**

How should we go forward? Nevada law provides some guidance. It limits the “designated structure” to that portion that is above ground. Examples include: “A building more than 45 ft in height, using the bottom of the lowest footing or the top of the pile cap as the point of reference,” and, “A structure requiring special expertise, including, but not limited to, a radio tower and a sign over 100 ft in height, using the bottom of the lowest footing or the top of the pile cap as the point of reference. Dynamic machinery and related equipment within the scope of mechanical engineering are not included.” Nevada’s law suggests that when a system or component of any project requires specialty engineering services, such services should be provided by an appropriately qualified and licensed professional engineer. Examples of such components include specialty foundations, geotechnical structures, and electrical and mechanical systems.

The Joint Task Force met and agreed on a consensus document that recently was adopted as a policy statement by the G-I and SEI. In it, a Geo-Structure is defined as “any structure that is loaded by or its resistance is derived from the earth, such as earth retaining systems and foundations.”

The statement further says: “Because both temporary and permanent geo-structures may be designs involving SEs, PEs, and GEs,
or any combination thereof, such structures should not be subjected to designation thresholds or SE licensure, even when such elements are part of or support a designated structure. In all cases, an appropriately qualified and licensed professional engineer shall be in responsible charge of the work.” The document then provides examples of such geo-structures.

If eventually adopted by ASCE and individual states that are considering structural licensure for designated structures, then the G-I/SEI Policy Statement (shown here) should allay concerns of geotechnical engineers regarding partial practice laws.

G-I members who have diligently worked on two renditions of this G-I joint task force are Hubert Deaton, John Wolosick, Allen Marr, and Paul Sabatini. The SEI task force includes David Odeh, Randall Bernhardt, and Greg Soules.

G-I/SEI Policy Statement regarding Geo-Structures and SE Licensure

Structural Engineering (SE) licensure is intended to be applied to designated significant structures. It is expected that designated significant structures will typically represent a relatively small number of all buildings and structures within a given jurisdiction. Those buildings and structures that fall outside of established thresholds could be designed by any appropriately qualified and licensed professional engineer.

This document defines Geo-Structures as any structure that is loaded by or whose resistance is derived from the earth, such as earth retaining systems and foundations. Because the design of both temporary and permanent Geo-Structures may involve structural engineers, geotechnical engineers, civil engineers, or any combination thereof, Geo-Structures should not be subject to designated thresholds contemplated for SE licensure, even when these Geo-Structures support a designated structure. In all cases, an appropriately qualified and licensed professional engineer shall be in responsible charge of the work. The following are examples of Geo-Structures:

- **Temporary and Permanent Earth Retaining Systems**
  - Conventional gravity walls
  - Modular gravity walls
  - Mechanically stabilized earth (MSE) walls
  - Non-gravity cantilever walls
  - Tieback anchored walls
  - Soil nail walls
  - Landslide stabilization systems (using any of those systems described above)
  - “Support of Excavation” systems (permanent or temporary)

- **Shallow and Deep Foundations**
  - Drilled shafts
  - Piles, micropiles, tiedowns
  - Ground improvement
  - Rigid inclusions

- **Underpinning of Structures Affected by Excavations**

- **Shafts and Tunnels**

- **Dikes (not used as secondary containment), Dams and Levees, Soil and Rock Slopes**
When it comes to the complexities of underground construction,

**CHOOSE THE RIGHT PARTNER AND CHOOSE THEM EARLY.**
Geotechnical reports must clearly convey the geotechnical engineer’s conclusions and recommendations to the design team and help to manage the project’s geotechnical risk. Partly from the reluctance of architects to directly hire geotechnical engineers as part of the design team, and partly because many geotechnical engineers do not want the risk of actually generating contract documents, the geotechnical engineer often takes a role somewhat outside of the core design team. The result is that management of the geotechnical risk unfairly falls to the engineering team generating the contract documents. Guidelines produced by the Structural Engineering Association of Northern California (SEAONC) Professional Practice Committee, available at seaonc.org/free-publications, strongly recommend that geotechnical risk management should belong squarely with the geotechnical engineers.

In practice, the geotechnical report is intended by its author to function as a reference document for preparation of the contract documents, but is not binding to the contractor (with the notable exception of geotechnical baseline reports). The civil engineer, structural engineer, and other design disciplines (CSMEP with mechanical, electrical, plumbing, and others) are responsible for generating the contractually binding plans and specifications. The geotechnical engineer (the “G” in GCSMEP) has little control over the use of the
To compensate for the lack of geotechnical input to the construction documents, some structural engineers have added a note on their drawings to the effect that the contractor must comply with the recommendations in the geotechnical report. These shortcut directives are dangerous, as they turn the geotechnical report into a construction document. The SEAONC guidelines document states, “A structural engineer who decides to convert the geotechnical report into a construction document can be regarded as the de facto geotechnical engineer...” Then the structural engineer — not the geotechnical engineer — becomes liable for the consequences. Obviously, this significantly increases the liability exposure of the structural engineer, but can also catch the geotechnical engineer unaware if there is an unintended discrepancy between the geotechnical report and construction documents.

Admittedly, involving the geotechnical engineer on all projects will raise design team costs for owners. On larger projects, maintaining involvement of the geotechnical professional through design is common, but rarely does the geotechnical role include drawing development or specification writing. Many geotechnical reports used to include sample specifications, but they have been dropped as part of fee and liability exposure reduction (geotechnical engineers would not be liable for a specification they didn’t author). Sample specifications don’t (and didn’t) belong in a geotechnical report at all; rather, actual specifications should be written by a geotechnical professional as a part of the design team.

On smaller projects, design budgets are smaller. Notes on the drawings are often used in place of formal specifications, and the earthwork, grading, and foundation work is deemed minor in nature. For a small fee, the geotechnical professional can seal and sign a separate drawing prepared by others with the typical contractual obligations (e.g., compaction specification, fill placement thickness, requirements for subgrade checks) prepared from the recommendations of the geotechnical report. This integrates the geotechnical engineer with the traditional CSMEP team, while preserving the geotechnical engineer’s consultant role.

Construction documents should provide the necessary geotechnical contractual obligations and should be coordinated with the geotechnical report. Structural engineers should be wary of including language that inadvertently exposes them to the project’s geotechnical risk by converting the geotechnical report to a contract document. The geotechnical professional community must engage more with the other members of the design team, manage more geotechnical risk during design, and charge an appropriate fee for the service. While this requires the support of our CSMEP colleagues, it’s up to the geotechnical professional community to step in and manage a project’s geotechnical risk, participate in generation of geotechnical aspects of plans and specifications, and be part of the integrated GCSMEP team.

MARTIN WALKER, PE, GE, M.ASCE, is a senior engineer with Arup in San Francisco, CA. He can be reached at martin.walker@arup.com.

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Lessons Learned from GeoLegends


Harry Poulos is recognized as a leading authority in foundation engineering. His other areas of expertise include soil behavior and piled foundations, marine geotechnics, and earthquake geotechnics. Poulos has held dual roles in academia and industry and specializes in tall building foundation design. The dual roles have allowed him to find practical problems, conduct research, and deliver the results back into industry practice. In recent years he has been involved with foundation design for the Burj Khalifa (currently the world’s tallest building) in Dubai, the proposed Incheon 151 Tower in Incheon, South Korea, and the Diamond Tower in Jeddah, Saudi Arabia.

In 1961, Poulos earned a bachelor’s degree in civil engineering from the University of Sydney, where he later obtained a PhD degree in 1965. Before transitioning into academia, he was an engineer at MacDonald Wagner & Priddle. Poulos joined the Department of Civil Engineering at Sydney University in 1965 and was appointed professor in 1982, a position that he held until his retirement in 2001. In 1989, he joined the consulting firm of Coffey Partners International, where he is currently a senior principal with Coffey Geotechnics. He is also an emeritus professor at the University of Sydney, and an adjunct professor at Hong Kong University of Science and Technology. He has published books and technical papers about foundation settlements, pile foundations, and offshore geotechnics, and has been involved in over 300 major projects in Australia and overseas.

Poulos has been internationally recognized by numerous awards and honors. In 1989, he delivered the 29th Rankine Lecture, “Pile behaviour - theory and application,” organized by the British Geotechnical Association. In addition, in 2004 he was chosen to deliver the 40th Karl Terzaghi Lecture, “Pile
behaviour: consequences of geology and construction imperfections,” for his contributions to the geotechnical engineering field. In 1993, he was made a Member of the Order of Australia for his services to engineering, and in 2010, he was elected a Distinguished Member of the American Society of Civil Engineers, the first Australian to be so recognized. He was inducted as a Foreign Member of the U.S. National Academy of Engineering in 2014.

Q. How did you decide to go into geotechnical engineering, and why did you choose or end up working in foundation design?
I have to tell you that even before becoming a geotechnical engineer, my choice of civil engineering was something that I had not really planned to do. I actually wanted to be a chemist, but there are various reasons that I did not end up doing chemistry at university. My high school advisor said that I was not bad at mathematics and suggested I try civil engineering. Then he briefly explained civil engineering, and it sounded cool. So, I did my undergraduate studies in civil engineering with majors in structural and geotechnical engineering. I found structural engineering a little bit repetitive, while I found that geotechnical engineering had certain elements of challenge and novelty.

Additionally, part of the reason was that I had read Terzaghi’s textbook, Theoretical Soil Mechanics, when I was an undergraduate. I did not understand it all that well, but it stimulated me. I realized that projects involving soils and rocks are all different. You could not say the same thing for structures because you have control on what you do above ground. You have to contend with nature for underground structures. So, I decided to study for a PhD in soil mechanics.

Q. How did you decide to go into geotechnical engineering, and why did you choose or end up working in foundation design?

Q. How important is the mentoring?
Professor Ted Davis taught me soil mechanics. He was a nice person and very stimulating in terms of soil mechanics and geotechnical engineering, so I studied under him. It was very fortunate for me because it is important to study with someone you respect, who has a deep knowledge of the subject and real concern for you when you are starting your career. Your mentor should have connections with other people outside the university so that you can grow your network with people who have experience.

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Q. What was the most interesting project, or the project that you learned the most from, during your career?
I guess the most prominent project that I worked on was the Burj Khalifa, the tallest building in the world. It’s not very often that one gets the opportunity to work on such a high-profile project like this. I learned a lot, but there were many other opportunities to learn as well. For example, in 1980, when I was still working full time at the university, we got involved in extensive research on offshore foundations, particularly offshore pile foundation in calcareous soil. At that time, we had a major problem with an offshore platform in Australia, and that led to a whole series of research projects that I supervised. We studied the mechanisms of piles in calcareous soil, along with compressible soils more generally. Calcareous soils are composed of small sea creatures, which, when they die, fall through water slowly and are deposited on the sea floor. So, they have a very high, natural void ratio. That’s the key reason why the capacity of foundations in the calcareous soil is so much lower than in normal onshore soils.
Q. In 2010, you were recognized as the first Australian to become a distinguished member of ASCE. How do you feel about that?

I was obviously very pleased. I have had a long association with the ASCE. I think I joined in 1970 because it was a major source of geotechnical information at a time when we didn't have a vast number of journals. We had *Géotechnique* and ASCE journals, and that was pretty much it in terms of international literature. I was lucky enough to spend my first sabbatical at MIT, and I had a few papers published by ASCE. I also co-authored a few papers with Dr. T. William Lambe, and that was extremely helpful for my career. I have been associated with ASCE for many years and became a Fellow in 1984. This was something that I was extremely pleased about at that time, because it is one thing to be recognized in your own country, but it is another thing to be recognized internationally, particularly here in the U.S.

Q. Do you believe that today’s universities place enough emphasis on both fundamental and practical ideas?

I'm a very strong believer in universities being places where we learn the fundamentals. Unfortunately, some universities have reduced the amount of fundamental work they teach to introduce subjects like management. I’m not saying that management is not valuable; in fact it’s critical. But that’s the sort of thing that you can learn after graduation. I think learning the basic principles for our specialty — physics, mathematics, and now chemistry — is very important. Those are really critical issues, and I think some universities really need to reassess their curricula.

There are many things that can be learned afterwards, maybe as a postgraduate, but once you leave the university, if you haven’t learned the fundamentals, it's going to be a difficult road ahead. I think, particularly in our discipline, understanding the fundamentals of soil mechanics is very important. I look back at some of the giants of our profession, for example Ralph Peck, who was an idol of mine. He never did a finite element analysis in his life, but he knew the mechanics of soils very well. He recognized when there was a problem because he had vast experience, and he understood how soil behaves. If you have an understanding from the fundamentals of what the possible causes of a problem are, you can investigate them more carefully rather than just doing a blind numerical exploration which may or may not reveal the source of the problem.

Q. How has your consulting experience helped you as an educator and researcher? And does this experience help you better explain the concepts in the textbooks?

I feel strongly about this. When I stopped being a full-time academic, I was still a part-time academic, while working primarily with a consulting firm. That was over a 12-year period and probably the best 12 years of my professional career, simply because I worked on lots of interesting projects in the consulting firm that involved unsolved problems. For example, what happens if we drive a tunnel near an existing pile foundation? What should we do with the piles, recognizing that we are creating disturbance and possibly adversely affecting them?

I had a series of PhD students working on those problems, which had arisen directly from practice. The students were enthusiastic because they knew that they were working on a real problem. And from an academic point of view, we perfected certain techniques — and in some
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cases, design charts and methods — that we actually use routinely in practice today. And that’s why I think that combining practice, academia, and research is really a good one; you will find a lot of successful research groups in universities having an attachment in some way to practice. They work on problems that are not only theoretical, but also practical. For example, in the 1960s and 1970s, the late Professor Harry Seed worked on liquefaction, which was a major problem at the time after the earthquakes in Japan in 1964. He and a series of his students worked on the problem, and they came up with the technique which is now widely used, and which remains the basis of common practice today. So that’s a good way of getting research into practice, when there is a definite and urgent need for the research to be done.

Q. How do you balance your family life with overseas projects? What advice can you offer?

Have a very tolerant partner! I’ve been traveling overseas a lot the last few years, and it’s not easy. I’ve been away as much as three or four months a year, although not continuously, but you get to realize how much time you haven’t been at home. You have to look at both sides of things and always try to appreciate the other person’s viewpoint. It’s not easy; it’s a balancing act. The other alternative, which some people are fortunate enough to do, is to take their partner with them. My wife doesn’t like traveling very much, but she does come with me about once a year. She came with me to Paris for the ISSMGE conference in 2013, and she came again to the U.S. last October. For a traveling husband, one other thing that may be necessary is to be prepared to spend a lot of money for jewelry for your wife!

Q. We read that you have a personal library with a large book collection. Can you describe your favorite book and how it affects your life?

Ever since I was young, I’ve loved reading and read fiction and non-fiction. In particular, I enjoy reading philosophy...it is one thing to be recognized in your own country, but it is another thing to be recognized internationally, particularly here in the U.S.
and history. My favorite book probably is *Walden* by Henry David Thoreau. Written in 1854, this very influential book describes two years when Thoreau lived on his own at Walden Pond, a lake in Concord, MA. He wrote about his time there, and how he was able to live in a very healthy and simple way. There are two words from the book that are easy to remember: “Simplify, Simplify.” He said there’s too much complexity and unnecessary things in our lives. If you live a simple life, you can still be happy without needing a lot of material things, like an iPad, iPhone, and television (although maybe you still need books). I first read *Walden* way back when I was 19, and I probably have 10 versions of it. I still enjoy reading about this rather unique person, who was able to put aside complex things in his life and focus on living each day.

**Q. As a professor and GeoLegend, what’s your advice to colleagues? And what’s your expectation for young geoprofessionals?**

For young geoprofessionals I think it’s important to form a geotechnical network and try to positively influence each other. Initially, your mentor will have a major influence on your career. He or she hopefully introduces you to people at a conference who can help you grow your professional circle. That’s one of the good reasons to attend geotechnical conferences. Obviously, there is a technical benefit in terms of learning what is happening, and particularly you can hear good lectures from key persons in the profession, but also you get to know lots of people.

Sometimes these contacts can benefit your future career. Sometimes they can provide ideas for your research, and sometimes you might even be able to collaborate on research with them. As time goes on, there may be a trend for researchers to collaborate more, not so much on individual research, but as part of a research team. It has certainly happened in my country, where I am part of a large, government-funded research project. It is very broad and has three or four different aspects, with 150 geotechnical researchers involved from three universities and four industry partners.
Lessons Learned from GeoLegends

Final Words...
I don’t think of myself as a GeoLegend. I’m just somebody from a rather remote country who enjoys what he is doing. And I’m privileged to be able to travel and see the world as part of my profession. I really hope that you, in your professional life, will be able to get the same sense of satisfaction and pleasure that I have enjoyed in my professional career.

MERVE GIZEM BOZKURT, EIT, S.M.ASCE, is a PhD candidate at the University of Wisconsin-Madison, where she is researching dynamic response of unsaturated soils and implications to the civil infrastructure. She is the vice president of outreach of the G-I Graduate Student Organization at UW-Madison, where she also serves as the representative to the G-I Graduate Student Leadership Committee. She can be contacted at mervegizembozkurt@gmail.com.

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On the Benefits of Being Different
By John P. Bachner

“What makes your firm different?” Insofar as geotechnical engineers are concerned, only one answer is universally applicable. That answer is not “Nothing,” although it sometimes seems to be. For as much as geotechnical engineers lament, “We’re treated as though we’re all the same,” they seem to go out of their way to actually be the same. Consider proposals and reports that you issue to client representatives. How often do the cover letters or emails begin with, “Enclosed please find...,” “Attached please find...,” or “Please see...”? How often do they conclude with, “If you have any questions, please do not hesitate to ask”? 
In fact, if you want to stand out from the crowd, you have to deliver technical excellence that is unsurpassed; on a par with others who are the best of the best...

And while we’re at it, let’s talk about geotechnical engineering reports: How many of them feature the mind-numbing black-left/right-justified-type-on-a-white-background style that was so popular before the invention of the Internet? My guess? 95 percent or more. And how about the writing style used? How many geotechnical engineering reports demonstrate passive-voice addiction – PVA, also mind-numbing – so that things happen without human involvement; e.g., “The study was conducted...” and, “The findings were developed...”? In my experience, the number has to come close to 100 percent. What about changing to something more contemporary; you know, a writing style that became common in, say, 1950, vs. the 1870s when passive voice was so popular!

And how about geotechnical engineers’ routine emails? How often do they conclude with something along the lines of, “I hope you have a great day” or “I hope you have a great weekend”? Again, from what I’ve seen, that hollow hope is used extensively. (Personally, I’ve never understood why senders so limit their false hopes. Why not say something like, “I hope the rest of your life is wonderful”? It costs no more than a hope for a good ten more hours or even a whole weekend. And you only have to say it once!)

What about your offices? Do they rely on cubicles? Are those who inhabit them given the freedom to have a variety of personal articles on display, so that visitors to the office are treated to a wholly unprofessional, visual hodgepodge? What’s on the walls? Are they bare, for the most part? And tell me about the furniture: Is it modern and comfortable? Or does it not even get a second thought… or cleaning?

Here’s the issue in a nutshell: If you do the same things as every one of your competitors, how can client representatives and colleagues not think geotechnical engineers and their firms are all the same? And if they think you’re all the same, how can you get upset when they ask you to submit a priced proposal or just a price? You’re doing this to yourselves!

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little-things-mean-a-lot things differently — by doing things almost exactly as all your peers/competitors do — you have turned your professional community into a professional commodity where price seems to be the only real differentiator.

Now imagine a geotechnical engineering firm that delivers its proposals and its reports’ executive summaries via YouTube videos, in addition to the written word. And imagine those documents that convey written words doing so in the active voice while complementing that difference by using photos, color, and hyperlinks to make the documents more similar to modern websites than 19th-century treatises prepared as cures for insomnia. Imagine a proposal that allows recipients to connect to videos that convey one- or two-minute autobiographic summaries of each proposed team member. Imagine an office that uses interesting colors on the walls, and good graphics — good art of some type, perhaps even the art of youngsters who created their pieces as part of an area-wide contest sponsored by your firm.

Do you realize that, if you broke the mold, you would be more or less alone? You wouldn’t have to answer, “What makes you different?” with lame responses like, “We really care” or “We’re employee owned.” Your business cards would be different (maybe printed on clear plastic); your proposals would be different; so would the appearance and content of your reports and your offices. But you would not be different just to be different; you would be different to better relate to the times we live in and the profession you represent. That superior difference would not excuse you from performing your technical services well, of course. In fact, if you want to stand out from the crowd, you have to deliver technical excellence that is unsurpassed — on a par with others who are the best of the best… but whose penchant for looking and sounding like all the others just about nullifies their technical advantage.

But what about that one universally applicable response to, “What makes your firm different?” Do you know what it is? It’s this: “I do,” preferably augmented with something like “… because mine is the only geotechnical engineering firm that provides me to handle your account and show you what truly world-class service is all about.” Of course, few if any geotechnical engineers would dare say anything like that, because that’s not what anyone else in the herd does. And that needs to change, because – until geotechnical engineers and their firms dare to be different – the best of the bunch will look just like the worst: the ones that feed on the bottom. If that’s not acceptable to you, do something about it. I dare you.

JOHN P. BACHNER is an independent consultant who served as the Geoprofessional Business Association’s (GBA’s) executive vice president from 1973 through 2015. GBA is a not-for-profit association that develops programs, services, and materials to help its member firms and their clients confront risk and optimize performance. GBA-Member firms provide geotechnical, geologic, environmental, construction-materials engineering and testing (CoMET), and related professional services (en.wikipedia.org/wiki/Geoprofessions). GBA invites geoprofessional constructors, educators, and government officials to become involved. Contact GBA at info@geoprofessional.org.
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NATURE SIDES WITH THE HIDDEN FLAW
LESSONS LEARNED FROM FAILURES OF EARTH-SUPPORT SYSTEMS

By James W. Niehoff, PE, M.ASCE
n recent years, the demand for excavations and fills of significant height has increased due to many factors, including requirements for below-grade parking for urban buildings and the need to construct on sites with difficult terrain and topography. Fortunately, substantial advances in engineering techniques and systems are now available for the support of cuts and fills, including mechanically stabilized earth (MSE), soil nailing, contiguous pile walls, diaphragm walls, deep soil mixing, and soil freezing, among others.

But despite our increasing knowledge and understanding of soil-support systems, failures still occur with some regularity. Failures are defined as support systems which do not fully meet project performance criteria or the end users’ expectations. While there are many causes for failures of earth retention systems, most can be attributed to:

- Soil and groundwater conditions that were inadequately characterized
- Insufficient or improper engineering evaluation
- Limitations of construction equipment and procedures
- Changes to the design during construction

The study of failures is critically important to advance the state of practice and to avoid similar problems on future projects. The following case histories illustrate just a few of the types of issues that can result in the poor performance of engineered systems supporting earth cuts and fills.

**Crib Walls**

In the late 1970s, several companies introduced proprietary concrete crib wall systems, which could be designed and installed for costs well below cast-in-place retaining walls. As part of a package design-build system, one such firm used a computer program that “designed” crib walls considering the wall height and the engineering properties of the retained soil and backfill. This program considered the wall to be rigid and assessed sliding and overturning resistance for the selected crib configuration. Many of these crib walls, 15 to 25 ft in height, were designed and installed with success. However, walls 30 ft and higher were found to consistently fail over a period of time (Figure 1).

Forensic studies of the failed walls focused on soil and water conditions, as well as the overall geometry of the wall system. They confirmed that the failed walls incorporated adequate factors of safety against sliding and overturning using accepted analysis procedures if the walls behaved rigidly, as assumed in the computer program. However, observations revealed that the taller crib walls had deformed prior to failure, resulting in an outward bulge within the lower third of the wall.

*Figure 1. View of shear plane in soil caused by utility line construction.*
Conditions can differ beyond the limits of the project site, particularly when soils have been disturbed by previous construction or the installation of utility lines.

It was clear that the walls were not behaving as rigid gravity structures, but were relatively flexible. This flexibility caused the center of gravity of the walls to shift outward during construction, resulting in stress concentrations on the toe of the walls. Differential settlements caused by these high toe stresses gradually increased the deformation of the walls, further shifting the center of gravity outward. Ultimately, some of the concrete crib elements became overstressed and fractured, causing catastrophic wall failures.

While computer programs have clearly simplified the practice of engineering, it’s critical that they consider not only the proper soil conditions and properties, but also accurately model the support structures. No engineer should rely on the output of any computer program without understanding the methods of analysis used and their limitations.

**Beyond the Cut**

A major office development in the southeastern U.S. required an excavation to a depth of 30 ft below surrounding grades to provide for three levels of below-grade parking. Soil conditions within the depth of excavation consisted of competent residual clayey and sandy silts derived from the weathering of native granitic gneiss and schist bedrock. The bedrock was generally found to be present at or within a few feet of the lowest basement level. To support the excavation during construction, the plans called for the cut to be graded to a 1.5H:1V slope to a depth of 5 ft. Below this level, a conventional soldier beam and lagging system with anchors was selected to support the vertical cut to the lowest basement grade.

The upper part of the cut was successfully sloped, and soldier beams were driven into weathered bedrock a few feet below the proposed depth of the cut. The excavation continued downward toward the first row of tie backs, which were to be installed at a depth of about 15 ft below street grades. Before reaching this elevation, however, the soldier beams rotated inward several feet, causing damage to the adjoining street.

A forensic investigation of the failure revealed that a deep, buried utility line was present beneath the street, a few feet beyond the property limits. The vertical cut for the utility trench had created a weak plane in the soil extending to a depth of greater than 10 ft (Figure 2). As a consequence of this weak plane, the soil offered insufficient shear resistance against a global slope failure.

As with most projects of this type constructed in urban settings, the geotechnical exploration was limited to the project site itself. Subsurface conditions beyond the site boundaries were extrapolated for the purposes of shoring design, assuming some consistency with boring data collected within the property limits. As this case history demonstrates, conditions can differ beyond the limits of the project site, particularly when soils have been disturbed by previous construction or the installation of utility lines.
While it’s often difficult to obtain subsurface data offsite, consideration must be given to potential anomalies and variations in subsurface conditions beyond the limits of the cut, as these conditions can adversely affect the performance of the earth retention system.

A Tale of Two Secant Pile Walls
Two projects in a large western city required several levels of below-grade parking as a result of building height restrictions and other factors. Both sites were underlain by 40 to 50 ft of coarse alluvial sands, gravels, and cobbles deposited on top of relatively continuous and competent shale bedrock. Groundwater was present at a depth of about 20 ft below the ground surface throughout the area. Most similar buildings in the site area had employed soldier beam and lagging systems coupled with extensive dewatering systems to excavate sites for basement construction. However, due to the required 40-ft cuts, coupled with the site’s proximity to surface waters, it was estimated that a dewatering system would need to discharge over 2,000 gal/minute to keep the excavations dry using this approach.

Consideration was given to using a number of alternative excavation bracing and cutoff wall systems. Ultimately, a secant wall was chosen as the most cost-effective system for both sites. A secant wall consists of a series of overlapping piles which extend through pervious strata into low-permeability materials and serves both as an excavation bracing system and as a positive barrier to groundwater infiltration. Typically, low-strength piles are constructed first on a roughly 1-1/2-pile-diameter spacing, center to center. Then, high-strength, reinforced piles are drilled between and into the outer portions of the low-strength piles, creating a continuous wall. Templates are employed at the ground surface to control the overlap of adjacent piles to produce the required seal.

For both of these projects, the secant walls were designed with multiple levels of tie back anchors to provide supplemental lateral support during construction. The tiebacks were to be destressed and cut as the building frame progressed upward and provided permanent lateral support for the wall system.

For the first of the two projects, secant piles were installed using a thick-walled casing fitted with cutting teeth, which was advanced through the overburden soils and into the upper portion of the bedrock. The casing was subsequently cleaned out and the borehole advanced to its final depth with a conventional pier drilling rig. Upon completion of each borehole, concrete was introduced by freefall from the top, through the open casing. The casing was then extracted.

The second project employed a continuous flight auger (CFA) system for secant pile installation. In this technique,
augers were advanced using a template at the surface for alignment, through the overburden soils and into the underlying bedrock without the use of casing. Torque was measured during the drilling process to confirm proper penetration of the augers into the bedrock. Then, concrete was pumped through the auger to the tip, forming the pile as the auger was slowly withdrawn. In general, this approach proceeded more quickly than the casing method of secant pile installation.

Materials interior to the sites were subsequently excavated in stages to final grades, with tiebacks furnishing intermediate support. Both walls were found to be structurally intact and sufficiently strong and rigid to support earth and hydrostatic pressures.

The wall installed by the casing method was found to be straight, properly aligned from top to bottom, and relatively watertight (Figure 3). In contrast, the wall employing the CFA methodology was found to be consistently straight and in alignment only within the top 15 to 20 ft. In some areas, the lower portions of the piles were found to deviate from vertical up to 30 in. (Figure 4). This resulted in poor seals between adjacent piles in numerous locations, which, in turn, allowed significant seepage. In one area, the gap was large enough to permit erosion of materials from the outside of the wall, which triggered localized subsidence. The cause of the misalignment was attributed to variations in subsurface materials and the flexibility of the auger flights.

For the ground conditions in this geologic setting, the casing method of secant pile wall installation more fully met project specifications and developer expectations. Conversely, the wall employing the CFA system required significant post-construction grouting to compensate for poor pile alignment. Both of these techniques can and often do provide high-quality excavation bracing and cutoff wall systems. However, field experience provides critical information for the proper selection and use of appropriate construction methodologies for specific wall depths and geologic conditions.

MSE Wall

In the late 1980s, a major southern city elected to widen an interstate highway through its downtown area. To provide for grade separation at the location of an access ramp, the highway designer selected an MSE system. Backfill for the MSE wall consisted of a relatively clean, medium to coarse sand to provide high friction with the reinforcing elements as well as effective drainage.

Just before construction, a representative of the state department of transportation expressed some concerns that the sand backfill would allow water to penetrate into the foundation soils, which consisted of highly plastic, expansive clays. As a consequence, the contractor was directed to install a layer of plastic between the sand fill and the underlying clay. The original designer of the proprietary wall system was neither consulted nor informed of this design modification.

Shortly before the wall was completed, it rained heavily. By the next morning, a portion of the wall had shifted laterally into the shoulder of the highway — a distance of up to 14 ft (Figure 5). The failure investigation focused on the layer of plastic at the base of the wall. Tests revealed that the shear strength of the plastic-clay interface was no greater than 300 psf. A sliding stability analysis indicated a factor of safety of less than 0.5, assuming that the sand backfill had become saturated to about 8 ft above the layer of plastic.

This incident points to the fact that the modification of one part of a design can have an unintended impact on the overall performance of an earth support system. It’s critical that the design engineer be involved in and evaluate the consequences of any changes to confirm that performance will not be adversely impacted.

The Path Forward

Geotechnical engineering relies heavily on the observational method, wherein all aspects of exploration, analysis, design, and construction are subject to review and modification based upon positive and negative field performance.

At present, positive experiences tend to dominate the profession’s communication channels. Failures result in lawsuits, which often restrict the wide dissemination of information relating to causation and lessons learned. As a consequence, geotechnical engineers must take the initiative to reach out and communicate with each other as well as with structural engineers and contractors to learn from their collective project experience and advance the state of practice.
At the same time, owners and developers must understand and accept that there are limitations to the characterization of subsurface conditions and to the methods of analyses of complex geostructural systems. Despite advances in the collection and evaluation of data, and in construction techniques, there will always be a risk that designs will not fully meet client expectations. The communication of these risks to project owners is, and always will be, a critical part of the overall design and construction process.

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Soil Nailing in the 2010s

Its Evolution and Coming of Age

By Carlos A. Lazarte, PhD, PE, GE, M.ASCE, Helen D. Robinson, PE, M.ASCE, and Allen W. Cadden, PE, D.GE, F.ASCE

While the early 2000s witnessed soil nailing as a well-established method in the U.S. for providing temporary and permanent support of excavation (SOE), the technique has since continued to evolve thanks to the unceasing ingenuity of manufacturers, contractors, and designers. The advancement of soil nailing has also been bolstered by public and private entities that have expanded its use through increased acceptance for new temporary and permanent project conditions. This article presents a broad view of recent innovations and advances of this technology in the areas of materials and applications.

The descriptions provided herein go beyond the use of permanent soil nail walls for public transportation projects, which was the focus of Geotechnical Engineering Circular (GEC) 7, first published by the Federal Highway Administration (FHWA) in 2003 and then reissued in February 2015. The article also presents innovations derived from projects in the commercial sector.
Tiered soil nail walls and tiebacks. Layout includes cut faces inclined at 0.5H:1V. Benches 20-ft wide and a tie beam to support a row of tiebacks.

(Photo courtesy of Schnabel Engineering.)
Conventional Definition of Soil Nails

With recent advances in related technologies, a clarification about what is classified as a soil nail is needed. Over the last few years, some soil-reinforcing technologies resembling traditional soil nails have emerged, including “launched” soil nails and “screw” nails. However, when the governing stability mechanisms and load transfer from the reinforcing elements to the ground are considered, these alternative technologies differ from conventional soil nails. To distinguish between those alternative techniques, soil nails are defined as passive elements that:

- Are drilled and grouted sub-horizontally in the ground to support excavations in soil or in soft and weathered rock
- Contribute to the stability of the system, mainly through tension in the reinforcement as a result of deformations in the retained ground
- Transfer tensile loads mobilized in the nails to the surrounding ground through shear stresses (i.e., bond stresses) developed along the grout-ground interface
- Develop resistances that can be estimated with established design procedures
- Have long-term, demonstrable corrosion protection to ensure adequate, long-term performance of the system
- Interact structurally with the facing of the excavation
- Are load-tested according to prescribed methods
- Are routinely subject to construction QC/QA, according to established procedures

Added Advantages from Innovations

The numerous advantages that were already offered by soil nailing, including relatively small space requirements, quick installation, ease of field adjustments, reasonable tolerance to ground movements, and structural redundancy, have been increased by recent innovations and advances. Nowadays, the use of soil nails in conjunction with other systems provides a broadened range of design alternatives. These alternatives, called hybrid systems, allow even greater flexibility to accommodate challenging topographic and sub-surface conditions, as well as to support greater surcharges than those traditionally considered with soil nails alone.

Product and Material Innovations

Solid Bar Soil Nails (SBSN). A wide range of bar types, grades, and sizes are available in the U.S. today. Steel reinforcing bars, also called tendons, are commonly available in Nos. 6, 7, 8, 9, 10, and 11 bar sizes, and occasionally in larger diameters. Tendons with a diameter smaller than No. 8 are not commonly used, and No. 14 and larger sizes may result in design inefficiency. The tensile capacity of large-diameter bars might not be fully utilized because they are limited by pullout resistance (a geotechnical limit state) and/or the strengths of facing elements (alternative structural limit states).

Solid bars are now typically available in Grades 60, 75, 95, and 150 (ksi), but bars in Grades 60 and 75, which are ductile steels, are most commonly used. While soil nails have been designed using Grade 150 tendons, these are more routinely used as ground anchors due to the much larger load capacity requirements of ground anchors compared to those of soil nails.

Hollow Bar Soil Nails (HBSN). The main advantage of HBSNs is that the drilling, grouting, and bar installation are all completed in a single process, thus saving time during construction. HBSNs are advanced by injecting grout under pressure through the hollow bar and out through ports located in the sacrificial drill bit. The injected grout flushes soil cuttings out of the drill hole while filling the annulus between the bar and the drill hole.

HBSNs have been particularly successful when installed in collapsible soils (e.g., moist and submerged sands with little or no apparent cohesion). In this setting, the pressure-injected grout flushes soil cuttings, helps advance the bit, and supports the drill-hole against collapse. Hollow bars range in size from about 3/4 to 3 inches OD. The steel is available in average yield strengths of 85 ksi and ultimate strengths of 105 to 110 ksi.
Glass Reinforced Polymer Fiber (GRPF) bars. Composite GRPF bars have been used as soil nails on a few projects for temporary SOE applications. While achieving tensile resistances as high as steel bars, they can dramatically reduce corrosion issues associated with metallic reinforcement. In some highly-congested urban settings where myriad modern data-transmission lines (e.g., fiber optics) exist, GRPF bars can also help eliminate the interaction of metallic elements when the data transmission lines are buried near a soil nail wall. Another advantage is that Tunnel Boring Machines (TBMs) can penetrate faces that have been stabilized with GRPF soil nails, as opposed to steel reinforcement, which would otherwise damage the cutting tools of the TBM. However, potential disadvantages associated with GRPF bars include relatively low shear resistance and difficulties with load testing.

Fiber-Reinforced Shotcrete. Conventional steel rebar and welded-wire mesh (WWM) continue to be the most commonly used facing reinforcement in soil nail projects. However, polymer and steel fiber-reinforced shotcrete is occasionally used, as it may offer advantages for some project conditions. For example, fiber-reinforced shotcrete may allow a highly irregular excavated face or natural ground surface to be stabilized with soil nails.

The previous scenario often arises with cuts into rock or rock-like soils. In these cases, it's desirable to avoid fabricating overcomplicated rebar/WWM sections for the reinforced shotcrete, primarily due to the excessive labor involved. In addition, fiber-reinforced shotcrete can be used if a flush finish is not needed. The use of fiber-reinforced shotcrete reduces shotcrete quantities by contouring the undulations and crevices existing on the exposed, highly irregular surface. Design methods for fiber-reinforced shotcrete in soil nail wall facings have not been fully established or vetted, and there is some active discussion in the industry regarding the shotcrete flexural capacity and modulus of rupture. There is also concern related to the unreinforced cold joints between facing lifts, which are not present when using overlapping WWM and rebar.

Epoxy Coatings. A wide selection of fusion-bonded epoxy coatings is now available to provide soil corrosion protection. The coating is applied to the tendon and shotcrete facing rebar.
Nowadays, the use of soil nails in conjunction with other systems provides a broadened range of design alternatives. These alternatives, called hybrid systems, allow even greater flexibility to accommodate challenging topographic and subsurface conditions, as well as to support greater surcharges than those traditionally considered with soil nails alone.

by the bar manufacturer or fabricator. These epoxy coatings are usually referred to as “green,” “gray,” and “purple.”

The traditional, green epoxy coating is more flexible than the gray and purple varieties, and hence is more commonly used when bars are bent after the epoxy-application. The less flexible gray and purple coatings are usually applied when bending of the bars is not anticipated and when a greater chemical resistance is required. Damage to epoxy-coated bars must be avoided during fabrication, transportation, and installation because once a nick is created in the coating, the potential for localized pitting corrosion may substantially increase under certain conditions.

Galvanization or Zinc-Coating. This coating, which is applied by hot-dipping bars and other metallic elements, furnishes a protective layer of sacrificial zinc oxide that provides both physical and chemical protection. Galvanization has been used in commercial soil nailing projects for years; however, it was not until recently that zinc-coating began to be accepted more routinely for SBSNs in public transportation projects.

Corrosion Protection for HBSNs. Special consideration must be given to the durability of HBSNs during design because the protection provided by epoxy- or zinc-coatings is often compromised during installation. Coating damage can result from abrasion caused by the grout and soil cuttings exiting the drill hole and the movement of bar centralizers during drilling and flushing.

Research has been conducted to evaluate the performance of coatings applied to HBSNs by observing corrosion patterns on tendons that had been removed from the drill hole before the grout set. These bars were all installed in generally comparable subsurface conditions and using essentially the same installation methods. Several corrosion features, which were accentuated as the exhumed bars were left outside for several months, are shown in Figure 1.

The zinc coating exhibited fewer and smaller corrosion features than the two types of epoxy coatings, but still showed delamination. These observations confirm statements made in an FHWA report titled Hollow Bar Soil Nails Pullout Test Program (FHWA-CFL/TD-10-001); when corrosion protection must be provided to HBSNs, the only reliable corrosion protection method for these bars is using sacrificial steel (GE 7 provides guidance on this matter).

Other Material Advancements. A grout consisting of a highly-permeable mix of cement and aggregate can be installed along with soil nails to help relieve hydrostatic pressures developing behind the soil nail wall. These drilled drains should ideally slope toward the facing to favor drainage (usually 5 to 10 degrees), and may be placed alternating with conventional soil nails. As an added benefit, drilled drains can also reduce ice pressure build-up behind the facing of soil nail walls during periods of freezing. Drilled drains are typically installed in a single operation, without casing and using rotary percussion drilling.

During soil nail installation, the potential for drill hole collapse or grout leakage may be excessive in highly permeable, granular soils, such as poorly-graded gravel with an open matrix and no cohesion. This potential may still exist even if stiff grout is used, and its occurrence will likely result in poor grout coverage and/or low bond stresses. Some contractors have successfully used a grout “sock,” which consists of a geotextile sheath placed around the steel bar and tremie pipe before the entire assemblage is placed in the drilled hole. This system greatly reduces the potential for drill-hole collapse and grout flow into the surrounding soils.

The costs of these innovative products and materials vary, and the cost impacts are largely a function of the unique project conditions. For example, the added costs of providing permanent corrosion protection by epoxy- or zinc-coatings, when their use is admissible, are nominally low in most projects. In some projects, the unit costs of these innovative
materials and/or products are higher than that of conventional materials, but their use results in a shortened construction schedule, and may ultimately result in less costly construction overall. GRPF bars are generally much more expensive than steel bars.

**Innovative Uses**

*Hybrid Soil Nail/MSE Walls.* Innovative uses of soil nail walls include the combination of these walls with mechanically stabilized earth (MSE) walls in cut/fills, where the construction of a full-height MSE wall (significant excavation) or secant drilled-shaft wall would be too expensive (Figure 2). This scenario may arise in projects involving the widening or raising of roadways over existing sloping terrain. The design of these hybrid systems requires engineering the reinforcements separately, where the MSE section is designed using conventional methods and the soil nails are designed considering the effect of the MSE wall above as vertical and horizontal surcharges. Alternatively, they could be designed as a single system, where suitable limit-equilibrium, slope stability software is simultaneously used to model the soil nails and the MSE reinforcement.

Design engineers must make special considerations to evaluate global stability. Critical slip surfaces may not be apparent using the separate, conventional approach. Special design provisions are needed for the connection between the facings of the soil nail and the MSE portions. The connection can be resolved with a step back at the top of the soil nail wall. In this case, each portion is treated differently. The step back also offers a working platform to help erect the MSE facing panels. Alternatively, the facing connection can be resolved as a continuous facing, where precast-concrete panels are used from bottom to top, after an initial facing is competed in the soil nail portion.

*Shored Mechanically Stabilized Earth (SMSE) Walls.* Soil nails can also be used in fill areas where the terrain is too steep and not enough room exists to create a flat bench for placing MSE reinforcement at its conventional length-to-height ratios. In these cases, soil nails can be used as a shoring system to stabilize the back-cut first (Figure 3), and then the MSE wall is erected in front of the soil nail wall (FHWA-CFL/TD-06-00). Because the soil nails support some of the lateral loads from the back-cut, the long-term, lateral earth pressures to be supported by the MSE wall can be smaller than those considered in conventional MSE design. In very steep terrain, the evaluation of deep potential slip surfaces is also critical.

*Soil Nails and Ground Anchors.* Soil nails and ground anchors (or tiebacks) can be used in combination when sensitive structures exist above the wall and where lateral movements of the cut must be controlled. Such combinations can also help create tall cuts in residual soils and soft, weathered rock without the need for excessively long soil nails. In these situations, soil nails provide local stability near the cut surface. The tiebacks, which can develop much larger tensile capacities than the nails, contribute to the global stability of the system.

An example of this use is a series of walls created in Alabama to support cuts with a maximum retained height of approximately 116 ft (Figure 4). The subsurface at the site consisted of residual soils (sandy clay, sand, silty sand, and sandy silt) and weathered rock, predominantly sandstone. The wall included two- to four-tiered soil nails walls, and 1-3 rows of tiebacks. The layout consisted of cut faces sloped at 0.5H:1V and 20-ft-wide benches between the wall tiers to provide access and improve overall stability. Drainage collection systems were installed at the base of each wall tier to eliminate potential groundwater buildup.

*Other Uses of Soil Nails.* One recent case study combined the use of soil nail walls with a hybrid system of secant piles, which were supported by tiebacks, and permanent anchors for the construction of a new spillway for an existing dam (Figure 5). The secant piles were utilized to support large
lateral loads at the spillway. In areas adjacent to the spillway, soil nails were used to support cuts in a reduced space to protect the existing structures.

**New Applications Are Now Available**

Numerous innovations, including the combined use with other systems as described above, have resulted in soil nails being selected for projects with more difficult ground conditions and with larger load capacity requirements than previously would have been considered. The cost and schedule benefits offered by these innovations continue to make soil nailing one of the most advantageous earth-retaining systems used in top-down construction, both as temporary and permanent SOE.

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The Geo-Institute Chapter of the Colorado Section of the American Society of Civil Engineers (ASCE), the Rocky Mountain Section of the Association of Environmental & Engineering Geologists (AEG), and the Colorado Association of Geotechnical Engineers (CAGE) have hosted the Rocky Mountain Geo-Conference since 1984. This conference focuses on geotechnical projects in Colorado and the Rocky Mountain Region, and is a one-day opportunity for geo-professionals to share experiences and state of the practice with their colleagues. Papers will be published by ASCE as a Geotechnical Practice Publication (GPP) and distributed at the conference.

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EMERGENCY RETAINING WALL REPLACEMENT

The East 26th Street Slide Repair in Baltimore, MD
During a record rainfall on April 30, 2014, a century-old, stone retaining wall between a dense urban roadway (26th Street) and the CSXT railroad track in Baltimore, MD, failed. The stone retaining wall was approximately 320 ft long and over 40 ft tall. The wall connects two tunnel portals — the railroad tunnel below North Charles Street on the west side, and the railroad tunnel below St. Paul Street on the east side (Figure 1). The failure sent part of the roadway, along with tons of soil, boulders, light poles, and eight parked cars, nearly 40 ft down, obstructing the tracks and halting rail traffic on this very busy railway that provides service between the Port of Baltimore and the north. Fortunately, no one was injured. Video of the failure, captured by onlookers, was broadcast via national media (youtu.be/MrNluXrrHKY). The failure forced the evacuation of 19 homes until the first phase of earth-retention construction was completed. Due to the time sensitivity of the temporary retaining wall construction, the City of Baltimore (City) engineer, general contractor, and geotechnical contractor collaborated and worked seven days per week until the residents were able to return to their homes.

Emergency Response and Construction Mobilization

Emergency responders began by removing cars from the street level and pulling eight cars and much soil off the tracks. To stabilize the failed slope while minimizing the duration of the railroad traffic disruption, a temporary rock buttress was constructed using on-site granite blocks and soil cleared from the failure. Before any stabilization could occur, emergency personnel removed a ruptured sewer line from service, bypassed water and turned off gas services, relocated residents for their safety, and protected the slope from being further damaged by water. Crews mobilized excavators and cranes to remove the cars, boulders, and soil from the railroad tracks within hours after failure of the wall (Figure 2), and installed safety fencing at the top of the failed slope.

By Joseph K. Cavey, PE, M.ASCE, James A. Guinther, PE, M.ASCE, and Anthony E. Passaro
Several large blocks (3 ft tall x 4 ft wide x 12 ft long) of the failed wall had fallen down into the debris, which had to be trucked off the site one at a time. Whitman, Requardt and Associates, LLP (WRA), retained by the City, designed a temporary soldier pile and lagging wall with tieback anchors along the centerline of East 26th Street. This stabilized the street and area in front of the homes, which provided a safe and stable platform to allow permanent wall construction. Residents could then return to their homes as quickly as possible.

The plan of action for a temporary and permanent wall allowed crews to begin construction while permanent repairs were designed and approved. With the plan in place, the large granite blocks could be removed along with the unsuitable soil and debris. A safe distance of 20 ft from the curb line was established for all heavy equipment, which left a border of approximately 10 ft from the edge of the slope failure (i.e., the edge of the cliff that was left after the wall collapsed).

Because the wall failure was located so close to busy St. Paul Street, and because it affected railroad traffic and displaced so many residents, immediate engineering decisions were needed. Public safety, rail line traffic, and a well-devised plan for working around an unstable slope had to be considered — quickly. The City granted emergency permits for moving oversized equipment on roadways, which allowed heavy equipment mobilization to occur within one day. The City also collaborated with the county and city permitting agencies between Philadelphia and Baltimore to accelerate the permit. (Typical mobilizations require 7 to 10 days to secure permits and transport equipment and material to the project site.)

**Soil Exploration and Subsurface Conditions**

Immediately after the wall failed, the City retained WRA to assist with emergency response and to design the temporary and permanent wall repairs. The site was quickly surveyed, and survey monitoring points were set up along the residences on the night of the incident. All of the monitoring and assessing helped to develop an immediate plan of action.
Subsurface investigations, including borings, ground penetrating radar (GPR), and test pits, were conducted along with the installation of monitoring equipment. The borings taken along the 320-ft-long section of East 26th Street indicated that the subsurface profile included 7-9 ft of clay, which was likely fill material, overlying 15 ft of silty sand, overlying 20-40 ft of silt/decomposed rock. Gneiss bedrock was encountered at a depth ranging from 40-70 ft.

Because of the wall failure along East 26th Street, the City requested that the surrounding streets of Charles, St. Paul, and East 26th, east and west of the incident site, be investigated for voids under the roadway. The results of these tests found anomalies along Charles Street and East 26th Street that warranted further investigation to confirm that no voids were present below the roadway. Test pits were then excavated at any location where an anomaly was found during GPR testing. Geotechnical instrumentation was installed to monitor points on East 26th Street ground and slope movement. Two inclinometers were placed along East 26th Street between the failed wall and the existing row homes to monitor for movement during the reconstruction.

**Concurrent Design and Construction**

The permanent wall would consist of a 43-ft-tall (maximum height), concrete gravity wall; however, a temporary soldier pile and lagging wall would be constructed as one of the first steps in the emergency response to allow for track clearing, occupancy of the adjacent housing, and permanent wall construction. The soldier pile wall was aligned along the center of East 26th Street, and the permanent gravity wall was constructed between the temporary wall and the railroad tracks, along the alignment of the previous wall. The soldier pile wall was braced by three rows of temporary anchors. Figure 3 shows the geometry of the anchored soldier pile wall and approximate stratigraphy.

Construction of the temporary wall commenced prior to final design of the temporary wall. For example, determination of final anchor loads, wale sizes, and anchor spacing had
not been completed before soldier pile installation. Similarly, the design of the permanent wall was ongoing during construction of the temporary wall. Additional soil exploration and design calculations were conducted concurrently with soldier pile installation.

Soldier piles with anchors extending through walers were selected for the temporary wall for logistical reasons: the HP14x89 soldier piles could be obtained quickly; stabilization of the ground surface was possible without working on the track side; and the wall could be constructed through saturated conditions which existed at the bottom of the wall.

Hayward Baker, Inc. (HBI) installed the soldier piles and tieback anchors. Figure 4 shows the site conditions during soldier pile installation. Drilling for soldier piles and anchors was challenging due to variable conditions of collapsing sand, silt, decomposed rock, and hard bedrock. Temporary casing was placed for the soldier piles at the pile locations where collapsing soils were encountered. On the east side of the site, very hard rock was encountered, requiring a large, air-driven, down-the-hole hammer to drill out sockets at each location. In addition to the unexpected time required to drill the very hard rock, additional time was required to move two drills onto each soldier pile hole. One drill was used to auger the upper soils and set a casing through the soil, and the other machine was used to drill the rock socket. Soldier pile installation was completed within 30 days, requiring continuous, seven-day-per-week construction.

Lagging and tieback anchor installation began 47 days after the collapse, and the first row of anchors was completed on day 69. The initial group of anchors was installed on the first (uppermost) row with a post-grout tube and was subsequently post-grouted. This procedure allowed the anchors to reach the 100-kip design load successfully. Several first-row anchors were installed without post-grouting, and they also successfully reached the 100-kip design capacity.

The second (middle) row of anchors was installed from 76 to 105 days after the collapse, and the third (lowermost) row from days 112 to 141. Post-grouting was not performed on the second row of anchors, based on the observed load test performance of the first row anchors. However, initial testing of anchors on the second row demonstrated that the required capacity had not been reached. Therefore, remedial anchors were necessary, and post-grouting was performed on all remaining anchors. The need for post-grouting the second and third rows was largely due to the anchors being bonded in the silt layer, rather than the upper sands. Drilling on the
third row proved more difficult because equipment had to be moved around a large mound of soil, which had been used to raise the excavation equipment to allow for soil to be lifted to the road elevation. An example of the site congestion and working conditions is shown in Figure 5.

The temporary wall required over four months to complete. When it was done, reconstruction of the permanent, concrete gravity-retaining wall began in September 2014. Crews excavated everything between the face of the pilings and the railroad tracks as installation of the tiebacks progressed. Once the subgrade elevation was reached, subgrade verification testing was conducted in accordance with guidelines set by CSXT. Following subgrade verification, construction of the new 40-ft, cast-in-place retaining wall, which incorporated architectural treatments and a concrete face that matched the railroad tunnel portals, commenced. A schematic of the geometry and details of the permanent wall, in relation to the existing structures and temporary wall, is provided in Figure 6.

WRA civil engineers also collaborated with the City’s Department of Public Works to design sewer and storm drain replacements along the corridor. To expedite approvals, keep construction crews progressing with construction and procurement of materials, and to allow for community input, the two entities agreed to break the job up into emergency and temporary support of excavation plans, permanent retaining wall plans, and final roadway restoration and streetscape plans. This allowed work approvals to progress while more detailed input was obtained on the streetscape and final restoration plans.

During the first two months of emergency response, weekly briefings were held between the engineers, the City, and community members to keep all informed of progress, problems, and proposed solutions. As the residents returned to their homes and the project moved into the temporary excavation support and retaining wall reconstruction phase, monthly meetings were held to update the community and receive input regarding streetscape planning. The construction of the permanent wall was substantially finished by January 2015.

As previously discussed, final design was not complete at the time of mobilization, which required a significant amount of cooperation and communication between CSXT, the City, engineers, and contractors. Several other items were critical and required careful coordination: the CSXT railroad schedule, adjacent utility relocation, instrumentation and monitoring access, and sequencing soil excavation while maintaining production on the temporary wall construction.

**Collaborative Effort Results in a Quality Project**

If asked to estimate the time it would take to design, obtain permits, demolish an existing 320-ft-long stone retaining...
wall, construct a temporary wall, and build a new finished wall in a non-emergency situation, consultants and owners would probably say at least three to four years. Considering the project is aligned between a residential street and a critical railroad line, and bordered laterally by two of the busiest streets in Baltimore, some estimates would be even longer. However, this project was largely completed in nine months due to the collaboration between all of the key stakeholders.

How was time saved? All parties communicated throughout the design and construction process, understanding that work had to continue, regardless of the obstacles that were encountered. This type of collaboration is unfortunately not the norm on most projects, but it certainly made the East 26th Street project unique. There are many examples of this collaboration. The City assisted the contractor in obtaining permits to transport heavy equipment in less than 24 hours. The designer responded to the project within one hour of the wall failing, and provided essential input to the emergency response. The general and specialty geotechnical contractors provided input to the designer to improve the temporary and permanent wall design constructability. Executives from the designers and contractors met weekly with the City's director of public works. Without such timely input and response by the project's key stakeholders, positive outcome of the East 26th Street slope repair would not have been possible.

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GeoAmericas 2016 will be where everything geo and beyond happens in 2016! Hosted in easy to reach Miami Beach, Florida, GA16 is designed to provide a comprehensive and diverse offering which will range from introductory to state of research. The theme is “Geosynthetics in the Americas,” and multiple special sessions have been arranged to further the depth of information.

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  - Geosynthetic-Reinforced Pavements – Dr. Jorge Zornberg
  - Factors Affecting the Performance of GCLs Both Alone and in Composite Liners – Dr. Kerry Rowe
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Achieving Innovation Through Adaptation

By Mark K. Seel, PE, PG, M.ASCE, and Luis Berroteran, PE, M.ASCE

We all know the high price of land development these days, so it’s more important than ever for owners and their designers to maximize available land area. Occasionally, this demand is constrained by topography and difficult or uncertain subsurface conditions. One such project involved a retail development in southern Connecticut that borders a residential community set along a ridgeline, where a stabilized steep cut was made in close proximity to a proposed store (Figures 1 and 2).

Deep, steep cuts on the sloping retail property were required to achieve the final site grades, which included placement of the retail store “box” in a rear corner of the site to accommodate the retailer’s need to maximize parking at the front of the store. Available mapping indicated the surficial soils consisted primarily of dense glacial till overlying medium-to-fine-grained schist bedrock. Geotechnical exploration findings and structural geologic mapping helped verify that the retail store “box” could be placed as far to the rear of the property as possible so that the retail program was optimized.
Figure 1. Final stabilized cut shortly after completion (looking north).
(Photo by M. Seel.)
As engineers and contractors, we prefer to maintain consistency in our approaches to problem solving and construction techniques. On this project site, a “one size fits all” solution was not going to work. To achieve the project goals, conventional slope stabilization techniques were introduced and adapted to address specific ground conditions, while implementing a more modern stabilization system for the whole land mass.

**Dealing with Geology and Site Constraints**

Maximizing storefront parking and providing required delivery truck loading docks, service vehicle parking, and truck turn-around areas at the rear of the store had to be balanced by achieving a constructible site. Figure 3 shows several key original and proposed site features. The combination of the retail program requirements necessitated that the rock be cut very steep (i.e., 2V:1H or steeper) to fit in the desired location.

The site design constraints left little to no space at the base of the cut for rockfall catchment, which is the preferred method of managing rock cuts versus installing active restraint systems on a cost basis. Therefore, because there wasn’t a suitable catchment for the steep rock cut, robust active restraint (i.e., rock reinforcement) and rockfall protection measures were required to provide stability to the steeply inclined cut land mass and protection to the public (Figure 4).

Based on the initial project subsurface investigation findings, structural geologic mapping, and site constraints, a combination of steel rock bolts and high-strength steel netting was selected as the most appropriate method for providing the required restraint and rockfall protection. The proprietary Tecco® slope stabilization system, manufactured by Geobrugg, was chosen for its flexibility and utility in addressing several different design conditions, such as soil slopes, rock slopes, mixed soil-rock slopes, and rockfall restraint. Tecco is a high-strength, steel mesh netting/steel bolting system that consists of 1-in.-diameter, epoxy-coated, Grade 75 steel rock bolts and 0.12-in.-diameter, super-coated, Grade 256 steel wire. The rock bolts were to be embedded 15 to 20 ft into rock.

In addition to the Tecco system, fiber-reinforced shotcrete was to be utilized for “dental” treatment of the rock locally, where required. Large-block retaining walls were proposed to accommodate relatively small grade changes near the ends of the cut, which would be in soil. The dense soil slope above the rock was seeded with a mixture of grasses and Crown Vetch (Figure 5), which is an invasive species that has a long tap root and a horizontally-branched fibrous root system that is ideal for stabilizing the upper 3 ft of soil.

Based on past experience, the project team believed that combining these methods would provide the flexibility needed to adapt to varying geologic conditions and site constraints during the construction phase.

**Site Setting and Geological Design Conditions**

The pre-development site conditions included an exposed rock cut that ranged in height from roughly 12 ft to 20 ft, with a back slope ranging from roughly 17° to 28° from horizontal that extended upslope roughly 30 ft to 70 ft to the property. The slope’s vegetative cover consisted of a mixture of grasses, shrubs, and trees. As shown on Figure 1, the proposed store was to encroach upon the existing slope, and the proposed rock cut was L-shaped, with two perpendicular sides connected at the corner by an arc having a radius of curvature of 55 ft.

One leg of the proposed cut parallels the western property line, and ranges in height from about 7 ft immediately adjacent to the southern large-block retaining wall to about 54 ft in the north-west corner of the site. The other leg of the cut roughly parallels the northern property line, and extends eastward from the proposed cut corner to the eastern large-block retaining wall, where the slope height is about 8 ft.

During the initial design phase, the project team had performed geologic mapping of rock outcrops on site for the purpose of evaluating the slope characteristics that influence structurally controlled rockfall. Measurements of dip and dip direction were collected along joints and foliation on the rock outcrops. The orientations of the measured joints and foliation, which are three-dimensional data points, were plotted on an equal-angle stereonet.

Subsequent kinematic analysis, which is a method of evaluating
discontinuity data using stereographic projection, allows the three-dimensional data to be analyzed in a two-dimensional format. This aided in identifying trends in the rock mass structure that govern the type of potential block failure modes relative to the proposed cut slope alignment. This analysis was then used to optimize the orientation of the retail building and adjacent rock cut slope.

After finalizing the site layout, a geotechnical sub-surface investigation was performed consisting of drilled borings, test pits, and soil probes within the proposed back-slope. The explorations confirmed that glacial till was present and that the schist bedrock possessed localized gneissic zonation. The till consisted of very dense sands containing variable amounts of gravel and silt. Laboratory testing of the till indicated soil internal angle of friction values on the order of 38° to 40°.

The schist was found to be generally hard, with well developed, near-vertical foliation. The schist possessed two primary joint sets. One joint set had a predominant orientation of 50°/234° measured as dip/dip direction. The second joint set had a predominant dip/dip direction of 7°/0°. The rock quality designation (RQD) values obtained from the rock cores ranged from 21 to 57 percent, indicating generally poor to fair rock quality based on the Rock Mass Rating (RMR) system. Geologic Strength Index (GSI) was used for the estimating rock mass strength and deformation by focusing on rock structure and block surface conditions. Based on outcrop mapping, which indicated a generally blocky structure having a good quality surface condition, a GSI value of 65 was assigned to the rock mass.

Strength parameters utilized in the computer-aided design models were assigned to the soil based on laboratory testing and Standard Penetration Test (SPT) N-value correlations from borings. The rock-related GSI and RMR parameters were used to aide in the determination of Hoek-Brown failure criterion — which is an empirical index that provides quantification of the relationship between the stress state and RMR. A Mohr-Coulomb rock-failure envelope was then developed by fitting an average linear relationship to the Hoek-Brown criterion curve to determine the rock-mass equivalent angle of friction and cohesive strength. The resulting values were then incorporated into the computer models for performing slope stability analyses.

Figure 3. Development plan. (Drawing by Langan Engineering and Environmental.)
The slope stability computer program Slide, V 5.0, from RocScience, was used for evaluating the global slope stability of the proposed cut slope. The rock mass was considered to be globally stable, but would benefit from the localized use of rock bolts. Geobrugg’s proprietary Ruvolum® software program was utilized to analyze the various cut slope configurations stabilized with the Tecco system. Rock bolt spacings of 8 ft by 10 ft were found to be appropriate, based on the analyses. The large-block gravity retaining walls were designed using the manufacturer’s commercial software package.

The design team anticipated a relatively small section of the proposed cut immediately north of the southern large-block retaining wall would be excavated entirely in soil based on site investigation findings. However, the precise location of the transition would not be known until construction. Therefore, because of the required steep slope, a soil nail wall was designed to bridge between the retaining wall and the Tecco system at the soil-rock transition.

**Adapting to Varying Site Conditions During Construction**

Recognizing the limitations of any subsurface exploration and geologic mapping program in characterizing a site, the project team took advantage of observing previously inaccessible areas of the slope along the proposed high wall cut alignment during clearing and rough grading. Observations made at that time included some areas having considerably thicker soil cover than anticipated during the design phase, and other areas where the rock was more weathered and/or fractured than the design phase findings indicated. Essentially, where the rock cut was deepest, rock quality was good and generally improved with depth, but diminished laterally with descending slope in the direction of the large-block gravity walls at the ends of the cut.

Ordinarily, these differing/varying site conditions would have compelled the designers to flatten the slope where the rock is of poorer quality, such as between the deepest part of the cut and the retaining walls. In this case, however, because the site constraints and the flexibility of the selected stabilization methods, no change in design was required. However, attention would have to be given to monitoring the changing soil and rock conditions during excavation so that the location and condition of the soil/rock interface could be identified immediately upon excavation. Because several operations were required to complete the work, the engineering design team and the specialty rock stabilization contractor collaborated closely to ensure optimization of the design with the contractor’s means and methods for construction.

The excavation and stabilization work had to be sequenced to accommodate the variable conditions while maintaining a safe excavation face. The excavation procedure consisted of removing soil from the highest elevation in descending fashion. When the proposed top of near-vertical cut slope alignment was encountered, drilling of rock and blasting would commence. Prior to initiating the rock drilling, the Tecco system was to be installed at the top of the slope in soil, and the netting lowered to a position just above the rock. This way, once the shotcrete stabilization of the upper 5 ft of the near-vertical cut was completed, the Tecco installation could follow the excavation work top-down (Figure 6).

After drilling and blasting started, the near-vertical slope was cut and that material excavated in roughly 5-ft vertical lifts in sections about 10-ft long. The uppermost 4 to 5 ft of this exposed soil and/or rock was stabilized by applying 6 in. of fiber-reinforced shotcrete. Subsequent adjacent 10- to 20-ft-long sections of the rock mass were then excavated, and the material stabilized similarly. This upper 4- to 5-ft zone containing the soil-rock interface also received 10-ft-long, grouted,
galvanized, steel rock bolts spaced every 8 ft. Drilling and blasting activities were staggered, but continued during periods after the shotcrete had cured sufficiently.

All rock cuts were mechanically scaled to remove loose rock; locally, steel fiber-reinforced shotcrete was placed in one to two, 3- to 4-in.-thick lifts, depending on the condition of intersecting joints. Where favorable, little to no shotcrete was applied. Where intersecting joint conditions were less favorable or unfavorable, greater amounts of shotcrete were applied to lock-up potentially damaging rock blocks and/or to provide a more uniform bearing surface for the steel netting. Drainage holes were drilled through the shotcrete to prevent build-up of water. A few additional rock bolts were added in locations where adverse jointing necessitated additional support.

System performance was monitored to assess the stabilization program, and included monitoring of shotcrete spall along a thinly placed margin, and dislodging of any rock restrained by the steel netting. The system performed suitably over the first winter; only a relatively small amount of spall and restrained rock fall occurred. Based on those observations, a secondary application of shotcrete, nearly doubling the amount initially applied, was completed about 13 months after the initial work, utilizing the store’s maintenance budget. No further spall or rockfall has occurred.

**Lessons Learned**

Each stabilization component provided certain advantages for ensuring long-term stabilization of the cut slope and protection against rockfalls. The shotcrete proved to be particularly useful due to its adaptability to the variable rock cut and overlying steel netting by creating a durable uniform contact area over which the compressive forces from the Tecco system could be uniformly applied. The result was a unique combination of a reasonably priced durable and appealing combined landscape/hardscape.

Although a thorough subsurface site characterization is always beneficial to a project, the site constraints of this project eliminated many stabilization options, and focused attention on systems that provided flexibility to address the constraints. In addition, close integration of the design and construction teams ensured prompt responses to changing conditions.

Although the budgetary constraints realized during construction may have restricted the amount of shotcrete that could be initially applied, the adaptability of the system components allowed the owner to plan ahead and budget for a long-term monitoring and maintenance program.

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**Figure 5.** Crown Vetch seeding. (Photo by M. Seel.)

**Figure 6.** Top-down installation of Tecco® mesh. (Photo by M. Seel.)
HIGHWAY RETAINING WALLS ARE ASSETS

A RISK-BASED APPROACH FOR MANAGING THEM

By Mo Gabr, PhD, PE, F.ASCE, D.GE, Cedrick Butler, EI, William Rasdorf, PhD, PE, F.ASCE, Daniel J. Findley, PhD, PE, and Steven A. Bert

Photo by Beyond My Ken
Throughout history, retaining walls (RWs) have served a vital role in supporting civil infrastructure. The ruins of dry stone walls that purportedly supported the hills and slopes of ancient Rome can be seen today in the underground corridors of the Colosseum, and within the ruins of the Forum and Circus Maximus. Within our National Highway System, retaining walls are an integral part of bridge abutments, grade separations, and highway embankments, and in many situations are used to support and protect transportation assets such as roads, rivers, and railways. Compared to pavements and bridges, retaining walls require less maintenance. However, and perhaps due to such success, records of wall construction, design, and performance are minimal.
Many of the walls in place today were constructed decades ago, and neither present nor past conditions of fill materials, foundations, drainage, facing, and other key elements are known or documented. Therefore, it’s not surprising that some agencies do not even maintain records of locations for many of their RWs... at least until a failure occurs. The New York City Department of Transportation first realized the importance of implementing an inventory and inspection program for its RWs after a few failures occurred dramatically, and without warning. One of those failures happened in 2005, when a 75-ft-high earth retaining wall crashed onto Riverside Drive in Manhattan, NY (Figure 1).

### Wall Inventory and Condition Assessment Systems

The “Moving Ahead for Progress in the 21st Century Act” (MAP-21), signed into law by President Obama in 2012, specifies that transportation agencies develop a performance-based process for building, maintaining, and managing infrastructure on the National Highway System. The act mandates that measures be put into place for infrastructure assets that may potentially fail with aging, including retaining walls. MAP-21 ties such a requirement to federal funding, but only a few highway agencies systematically manage, inventory, and assess their RWs on a regular basis. A summary of existing inventory or/and condition assessment systems is shown in Table 1.

Some of these systems are for specific wall types, and some include condition assessment in addition to inventory. The majority are not integrated into a system-wide asset management program, similar to, for example, pavement or bridge management systems. For example, the City of Cincinnati has been using a system since the 1990s with ratings that range from 0-4 to survey nearly 7,000 walls. The results are used to prioritize repairs and replacements. The New York City Department of Transportation uses a numerical rating system that ranges from 1-7 to survey nearly 2,000 earth retaining structures (ERS). Likewise, the Pennsylvania Department of Transportation and the Nebraska Department of Roads have developed inspection and conditions assessment procedures that are focused on mechanically stabilized earth (MSE) walls, which rely on a numerical rating of 2-8 and 0-9 respectively. Conversely, the Oregon Department of Transportation relies on a three-level rating system based on good, fair, or poor condition ratings. The Ohio and Utah Departments of Transportation also use a qualitative assessment method to evaluate the condition of MSE walls. In both of these rating systems, condition assessments are based on a “Yes” or “No” response to particular observations.

The RW inventory and inspection program developed by the Central Federal Lands Highway Division (FHWA-CFLHD) for the National Parks Service (NPS) is perhaps the most comprehensive to date. This system was developed considering various wall types, and is based on a rating scale ranging from 1-10, where 10 is the best and 1 is the worst. The system rates individual wall elements. The database for the FHWA-CFLHD system includes over 3,500 RWs located in national parks throughout the U.S.

### Table 1. Agencies with an inventory and inspection program.

<table>
<thead>
<tr>
<th>AGENCIES</th>
<th>INVENTORY OR INSPECTION PROGRAM</th>
<th>INVENTORY + INSPECTION PROGRAM</th>
<th>INVENTORY + INSPECTION W/ ADVANCED ASSET MANAGEMENT SYSTEM</th>
<th>ONLY ACCESSIBLE GUIDANCE MANUALS AND/OR INSPECTION FORMS</th>
<th>RATING SCALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alaska DOT</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>British Columbia MOT</td>
<td>X</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>California DOT</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>City of Cincinnati (7,000)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Colorado DOT</td>
<td>X</td>
<td>-</td>
<td>-</td>
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<tr>
<td>FHWA &amp; NPS (3,500)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>1-10</td>
</tr>
<tr>
<td>Kansas DOT</td>
<td>X</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Maryland DOT</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Minnesota DOT</td>
<td>X</td>
<td>-</td>
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<td>-</td>
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<tr>
<td>Missouri DOT</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>New York City DOT (2,000)</td>
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<td>X</td>
<td>1-7</td>
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<tr>
<td>New York State DOT (2,100)</td>
<td>X</td>
<td>X</td>
<td>-</td>
<td>X</td>
<td>1-7</td>
</tr>
<tr>
<td>Oregon DOT (500)</td>
<td>X</td>
<td>X</td>
<td>-</td>
<td>-</td>
<td>Good/Fair/Poor</td>
</tr>
<tr>
<td>Pennsylvania DOT</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>-</td>
<td>2-8</td>
</tr>
<tr>
<td>Victoria, Australia</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>1-4</td>
</tr>
<tr>
<td>Nebraska DOR</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>0-9</td>
</tr>
<tr>
<td>Ohio DOT</td>
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<td>-</td>
<td>X</td>
<td>Yes/No</td>
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<tr>
<td>Utah DOT</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>X</td>
<td>Yes/No</td>
</tr>
</tbody>
</table>
In some cases, assessment systems are developed for specific types of walls, such as the one developed by the Nebraska Department of Roads (NDOR) for MSE walls. In this case, the rating system evaluates 14 criteria to determine an average score that represents overall performance. The system uses a rating scale ranging from 0-9 to describe the extent or severity of each criterion. Because there are 14 individual rating criteria (with the highest possible rating being a 9), the maximum possible total rating is 126.

Most of the agencies that have ongoing inventory and inspection programs for RWs use a numerical rating system that relies on a single number to reflect the overall condition of the wall. In general, it’s not advantageous to use a single number rating system, especially when a key component(s) of a wall is severely distressed. The use of a single number through averaging masks the presence of deteriorated safety-critical wall elements and provides little insight about the location of a problem. In addition, the averaging process provides an unrealistic sense of safety. For example, a wall rating of 74 could be perceived as an acceptable wall in “fair” condition. However, upon closer review, it may be that a critical element such as drainage merits an element rating of “poor.” Poor drainage can lead to failure even though a wall rating of 74 may suggest no urgent issue.

The NCDOT Approach

Due to the absence of national guidelines, the NCDOT inventory and rating approaches are developed on an ad hoc basis. The work in this article describes a system for the development of an inventory, inspection, and condition assessment of RWs as highway assets in concert with the AASHTO program for bridges and abutment walls. The Wall Inventory and Condition Assessment System (WICAS) was developed for the North Carolina Department of Transportation (NCDOT) using the following guiding principles:

- Employs a relational database with three main categories: inventory, conditions assessment, and qualitative risk based on societal impact
- Identifies both the condition of a RW, and the location and nature of its distressed elements, in combination with the 1-4 (best-worst) rating scale used by AASHTO for bridges and abutment walls
- Highlights distressed elements or safety criteria which are critical to the

<table>
<thead>
<tr>
<th>ELEMENT CONDITION RATING</th>
<th>DEFINITION</th>
<th>EXAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 “GOOD”</td>
<td>Low-Severit Distress Distress does not significantly compromise structure function, nor is there significant severe distress to major structural components. A rating of 1 indicates highly functioning wall elements that are only beginning to show the first signs of distress or weathering to no distress whatsoever.</td>
<td>Soldier pile wall may have moderately extensive to minor surface corrosion on piles where protective paint has weathered/pooled, and wood facing is beginning to split. Distresses are very low overall, present over a modest amount of the wall, and do not require near-term attention.</td>
</tr>
<tr>
<td>2 “FAIR”</td>
<td>Low-to-Medium Extent of Medium-Severity Distress Observed distress does not compromise element function, but lack of treatment may lead to impaired function and/or elevated risk of element failure in near term. A rating of 2 indicates functioning wall elements with specific distresses that need to be mitigated in near-term to avoid significant repairs or element replacement in the longer term.</td>
<td>Numerous anchor struts holding MSE wire facing elements in place are beginning to break due to corrosion and suspected over-stressing of connections at time of construction. Although overall function of MSE wall is not in jeopardy, failing wall facing baskets are allowing facing fill to spill out. If several overlying baskets experience this isolated element failure, significant wall face sag and deformation may result at top of wall, eventually impacting overlying guardrail. This element should be inspected carefully along entire wall and repaired as needed to forestall more basket deterioration.</td>
</tr>
<tr>
<td>3 “POOR”</td>
<td>Medium-to-High Extent of Medium-Severity Distress Observed distress threatens element function, and strength is obviously compromised and/or structural analysis is warranted. Element condition does not pose an immediate threat to wall stability, and closure is not necessary. A rating of 3 indicates marginally functioning, severely distressed wall elements in jeopardy of failing without element repair or replacement in near-term.</td>
<td>Mortar throughout a stone masonry wall is cracked, spalled, highly weathered, and often missing. Individual stone blocks are missing from wall face, and adjacent blocks show signs of outward displacement. Although not an immediate threat to overall wall stability, stone block replacement and repointing throughout wall in near term are needed to forestall rapid wall deterioration.</td>
</tr>
<tr>
<td>4 “SEVERE”</td>
<td>High-Severit Distress Element is no longer serving intended function. Element performance threatens overall stability of wall at time of inspection. A rating of 4 indicates a wall that is no longer functioning as intended, and is in danger of failing catastrophically at any time.</td>
<td>A 15-ft.-tall CIP concrete cantilever wall has a large, open, horizontal crack running full length of wall at base of stem. Vertical cracks are also beginning to open up in wall face. Water is seeping from most wall cracks, and is running from basal horizontal crack at several locations. Wall face has rotated outward, resulting in a negative batter of several degrees. Overlying guardrail is highly distorted above wall, and adjacent roadway is showing significant settlement above retained fill. Wall is in imminent danger of failing catastrophically, requiring overlying roadway to be closed to all traffic until wall is replaced, or retained soil back slope is stabilized.</td>
</tr>
</tbody>
</table>

Table 2. Element condition rating definitions.
stability and function of the RW systems that may otherwise go unnoticed

Communicates concise information regarding the criticality and condition risk of an RW as an asset

Figure 2 shows the field condition inspection form that was developed for the NCDOT. The form has 23 condition assessment criteria and partitions a wall site into three components: wall facing, backfill, and drainage. Criteria 1 (tilting), 2 (local distortions), 3 (settlement), 15 (backfill settlement/cracking), 16 (active backfill movement), and 21 (clogged weeps) are designated as safety-critical, and ratings for these criteria influence the overall rating of the wall. For this numerical rating scale, 1 is the best and 4 is the worst. The definition of the elemental rating score is shown in Table 2 and is modified from the FHWA’s element condition rating definitions to fit the 1-4 rating system by AASHTO for bridges and abutment walls.

Figure 2 shows the layout and criteria of the Condition Assessment Form.

The summary rating score has two parts as shown in Figure 2: the first is a composite score that reflects an average of the 23 criteria, and the second is three individual scores that reflect the condition of each of the three main components. When a safety critical criterion receives a poor condition rating (3 or 4), such a score overrides the composite score. For example, if the wall exhibits the presence of distortion, deflection, settlement, or tension cracks in the backfill, it is deemed to be in a critically distressed condition. The final rating for the “backfill component” will reflect such a distressed condition, regardless of the composite score computed using all criteria in the component.

System Application

A study was conducted considering 11 NCDOT RWs with different characteristics. Three MSE walls, two soil nail walls, two anchored walls, two gravity walls, and two cantilever walls were selected for the study. In addition to the application of the NCDOT rating system, the FHWA-CFLHD and NDOR RW assessment approaches were also applied for comparison.

Unfortunately, it’s not clear with either FHWA-CFLHD’s or NDOR’s rating systems when the condition rating designates a good, fair, poor, or severe condition. For the purpose of comparison, Figure 3 shows thresholds defined by solid horizontal lines extending from 1.5, 2.5, and 3.5 (on the vertical secondary axes). Condition ratings above the solid horizontal line at 1.5 represents an RW in good condition, between 1.5 and 2.5 represents an RW in fair condition, and between 2.5 and 3.5 represents an RW in poor condition. A condition rating below the solid horizontal line at 3.5 represents an RW in severe condition.

In general, the condition ratings presented in Figure 3 for walls in good condition are fairly consistent in each system except for RW No. 11. The primary issue with Wall No. 11 (a soil nail wall) was poor drainage where all the weep holes were clogged. In the FHWA-CFLHD’s rating system, the condition rating was reduced because of that poor drainage condition. However, because the wall’s performance was still satisfactory at the time of this survey, the final condition rating ended up as an 82. This illustrates how using a single rating provides little insight about a potential problem with a safety-critical wall.
element. In the proposed rating system, the drainage element was given a rating of 3.0, thereby producing a composite score of 3.0. Accordingly, not only is the distress clearly reflected in the two-part rating, but also the identification of the issue (drainage = 3.0).

In the case of RWs deemed to be in poor condition, the condition ratings were not consistent across each system. When using the FHWA-CFLHD’s system, the condition ratings ranged from 53-84 on a 100 scale. In the rating system proposed by the NCDOT rating process, all the composite scores generated for RWs in poor condition were 3.0. When the NDOR’s rating system was used to evaluate the one MSE wall in poor condition (No. 14), a condition rating of 81 was generated. In this case, the wall was tilting and showing signs of settlement. Even though the “wall tilting” criterion in the NDOR’s rating system was rated poorly to reflect this critically distressed condition, the rating system still produced a final condition rating that ultimately suggests there are no urgent issues with this earth retention system (ERS). This is another example of how an assessment rating resulting in a single score can potentially mask a deficiency of a critical safety element.

Criticality and Risk Assessment
The NCDOT RW assessment process incorporates a qualitative approach for specifying risk assessment on the basis of the condition and consequences of wall failure. The direct and indirect impact of wall failure can include threats to people (traffic delays, personal injuries, or fatalities), property, the environment, or cultural resources. Five criteria are incorporated in the NCDOT RW assessment process to indicate the criticality of a wall: relative proximity of wall to roadway facility (H/D), supported or protected infrastructure, roadway type, traffic volume, and detour impact. Obviously these are not necessarily unique and can be altered to suit conditions at a given geographic location (e.g., urban vs. rural areas).

The “Criticality Assessment Form” is presented in Figure 4. Similar to the two-part condition assessment rating, the rating process uses a two-part criticality rating approach. The first part is the Composite Rating, which represents the average of the two criticality categories (wall and roadway). The second part (reported in parentheses adjacent to the composite rating) is the individual criticality ratings, for the wall and the roadway. The maximum possible rating (worst) that can be achieved is 4.0. Thus, for example, if either the “Relative Proximity to Roadway Facility” or “Roadway Type” criteria warrant a rating of 4.0, then it is not necessary to rate the other three criteria because both categories are already deemed to be critical.

Based on the study results, a risk assessment matrix (Table 3) has been proposed. The risk is evaluated qualitatively as a function of condition rating (i.e., whether the likelihood of failure is “very high,” “high,” “moderate,” or “low”) and criticality rating (i.e., whether the consequence of failure is “high,” “medium,” “low,” or “none”). The definitions of the level of risk are selected in a rather simple manner to inform decision makers regarding the frequency of wall inspections, needed remedial actions, and prioritization of maintenance work.

Where Do We Go from Here?
The establishment of a well-founded method to document the attributes of an RW, thus quantifying the level of distress and its potential failure risk, is paramount. This will enable agencies to determine the necessary frequency for wall inspections, and to help seek and prioritize funding to implement needed maintenance and remedial actions. To assist transportation agencies as they attempt to align their business processes with MAP-21 requirements, a two-part condition rating system has been developed to better integrate RWs into a system-wide asset management plan. A criticality rating is integrated with the condition assessment process to provide a risk metric that takes into account societal impacts. Information from such a system should be used as a trigger for further in-depth investigation when a wall in poor condition is identified. In these cases, collection of in-situ soil properties,
as-built dimensions of the wall, stability analyses, and the implementation of field monitoring may be warranted for the development of the most appropriate rehabilitation approach.

There are several logistic challenges associated with implementation of the proposed system. Given the reliance on visual inspections, those conducting the inspection should be experienced geotechnical engineers with well-trained support staff. A retaining wall inspector should be trained in a similar manner and degree to which bridge inspectors are trained and qualified for the job. Furthermore, the qualitative risk assessment, as presented in this article, has the added dimension of time sensitivity. For example, losing the function of a major thoroughfare for one day may not be well tolerated by the public. A wall with a rating score at the lower boundaries of risk and consequences might still trigger an action, given the societal consequences of an unexpected need for repairs. As the proposed RW inventory and assessment tool is integrated into a system-wide asset management framework, human judgment needs to always be a part of the decision-making process that influences the prioritization of investments. Perhaps this will be the case for managing retaining walls as highway assets until a significant level of experience and confidence is gained on the veracity of such systems.

Acknowledgement
This work was funded by the North Carolina Department of Transportation. The authors gratefully acknowledge the contribution of our NCDOT colleagues to the RW assessment system’s development.

Table 3. Risk assessment matrix.

<table>
<thead>
<tr>
<th>CRITICALITY RATING (LIKELIHOOD)</th>
<th>1.0 - 1.4 (LOW)</th>
<th>1.5 - 2.4 (MODERATE)</th>
<th>2.5 - 3.4 (HIGH)</th>
<th>3.5 - 4.0 (VERY HIGH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5 - 4.0 (High)</td>
<td>Moderate</td>
<td>Moderate</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>2.5 - 3.4 (Medium)</td>
<td>Moderate</td>
<td>Moderate</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>1.5 - 2.4 (Low)</td>
<td>Low</td>
<td>Low</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>1.0 - 1.4 (None)</td>
<td>Low</td>
<td>Low</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

Figure 4. Criticality assessment approach.

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Look Who’s a D.GE

Tom Witherspoon, Ph.D., P.E., L.S., D.GE, M.ASCE

Tom Witherspoon wears many hats: he is a licensed professional engineer, land surveyor, irrigator, sanitary, geoscientist, structural repair specialist, certified foundation repair specialist, structural engineer, and diplomate, geotechnical engineering.

He founded S&W Foundation Contractors in 1986 (tomwitherspoon.com), which was recognized as one of the fastest-growing private companies in 1991 and 1992 by Inc. 500™.

Witherspoon has more than 40 years of residential and commercial construction and engineering experience. His doctoral research was the first of its kind to evaluate and assess remedial piering and piling systems used to repair foundations. This research has improved knowledge of foundation underpinning systems, helping homeowners and contractors to properly assess remedial designs.

He received his bachelor’s degree in civil engineering from Southern Methodist University in 1971, his master’s degree in management and administrative science from the University of Texas at Dallas, and his PhD from the University of Texas at Arlington in 2006.

He has served as a member of the following associations: ASCE, ASPE, ASPG, SEAOT, ADSC (as past president and a member of the board of directors), FRA (president), and NAWSRC board member. He is often asked to speak to these organizations, as well as to DFI, Lorman, World of Concrete, ConExpo (ENR), and the Foundation Repair Association.


He has been married to his high school sweetheart, Sandra, for 44 years and has two children, Stephen and Mary-Jac.

He is a five-time Texas state champion in Olympic weightlifting (open division), and for three years, (1990, 2000, 2014) he was the Pan American masters weightlifting champion.

What class did you enjoy the most while in school?
Deep Foundation Design.

What was your favorite project?

What item did you always want to have?
An Olympic gold medal. (It never happened.)
What’s your favorite song and artist?
Harper Valley PTA by Jeannie C. Riley.

What’s your favorite movie or television show?
Big Bang Theory.

Where did you spend most of your childhood, and what was it like for you growing up there?
I grew up in a town of 160 people, nine miles east of Ferris, TX. I spent my childhood roaming the hills and hunting and digging for arrowheads and fossils. I spent much time building everything from diving boards for the stock tank to little cars that I had my younger brother test drive.

When did you realize that you wanted to study civil engineering, and what were the key factors in your decision to become a civil engineer?
I came to the realization in sixth grade; I wanted to be outdoors and build things.

How do you feel about the state of civil engineering and the profession as it is today?
I will be 66 years old on February 1 and cannot fathom ever retiring. I love what I do. I don't feel like I ever work, but I do put in a lot of time in my profession. I plan to work until I can't walk.

What do you feel are the biggest challenges on the horizon for the profession?
We need to attract younger people to our profession. To do that, we have to show them what I see, which is the most rewarding profession you can pursue. We have to hold our engineers up as role models and heroes. Society depends upon us solving problems, and if we are good, we can love our job and be well rewarded for it.

Do you have a message about specialty certification which you would like professional engineers to be aware?
We live in an age of specialization, and the Diplomate certification/designation is recognition that we have reached a level of competence that makes us stand out.

Why did you apply for D.GE certification?
I appreciate the level of competence that this certification exhibits and the responsibility to not only society, but to our customers.

How was the application process?
I found it fair and complete.

What are some of your personal hobbies and interests?
I still compete in Olympic-style weightlifting, which makes me continue to train with young people who are 40+ years younger than me. In August of 2015, I won the World Cup in weightlifting in the 65-69 age group and the 94 kg class. I have a ranch in Van Alstyne, TX, where I raise Red Angus cattle. I love mentoring the younger generation and find their interest fascinating because of the world they have come into. I fill in two times a year for our minister by delivering a sermon to the congregation. Past sermons included “God, the World’s Greatest Engineer,” during which I provided the geotechnical and structural engineering background behind the failure of the walls of Jericho.

For the complete interview, please visit geoprofessionals.org.
TenCate Geosynthetics Announces New Hires

TenCate Geosynthetics has hired four new engineering business managers:

Brian Baillie will serve the South Central Region (TX, LA, AR, and MS). Based in Austin, TX, he has a bachelor’s degree from Louisiana State University and is a professional civil engineer with 15 years of experience. He specializes in structural and geotechnical design, including a focus on geosynthetics and environmental applications. His broad project portfolio includes designs with levees, embankments, retaining walls, pile- and column-supported foundations, veneer stability, void bridging, and capping systems.

Nathalia Castro holds a bachelor’s degree in civil engineering and a master’s degree in geotechnical engineering. She researches geosynthetic functions and applications, focusing mainly on environmental engineering. Castro’s thesis studied all mechanical and hydraulic

“We’re Looking Out for You!”

The Geo-Institute Organizational Member Council (OMC) invites your organization to join us. Enjoy the numerous benefits that G-I organizational membership offers, including the following:

• Up to a 50 percent discount on the G-I annual Geo-Congress for one person.
• A 5 percent discount for advertising in GEOSTRATA magazine.
• Forty percent ($400) of your annual G-I OM dues go directly to fund G-I student activities. A portion of that money finances student travel to the annual Geo-Congress and the OM/Student Career Fair.
• Each year during the annual Geo-Congress, the OMC hosts an OM Career Fair/Reception. Two OM members from each OM firm are invited to participate, along with 45-50 students carefully chosen by the OMC.
• Opportunity to publish news about your company, including awards, new staff and promotions, company projects, etc.
• Your company logo posted on the G-I website at geoinstitute.org/membership/organizational-membership.
• Your company name listed in Organizational Member News in each issue of GEOSTRATA magazine.
• Opportunity to display the G-I logo on your website and on printed materials.
• Opportunity to display a G-I Organizational Member placard at your exhibit booth.

For more information, visit the G-I website at geoinstitute.org/membership/organizational-membership, where you can download the Organizational Membership application.

1 Jay Beech  2 Michelle Bolding  3 John Bischoff  4 James D. Hussin  5 Stanley Boyle  6 Kord Wissmann
properties involved in the use of geotextile tubes for dewatering contaminated sediments. Her professional career has included 10 years of design experience with geosynthetics. Based in Tampa, FL, she will work for the South East Region (FL, AL, and the Caribbean).

**Brock Nesbit** is a civil and structural technology graduate of the British Columbia Institute of Technology (ASCT). He has more than 19 years of technical sales experience in the heavy civil/industrial construction sectors, including geosynthetics. Based in Vancouver, British Columbia, Nesbit’s territory will include British Columbia, Alberta, Saskatchewan, the Yukon and Northwest territories.

**Juan Pablo Broissin** has a degree in civil engineering from the National Polytechnic Institute in Mexico City and a master’s degree in business administration. Since graduation, he has been working in engineering and construction and has spent the last five years in the geosynthetic industry. Now, Broissin will be responsible for Mexico, Central America, and South America.

**Moretrench President Arthur B. Corwin, PE, to Receive Moles Member Award**

Moretrench is pleased to announce that company president and CEO Arthur B. Corwin, PE, has been recognized by his fellow Moles with the 2016 Member Award for Outstanding Achievement in Construction, the organization’s top honor. Corwin joined specialty geotechnical contractor Moretrench in 1978 and has dedicated his entire career to the growth of the company, serving in various engineering and executive capacities including chief engineer, executive vice president, and chief operating officer. He was elected to the Board of Directors in 1988 and was then appointed president and COO in 2003, CEO in 2007, and chairman of the board in 2010. In addition to providing the dynamic leadership that has placed Moretrench in the forefront of the industry, Corwin is treasurer of the General Contractors Association of New York, serves on the board of the Associated Construction Contractors of New Jersey, and sits on the Industrial Advisory Committee at Columbia University.
Kleinfelder Names Interim CEO
Kleinfelder, Inc. announced that President and Chief Executive Officer Bill Siegel has resigned, effective immediately, to pursue other interests. The board of directors has appointed Kevin Pottmeyer, senior vice president and chief strategy officer, as interim CEO while a search is conducted for a new CEO.

“Bill has accomplished a great deal for our company in his time with us,” said Rodger Johnson, chair of Kleinfelder’s board of directors. “We thank him for his commitment, service, and leadership.”

Siegel said, “I’m proud of the progress we’ve made in the last seven years to transform our business. We are at a point in the lifecycle of the company to take our business to the next level and deliver on our 2020 objectives. I greatly value the relationships and experiences realized over my nearly 30 years with the firm and look forward to applying this experience to the next chapters in my professional career and life.”

Terracon Acquires NORCAL, Strengthens West Coast Presence
Terracon, a leading provider of environmental, facilities, geotechnical, and materials engineering services, is pleased to announce the acquisition of NORCAL Geophysical Consultants, Inc., of Sonoma County, CA. Terracon is retaining NORCAL’s 11 employees.

Nicholson Completes Emergency Work on Indiana’s I-65
Nicholson Construction recently completed emergency repair work to an unstable pier supporting a bridge on INDOT’s Interstate 65. These repairs enabled a 37-mile section of the highway’s northbound lanes to be reopened after a four-week closure.

The highway was in the process of being rehabilitated and widened when the pier was damaged by steel piles driven into the watertight ground below it. The pier began to settle and eventually rotated 10 in.

Nicholson developed a design-build solution that used micropiles to transfer the loads to more stable soils and low-mobility grouting to fill voids and densify the upper subsurface layer.
Maryland Chapter Promotes G-I License Plates
Carrie Nicholson, PE, will be stepping into the role of co-chair for the Maryland Chapter to join Greg Simmons, who has been chair since 2006. Over the past few years, the Maryland Chapter has grown from an average attendance of less than 20 members at just a few meetings per year, to about 30 members attending regular monthly meetings (during the season). The group is counting on its members to grow that number even more for the 2016-2017 session.

In order to promote the Geo-Institute on a broader scale, Simmons was able to secure approval for Maryland state G-I auto license plates (pictured). Now, almost 50 members are proudly sporting the tags on their cars.

San Antonio Chapter Hosts Upcoming Seminar on Current Topics
San Antonio’s G-I Chapter is hosting a one-day seminar, “Geotechnical Advances in the Transportation Sector,” to be held on March 18th at the San Antonio campus of the University of Texas. Speakers from throughout the state will discuss a variety of pertinent technical subjects, including soil nailing design methodology, geosynthetic pavement design, polymer soil stabilization, reliability of the TxDOT Texas Cone Penetration design method, an ethics talk, mechanistic approach to inverted pavement design, successful pavement projects in the San Antonio area, and solar pile driving performance monitoring systems. For more information, visit saasce.org.

EMployment
Senior Technical Manager (Civil Engineer)

One of the nation’s largest and most dynamic nonprofit organizations is currently searching for a civil engineer to provide technical and product support within our Geo-Institute. Do you like working with others who are passionate about their work? We are looking for the right person to join our team of professionals providing geotechnical engineers with the resources they need to advance their careers.

The American Society of Civil Engineers (ASCE) is a nonprofit professional membership association dedicated to the advancement of civil engineering in order to serve the public good. For consideration, submissions of interest must contain a resume and cover letter with salary history and requirements.

Responsibilities include:

- Serving as liaison to technical, board, and editorial board committees
- Working with regional and allied groups on collaborative technical activities
- Facilitating the development of manuals of practice, technical briefs, short courses, workshops, webinars and seminars
- Managing, developing, and enhancing geotechnical guidance documents and standards
- Managing the production, and developing sections of our bi-monthly GEOSTRATA magazine

The ideal candidate will have:

- A BS in Civil Engineering (Master’s preferred)
- Five to eight years’ experience (association experience a plus)
- PE license preferred (or ability to obtain within 1 year)
- Experience (or an interest) in geotechnical engineering

To apply, go to: https://asce.applicantpro.com/jobs/318125.html
GeoAmericas 2016, the Third Pan-American Conference on Geosynthetics

GeoAmericas 2016 will be held April 10-13, 2016, at the Loews South Beach Hotel in Miami, FL. The conference, “Geosynthetics in the Americas,” is a 4-day event featuring short courses, training lectures, technical sessions, panel discussions, and social and networking events.

The Keynote Lecture, “Lifetime Predictions of Exposed Geotextiles and Geomembranes,” will be provided by Robert M. Koerner, PhD, PE, D.GE, NAE, Dist.M.ASCE, emeritus professor of civil engineering at Drexel University and director emeritus of GSI.

Koerner’s interest in geosynthetics spans 40+ years of teaching, research, writing, and consulting. He has authored and co-authored 700+ papers on geosynthetics and geotechnical topics for international journals and conferences. He published the first textbook on geosynthetics, and he is the author of the widely used publication Designing with Geosynthetics, which is now in its sixth edition and has been translated into five languages.

The Mercer Lecture, “Stabilization of Paved Roads Using Geosynthetics,” will be provided by Jorge Zornberg, PhD, PE, M.ASCE. Zornberg is a professor and the William J. Murray, Jr. Fellow in the geotechnical engineering program at the University of Texas at Austin. He has more than 25 years of research and practice experience in geotechnical, geosynthetics, and geoenvironmental engineering.

For more information, please visit the conference website at geoamericas2016.org.

U.S. Topo Maps Reach Milestone

With the release of new U.S. topographic (Topo) maps for IL and SD, the U.S. Geological Survey (USGS) has completed the second, three-year cycle of revising and updating electronic U.S. Topo quadrangles. This means that since late 2009, the USGS has published nearly every map in the conterminous U.S., twice. In the past year, the production staff updated, revised, and loaded 18,767 U.S. Topo quads covering 18 states. That equates to the assembly, inspection, and loading of nearly 75 maps per working day. Additionally, the staff created more than 635 new 1:24,000 scale maps for AK, as part of the Alaska Mapping Initiative. All of the new U.S. Topo maps are digital and offered for free download at on.doi.gov/1MVDPV0, as the USGS no longer prints topographic maps using traditional printing technologies.

Symposium in Honor of I.M. Idriss

The contributions of I.M. (Ed) Idriss, PhD, PE, NAE, Dist.M.ASCE, to geotechnical earthquake engineering will be honored at a one-day symposium at the University of California at Davis on June 17, 2016. Proceeds from the symposium will go to the Mariam and Izzat M. Idriss Endowment Fund for Geotechnical Engineering Education. This endowment supports educational activities that enrich graduate school experiences in geotechnical engineering.

GBA Spring Conference in Dallas

The Geoprofessional Business Association (GBA) is preparing for its spring conference in Dallas, TX, April 14-16, 2016. The theme of the conference is “Optimizing Performance for Our Firms and Our Clients: Professionalism in Motion.”

For registration information, please visit the GBA website at geoprofessional.org or contact the organization at info@geoprofessional.org or 301/565-2733.
New GBA Publication - Strategic Association Involvement

“Few firms take the time to analyze how much money and billable time they spend on associations and societies and how much they receive in return.” That’s the underlying theme of Strategic Association Involvement, the most recent addition to the Geoprosfessional Business Association’s (GBA’s) series of GBA Best Practices monographs. The new publication advises geoprofessional and similar firms to adopt the fundamental rule of strategic association involvement: “Only staff members who participate actively in strategically important associations and societies will receive the financial support and paid time off that active involvement requires. The firm will not support casual involvement.”

According to GBA Executive Director Joel G. Carson, “Strategic association involvement, or SAI, does not mean that firms should focus only on monetary issues when selecting organizations to support. Instead, they should start by identifying organizations worthy of support and then, from that group, identify those that promise the best return on investment.”

GBA Best Practices monographs are available only to GBA members, without charge. Members can download Strategic Association Involvement from geoprofessional.org.

Deep Foundations Institute Conferences and Events

SuperPile ’16 will be held June 7-9, 2016, in Chicago. The two-day conference includes presentations about the latest developments in driven piles, augered cast-in-place/drilled displacement piles, micropiles, marine foundations, testing and evaluation of foundation systems, seismic and lateral loads, drilled shafts, ground improvement, and helical piles and tiebacks.

S3: Slopes, Slides, and Stabilization Seminar is a two-day event tentatively scheduled for August 2016 in Denver, CO.

Helical Piles and Tiebacks Seminar will take place in July in Los Angeles, CA. The one-day seminar will offer technical presentations and case studies about helical piles and the current state-of-practice worldwide.

Soil Mixing Seminar is scheduled for September in Orlando, FL. This one-day seminar will cover design, quality assurance and control, construction, applications, and case histories for soil mixing projects.

International Conference on Deep Foundations, Seepage Control, and Remediation is being held on October 12-15, 2016, at the Marriott Marquis Hotel in New York City.

State/County Bridge Building with Geosynthetics Wins Award

Among recent recipients of the Federal Highway Administration’s (FHWA) Accelerated Innovation Deployment (AID) awards is the Arizona Department of Transportation in conjunction with Mohave County. These agencies partnered to design and build a geosynthetic-reinforced, soil-integrated bridge system (GRS–IBS) project on Oatman Highway in northwestern AZ. The bridge now spans the Sacramento Wash to provide a low-tech, low-cost solution to flooding issues in this area.

The GRS–IBS is an innovation for helping reduce bridge construction time and cost. Due to the ease of construction and the use of readily available equipment and geosynthetic materials, GRS-IBS projects can be built in weeks instead of months.

Originally developed by the FHWA under the Bridge of the Future Initiative, GRS–IBS can help states and local public agencies meet the country’s demand for small, single-span bridges by delivering low-cost, strong, and durable structures in less construction time.

The technology consists of three main components: (1) the reinforced soil foundation, (2) the abutment, and (3) the integrated approach. Alternating layers of compacted granular fill and geosynthetic reinforcement provide support for the bridge.

The closely spaced reinforcement and granular soil create an efficient composite material that is internally stable and capable of carrying significantly higher than design bridge loads with predictable and reliable performance.

Geosynthetics Middle East Conference Names Award Winner

During the recent Geosynthetics Middle East conference and trade show in Abu Dhabi, Maccaferri was named the winner for the “Best Geosynthetics Project.”

The title of the winning project is “The 32-m-high ParaMesh retaining wall at the Al Jais Mountain Road Project in Ras al-Khaimah, United Arab Emirates (UAE).”

A Maccaferri press release described the project:

“To cover the road length of 36 km, which rises up to a height of 1,700 m (5,577 ft), many sections run alternatively due to mountainous morphology. Retaining wall construction was done adopting the ParaMesh soil reinforcement system technology by combining the Terramesh System (as facia and secondary reinforcement) and high-strength geogrids as primary soil reinforcement.”

Maccaferri described it further as “a modular system used to form rock-faced reinforced soil walls — also known as mechanically stabilized earth walls (MSEW) — and embankments.”

The press release noted that this system allows the use of rock-blasted material up to 20 cm to be used as backfill material due to increased vertical spacing between the geogrid layers and the polyethylene coating.
ASCE/G-I Co-Sponsored Online Live Webinars
All posted webinars offer 1.5 professional development hours (PDHs).

- **Geotechnical Investigations in Karst – NEW**
  March 11, 2016, 11:30 a.m. – 1:00 p.m. (ET)
- **Inspection and Rehabilitation Methodologies for Large-Diameter Water Transmission Pipelines**
  March 25, 2016, 11:30 a.m. – 1:00 p.m. (ET)
- **Underpinning and Strengthening of Foundations**
  March 28, 2016, 12:00 p.m. – 1:30 p.m. (ET)
- **Geosynthetic-Reinforced Mechanically Stabilized Earth Walls**
  March 29, 2016, 11:30 a.m. – 1:00 p.m. (ET)

### ASCE/G-I Seminars
All posted seminars offer continuing education units (CEUs).

- **Design of Foundations for Dynamic Loads**
  March 2–4, 2016, Baltimore, MD
- **Soil and Rock Slope Stability**
  March 3–4, 2016 – Brentwood, TN
  April 28-29, 2016 – Nashville, TN
  May 19-20, 2016 – San Francisco Metro Area, CA
- **Construction Dewatering and Groundwater Control — Design and Application**
  March 10–11, 2016, Denver, CO
- **Risk-Based Seismic Design and Evaluation**
  March 10–11, 2016, Philadelphia, PA
- **Deep Foundations: Design, Construction, and Quality Control**
  March 14–15, 2016, Orlando, FL
- **Earth-Retaining Structures: Selection, Design, Construction, and Inspection — Now in an LRFD Design Platform**
  March 17–18, 2016, Orlando, FL
- **Design and Installation of Buried Pipes**
  April 28–29, 2016, Nashville, TN
- **Seismic Hazard Evaluation and Mitigation Using Simple Methods**
  May 12-13, 2016, Philadelphia, PA

For more information about webinars, seminars, and on-demand learning, visit the ASCE Continuing Education website: asce.org/geotechnical-engineering/education-and-careers.

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As I See It: Geotechnical Research Pays Off
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What’s New in Geo? Advances in Ground Improvement
By George Filz and Don Bruce

Foundation Reuse and Enhancement — A Viable Option for Bridge Widening and Replacement Projects
By Frank Jalinoos, Mohammed A. Mulla, and Vernon R. Schaefer

Optimized Drilled Shaft Design through Post-Grouting
By Antonio Marinucci and Silas Nichols

Geotechnical Aspects of Pavements
By Charles Schwartz, Barry Christopher, and Erol Tutumluer

Geotechnical Instrumentation for Roadways
By Ming Zhu and Ali Ebrahimi

Lessons Learned from GeoLegends: Paul W. Mayne
By Md Zahidul Karim, Marta Miletic, Weston Koehn, Tri Tran, and Steven Halcomb

GeoAmericas 2016
3rd Pan-American Conference on Geosynthetics
April 10-13, 2016
Miami Beach, FL
geoamericas2016.org

4th GeoChina International Conference
July 25-27, 2016
Shandong, China
gocha2016.geoconf.org

Geo-Chicago 2016:
Sustainability, Energy, and the Geoenvironment
August 14-18, 2016
Chicago, IL
goeenvironmentconference.org

3rd International Conference of Transportation Geotechnics
September 4-7, 2016
Portugal

IACGE 2016
October 12-13, 2016
Beijing, China

Rocky Mountain GeoConference 2016
November 4, 2016
Lakewood, CO

Geotechnical Frontiers
March 12-15, 2017
Orlando, FL
gotechanicalfrontiers.com

Geo-Risk 2017
June 4-7, 2017
Denver, CO

Grouting, Deep Mixing, and Diaphragm Walls 2017
July 9-12, 2017
Oahu, Hawaii

GeoMEast 2017
July 15-19, 2017
Sharm Elsheikh, Egypt
goeast2017.org

3rd International Conference on Performance-Based Design in Geotechnical Engineering
July 16-19, 2017
Vancouver, BC

PanAm-UNSAT 2017: Second Pan-American Conference on Unsaturated Soils
September 10-13, 2017
Dallas, TX

IFCEE 2018
March 13-17, 2018
Lake Buena Vista, FL

Geotechnical Earthquake Engineering and Soil Dynamics V 2018
May 27-30, 2018
Austin, TX

For more seminar information:
asce.org/continuing-education/face-to-face-seminars
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The SVDESIGNER™ conceptual modeling software package is a brand new program that is tightly integrated within SVOFFICE™/GE and allows for the creation, manipulation and visualization of complex multi-dimensional geometry and takes 3D modeling to a whole new level.

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    - Export to 2D or 3D numerical models;
    - Rapid prototyping of geotechnical designs;
    - Manage, edit and visualize construction/excavation activities.

- **ENHANCED**
  - **SVSOILS™ Knowledge-Based Database:**
    - Premier product for estimating the hydraulic properties for flow modeling in unsaturated soils has been completely redesigned;
    - Simplified user interface for increased workflow efficiency;
    - Significant increase to a total of 34 available estimation methods;
    - Simple data mining/searching interface;
    - Development of oil-sand constitutive models;
    - Improved high-quality exportable charts.

- **SVSLOPE® Significantly Improved:**
  - Advanced multi-directional slope stability analysis. Fully build 3D models and analyze slip in any direction – a feature exclusive to SVSLOPE®3D and not available in any competing package.
  - “Optimize” slip surface refinement function;
  - Improved 2D block searching capabilities;
  - Support for triangulated surface meshes;
  - Faster solution times.

- **High-Performance Graphics Engine:**
  - Manipulation of larger more complex models;
  - Quicker rotation and translation of objects;
  - Faster transformations;
  - High quality / print-ready client visuals;
  - Improved CAD editing controls/responsiveness.

- **SVOFFICE™ Manager:**
  - Completely rewritten / redesigned;
  - Expert/learning modes;
  - Project grouping;
  - Simple to use.

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