

September 2017 Vol. 4 Issue 6

civil + structural ENGINEER

CELEBRATING THE DESIGN AROUND US



WOOD VS. CONCRETE

THE BATTLE FOR MULTIFAMILY CONSTRUCTION MARKETS

Mass timber high-rise buildings

Refined dam design

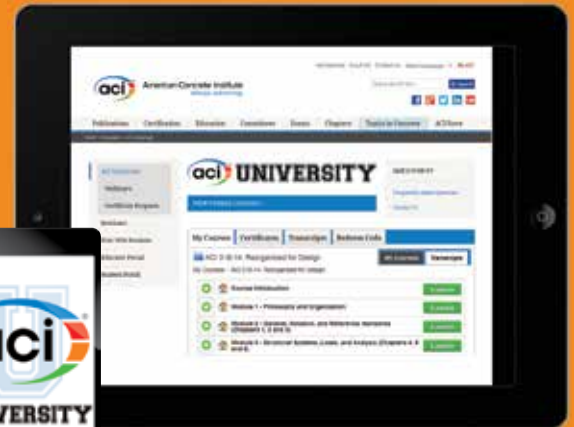
Stormwater risks and liabilities



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Arup implements comprehensive energy strategies at new Northeastern University Interdisciplinary Science Complex.

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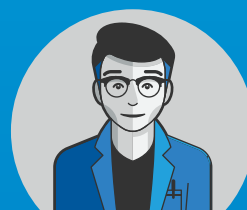
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LEADERSHIP QUALITIES

TAKE THESE 10 ACTIONS TO BECOME MORE 'LEADERLY.'

ALL CIVIL AND STRUCTURAL ENGINEERS have a chance to be leaders: Leaders in the organizations that employ you; leaders in professional and technical societies; leaders in your fields; leaders in your communities. But aside from working hard and being decisive, what are some other “leaderly” qualities you may want to be developing? Here are my thoughts:

1. Don't accept every excuse for a lack of results as valid. While some excuses people have for not performing may be justified, many are not — certainly, all are not. Engineering project leaders have a tendency to accept every excuse in the name of protecting their “family” work atmospheres. It hurts the organization and demotivates everyone else — not to mention it can ruin the project.

2. Value your time. You have to set the example for valuing your time. It means you don't get sucked into trivia, don't waste your time doing things other people can do, and do not accept every single interruption as normal, especially if it keeps you from doing something more important.

3. Take care of yourself. Eat right, sleep, exercise — don't let yourself go. When you can show some self-discipline and care for yourself, you set a good example for everyone else. You also show that you don't let circumstances dictate what happens to you.

4. Don't let negative stuff destroy your optimism. There is so much negativity — so many negative people you can associate with — and all of it will suck you down. It doesn't mean you have to live in a bubble, but it does mean you can turn it off when you have to because you know it is hurting you and your ability to lead a bunch of other people who are probably exposed to more negative stuff than you are on a daily basis.

5. Don't be afraid to try something that hasn't already been done a million times. We are so conforming in the construction industry. If you do everything just like everyone else, why would you ever be more successful than they are?

6. Tolerate criticism or skepticism yet keep moving forward. Not everyone will like you, trust you, or believe in you. And there will always be people taking shots at you. Thicken up that skin. Be ready for criticism — expect it, embrace it, and then prove the critics wrong.

7. Make a plan, share a plan, and implement a plan. You will never get out of the woods without a map or at least a good sense of where the “exit” is. This has to be explained and shared with everyone else in your party because, if not, they will all be worried, fearful, and paranoid.

8. Keep your cool under fire. Losing your temper is never good. You have to remain calm and in control of your emotions no matter what. That said, I have been able to use what appears to be emotion effectively at times as a communication tool. Be smart about what you “show” people!

9. Be self-critical. Everyone loves someone who knows what they are good at and what they aren't. It's especially endearing when you can be self-deprecating. You cannot be the jerk who honestly thinks he or she is better than everyone else and acts accordingly. You aren't perfect — acknowledge it. Work on your weaknesses; maximize your strengths.

10. Be trustworthy. You have to be able to keep a secret. If not, you won't really know what is going on in your company because no one will tell you anything.

We have another great issue of Civil + Structural Engineer magazine. And because we aspire to be leaders in our field, we need your feedback! Please tell us what you like and don't like about our publication by emailing me at mzweig@zweiggroup.com. Every email will get a response — and I promise every idea will receive a thorough consideration. Thank you!

MARK C. ZWIG
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Civil + Structural Engineer provides news and articles online to supplement content in this print issue. Visit csengineermag.com daily for the latest news and check out the following articles posted online with the September 2017 issue:

PROJECT PROFITABILITY: BEFORE THE CONTRACT IS SIGNED

By Howard Birnberg, Association for Project Managers

In the effort to obtain a design contract, many marketers and senior managers lose sight of the consequences that success brings. It is not sufficient to market your design firm to a potential client. I have seen a number of cases of seller's remorse after a contract is signed. It is important to fully evaluate your ability to meet contractual obligations, satisfy your new client, and make money in the process.

Before the contract is signed,

- evaluate your own capabilities;
- understand your own costs and cost structure and your own cost of doing business, such as multipliers, overhead rates, and profit targets;
- require a well-written and complete scope of services;
- prepare a complete project budget.

Unfortunately, in the rush or excitement to begin a new project, many engineers and architects fail to adequately evaluate the challenge ahead and to objectively examine the cost/benefit of the work.

Read the entire article at <http://tinyurl.com/projectprofit-sept17>.

DIVERSIONS: NOTHING PERSONAL, JUST BUSINESS

By Andy Sciarabba, P.E., T.G. Miller, P.C., Engineers and Surveyors

Side effects may include nausea, headache, upset stomach, loss of bladder control, or insomnia. Some people may experience certain sound effects: Gee, my voice is REALLY LOUD. Why am I talking in a vacuum? What is that echo... echo... echo? Am I having an out-of-body experience?

Have you taken the wrong medication? Are you having a stroke? Did you just shot-gun two Monster Energy drinks?

Nope, you have a presentation to make: A big, important public presentation.

But you've done this hundreds of times. What's the big deal? My God — there are more people here than attended the Super Bowl!

Read the entire article at <http://tinyurl.com/diversions-sept17>.

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ENTER THE FIRE

Never has there been a time with so much opportunity for advancement.

ENGINEERING FIRMS are busier than most of us have seen in our careers. Backlogs are at historic levels along with an overall economy that continues to set records. What this translates to for many firms is a labor shortage that is causing lots of long hours for many design and technical professionals.

Recruiting and retention are top of mind for many firm leaders right now, and they are looking hard for any and every solution to the problem. If firms cannot add staff to address this market demand, they risk valuable relationships with clients that have significant needs, while also losing dollars that can be used to grow the firm and provide better benefits.


I get to sit in on many high-level conversations where firm leaders are discussing solutions. One thing that is very apparent is that there are many gaps in these organizations that need filled. That spells opportunity for you.

Hiring from the outside is challenging but necessary to keep up with the demand in many firms. But what firm leaders are really looking for is people to step up internally first and then figure out who needs to be brought in after that. Priority almost always goes to internal candidates who show an ambition for growth and advancement.

Figure out what you need to do to fill any of these immense needs and go do it. Take a risk and throw yourself into the fire if needed and learn along the way. Never has there been a time with so much opportunity for advancement.

With such a strong economy, you don't have to switch companies to make a major advancement. Look hard at the opportunities right down the hall from you. Firm leaders need you to speak up and step up. Seize the day now!

CHAD CLINEHENS, P.E., is Zweig Group's president and CEO. Contact him at cclinehens@zweiggroup.com.



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GANGS, EARTHQUAKES, AND PUPUSA

TAKING RISKS TO BE CHANGE AGENTS IN
DEVELOPING COUNTRIES.

By H. Kit Miyamoto Ph.D., S.E.

WE ARE DRIVING on a bumpy urban jungle road, right behind an armed police escort. Hot equatorial sun beats down on our black truck, keeping it nicely humid and hot. I am in San Salvador, the capital of El Salvador, heading to a gang-ridden public housing area.

This is the city where a moderate, M5.5 earthquake killed more than 1,500 people in 1986. We are on a mission, working together with the government to assess the seismic risk of the city and identify gaps in earthquake disaster preparedness.

We park in the muddy parking lot in the front of smog-stained, five-story concrete apartments. As soon as our team gets out of the truck, armed police escorts rapidly scatter around the perimeter. Many of the buildings are haphazardly out of plumb, either caused by settlement or cracked concrete. A city engineer explains to me that many of these buildings were damaged by the 1986 earthquake and red-tagged, but people went back to live there anyway, having no place else to go.

As we assess the buildings, my interpreter nervously whispers to me, “Kit, you see a teenage boy around the corner who is looking at us? I guarantee that he is a member of a powerful local gang group. By now, everybody knows we are here.”

The first step of the risk assessment is on-the-ground building data collection. Combining this data with remote sensing satellite images, we can construct an accurate picture of the city’s built environment and population. As engineers, we sometimes need to expose ourselves to certain risks. Being in a gang-controlled area is one thing, but being on a normal construction site is also filled with danger. Nevertheless, society needs us to do this; it is our job.

We get back to our ever-more-heated truck and head back to safer city areas. It is a 13-hour day road trip around the traffic-jammed city with a 15-minute gas station hot dog lunch stop. We are meeting various agencies to understand their preparedness capacity. We arrive at a ministry that is in charge of multi-hazard risk monitoring. A young researcher greets us with fluent English. A semi-dark room is full of blue computer screens showing real time weather and earthquake monitoring.

In 2010, the UN ranked El Salvador as having the highest natural hazard risk in the world. But it is an absolutely beautiful place — untouched jungles, wild beaches, 1,000 volcanoes. It is also a truly undiscovered place. We saw very few foreign tourists besides rogue surfers and businessmen escaping the capital city on weekends. Salvadorians are very kind and friendly. I say, the coffee is the best in the world, and their national dish — cheese-filled pupusa — is something I dream about.

The young researcher explains how they monitor earthquakes. Later we learned that she is a director of the agency. Impressive, where male dominance is common in this part of the world. This is something I often find in many developing countries. Talent and knowledge are sometimes buried and fragmented. Foreigners like us can help as change agents by breaking pre-existing social or political barriers, connecting dots, and supporting talents.

H. KIT MIYAMOTO, PH.D., S.E., is the CEO and a structural engineer for Miyamoto International (<http://miyamotointernational.com>), a California seismic safety commissioner, and president of the technical nonprofit Miyamoto Global Disaster Relief. He specializes in high-performance earthquake engineering and disaster mitigation, response, and reconstruction.



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2017 COMMERCIAL UAV EXPO

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According to organizers of the Commercial UAV Expo, Oct. 24-26, 2017, in Las Vegas, the event is “geared to data acquisition professionals tasked with highly technical projects that fall into one of the ‘4Ds’ — dangerous, difficult, dull, or dirty work.” These projects might include pipeline monitoring; transmission line inspection; infrastructure analysis; digital terrain models and digital elevation models; simulations for asset analysis and risk management; multi-spectral sensing for complex infrastructure such as bridges, roads, tunnels, rail, and utilities; or any work that requires survey-grade data with high levels of accuracy, often in hazardous environments.

Conference content and exhibits focus on considerations for drone integration in seven industry segments:

- process, power, and utilities;
- civil infrastructure;
- construction;
- surveying and mapping;
- mining and aggregates;
- precision agriculture; and
- law enforcement, emergency response, and search and rescue.

Conference program topics address understanding specific return on investment and benefit metrics for using UAVs; integrating UAV data into current workflows; storing and sharing project data both internally and externally; incorporating software for flight planning, post-processing, and data analysis; determining alternative options for when UAVs are not the right tool for an application; and identifying UAV regulatory, environmental, operational efficiency, and safety challenges.

In addition to the main conference program, AirGon is offering a Technical Seminar: High Accuracy Mapping with DJI Phantom and Inspire, and the American Society of Photogrammetry and Remote Sensing (ASPRS) is hosting a preconference unmanned aerial system (UAS) technical symposium. During this full-day symposium eight topics will be presented by ASPRS members and practicing service providers. Each topic will build on the previous, giving attendees a comprehensive understanding of UAS mapping in accordance with geospatial accuracy standards. The symposium will end with a presentation on the new ASPRS UAS Mapping Certification.

More information and registration details for the Commercial UAV Expo are available at www.expouav.com.

CIVIL + STRUCTURAL ENGINEER WILL BE AT BOOTH #830

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SEPTEMBER 2017

INTERDRONE

SEPT. 6-8 — LAS VEGAS

UAV conference featuring more than 120 panels, sessions, classes, and drone workshops and an exhibition with more than 185 unmanned system manufacturers and sellers.

www.interdrone.com

32ND ANNUAL WATEREUSE SYMPOSIUM

SEPT. 10-13 — PHOENIX

What's working, what's new, and what's next in water reuse policy, operations, technology, and public perception, featuring more than 100 presentations, panel discussions, and workshops.

<https://watereuse.org/news-events/conferences/annual-watereuse-symposium>

HOT FIRM AND A/E INDUSTRY AWARDS CONFERENCE

SEPT. 21-22 — SEATTLE

Comprehensive business conference for leaders and aspiring leaders of AEC firms in the U.S. Conference agenda includes topics on technology, leadership challenges, business planning, marketing methods, recruiting and retention, and growth strategies.

<http://hotfirm.com>

REBUILDING AND RETROFITTING THE TRANSPORTATION INFRASTRUCTURE

SEPT. 26-27 — WASHINGTON, D.C.

Conference highlights best practices and breakthrough ideas for transportation infrastructure concepts, designs, and materials, disruption management, intergovernmental actions and policies, decision making, and asset management.

<https://www.transportation.gov/utc/utc-spotlight-conference>

OCTOBER 2017

SMART CITIES WEEK 2017

OCT. 3-5 — WASHINGTON, D.C.

Government leaders gather to discuss examples of smart infrastructure solving tough urban problems. Includes keynote addresses, workshops, roundtable discussions, and panel sessions aligned to six tracks, plus an exhibition hall.

www.smartcitiesweek.com/2017-Washington

THE YEAR IN INFRASTRUCTURE CONFERENCE

OCT. 10-12 — SINGAPORE

Bentley Systems' annual forum addressing current priorities and opportunities impacting the infrastructure industry. Includes a technology update, six industry-focused forums, an Alliance Partner Pavilion, and the Be Inspired Awards ceremony.

www.bentley.com/en/yii/home

THE CONCRETE CONVENTION AND EXPOSITION

OCT. 15-19 — ANAHEIM, CALIF.

More than 2,000 engineers, architects, contractors, educators, manufacturers, and material representatives are expected to convene to collaborate on concrete codes, specifications, and standards. Technical sessions highlight research, case studies, and best practices.

www.aciconvention.org

MEETING OF THE MINDS 2017

OCT. 23-25 — CLEVELAND

Tools and best practices working for city leaders across the globe, including smart cities, IoT, mobility, climate and resiliency, clean urban water and energy, infrastructure, and more.

<http://cityminded.org/events/motm2017>

COMMERCIAL UAV EXPO AMERICAS

OCT. 24-25 — LAS VEGAS

Unmanned aerial systems selection and integration; developing enterprise workflows, guidelines, and policies; data management and integration; and legal, safety, and regulatory considerations.

www.expouav.com

25TH SHORT COURSE ON COLD-FORMED STEEL STRUCTURES

OCT. 24-26 — ST. LOUIS

Course provides an introduction to the behavior of cold-formed steel members and connections and how that behavior is addressed by the AISI Specification. The course also is intended to strengthen experienced engineers' understanding of the fundamental behavior of members and connections, as well as provide a better understanding of cold-formed steel design.

<http://ccfssonline.org/cfs-short-course>

DFI 42ND ANNUAL CONFERENCE

OCT. 24-27 — NEW ORLEANS

The conference features technical presentations focusing on deep foundations and ground improvement, and associated risks and mitigation practices.

www.deepfoundations2017.org

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OCT. 26-27 — SAN DIEGO

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<http://zweiggroup.com/seminars/the-principals-academy>

ITS WORLD CONGRESS 2017

OCT. 29- NOV. 2 — MONTREAL, CANADA

Brings together global leaders in intelligent and transformative transportation to showcase and evaluate the latest innovative concepts, active prototypes, and live systems. A pavilion in the exhibit hall will highlight smart cities from around the world.

<http://itsworldcongress2017.org>

DESIGNING CITIES 2017: CHICAGO

OCT. 30-NOV. 2 — CHICAGO

National Association of City Transportation Officials convenes transportation leaders and practitioners to discuss key trends in urban street design and transportation policy.

<https://nacto.org/conference/designing-cities-conference-chicago-2017>

WATER INFRASTRUCTURE CONFERENCE

OCT. 30-NOV. 2 — SAN DIEGO

American Water Works Association conference features five workshops, five session tracks, and an exposition focused on solutions to utility infrastructure challenges.

www.awwa.org/conferences-education/conferences/water-infrastructure.aspx

NOVEMBER 2017

LEADERSHIP SKILLS FOR AEC PROFESSIONALS

NOV. 7-8 — ARLINGTON, VA.

Specifically developed to provide design and technical professionals with the skills to become more competent leaders, including strategies and techniques that will help them grow personally and professionally.

<http://zweiggroup.com/seminars/leadership-skills-for-aec-professionals>

GREENBUILD

NOV. 12-16 — ORLANDO, FLA.

Greenbuild, claimed to be the world's largest conference and expo dedicated to green building, includes speakers, networking opportunities, industry showcases, LEED workshops, and tours of the host city's green buildings.

<https://greenbuildexpo.com>

INTERNATIONAL WATER CONFERENCE

NOV. 12-16 — ORLANDO, FLA.

Dedicated to advancing new developments in the treatment, use, and reuse of water for industrial and other engineering purposes.

<https://eswp.com/water>

AUTODESK UNIVERSITY

NOV. 14-16 — LAS VEGAS

Autodesk's annual user conference features technology keynote addresses, an exhibit hall, certification exams, and hundreds of classes for designers, engineers, and industry professionals.

<http://au.autodesk.com>

AEC BUSINESS DEVELOPMENT TRAINING

NOV. 16 — SEATTLE

Specifically developed to help design and technical professionals become more comfortable dealing with clients and promoting the firm and its services.

<http://zweiggroup.com/seminars/aec-business-development-training>

EXCELLENCE IN PROJECT MANAGEMENT

NOV. 29 — CHARLESTON, S.C.

Tutorial and case study workshop sessions present critical areas every project manager should know from the perspective of architecture, engineering, and environmental consulting firms.

<http://zweiggroup.com/seminars/excellence-in-project-management>

DECEMBER 2017

2017 NATIONAL ACCELERATED BRIDGE CONSTRUCTION CONFERENCE

DEC. 6-8 — MIAMI

The conference and preconference workshop is sponsored by the Accelerated Bridge Construction-University Transportation Center at Florida International University.

<https://abc-utc.fiu.edu/conference>



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FOR EVENTS LATER IN 2017 AND 2018. SEND

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AWARDS, PROMOTIONS, AND NEW HIRES

Mahesh Kailasam, Ph.D., joined Thornton Tomasetti's Weidlinger Applied Science practice as a vice president and director of the Cupertino, Calif., office. **Leo A. Fernandez, P.E.**, joined the firm's Wall Street, New York office as a vice president in the Weidlinger Transportation practice. He has more than 20 years of experience in the inspection, analysis, rehabilitation, and design of roadway, rail, pedestrian, and long-span bridges.

Julie L. Labonte was named senior vice-president and senior program manager within AECOM's Design and Consulting Services group's Program and Construction Management business. She has nearly 30 years of water and wastewater expertise. AECOM named **Zeynep Erdal, Ph.D., P.E.**, regional business line leader for its water business in the Los Angeles Metro+ region, which encompasses Southern and Central California and Nevada. **Randall A. Wotring** was named chief operating officer, effective July 1, 2017. He has more than 30 years of experience in the engineering and construction industry and was promoted in September 2016 to group president, Technical and Operational Services.

Jon Helhowski, P.E., LEED AP, joined STV as vice president and chief mechanical engineer. He will be based in the firm's Douglassville, Pa., office where he will lead mechanical engineering efforts for STV's Buildings & Facilities Division.

Barbara Arens, P.E., was named Central region business manager of the transportation and infrastructure sector at WSP USA. **Stephen Bonina, P.E.**, was named a vice president in the Newark, N.J. office of WSP USA, where he will serve as the Eastern region fleet manager for WSP's transit and rail technical excellence center. **Shannon Williams, P.E.**, is a lead water resources engineer in the Portland, Ore., office of WSP USA, where she will oversee projects involving stormwater management, drainage conveyance systems, water mains, sanitary sewer systems, and pump stations. **Axel Nitschke, Ph.D., P.E.**, was

named a tunnel practice leader, based in WSP USA's Washington, D.C. office, and will lead the firm's practice using the New Austrian Tunneling Method. **Luis A. Porrello, Ph.D., P.E.**, was named senior vice president and business development director for the West region of the transportation and infrastructure sector of WSP USA. **Mel Sears, P.E.**, was named Northwest Pacific district manager and Seattle office area manager at WSP USA, responsible for oversight of the firm's operations in Washington, Oregon, Hawaii, and the South Pacific.

GZA promoted **Bruce Fairless, P.E.**, to principal, operating from the company's Boston office, where he was recently named manager. His areas of specialization are geotechnical and geothermal well field design and construction. **Kenneth D. Boivin, CHMM**, was promoted to principal and senior vice president at GZA's Bedford, N.H., office.

McLaren Engineering Group expanded its Orlando, Fla., office with the addition of **Brett Rowan, P.E.**, senior structural engineer, and **Mauricio Posada, P.E.**, senior marine engineer. McLaren's Orlando-area projects have included work for multiple high-profile theme parks. McLaren has also engineered marine structures across the state.

Don Sepulveda, P.E., was promoted to vice president and deputy national market lead in the Railroad and Transit Practice for Michael Baker International's West region based in the firm's Los Angeles office. **Mary Jo Hamman** was promoted to office executive, overseeing Michael Baker's two Indiana offices and more than 25 team members in Indianapolis and Highland. As part of her 31-year career, she spent 17 years with the Indiana Department of Transportation as a Design Development Section manager. **Sue Barker, P.E.**, was promoted to office manager, overseeing 12 team members in Michael Baker's Madison, Wis., and Milwaukee offices. She has more than 30 years of experience in transportation planning, design, construction management, and public involvement. **Rick Robyak, P.E.**, was promoted to senior vice president and office executive in Michael Baker's Moon Township, Pa., office. This position was created to further drive the firm's strategic growth in the region.

NV5

2017 **HOT FIRM**
ZWEIG GROUP
NUMBER ONE

2017 ZWEIG GROUP HOT FIRM LIST

NV5 GLOBAL TOPS THE RANKINGS WITH
THREE-YEAR REVENUE GROWTH OF 107 PERCENT.

By Richard Massey

THE ZWEIG GROUP Hot Firm List and Best Firms To Work For (see page 20) will be celebrated on Sept. 21-22 at the Hot Firm and A/E Industry Awards Conference at the Fairmont Olympic Hotel in Seattle. The top 25 Hot Firms this year (see “2017 Hot Firm List Top 25”) showed the industry what it means to grow. On average, the Top 25 grew by 129 percent in terms of three-year percentage growth, and by more than \$43 million in terms of dollar growth. Hot Firm rankings are based 50-50 on percentage growth rate and dollar revenue growth rate over the previous three-year period.

This is the 18th year for the list, which began when The Zweig Letter started ranking firm growth. While this year’s list features newcomers such as Patel Greene & Associates, PLLC, one of the mainstays of the list are firms that appear in the rankings year after year, such as Hill International.

“Getting on the list is like winning an Oscar,” said Mark Zweig, founder and chairman of Zweig Group, and the founder of the Hot

Firm List. “It says you are the best at what you do — running an A/E/P or environmental consulting firm in an industry made up of 100,000 companies.”

While the Top 25 were clearly ahead of all the other firms, those that appeared on the list from 26 through 100 had nothing of which to be ashamed. Firms in the lower quartile, for example, still grew by an average of 51 percent and had a dollar growth of nearly \$9 million. Not bad for firms on the “bottom” of the list.

The top Hot Firm, however, deserves special mention. NV5 Global Inc. (www.nv5.com), of Hollywood, Fla., pulled off an amazing feat — three-year growth of 107 percent, or in terms of dollars, \$126 million.

NV5, with a combined 104 offices across the United States and in China, Vietnam, and the autonomous territory of Macau, is a truly global enterprise that serves the infrastructure, construction, real estate, and environmental markets. During the last three years, the firm has experienced meteoric growth, from 2014 gross revenue of \$108 million to \$224 million in gross revenue last year — a 107 percent increase, according to figures published in the firm’s 2016 Annual Report.

The firm’s chairman and CEO, Dickerson Wright, has more than 35 years of experience managing engineering firms. He earned a bachelor of science degree in engineering from Pacific Western University and is a board-certified engineer in California and Wisconsin. He took time out of his busy schedule to discuss a few key aspects of running a powerhouse firm.

What’s the recipe for creating an effective board?



2017 Hot Firm sponsor is led by Dawson Fercho, a business development guy who is part 'social worker,' part 'psychologist.'

Dawson Fercho says he likes to laugh. And why not? At 46, he's co-founder of a growing firm, Corporate Tax Advisors, is an IRS enrolled agent in all 50 states, and is licensed by the U.S. Department of the Treasury.

He's oftentimes out on the road doing his thing – selling tax and financial services to architecture and engineering firms, and helping them enhance their bottom lines. He also has a wife, three kids, and is a coach of youth sports.

So it's pretty easy for Fercho to laugh. He's got a lot going on, and it's all going his way.

But don't let the easygoing nature fool you. Fercho is a hard-charging businessman who knows how to fill a niche and can walk into a room full of engineers and not meet a stranger. Not the easiest thing to do. But for Fercho and his company, that's how it has to be.

"We want to know the firms we work with," he says. "We want to be a valued member of their financial team. But I don't want to always talk about business. There are other things going on."

But when it comes down to business, Fercho and his team know the score. Experts in three sections of the Tax Code – the Research and Development Tax Credit, the Energy Efficient Commercial Building Deduction, and Cost Segregation – Corporate Tax Advisors finds dollars that firms didn't know they had.

"There are 9,000 different code sections, and we focus on three," Fercho says. "Pick a beach head and be the best at that thing."

And the big benefit for qualifying firms? Reduced costs for research, labor, and an overall lower taxable income. In a video embedded in CTA's website, Fercho says he wants to "demystify" the R&D Tax Credit. The biggest mystery for firms, Fercho says, is simple: "Do they qualify?"

Of the three specialties handled by CTA, efficiencies through the R&D Tax Credit are the most sought after. But firms oftentimes consider the R&D Tax Credit and think of white coats, petri dishes, and the Scientific Method. While

those staples are certainly covered under the umbrella of the credit, the definition captures a much broader array of endeavors.

"I unpack what R&D really is in terms of the U.S. Congress' interpretation," Fercho says. "When the credit first came out, it applied well to the widget makers, and they didn't think it could apply to a design package."

But it does. And in Fercho's experience, most of the firms looking at the tax credit end up qualifying. And word has trickled down from the big firms to the firms that have around \$5 million a year in revenue and around 20 employees. CTA also works with software firms, light manufacturing, aerospace/defense, and construction, among others.

Founded in 2014, CTA is based in Huntsville, Alabama, but has offices in Atlanta, Detroit, Houston, Kansas City, and Los Angeles. Flexibility, Fercho says, is key for the firm, which has a staff of 15 attorneys, CPAs and engineers.

"We're decentralized," he says. "We go where the clients are."

CTA is a small firm and wants to grow, but not necessarily by too much.

"There's certain things you lose – aggressiveness and spontaneity – when you get big," he says.

Fercho worked at two firms prior to co-founding his current company with co-principals Mike Woeber and Rob Kling. While he learned the tools of the trade prior to CTA, he also figured out what he did not want the new firm to be – "fee-centric" rather than "client-centric."

"If you're in it just for the money, you'll burn out quickly," Fercho says.

Clients range from those with \$5 million in annual gross receipts to those with \$250 million. Regardless of the size, Fercho's approach is the same. A born people person and a salesman, he gets to use his skills when out on business development trips.

"You can't be afraid," he says. "At some level you're a social worker, or a psychologist. You can't be an introvert. You have to be able to talk and be able to listen."



DAWSON FERCHO is a principal at Corporate Tax Advisors. He can be reached at dawsonf@corporatetaxadvisors.com.

Wright: In addition to having deep knowledge and a wealth of experience in our specific industry, our board members must understand and support the culture of our organization and our growth strategy. Everyone on our current board brings a different point of view to the table. They feel very comfortable voicing their opinions if they disagree with a particular deal or potential decision, but they all understand NV5's goals and our business philosophy. Many of our board members also come from very large successful firms, so their input comes from a standpoint of growth and looking to the future, which is what we always want to remain focused on.

Is there a secret to effective ownership transition?

Wright: Culture, culture, culture. Our definition of culture is very specific at NV5. We are a public company because we want partners, not key employees. We are a company focused on growth. The companies we acquire must agree to be integrated into our shared services platform so we know everyone's progress is being measured the same, so we are all working toward the same goals, and so everyone has the same protections and resources that will allow them to do the best work possible. By being a public company and putting stock into our deals, we also eliminate the polarization of company owners who are seeking an exit strategy and their employees who have been growing the business and the client base and are seeking ownership.

What has your firm done recently to upgrade its IT system?

Wright: Great question because this is something we have been giving a lot of attention to lately. In addition to making sure we are maintaining the highest standards of safety and protection of our information, we now have 104 offices throughout the United States and abroad and that comes with opportunities and challenges of another kind. With such talented experts so geographically dispersed, we want to make sure that any engineer can support any project, no matter where it is, and having cutting edge technology is key to that ability. Eliminating sub-consultant fees where possible is a big focus of ours and we do this through cross-selling our services among our verticals. Technology is one thing we can do to make this initiative easy and intuitive for our team.

What's the best way to recruit and retain top talent in a tight labor market?

Wright: We drive stock very deep into our organization and that is one key reason we are a public company. It ensures that our employees own the same shares as our management team, as our investors, and that everyone has an opportunity to share in the company's success, which can be measured objectively through public disclosures and our stock performance. Each of our verticals is run by an entrepreneurial leader who has a particular interest and expertise in his or her specific practice. They have an opportunity to grow those verticals and shape the business, but they also get the support needed to spur growth from the other verticals and the corporate organization. For this reason, we tend to attract employees who are interested in a fast-growing, flexible organization with clear opportunities for autonomy and leadership. Our company is flat and vertically structured, so there are also many points

of access to leadership and our management team is constantly accessible to our employees.



**Dickerson Wright,
chairman and CEO,
NV5 Global Inc.**

RICHARD MASSEY is director of newsletters and special publications at Zweig Group and editor of The Zweig Letter. He can be reached at rmassey@zweiggroup.com.



HOT FIRM LIST TOP 25

1. NV5 Global, Inc.
2. CMTA, Inc.
3. The Vertex Companies, Inc.
4. WGI, Inc.
5. WSB
6. LJA Engineering, Inc.
7. Partner Engineering and Science, Inc.
8. Huckabee
9. Hargrove Engineers + Constructors
10. ISG
11. Rincon Consultants, Inc.
12. EN Engineering, LLC
13. Maser Consulting P.A.
14. NWH
15. BHC RHODES
16. McMillan Pazdan Smith
17. ESP Associates, PA
18. Cherokee Enterprises, Inc.
19. RTM Engineering Consultants, LLC
20. CRB
21. Ware Malcomb
22. Environmental Partners Group, Inc.
23. ECS
24. Long Engineering, Inc.
25. Orchard Hiltz and McCliment, Inc. (OHM Advisors)



We're all about superior support.

It's well known that steel joists, with their impressive strength-to-weight ratio, provide greater support. What might be surprising is all the ways the Steel Joist Institute provides outstanding support to engineers, architects and other industry partners.

Through publications, webinars and design tools, our goal is to provide information on how to build with steel joists and Joist Girders.

To take advantage of all the education tools created to help you design with steel joists, visit:

steeljoist.org

Upcoming Webinars

September

Bridging – How It Works and What to Work Around

October

Part 1: Evaluation and Modification of Open Web Steel Joists and Joist Girders

November

Part 2: Evaluation and Modification of Open Web Steel Joists and Joist Girders

2017 BEST FIRMS TO WORK FOR

LEADERS DISCUSS HOW BEING A 'BEST FIRM' HELPS MARKETING, TEAM BUILDING, AND RECRUITING.

By Richard Massey

RESULTS FOR THE 2017 Best Firms to Work For were generated from surveys of more than 11,300 people in the AE industry — from C-suite executives to administrative staff. This year, seven categories were honored: structural, environmental, multidiscipline, civil, geotechnical, landscape architecture/planning, and architecture (see “2017 Best Firms To Work For Top 3”).

Of note is the percentage of Best Firms — 40 percent — that offer tuition reimbursements for business school. Engineering and architecture are one thing, but running a business is another. The Best Firms “get” this dynamic, and through tuition reimbursements are clearly grooming the next generation of leaders.

Another standout in the survey results was the number of firms that use open-book management on a regular basis. Of the firms surveyed, nearly 21 percent said they share financial information with the entire firm on a monthly basis. But this is not markedly greater than the number of firms that don't, at 18.4 percent. Firms that conduct open-book management say the process instills vision up and down the org chart, giving employees at every level the information they need to help the firm succeed.

The combined list of employee-friendly firms reached 141 this year. The complete list of winners is available at <http://hotfirm.com/our-awards/best-firms-to-work-for>.

The leaders of the top Best Firm in each of this year's seven categories commented on the award and how it is good for marketing, team building, and recruiting.

HOW HAS BEING A BEST FIRM HELPED YOU RECRUIT AND RETAIN TOP TALENT IN A TIGHT LABOR MARKET?

Choice One Engineering

“Being named a Zweig Group Best Firm has played a small part in attracting new employees,” said Matt Hoying, president, Choice One Engineering (Sidney, Ohio), a 37-person civil engineering firm. “Our new employees have told us, though it wasn't a deciding factor in coming to work for Choice One, it was a reason they researched the company more and ultimately reassured them when making their final decision.”

Harper Houf Peterson Righellis Inc.

“Harper Houf Peterson Righellis Inc. finds being on the list for Zweig Group Best Firms extremely helpful in attracting new talent, but more importantly, helping us gauge how we are doing with our current employees and in-house talent,” said Dan Houf, president, Harper Houf Peterson Righellis, Inc. (Portland, Ore.), a 90-person landscape architecture firm. “We continually strive to be a great place to work, and to provide a professional and rewarding experience for all of our professional staff. The Zweig Group survey provides an opportunity to gauge areas of strengths, and to find opportunities to improve our firm. We use the rankings on our web page as well as advertisements for current openings. We also use our Best Firm standing in marketing, as it provides us with credibility to our clients that we treat our employees fairly, leading to low turnover and consistent client service.”

HOW HAS BEING A BEST FIRM HELPED YOU IN TERMS OF MARKETING YOUR FIRM?

Fitzmeyer & Tocci

“In 2014, we set a strategic objective to have a stellar reputation in the engineering community as the workplace of choice,” said Ted Fitzmeyer, president, Fitzmeyer & Tocci (Woburn, Mass.), a 40-person multidiscipline engineering consulting firm. “Being a Zweig Group Best Firm impartially confirms our commitment to our strategic plan, our staff, and ultimately to our clients. Receiving this prestigious

award illustrates the commitment we have to our employees and aids in attracting top-notch talent, which is key to our continued success.”

Huckabee

“We place great emphasis on excellence in everything we do, and this means investing in our team, our offices, and our culture,” said Chris Huckabee, CEO, Huckabee (Fort Worth, Texas), a 218-person architecture firm. “Where we are today, and the culture we’ve nurtured, is the result of 50 years of practice and focus in the educational market. We love to talk about our clients and our employees and the great work they are doing for Texas communities. Being named Best Firms to Work For gives us one more opportunity to spread the word about the people who make our workplace great. The award is also a message to our clients that we invest in our team because we are invested in you; at Huckabee, we are all-in to education, and this means recruiting people who are going to be all-in with us and with them.”

IN THE PROCESS OF BECOMING A BEST FIRM, WHAT DID YOU LEARN ABOUT BUILDING A GREAT TEAM?

Mulhern + Kulp

“To us, being voted ‘Best Structural Engineering Firm to Work For’ is an affirmation of one of our founding principles — that our people, both collectively and individually, are our most valuable asset,” said Mike Mulhern and Joe Kulp, founders, Mulhern+Kulp (Ambler, Pa.), a 60-person structural engineering firm. “We share a genuine concern for their personal well-being, career satisfaction, and overall success — achieved in a positive, open, friendly, and encouraging environment. We are motivated every day to grow our business so that we can provide new challenges and career advancement opportunities for every one of our employees.”

Comprehensive Environmental, Inc.

“The formula for happy employees includes the basics of good pay, good benefits and good working conditions, but more importantly, the daily gratification of a job done well and making a difference for our clients and for the environment,” said Eileen Pannatier, CEO and founder, Comprehensive Environmental Inc. (Marlborough, Mass.) a 30-person geotechnical firm.

Ecosystem Planning & Restoration

“Building a great team starts with visualizing the culture and environ-

ment you want to build for your company, and then pursuing team members who embody that vision,” said Sonny Kaiser, principal, Ecosystem Planning & Restoration, (Tomball, Texas), a 21-person environmental firm. “We learned through this process that identifying the best people to help build our company culture takes time, but is well worth the effort to find the right people. Identifying leaders who help embody and define our culture has been critical to becoming a Best Firm to Work For, and those leaders help us create an environment where people desire to work.”

RICHARD MASSEY is director of newsletters and special publications at Zweig Group and editor of The Zweig Letter. He can be reached at rmassey@zweiggroup.com.



BEST FIRMS TO WORK FOR TOP 3

Civil engineering

1. Choice One
2. Bowers and Kubota
3. Criado & Associates, Inc

Multidiscipline

1. Fitzmeyer & Tocci
2. Garver
3. Bowers and Kubota

Structural engineering

1. Mulhern & Kulp
2. Barrish Pelham
3. SidePlate Systems, Inc.

Architecture

1. Huckabee
2. Mackey Mitchell Architects
3. Hastings Architecture Associates

Landscape Architecture and Planning

1. Harper Houf Peterson Righellis
2. SCJ Alliance
3. Hitchcock Design Group

Geotechnical Engineering

1. Comprehensive Environmental
2. Geodesign, Inc.
3. R&M Consultants, Inc.

Environmental Services

1. Ecosystem Planning & Restoration
2. EHS Support
3. Comprehensive Environmental



Bentley software streamlined evaluation of alternatives that were prepared under changing design requirements, and facilitated work sharing and cross checking among team members.

SUSPENDING DISBELIEF

STREAMLINED DESIGN AND ANALYSIS OF SOUTH
AMERICA'S LONGEST SUSPENSION BRIDGE.

By Samantha Langdeau

IN SOUTHERN CHILE off the coast of Llanquihue Province, the people of Chiloe have cultivated an island culture steeped in history and tradition. This isolated enclave is famous for its coastal towns with colorful houses built on stilts, 17th century churches designated as UNESCO World Heritage sites, and national parks teeming with marine life. Yet to travel to and from the island, locals and visitors alike must book passage on an unreliable ferry for a 45-minute ride across the treacherous Chacao Channel.

Chile's Ministry of Public Works (MOP) first conceptualized a bridge to connect the Island of Chiloe to the port city of Puerto Montt on the mainland in the 1990s. After several false starts, a US\$740 million design-build contract was awarded in February 2014. Upon completion in 2020, the Chacao Bridge will be the longest suspension bridge in South America at 2.75 kilometers. The asymmetrical structure will feature 1,055- and 1,155-meter main spans and three towers that rise to heights of 157, 175, and 199 meters. The four-lane carriageway on deck will soar 50 meters above the turbulent channel waters.

As the cabinet-level office in charge of all aspects of public infrastructure in Chile, MOP is overseeing the international consortium retained to take on the engineering and construction challenges presented by the highly seismic region, strong currents, deep channel, and high winds. The consortium, Consorcio Puente Chacao, is comprised of Hyundai (South Korea), OAS (Brazil), Aas-Jakobsen (Norway), and Systra (France). MOP's Department of Roads, which is in charge of Chile's road network, is responsible for design verification, structural evaluation, and constructability of the bridge. Local consultants are providing an independent design check.

Overcoming site restraints

Funded by the government of Chile as a public works concession (P3), Chacao Bridge includes three public works projects: the suspension bridge, the access roads, and a service area. The aggressive 84-month schedule demanded rapid evaluation of design alternatives, streamlined design studies, highly collaborative workflows, and accelerated reviews. MOP implemented Bentley's RM Bridge to save time and reduce costs. The application is used to perform bridge design, analysis, and construction simulation to determine resiliency during seismic and natural events. It streamlines the massive analytical tasks and automates complex design and engineering functions.

When work began in 2014, the project team confronted several extreme challenges in designing the multi-span suspension bridge across Chacao Channel. The project site is in a remote area of the Los Lagos region, 1,100 kilometers south of Santiago. The channel separates the 200-kilometer-long island from the mainland, but both land masses are part of the coastal range noted for high seismicity. The bridge is just 80 kilometers from the fault zone where a disastrous 9.5 magnitude earthquake struck Valdivia, Chile, in 1960. In 2010, an earthquake of



The bridge design features 1,055- and 1,155-meter main spans that will clear the Chacao Channel by 50 meters.

8.8 magnitude struck offshore of Concepción, about 650 kilometers north. Seismicity was the most challenging design criteria for the team.

Additionally, the channel is prone to critical winds of up to 208 kilometers per hour, and ocean currents reach 9.7 knots or 18 kilometers per hour, with 8 meter waves. The deep channel plunges 120 meters to the sea floor. Mid-channel, rock protrudes enough to provide a base for the central support tower, but it presented problems with subsidence.

Fast, accurate analyses

To ensure the safety and serviceability of the bridge under these conditions, and adhere to strict environmental qualifications that protect local flora and fauna, archeological zones, and aboriginal communities, the project team performed global analysis and time-history analysis with RM Bridge based on multiple engineering studies. The analyses investigated factors influencing linear, non-linear, static, and dynamic behaviors, including bathymetric, geodesic, geologic, geotechnical, seismic, topographic, and aerodynamic. MOP implemented gINT to streamline data management and reporting for the geotechnical and geoenvironmental work.

Wind tunnel analysis studied the bridge's aerodynamic stability both in parts (deck, towers, and suspension cables) and as a whole. MOP used the advanced wind analysis capabilities of RM Bridge to conduct computational fluid dynamics studies. The seismic analysis focused on specific response criteria for both bedrock and soil behavior. The effects of wave impacts in the event of a tsunami also had to be considered. This comprehensive probabilistic seismic hazard analysis (PSHA) defined the structural response to seismic activity.

The structural design of Chacao Bridge was guided by seismic design criteria according to AASHTO LRFD Bridge Design Specifications (2012), in conjunction with Chilean Standards (NCh), Japanese norms, and Eurocodes. Given the harsh environmental conditions, RM

Bridge's parametric analysis capabilities reduced the time required to evaluate alternatives and verify the structural design. RM Bridge proved to be a powerful tool for checking complex structural designs and reacting quickly to conditions in the field that require design modifications.

"RM Bridge has been a very powerful tool for the challenging design tasks of the Chacao Bridge, improving the checking process and ensuring quality in the process," said Matias Valenzuela, Ph.D., Ministerio Obras Públicas de Chile. "The software is an excellent platform for innovation."

Economic bridge design

RM Bridge helped to resolve issues that arose during construction due to the harsh conditions. Because the bridge is asymmetrical, with two spans of different lengths, the three pylons carry the burden of balancing the uneven loads. The central, 175-meter tower, shaped like an inverted-Y, became the focus of intense mitigation efforts when subsidence of the mid-channel rock formation created a construction challenge. The problem was solved by using the advanced dynamics and wind analysis capabilities of RM Bridge. Performing 3D computational analysis aided in evaluating alternatives and improving the design of the central tower.

When construction is complete, MOP will assume responsibility for operations and maintenance of the bridge. MOP instructed the project team to consider operations and maintenance efficiency and economy in the bridge design, so the Ministry anticipates that the life cycle costs of this infrastructure asset will be optimized. Overall, MOP credits the high-quality design for this multi-span suspension bridge to the team's using the most advanced bridge engineering applications available.

With a 100-year design life, the Chacao Bridge will improve quality of life, commerce, and tourism for the Island of Chiloe and the port city of Puerto Montt. The bridge will replace the sporadic ferry service across the rough channel and shorten the trip to minutes. Improved access and mobility between the mainland and the island will encourage an influx of professionals to live and work in the area. The bridge will also serve as a conduit for water, power, and telecommunication lines, creating the opportunity for new development.

Ultimately, Chacao Bridge will connect the Island of Chiloe to Chile's highway system, uniting the island community with the rest of the country. The Chilean government estimates the advent of improved commerce will result in a 6 percent social return on investment in the region.

The Chacao Bridge is an emblematic project, as the first long-span suspension bridge in Chile. It represents an opportunity for the exchange of technological know-how among MOP and the partners participating in the consortium, and demonstrates that Chile provides a favorable business climate for developing large-scale projects.

SAMANTHA LANGDEAU is the senior product marketing manager - Structural & Bridge for Bentley Systems (www.bentley.com). She has worked in the structural, civil, and geospatial industries for more than 13 years.

LESSONS LEARNED FROM A LOST ART

LEVERAGING 2D FINITE ELEMENT ANALYSIS IN STRUCTURAL DESIGN.

By Peter R. Barrett, P.E.

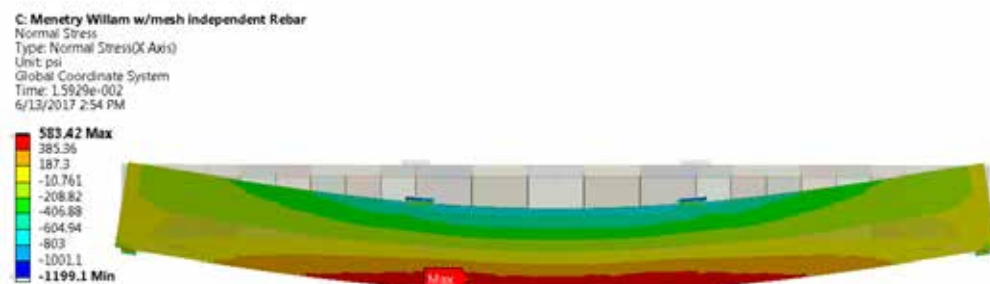


Figure 1: Nonlinear plane stress modeling of reinforced concrete beam

IN 1960, the first documented application named “the finite element method” was a 2D simulation of a gravity dam (Clough, 1960). This civil engineering application was part of the beginning of a new era in structural analysis and design. Yet in 2017, 2D stress analyses appear to have become a lost art. Increases in computational resources and software efficiencies have made 3D simulations the norm. But, many lessons can still be learned via 2D analyses where high-fidelity nonlinear structural response or automated design optimization can be captured in a reasonable time.

Most finite element analysis (FEA) simulations start from CAD drawings (see the author’s blog post, Practical FEA Simulations, at <https://caeai.com/blog/practical-fea-simulations>). Since the drawing file is often a 3D rendering, the analyst will often start by creating a 3D finite element model. Yet for many problems, a 2D simulation will provide quicker, more accurate results, allowing for additional design iterations and even design optimization in the same time required to perform a single 3D analysis. At a minimum, when the required simulations are highly nonlinear, lessons learned from 2D simulations can help streamline the input assumptions and convergence efficiency of the future 3D run. Two-dimensional loading can be applied in many forms, including in-plane forces, moments, pressures, accelerations, and temperatures. Special-purpose harmonic elements can also be used to represent non-axisymmetric loading on an axisymmetric FEA model using a Fourier series-based load case superposition approach.

Two-dimensional analyses can be used to model thin-walled structures using a plane stress assumption, very long construction systems using a plane strain assumption, and buildings of revolution using an axisymmetric solution. All three simulation types use the same 2D FEA mesh but different element stiffness formulations to simulate the physical differences, as summarized below.

Plane stress modeling

Plane stress is applicable for thin- to moderately thick-walled geometry, where zero normal and shear stress perpendicular to the structural model is assumed. The 2D plane stress FEA model has to lie in a single plane at $Z=0$ in most codes, but the geometry it represents does not

have to be of constant thickness. Modeling the life of a prestressed concrete beam, simulating the long-term effects of concrete creep and shrinkage along with thermal-induced cracking, would be an example where a 2D simulation is of great value since this type of detailed analysis requires a time-dependent solution that requires many equilibrium iterations (see Figure 1 for a 2D model of a standard four-point bend test).

Plane stress simulations allow for variable thickness inputs that can be combined with plane strain and/or axisymmetric models. When combining plane stress and axisymmetric elements, the plane stress

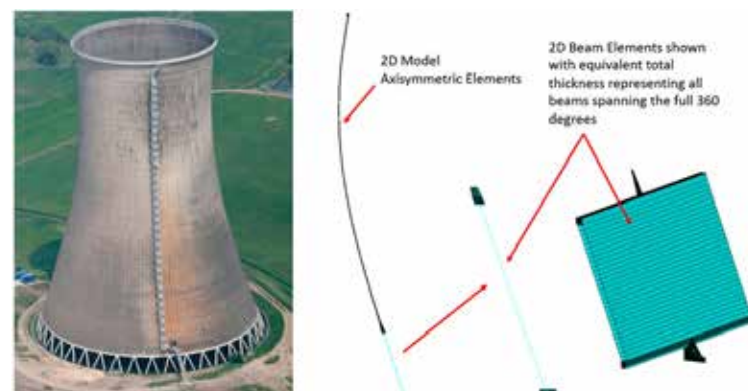


Figure 2: 2D beams and axisymmetric 2D model of cooling tower

element thickness must be consistent with the axisymmetric stiffness formulation, which is typically the full 360-degree stiffness. Thus, when representing a planar structure such as ribs or buttresses in a domed or cylindrical structure, the thickness defined for these non-axisymmetric components should be the combined thicknesses of all the ribs in the model.

An explicit example would be modeling an axisymmetric hyperbolic cooling tower that includes a base beam foundation superstructure. The photo on the left of Figure 2 illustrates the axisymmetric superstructure and the supporting beam framed base, which allows for a clear passage

of intake air. The images on the right of Figure 2 illustrate the 2D finite element model used in preliminary design. In this case, 2D beam elements are used to represent the combined stiffness of all the support beams where increased thickness is used to represent the equivalent stiffness of the entire array of support beams.

This 2D analysis model would be ideal for computing displacements and nominal design stresses under construction sequence loading where concrete curing is accounted for while minimizing the computing resources needed to simulate the step-by-step nonlinear “birth analysis” process.

Plane strain modeling

Plane strain assumes the out-of-plane geometry is large and/or constrained and that loading does not vary in the out-of-plane direction (Z) such that Z displacements are neglected. Common applications of plane strain include the analysis of dams and tunnels. The out-of-plane strain is either prescribed to be zero or held at a constant value in the special case of “generalized plane strain.” The physical geometry does not have to be rectangular, but it must be defined by a zero or constant rate of out-of-plane response.

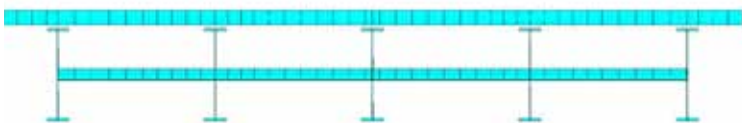


Figure 3: Generalized plane strain modeling of composite bridge cross-section

The generalized plane strain (constant out-of-plane strain) is typically required for temperature loads that would create near infinite normal stresses with the zero Z plane strain modeling assumption. Figure 3 illustrates a generalized plane strain model of a bridge deck cross-section. This simplified model is ideal for developing displacements and nominal stresses under cyclic thermal loading where nonlinear material response such as concrete creep and shrinkage might be simulated. While the model is predominately constructed from plane strain elements, the lateral braces are simulated with plane stress elements with reduced stiffness.

Axisymmetric modeling

For structures of revolution, including domes, pipes, piles, silos, or tanks subjected to axisymmetric loading, the 2D axisymmetric element formulation can save considerable computational time with increased stress accuracy. A parametric axisymmetric model of a concrete silo is used to illustrate the value of this 2D simulation. Figure 4 illustrates the design analysis performed, along with an example response surface interaction plot illustrating the sensitivity of adjusted design parameters on the structural response of the silo. Highlights from these design simulations include:

- A fully parametric model of the silo cross section is created as illustrated in the left image of Figure 4 to allow for variation in any design dimension.

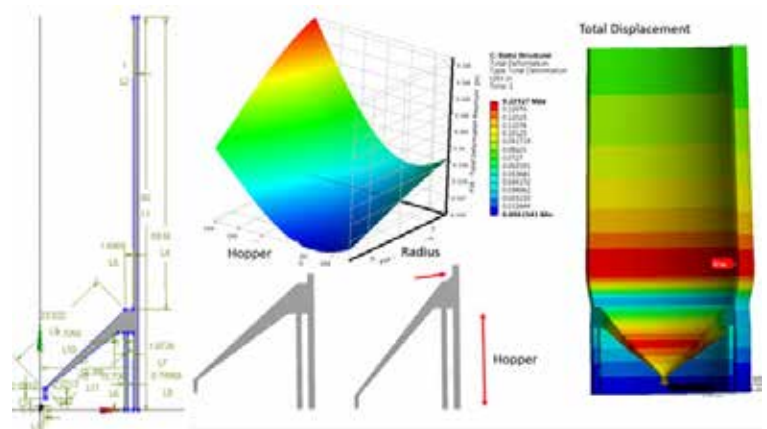


Figure 4: Parametric axisymmetric grain silo model

- Loading is defined via surface effect elements on the free internal model edges (representing the surfaces) utilizing a linearly increasing pressure representing the silo payload, such as grain.
- Material properties can be either linear or nonlinear depending on the analysis objective.
- Since the model solution time is very fast, a series of simulations were performed utilizing an automated design of experiments technique where multiple input and output variables can be monitored.
- In the bottom center images of Figure 4, the impact on the hopper height and ring beam to wall radii are defined as the input variables for this example.
- The output response monitored in this case is the maximum wall displacement. The right image shows the variation of displacement in the cross-section where the image is expanded to a 3D sector for better visualization.
- The response surface graph in the top center image illustrates the highly nonlinear interaction diagram documenting the variation in maximum displacement versus the associated changes in the parametric input variables.
- Utilizing a simple 2D model as shown allows the designer to quickly evaluate the impact of many input design variables that will be used to develop a more stable design. Once the stable design is developed, the 2D model can be easily revolved into a 90-degree or 180-degree sector upon which non-axisymmetric controlling wind loading could be simulated.

These are just a few of the many options in 2D finite element modeling. I welcome comments and/or examples that illustrate the value on performing 2D FEA simulations.

PETER R. BARRETT, P.E., vice president of CAE Associates (<https://caeai.com>), manages consulting engineering services and software training. With more than 30 years of experience in thermal-structural nonlinear and dynamic analysis applications using the finite element method, his structural engineering applications include Nuclear, Aerospace, Biomedical, and Offshore structures.

Reference

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STRUCTURAL SLAB DESIGN

EXPLORING USE OF FINITE ELEMENT ANALYSIS OVER THE TRADITIONAL STRIP METHOD.

AS SOPHISTICATED MODELING TECHNOLOGY has become available and widely adopted, the demand for innovative design is growing, leading the industry away from box structures and putting pressure on engineers to carry out more complex designs. Most engineers today face complex design challenges involving transfer girders, hanging columns, cantilevers, and sloped members. Column layouts supporting structural slabs are no longer uniform; increasingly irregular layouts and loading demand more unique and detailed design.

The need for flexibility in design makes the case for finite element analysis (FEA) over the traditional strip method. FEA can help solve challenging structural analysis problems, yet adoption has been slow. Why?

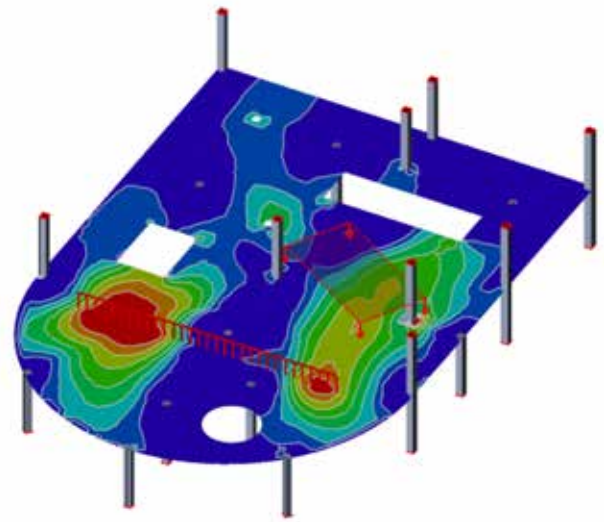
With the rise in more complex, irregular structures, the strip method falls apart. Instead of reverting back to the strip method, engineers should focus on the results of the analysis and look at where forces are actually occurring in the slab and then only placing the reinforcing in the slab where it is required.

Rethinking strip design methods

First, there is nothing wrong with strip design methods. With a regular slab, no significant openings, and regular loading, the traditional approach of strip design could even prove to be slightly more economic than FE design (although slower in design time).

Difficulties arise when layout and loading are not perfect. In this case, the engineer makes judgements to come up with idealizations that will result in a safe design. Inevitably these will err on the conservative side. The challenge becomes keeping them safe without being overly conservative and potentially wasteful. This approach moves analysis and design toward an art rather than a science, leaving room for interpretation and creating an opportunity to get the design seriously wrong.

On the converse, using FEA breaks those constraints. Design is faster and more flexible while simultaneously accommodating irregular slab



Design using FEA is faster and more flexible while simultaneously accommodating irregular slab geometry, significant openings, and irregular loading.

geometry, significant openings, and irregular loading. Reinforcement can be efficiently placed so that extra bars are only provided where they are required.

With FE, analysis and design become more of a scientific process with greater certainty and fewer errors.

Things to consider

Pragmatic design based on FEA still requires consideration of averaged design moments in localized strips. These can also be considered in the form of rectangular patches with associated reinforcement design. Problems can arise when trying too hard to extend averaging requirements in local strips and patches to exactly match the design strips considered in the traditional idealization.

The traditional strip method results should not be viewed as “correct” or totally accurate. Instead, they are simply acceptable and safe design forces in the regular situations where the method is applicable. This becomes quite apparent when comparing the similarities and differences between traditional approaches used in different countries working to different codes; all codes embrace a traditional strip method but there is quite significant variation in the proportioning of forces to the strips.

In an FE design, it’s important to embrace the concept behind the traditional strip idealizations without getting drawn into the need to replicate the method exactly. You’ll need to accept that averaging over slightly different strip widths is perfectly valid and will be safe, as long as you avoid averaging over greater widths than would have previously been assumed acceptable. So, the “art” that remains is using averaging to a reasonable degree. In addition, you don’t have to average everywhere, just where needed. Basically, keep it simple when possible.

You’ve run FEA, why not use that to place the reinforcing instead of being forced into the overly structured and rigid strip method?

Information provided by Trimble (www.trimble.com).

EXPERIENCING WHAT IS TO BE

MORTENSON CREATES AN AUGMENTED REALITY APP
FOR CONSTRUCTION VISUALIZATION.



Augmented reality app users can point their smartphones or tablets at the construction site on campus — or at a printed handout if off campus — to experience a life-like digital representation of the future CSE2 building.

AFTER PIONEERING THE USE of virtual design in construction, Mortenson Construction has developed a first-of-its-kind augmented reality (AR) mobile app to help the University of Washington (UW) community “see” the future CSE2 computer science building well before its doors open to students in January 2019. Similar to the popular Pokémon Go game, users can point their mobile devices at the construction site on campus — or at a printed handout if off campus — to experience a life-like digital representation of the future CSE2 building.

The app was developed by Mortenson's in-house immersive-technology team in Seattle, a project led by Marc Kinsman. Users can

experience the building’s exterior in AR and can then teleport inside for an immersive virtual reality (VR) experience in the main lobby, workroom, robotics lab, and offices. The app is designed to generate interest and engagement by faculty, students, and visitors during the building’s construction, which is located in a popular area of campus. A preliminary version of the Mortenson AR/VR app is now available for download on iPhone and Android devices.

“A typical campus construction project like CSE2 can last two years or more,” Kinsman said. “This window presents a tremendous opportunity to engage the public and to build excitement around campus. AR and



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Mortenson Construction's augmented reality mobile app helps the University of Washington community "see" the future CSE2 computer science building well before its doors open to students in January 2019.

VR represent a vast improvement over traditional public engagement methods like flyers, fencing signage, or a website. We are scratching the surface of what's possible."

In addition to serving as an immersive public engagement tool, AR carries the promise of reimagining the construction site. In this spirit, Mortenson was also among the first companies of any kind to partner with AR smart-helmet maker DAQRI (<https://daqri.com>) to test AR construction applications last year. AR headsets and goggles have the potential to provide crews with just-in-time instruction, projections of an installation layout on a concrete slab, or a data overlay that shows how each building system has been performing over time.

Completion of CSE2 will enable UW to accommodate a growing number of computer science and computer engineering students and faculty, while ultimately bridging the Puget Sound region's technology workforce gap. Presently, the bachelors-level workforce gap in computer science exceeds that of all other high-demand fields combined.

The 135,000-square-foot CSE2 project is designed by LMN Architects, the same architecture firm that teamed with Mortenson on the original UW computer science and engineering building that opened in 2013: the Paul G. Allen Center for Computer Science & Engineering. At a cost of \$105 million, CSE2 is being funded by a mix of public and private sources. In addition to classrooms, lab space, and workrooms for faculty, undergraduate and graduate students, and researchers, the building will include a 250-person lecture hall, seminar rooms, and conference facilities.

Mortenson's Seattle office — which helps drive VR and AR innovations across the company nationally — first used virtual design and construction modeling during its work on the iconic Walt Disney Concert Hall in Los Angeles in 2000. Some deemed the project unbuildable due to the architect's design and its absence of 90-degree angles. In partnership with Stanford University and Disney Imagineering, the team borrowed advanced modeling techniques from the manufacturing and aerospace worlds and applied them to construction.

The next leap came in 2006, when Mortenson used VR to model UW's Benjamin Hall Interdisciplinary Research Building. To inform its design, Mortenson's Seattle team outfitted a dark room with projectors that beamed a 3D building environment onto the walls and floor. The resulting technology was aptly named CAVE, which stands for Computerized Automatic Virtual Environment.

CAVE was subsequently used by Mortenson offices across the country, including the team that brought Penn State University its Pegula Ice Arena in 2013. The use of CAVE technology helped avert \$475,000 in changes by identifying them in the design phase. Mortenson's use of VR has also helped shave \$1.7 million from the cost of the Atlanta Braves' new stadium.

In Seattle, Mortenson's in-house integrated design team recently virtually modeled the 41-story AMLI Arc high-rise downtown, as well as the Residence Inn by Marriott hotel. Both projects are nearly complete.

Information provided by Mortenson Construction. See the company's extensive virtual design and construction initiatives at www.mortenson.com/vdc.

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TIMBER'S TIME

INCREASING USE OF TIMBER FOR MULTIFAMILY CONSTRUCTION
FACES INTENSE OPPOSITION FROM THE CONCRETE INDUSTRY.

By Richard Massey

THANKS TO A BIG CHANGE in the International Building Code, and a dramatic rise in building costs, concrete is losing market share to timber in the apartment construction industry — and the concrete industry is fighting back.

The National Ready Mixed Concrete Association (NRMCA), through an affiliate named Build with Strength, has mounted a campaign called “America is Burning,” in which every fire that takes place at wood-framed multifamily complexes — more than 50 since 2013 — is documented. Recent multifamily fires in Oakland and in College Park, Md., drew swift criticism from the concrete industry. “Maryland Apartment Fires Renew Calls for Stronger Building Codes,” reads the College Park release. The subhead for the Oakland fire says, “Fire Highlights Vulnerabilities with Wood-Framing, Lax Building Codes.”

Racing against the relentless pace of innovation, the building code, and a dramatic rise in the raw cost of concrete — from \$26 per gross square

foot to \$36 per gross square foot in the bellwether Washington, D.C., market — the concrete industry is trying to tell the world it’s more cost effective, lasts longer, and, of course, that it’s more resistant to fire than its wood competitor.

But is the message being heard?

Though there is no guess as to when and if it will pass, in March the Timber Innovation Act was introduced in the U.S. Senate, and among the nearly 100 organizations supporting the bi-partisan bill are state forestry groups from California to New England, the National Wildlife Federation, and timber giant Weyerhaeuser. The bill’s introduction in Washington comes as timber “plyscrapers” are sprouting up across Europe, and as the era of U.S. plyscrapers begins in Oregon with the permitting of a 12-story structure in Portland.

But for the NRMCA, the prime focus is not on wood towers but on the low- and mid-rise wood-framed apartment market, where a recent change in the building code brought about a profound change in the density multifamily wood construction can achieve. The change enabled what’s known as “five-over-two” and “five-over-three” construction, or five wood-framed levels separated by a concrete slab with two or three concrete-and-steel levels below (see Figure 1). What’s missing in all this? High-rise construction, the purview of concrete and steel.



Wood products industry at a glance

Employment:

- Wood products: 428,500 employees
- Forestry and logging: 135,600 employees
- Total: 564,100 employees

Manufacturing facilities:

- Sawmills, millwork, treating: 625
- Engineered wood and panel: 176
- Other wood products: 101
- Total: 902

Timberland (U.S. Forest Service, 2012; in thousands of acres)

- National Forest System: 98,308
- Other federal: 14,002
- State, county, and municipal: 48,668
- Private corp.: 111,279
- Private non-corp.: 248,896
- Total timberland: 521,154

Source: American Wood Council

By some estimates, "five-over-two" can be as much as \$70,000 per unit cheaper than high-rise, meaning builders are oftentimes opting for the more affordable option. The result? A dip in market share for concrete. And the numbers bear that out. Last year, according to the U.S. Census Bureau, of the 13,000 "multifamily buildings completed by framing," 11,000 were in wood, 1,000 in steel, and the remaining 1,000 framed with concrete.

But Kevin Lawlor, a spokesman for Build with Strength, a national coalition of architects, engineers, and fire officials directly affiliated with the NRMCA, is having none of the hype about wood.

"We see a lot of it going up and a lot of it burning down," he said.

And Lawlor has a point.

Based on the list maintained by the America is Burning campaign (<http://buildwithstrength.com/america-is-burning>), there have been more than 30 fires in low- and mid-rise wooden buildings across the country just this year. The May fire near Oakland was the second at the same location — a five-story wood-framed retail-apartment complex still under construction. The fire was huge, too, and nearly caused the collapse of a construction crane.

Another massive fire broke out in April at an under-construction apart-

ment complex in College Park, Md. According to local news accounts, it was the largest fire in the history of Prince George's County, causing about \$40 million in damage. The building employed "lightweight wood truss construction" in the upper floors, where the fire occurred, according to local accounts.

Enough said, in Lawlor's opinion. "We advocate for the use of non-combustible materials," he said.

In terms of price, Lawlor and his organization downplay the idea that building with wood is more cost-effective than building with concrete and steel, citing the key aspects of safety, efficiency, and durability.

"From the way we see it, it's that developers see [wood] as a cheap and quick way to build," Lawlor said. "That's a misconception people are buying into. We don't concede the cost argument."

But Dick Knapp, senior vice president of acquisitions for Washington, D.C.-based development firm Foulger-Pratt, disagrees with Lawlor. And, Knapp said, the concrete industry is only lashing out at wood because wood has made a big move in the market.

"They're threatened by the arithmetic," Knapp said. "They are responding to the competitiveness of stick."

SB 5379 opposition

Build with Strength offered the following rebuttals to 10 assertions in Washington State's SB 5379 (Constructing New Public Buildings with Cross-Laminated Timber):

1. Wood products help with carbon sequestration — Only 15 percent of CO₂ stored in a tree is actually sequestered. The rest goes up into the atmosphere as logging/mill waste and processing emissions.
2. Using timber prevents global warming — According to MIT, the operational-use phase of a building represents 88 percent to 98 percent of its global warming potential, dwarfing climate change impacts resulting from materials choice.
3. Logging is environmentally friendly — Atrazine, a known endocrine disruptor and likely carcinogen, is common in U.S. logging practices.
4. Logging is a sustainable business practice — Focusing on embodied carbon ignores the worst impacts of forest management — ecosystem depletion and biodiversity, as well as soil and water quality.
5. Since we can replant trees, logging is okay — Clear cutting is “an ecological trauma that has no precedent in nature except for a major volcanic eruption.”
6. New “wood technologies” are better for taller buildings — Wood burns and doesn't withstand Mother Nature. It's a building material that can't hold up to Washington State's need for resilient construction.
7. Taller mass timber buildings are safer — Mass timber, including cross-laminated timber (CLT), is classified as a “combustible construction” material in the International Building Code.
8. First responders support taller mass timber buildings — Heavy timber construction is one of the most dangerous types of construction facing firefighters and first responders. Research and experience shows CLT burns hotter and longer than even wood frame construction, putting occupants and firefighters at risk. Biased state legislation shouldn't replace the ICC process.
9. Taller mass timber buildings are code compliant — Fire and code officials do not have a quantitative method for assessing the level of fire safety of CLT buildings. This is why there is a newly created code committee to study this.
10. This bill will create jobs — A study on the impact of mandating wood construction in Oregon found that a mere 38.1 jobs were created in two years.

Source: Build with Strength



Mass timber — cross-laminated timber, nail-laminated timber, and glue-laminated timber — and wood has an appeal for multifamily low- and mid-rise construction. Photo: FPIInnovations

Knapp, however, said there's certainly a time and place for concrete — deep in the urban core where steep land prices dictate that only high-rise concrete-and-steel construction makes financial sense.

“That's where concrete shines,” Knapp said.

As it pushes for more restrictive building codes, Build with Strength also monitors local, state, and federal legislation, and is currently opposing SB 5379 in the Washington State senate. The bill, which requires public buildings under 12 stories tall to be constructed with cross-laminated timber, is currently in committee. Build with Strength opposes the bill on 10 points, challenging timber's key assertions that logging is sustainable and that timber buildings prevent global warming (see, “SB 5379 opposition”).

Build with Strength also opposes the Timber Innovation Act. Lawlor said he doubts the bill will pass, and criticizes it for picking “winners and losers” by giving incentives to the wood industry for research and development.

But timber appears unfazed by concrete's opposition. Robert Glowinski, president and CEO of the American Wood Council, brushed off concrete's criticism, saying, “What I think you're seeing is the response of a competing industry. I'm not surprised by it.”

Glowinski was quick to point out the obvious: “There's opportunity for all kinds of construction in the market.”

Glowinski is right. As the wood industry grows, concrete maintains its established place in the construction market at \$40 billion annually.

Still, a plug on the American Wood Council's website makes it clear how high the stakes are.

“With the global marketplace for green building materials estimated to reach \$529 billion by 2020, securing a strong place for wood is essential to the wood products industry's future growth. That means both telling the positive story of wood's renewable, energy-efficient advantages, as well as defending against anti-wood bias in rating systems. Strong, unified industry support is essential as the green building battlefield continues to spread from the state to the federal level.”



Since 2013, more than 50 fires have destroyed wood-framed multifamily complexes, according to Build With Strength.

With nearly 40 years in the industry, Glowinski has seen just about everything. What's come in recent years, however, has been transformative. Reductions in embedded energy — the energy it takes to produce a building — as well as air emissions and greenhouse gases have been considerable. Add to that mass timber — cross-laminated timber (CLT), nail-laminated timber, and glue-laminated timber — and wood has an appeal it didn't have not too long ago.

"The arc has been a progression," Glowinski said, referring to the re-emergence of timber products.

The proof of wood's ascension isn't hard to find, either. There's the Candlewood Suites in Alabama, the first hotel in the U.S. made with CLT, and the recently permitted Framework building in Portland, which, at 12 stories, will be the nation's tallest timber building when completed late next year (see "A framework for wood construction" on page 36). Currently, the tallest timber structure in the U.S. is the T3 office building in Minneapolis.

Perhaps the arrival of a new era for timber is best stated by Justin Adams, global managing director for lands at none other than The Nature Conservancy, considered the gold standard for environmental protection. In February, he addressed the crowd at a GreenBiz conference in Phoenix.

"What we have to do is start telling a business story of where the opportunities are to unlock the potential [of timber]," Adams said. "There's a huge opportunity for us to start thinking about and reimagining how we build in the future and how we create a new age for timber."

RICHARD MASSEY is director of newsletters and special publications at Zweig Group and editor of The Zweig Letter. He can be reached at rmassey@zweiggroup.com.

Fire testing completed on full-scale mass timber building

The American Wood Council reported that five, full-scale mass timber fire tests in a multi-story apartment building were completed "with promising results." The International Code Council Ad-hoc Committee on Tall Wood Buildings provided the five fire scenarios that were tested in each of the two, one-bedroom apartments constructed using mass timber. The test scenarios included various arrangements of exposed and unexposed cross-laminated timber (CLT) with open doors between living and sleeping areas. Additionally, automatic sprinkler systems effectiveness was evaluated.

- **Test 1** — A mass timber structure fully protected with gypsum wall board was subjected to a large furnishings and contents fire. The test was terminated after three hours without significant charring on the protected wood surfaces of the structure.
- **Test 2** — Approximately 30 percent of the CLT ceiling area in the living room and bedroom were left exposed. The test was terminated after four hours, providing additional time to determine if there would be any significant fire contribution from the exposed CLT. Notably, once the furnishings and contents had been consumed by the fire, the exposed CLT essentially self-extinguished due to the formation of char that protected the underlying wood.
- **Test 3** — Parallel CLT walls were left exposed, one in the living room and one in the bedroom. Similar to Test 2, once the apartment furnishings and contents had been consumed by the fire, during which a protective surface of char formed on the CLT, the mass timber surfaces essentially self-extinguished.
- **Tests 4 and 5** — Examined the effects of sprinkler protection. For both tests, all mass timber surfaces in the living room and bedroom were left exposed. Test 4 demonstrated that under normal operating conditions, a single sprinkler easily contained the fire. For Test 5, the fire was allowed to grow in the compartment for 23 minutes before water was supplied to the sprinklers, which quickly controlled the fire.

"The results of these fire tests will continue to be studied and will help inform code change recommendations from the Ad-hoc Committee later this year," said Stephen J. DiGiovanni, P.E., Ad-hoc Committee chair and fire protection engineer for the Clark County, Nev., Department of Building and Fire Protection. "These tests are an important part of the extensive research data the committee has reviewed to validate the performance of tall wood buildings."

The tests were funded in partnership with the U.S. Forest Service's Forest Products Laboratory and the American Wood Council, and were conducted at the U.S. Bureau of Alcohol, Tobacco, Firearms and Explosives Fire Research Laboratory. A General Technical Report FPL-GTR-247 on the fire tests will be available from the Forest Products Laboratory (www.fpl.fs.fed.us) in the near future.



Underneath the 48-foot span Perkins Bridge, crossing between Belfast Reservoirs Number 1 and 2 in Belfast, Maine. Image: Advanced Infrastructure Technologies, Inc.



The 54-foot span Farm Access Overpass in Caribou, Maine, with a stone finish precast concrete MSE wall. Image: Advanced Infrastructure Technologies, Inc.

Inspiring Bridge Innovation through High Performance Composites

University of Maine's Advanced Structures and Composites Center has spent the last decade taking arch bridge design and construction to a higher level. Using high-performance lightweight Fiber Reinforced Polymer (FRP) material, they have created a solution for short and medium span bridges that is recognized as one of the great new civil engineering innovations. The composite arch has already improved infrastructure deficiencies on roadway projects in more than twenty locations in the Northeast and Midwest United States.

Under a recent partnership between their spin-off company, Advanced Infrastructure Technologies, Inc. (AIT), and The Reinforced Earth Company (Terre Armée Group), the composite bridge system is fully-engineered and delivered on-site as InspirArch™. It combines the new composite arch innovation with a longstanding and thriving innovation, Reinforced Earth® Mechanically Stabilized Earth (MSE) retaining walls. The result is an efficient bridge solution with a 100-year design life.

InspirArch will accommodate a wide range of bridge geometries and site conditions, from the straight-forward to complex. The profile of the arch tube is custom-designed and fabricated to meet the geometry requirements of the bridge. They can be easily configured to allow for a skewed bridge alignment.

The materials and construction sequence are ideal for short to medium span bridges, especially when considering remote locations and accelerated bridge construction. The FRP arch units and decking are lightweight and can be installed with hand labor. The tubes are essentially pre-fabricated concrete formwork and reinforcement.

InspirArch structures consist of five major steps:

- FRP arch tube units are secured to cast-in-place concrete footing rebar on both ends of the bridge
- Cast-in-place concrete footings are poured
- FRP decking is installed along the top of the arch units
- Concrete is pumped into the top of the arch units
- MSE spandrel walls and wing walls are installed to create the roadway grade

Originally known as Bridge-in-a-Backpack™, the composite arch system, InspirArch was developed with military applications in mind, due to its lightweight and easily mobilized material. Other agencies have quickly recognized the value of the solution when applied to the Nation's badly needed infrastructure upgrades.

The American Association of State Highway and Transportation Officials (AASHTO) has completed a review of the composite arch system and published, "AASHTO LRFD Guide Specifications for Design of Concrete-filled FRP Tubes for Flexural and Axial Members."

The Federal Highway Administration has played an active role in the research and exploration of the use of FRP, and specifically the use of composites in bridge construction.

In addition to receiving an innovation award in 2011 from the American Society of Civil Engineers (ASCE), the composite arch system has been recognized as a "gamechanger" in ASCE's 2017 Infrastructure Report Card

InspirArch has proven to be the high-performance innovation needed to provide long-lasting upgrades to our transportation infrastructure.

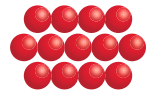
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1) FRP arch tube units are secured to cast-in-place concrete footing rebar on both ends of the bridge



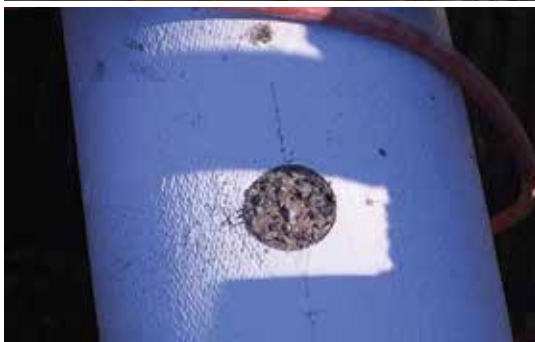
2) Cast-in-place concrete footings are poured



3) FRP decking is installed along the top of the arch units



4) Concrete is pumped into the top of the arch units



5) MSE spandrel walls and wing walls are installed to create the roadway grade

Project Photos from Crossroads Drive, Lewisburg, PA - AIT, Walsh Group



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When construction is complete, Framework will be the first high-rise building made from wood in the U.S., the tallest mass timber building in the U.S., and the tallest post-tensioned rocking wall project in the world. Image: courtesy of LEVER Architecture

A FRAMEWORK FOR WOOD CONSTRUCTION

FIRST MASS TIMBER HIGH-RISE BUILDING IN THE U.S. CLEARED FOR CONSTRUCTION FOLLOWING PERMITS APPROVAL.

IN EARLY JUNE, the Framework Project, LLC received approval for a building permit allowing construction of the first wood high-rise structure in the U.S. The permit, awarded by the State of Oregon and the City of Portland, designates Framework — a 12-story-tall wood resilient building planned for Portland’s Pearl District — as a “shovel ready” project, marking a landmark decision for the U.S. construction industry.

“Receiving a permit is a critical juncture for Framework and demonstrates the feasibility of using wood to build high-rise buildings in the U.S.,” said Anyeley Hallova, developer, project[^]. “With our path now clear to start building, Framework will start to unlock the demand for mass timber products at all scales, justifying new investment into rural manufacturing and job creation.”

Framework, stemming from a collaboration between project[^], Home Forward, Albina Community Bank, and Beneficial State Bank, aims to develop a pioneering model for a sustainable urban-rural ecology by



Structural model. Image: courtesy of LEVER Architecture

promoting sustainable building practices and economic opportunity in rural Oregon and ultimately across the U.S.

The official permit approves a regulatory pathway for Framework and, potentially, similar projects within the U.S. The building permit for Framework was approved following completion of a performance-based review process that included a series of fire, acoustic, and structural tests and oversight by an expert peer review team. The tests, which were carried out over several months in 2016, have proven that buildings constructed with mass timber, including cross-laminated timber (CLT) and glu-laminated timber (glulam), can perform to fire and life safety requirements and, in some cases, exceed current standards.

Seismic tests conducted on behalf of the Framework Project at Portland State University and at Oregon State University have been completed to validate Framework’s resilient structural design, which goes above and beyond the basic life safety requirements of the building code. This included full-scale tests on the project’s primary beam-to-

column connection, along with tests on the CLT shear wall panels to be used in the completed building. Structural seismic damage following a major earthquake is expected to be limited to replaceable “fuses,” which should allow for the building to be quickly repaired and limit downtime relative to conventional structures.

“The innovations in wood construction that are part of the design of the Framework building will help change how America builds in the years to come,” said Steve Lovett, CEO of the Softwood Lumber Board, a lumber industry organization that contributed \$1 million to the research and development phase of the Framework project as part of the U.S. Tall Wood Building Competition. “Modern wood-based building systems create opportunities to increase the use of wood products, which is better for both the environment and rural communities.”

Fire tests also provided proof that a mass timber assembly using CLT and glulam timber can be used safely as high-rise construction materials within the U.S. and meet stringent fire code requirements. In addition, the Framework project has completed extensive fire testing and computer modeling to demonstrate that select areas of wood in the Framework building can be exposed, adding to the overall aesthetic. Acoustic testing was also utilized to develop a solution that achieved the required sound insulation between apartment units. This is a departure from other high-rise projects around the world, which typically cover all of the wood product with drywall to meet fire and acoustic requirements.

“It is no accident that a first-in-the-nation project like Framework would be built in Oregon. Oregon’s unique building code system encourages innovation while ensuring projects comply with robust safety standards. We are proud to partner with local governments and industry



Mass timber beam-to-column seismic testing at Portland State University.
Photo: courtesy of KPFF Consulting Engineers

on this and other groundbreaking projects,” said Mark Long, administrator, State of Oregon Building Codes Division.

“The Framework project is literally a laboratory for the revival of building with mass timber, an investment for which Oregonians will be grateful for many generations to come,” said Valerie Johnson, president of D.R. Johnson. “The rural-urban divide in Oregon has existed too long. We hope our young people (in Douglas County) will now grow up believing there’s a future for them doing this type of work. It is inspiring for all of us to know that all together we are providing a more environmentally friendly, lower carbon-emitting, renewable and sustainable product for mass timber construction in urban areas.”

Information provided by The Framework Project, LLC
(www.frameworkportland.com).

MASS TIMBER WITH A STEEL CORE

A LOOK INTO THE FUTURE OF URBAN RESIDENTIAL CONSTRUCTION.

By Erica Spiritos and Mike Munzing

The City of Portland, Ore., is now home to the tallest mass timber hybrid building in the United States. Carbon12, the first building in the country to use timber framing for residential development at this height, stands tall at 95 feet and eight stories. A hybrid system of cross-laminated timber (CLT) floor and roof diaphragms and steel core, Carbon12 demonstrates the possibilities of mass timber hybrid construction.

Structural design

The primary structure of Carbon12 consists of a glulam post and beam with CrossLam CLT floor panels, steel buckling-restrained brace

(BRB) frame as the lateral force-resisting system, and light frame partition and exterior walls. The glulam beams and columns and CLT floor panels are exposed in most areas, allowing residents to experience and understand the structure of the building, so often concealed in residential construction. Beams and columns are connected with pre-engineered Ricon beam hangers, which are recessed beneath a sacrificial char layer of the timber to provide a 1-hour fire resistance rating.

The mass timber components, supplied by Structurlam, are integrated with a steel core to create a hybrid structure. This combination of structural systems is unique in multistory residential construction and serves to minimize the use of wet materials onsite and decrease the overall construction schedule. The BRB system allowed for most of the steel fabrication to take place offsite and be bolted together floor by floor, at the same pace as the wood construction, with minimal onsite welding. This allowed for reduced staging/shoring similar to traditional wood construction.

In addition to its lighter environmental footprint, the structure of Carbon12 is also significantly lighter in weight than its post-tensioned con-



The eight-story Carbon 12 uses a hybrid system of cross-laminated timber floor and roof diaphragms and steel core. Image: Baumberger Studio

Structure by the numbers

- 234 glulam columns
- 336 glulam beams
- 242 CrossLam panels
- 556 concealed, pre-engineered Ricon connections
- 56,000 self-tapping wood screws

crete counterpoint. Consequently, the lateral system did not need to be as robust, and the steel braces in the building's core were significantly smaller in dimension. The light weight of mass timber also serves the building in a seismic event. During an earthquake, Carbon12 will need only to withstand a force proportionate to the weight of its structure, roughly one-quarter the weight of an analogous concrete structure.

Testing

As Carbon12 is a tall wood building in a high seismic zone on the West Coast of North America, it may be subject to dynamic loading scenarios throughout its service life. A typical post-and-beam glulam structure will experience story drifts limited to 2 percent by design codes. The story drift will also subject the respective post-and-beam connection to additional stresses, resulting from gravity load and rotation of the beams against the post.

To ensure that the connections at major glulam structural members would withstand the inter-story drift demands of a major loading event such as an earthquake, testing was completed on the KNAPP RICON S VS Connectors under design load.

Prefabrication and assembly

Fabrication of the mass timber structure began in the Structurlam production facilities in Penticton, British Columbia, Canada. Glulam beams and columns were manufactured and CNC framed for steel connections based on the CadWork 3D model. RICON beam hanger connections were pre-installed into beams and columns prior to shipment to the site. Custom steel column connections were test-fit in the shop and delivered as part of the mass timber package. The mass timber package was shipped from Structurlam to the site on 22 flatbed trucks, sequenced for installation.

Following excavation and construction of the foundation, three levels of the steel core were installed. Glulam posts, beams, and CLT floors followed. Glulam beams and columns and CrossLam panels were lifted by a tower crane directly from the truck bed into position, with each component labeled and designated for a specific location in the structure. Construction proceeded with three crews under a single subcontractor — one each for the steel core, the mass timber structure, and the conventionally framed exterior walls.

During one of the wettest winters on record in Portland, construction of Carbon12 suffered only minor schedule impacts, while neighboring concrete construction projects were put on hold until the conditions allowed for pouring. Speed of assembly for the mass timber structure increased as the crew became more comfortable with the process. By the fourth level, all glulam was installed in one day, and all CLT panels were installed the following day. The crane was onsite for two and a half months, and the structure above ground was complete in eight weeks.

Unique features

On top of a rare hybrid design, Carbon12 features structural components unique to a building of its kind. The structure sits on drilled piers, a deep foundation system that is essentially a large-diameter concrete cylinder constructed by placing fresh concrete and reinforced steel into a drilled shaft. The robust foundation allowed for a 20-foot-deep basement, which houses a mechanical parking system. The only one of its kind in the U.S., the steel conveyor belt system allows drivers to type in a code and retrieve their car within a matter of minutes. The garage stores 24 cars within a two-story system.

Future of CLT

As an environmentally responsible building material, mass timber sequesters carbon dioxide from the atmosphere by storing carbon in the structure during the entire life of the building, while promoting sustainable forest management practices.

Carbon12 offers a glimpse into the possibilities of building with mass timber, and the associated benefits. CLT paves the way for a new paradigm of construction centered on renewable building materials, 3D modeling and coordination, cutting-edge prefabrication technology, and quick, clean, quiet assembly with minimal onsite waste.

ERICA SPIRITOS is mass timber specialist with Structurlam Products LP (www.structurlam.com). Mike Munzing is principle at Munzing Structural Engineering (www.mstructural.com).

REFINED DAM DESIGN

LEVERAGE 3D MODELING TO ENHANCE DAM
DESIGN AND CONSTRUCTION MANAGEMENT.

By Chad Davis, P.E.; Joseph Kudritz, P.E.; Jared
Deible, P.E.; and Jacob Bench, E.I.

Rendering shows completed dam construction project.
Image: Michael Baker International

CONTRACT DRAWINGS — long the backbone of every dam rehabilitation and construction project — are often limited because they only present two-dimensional (2D) information. Designers can counteract the limitations presented by contract drawings by incorporating three-dimensional (3D) modeling earlier into the design phase. Understanding and utilizing these emerging technologies plays a vital role in helping reduce misunderstandings between the design engineers and the contractor.

Throughout the life cycle of a project — from the initial design to construction — converting contract drawings into 3D models — both as renderings and scaled physical models created with 3D printers — has proven invaluable for improved visualization, design development and refinement, and constructability reviews and sequencing, among other processes.

Enhancing visualization during the design phase

Design engineers can use 3D modeling to refine complex design details that are often required in dam construction or rehabilitation. In the design phase of a project, this proves especially beneficial for visualization and refinement of details, verification of the design, and quantity and cost estimation.

Specifically, 3D models are being used to develop and refine design details for a number of dam construction project elements, including:

- structural components with joints and keys, including spillway walls and spillway slabs;

- complex concrete jointing and structures, including labyrinth spillways;
- components within concrete, including reinforcement, anchors and dowels, waterstops, pipes and outlets, formwork ties and rods, and drains;
- interfaces between components, including intersection of earth embankments and concrete walls; and
- additions to existing structures, including anchors, sheet pile, bridges, railings, and possible conflicts with existing components.

In practice, Michael Baker International engineers relied on 3D modeling during the design of a new control tower to be constructed on a new spillway slab. The design of this structure required detailing of the control tower exterior walls and interior bulkhead and the interface between the spillway slab and control tower walls. The design included the sizing of reinforcement, openings in the walls, and waterstop connections.

The initial design drawings for this portion of the project were used to build a 3D model for the area. As the design phase progressed, the model was refined to show waterstops and their tie-ins to the control tower wall, as well as to create additional cross sections, details, and an isometric view for the contract drawings for the project.

The 3D modeling detailed in this project translates across multiple facets of a project, proving valuable for checking designs developed and represented in 2D on the contract drawings by “constructing” the model from the developing contract documents. While the level of de-

tail inputted in the 3D models is at the discretion of the developer, the more detailed the model, the more useful it is for checking the design for a dam rehabilitation or construction project.

Since 3D models can be broken out for specific complex areas of a project, they prove particularly useful in evaluating reinforcement configurations, waterstop locations and clearances, and other conditions at joints in complex structures. When reviewing individual elements, the design can be easily modified to address potential conflicts in a cost-effective manner prior to construction.

Additionally, another design process benefitting from 3D modeling is quantity takeoffs for use in preparation of cost estimates. Elements included in the model are counted or measured, such as the length of waterstops, number of prefabricated waterstop unions, the volume of individual concrete pours, or the number of dowels and reinforcing members. The use of 3D models has proven particularly beneficial in cases where quantity takeoffs based on 2D drawings would be time consuming or likely to introduce error.

Developing an understanding of the construction sequence during the design phase of a dam project can be challenging, and a thorough constructability review during the design phase is critical for the success of a project. Developing a 3D model at different phases of the project encourages the designer to consider the construction sequence in detail and identify possible improvements or conflicts.

Achieving stakeholder buy-in

With the scope and visibility of dam projects, and the impact a dam plays on an entire region, receiving support from owners, public stakeholders, and regulatory agencies is paramount for a project's success. As an effective tool to visually create a realistic representation of a dam construction project prior to construction, 3D modeling is used to produce 2D renderings that incorporate images of portions of the project, such as a lake, shoreline, and surrounding area.

Renderings showing the completed dam rehabilitation or construction project are particularly useful for presentations to key stakeholders. They quickly and effectively convey the final appearance of the project after construction, reduce the time required for stakeholders to understand the project, and eliminate the need for detailed 2D drawings and other concepts that can be difficult to understand. These renderings are created without the need for a separate model, which can be costly and time consuming. Scaled physical models of the entire project or individual project components can also be produced from the 3D modeling to provide a tangible demonstration.

Construction uses

As a dam project moves from the design and presentation phases to the construction phase, the developed models are carried through with minimal additional effort and provide a valuable tool for personnel in the field. With available mobile applications to display 3D models directly on a mobile device or tablet, construction personnel can rapidly and efficiently access supplemental information and accurately record construction information.

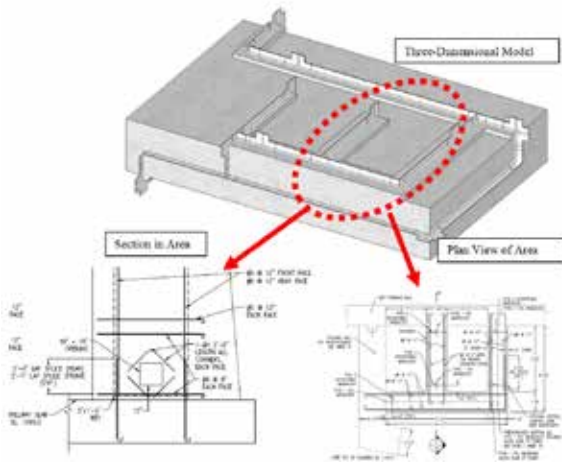


Figure 1: 3D model of control tower and spillway slab developed during design and construction details developed from 3D model included on contract drawings.

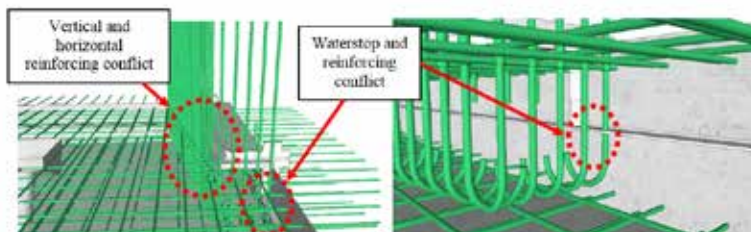


Figure 2: 3D model for complex joints with anchors, waterstops, and reinforcing.

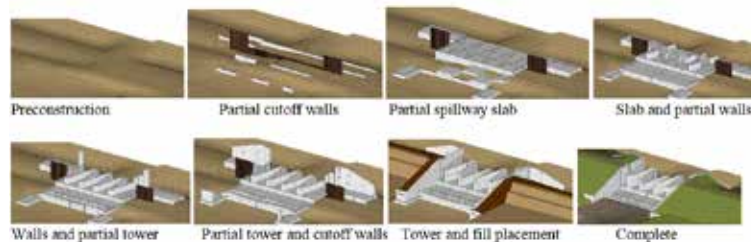


Figure 3: 3D model of labyrinth spillway and embankment construction sequence.

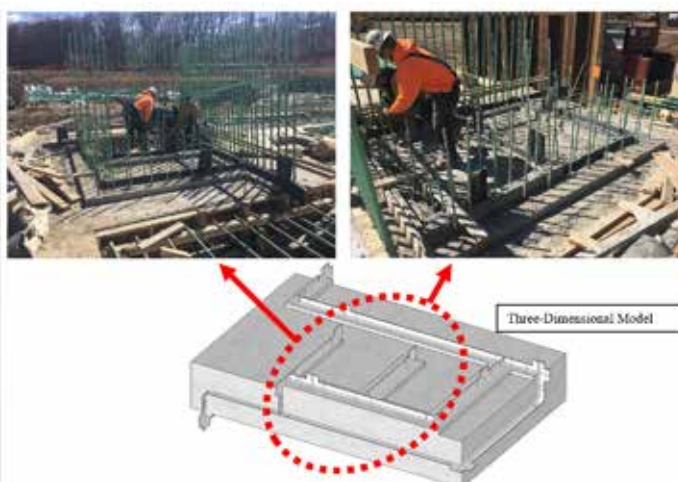


Figure 4: Construction of base of control tower and associated 3D model.

A 3D model can help with review of submittals, proposed construction sequences, and development of or changes to designs based on field conditions encountered. Design changes are often required in a short timeframe during construction, and 3D models can help to expedite the process.

During construction planning, models can include concrete formwork, equipment positions at various stages of construction, phasing for water control and diversion, and other features and can incorporate construction sequencing. This allows engineers to more effectively evaluate work plans, schedules, and other submittals.

Three-dimensional models are also helpful tools when performing construction inspections. The model is used by field personnel as a supplement to the contract documents to develop an understanding of what to expect in the field prior to construction. With the help of the 3D model, the inspector can identify potential errors or conflicts, alert the contractor, and if necessary, develop a solution before the issue significantly impacts construction.

One such example is the detailing of reinforcement around construction joints and waterstops. The 3D model is used by field personnel during construction to verify the waterstop orientation, location, prefabricated unions, reinforcement locations, formwork locations, and overall layout.

These models are carried through construction to track progress as it occurs in the field. The model is updated and modified as construc-

tion occurs, and quantities can be tracked or checked using the model. This allows construction personnel to rapidly and accurately review installed quantities, pay applications, and other progress submittals. Volumes, surface areas, lengths, and other quantities are available at the click of a button if a 3D model is properly updated as construction occurs. Updating the model during construction also allows rapid and accurate preparation or checking of as-built drawings, and provides for additional detail to be incorporated into as-built drawings.

Life cycle benefits

Three-dimensional modeling provides benefits for dam design and construction through enhanced visualization of the project during design, refinement of complex details within the contract drawings, modeling the anticipated construction sequence, and project visualization for the owner, public, and other stakeholders. This technology is particularly beneficial for complex components of dam projects such as control tower structures, spillways and training walls, or interfaces between components of structures.

Ultimately, as designers, engineers, and construction personnel continue to embrace the use of 3D modeling in the dam construction process, the resulting projects will be completed more effectively and efficiently.

CHAD DAVIS, P.E., vice president, Infrastructure Practice executive; JOSEPH KUDRITZ, P.E., civil engineer; JARED DEIBLE, P.E., technical manager; and JACOB BENCH, E.I., civil associate, are all with Michael Baker International (www.mbakintl.com).

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STORMWATER RISKS AND LIABILITIES

PREVENTATIVE STEPS TO PROTECT ENGINEERS AND
CONTRACTORS FROM A FLOOD OF COMPLAINTS.

By Sam Arden and Irene Vander Els

STORMWATER MANAGEMENT is an essential part of real property development. Unfortunately, certain activities can expose engineers and contractors to potential liability if the site work results in erosion, runoff, or sedimentation that impacts a neighboring property, despite implementation of runoff controls. Therefore, it is important for engineers and contractors to understand risks and liability, and plan appropriately to make sure they stay out of hot water.

Time and again, engineers and contractors are surprised to discover they have exposure for a neighboring landowner's damage claim even though the site design was prepared properly and approved by the local permitting authority. Even more surprising is that potential liability to neighboring property owners can arise after construction is finished and the property has been sold to a third party.

For example, a regional retail developer recently faced a lawsuit related to a shopping center north of Atlanta. The developer purchased acreage in the mid-2000s and developed a 300,000-square-foot retail center, which it then sold within two years. After the sale, the stormwater management system was modified pursuant to plans developed by the original design engineer.

In 2014, downstream property owners sued, alleging defects in the stormwater management system caused or contributed to property damage downstream. Although more than six years had passed since the original design and construction of the stormwater management system, because there had been a modification of the system, and because the neighbors claimed the development resulted in a continuing trespass of stormwater and sediment onto their property, the claims could not be dismissed short of trial or settlement. The matter was settled only after extensive expert discovery on the eve of trial.

Such risks exist in any development that modifies existing stormwater runoff patterns on the property, including redevelopment. In another recent case, a national retailer was sued by adjoining property owners after the redevelopment of a one-acre parcel into a different retail use in central Georgia. A drainage swale, part of the local municipality's stormwater management system, ran between the client's property and adjoining property owners' land and regularly overtopped during storms. The neighbors alleged that, before the redevelopment, both



the developer's property and the neighbors' properties were flooded when the swale overtopped.

Although the redevelopment added stormwater management infrastructure that resulted in a net decrease in impervious surface after new landscaping was added, the redevelopment also raised the elevation of the site. The adjoining property owners argued this design caused the overflow from the swale to be directed only to the neighbors' properties, so flooding increased when the overtopping occurred. Again, this matter was settled only after extensive fact-finding and expert discovery.



Often, when stormwater runoff issues like these arise, the cause of the problem may be unclear. When this happens, the developer, contractor, and engineer must work together to resolve the problem. The developer will look to the engineer and contractor, as the team members "on the ground," to identify any potential causes of negative impacts to neighboring property owners, and to make proposals to fix any problems and otherwise resolve the issues.

When stormwater runoff problems arise in development and result in litigation against the developer/owner, the engineer and contractor are often also brought into the lawsuit. This may be because the adjoining landowner who filed the lawsuit has named the developer, engineer, and contractor as parties, or because the developer, once sued, then brings the engineer and contractor into the lawsuit.

In one recent case, neighboring property owners sued the developer, engineer, and contractor in a lawsuit alleging damage to their downstream property because of an upstream development of a previously undeveloped 14-acre parcel into a shopping center and retail shops. The plaintiff argued that the engineering plans for the stormwater management system were flawed and that there were defects in the construction of the system, and was permitted to present those arguments to the jury. That lawsuit resulted in a lengthy jury trial in which a verdict was returned against all three defendants.



Even though engineers and contractors have professional liability insurance that may provide coverage for these types of claims, there are still significant costs associated with litigation. In addition to the hard costs of an insurance deductible, there can be enormous soft costs to the insured, such as the time spent by employees working with defense counsel to respond to the lawsuit, including factual debriefing, site inspections, review and collection of documents, and preparation for and appearance at depositions and trial.

Relative to other types of litigation, stormwater cases have one of the highest likelihoods of ending up in a jury trial. These proceedings can continue for weeks or months, depending on the complexity of the case. Engineers and contractors also can be exposed to punitive damages and claims for the neighbors' attorneys' fees for allowing runoff to continue after they become aware of it, even if they take steps to correct the condition. Such damages create a significant risk. Because the property damage claims that arise from stormwater runoff issues can be time-consuming and costly to litigate, it is important to get out in front of any issues early and aggressively.

Indeed, it is in the best interest of engineers and contractors to exercise due diligence and address complaints on the front end before lawyers become involved. Unlike developers, the engineer and contractor typically exercise more control over the daily conditions of the work site. If a neighbor makes a complaint, it is often up to the engineer or general contractor onsite. It is critical for those responding to complaints to be responsive, attentive, and polite. As issues arise, contractors and engineers must take complaints very seriously to limit exposure to these claims. Luckily, there are steps that can be taken to minimize risk.

First, review your commercial general liability and professional liability coverage. Professional liability insurance for engineers and contractors often has exclusions for pollution-related claims, which may encompass the types of damage at issue in these cases.

Next, review your consultant contracts and make sure that your form agreements require the owner to indemnify and defend you. While these provisions will certainly be subject to negotiation, starting from a provision that is as favorable to you as possible minimizes risk. If the developer insists on your indemnification of them, ask to limit the indemnification obligation to the contract price.

Another way to mitigate risk is to become familiar with neighboring properties during due diligence. Being aware of the uses of properties adjacent to a stormwater retention pond can minimize the exposure to stormwater liability. Look for potential uses that may be particularly sensitive to the impacts of stormwater, erosion, and sediment control, such as ponds and streams, and carefully account for this during site design and construction.

Finally, and perhaps most importantly, establish a protocol for addressing neighbors' complaints during construction. A crucial component in establishing liability for punitive damages and attorneys' fees in stormwater cases involves demonstrating that the party in control of the work site (which could be the developer, engineer, or contractor at different points) ignored or failed to adequately respond to neighbors' complaints about damage to their property. A contractor or engineer's statement, such as, "I thought someone else was responsible," will not be well received by a jury — especially in the context of a lucrative commercial development that is negatively impacting a neighboring residential property.

Make sure that clear lines of responsibility are established for responding to complaints, and that everyone is kept in the loop. This will help determine the best approach for handling a situation. For example, a silt fence blown away by a thunderstorm is easily fixed by the contractor. However, if a temporary silt pond is leaking onto the neighboring property, the engineer should be notified immediately and consulted if the fix is not obvious. Engineers should arrive to the site to inspect a serious situation as quickly as possible and individuals onsite should maintain a record of all conversations.

Issues arising from stormwater runoff can be tricky and can present substantial risk for contractors and engineers. To limit exposure, you must identify and monitor potential impacts on neighboring properties and ensure that your team is responding to issues in a timely and effective manner.

SAM ARDEN and **IRENE VANDER ELS** are attorneys with Hartman Simons & Wood LLP (www.hartmansimons.com), a commercial real estate law firm in Atlanta.

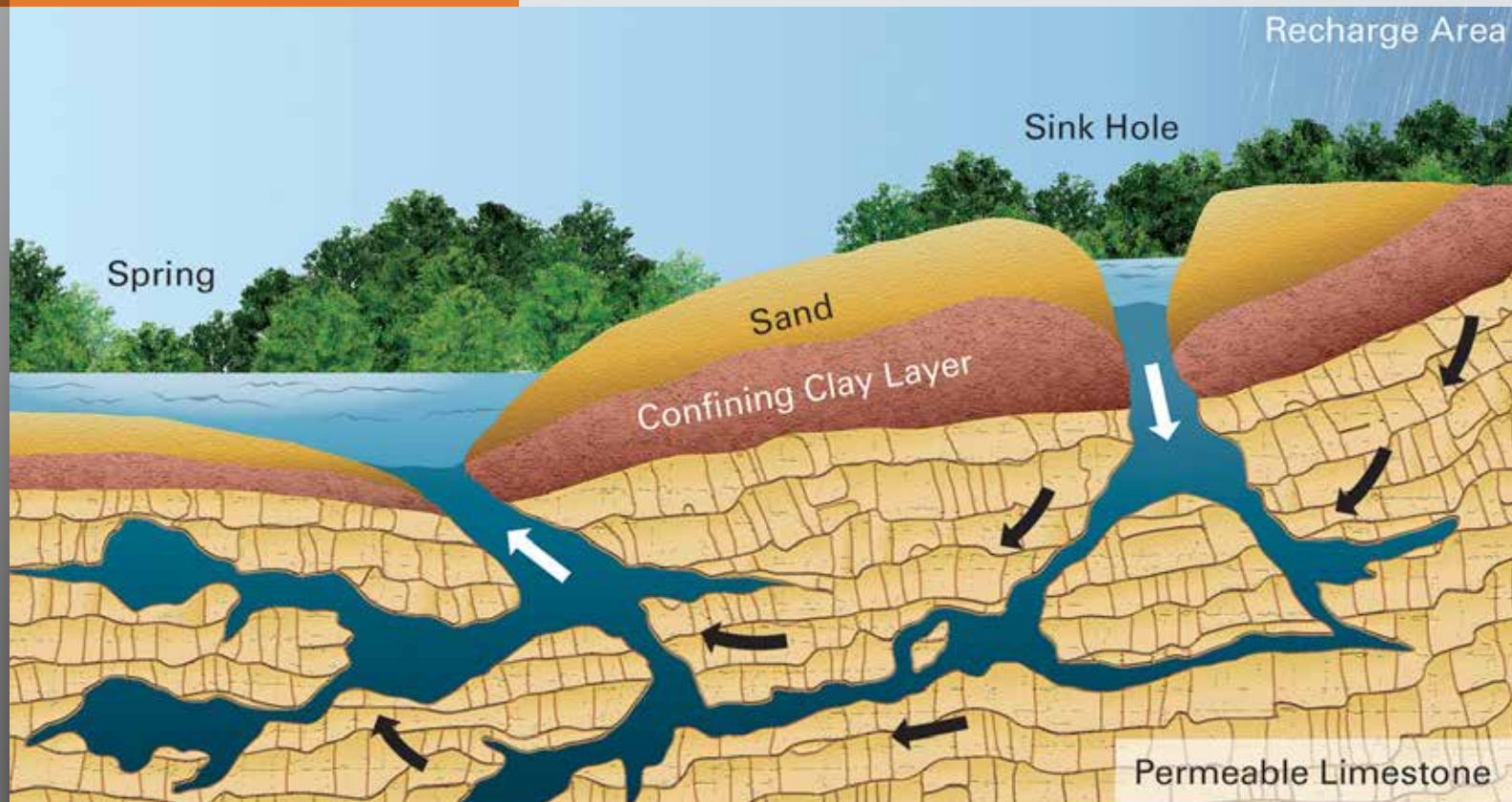


Figure 1: Florida aquifer water cycle and natural springs. Image: Dewberry

PROTECTING FLORIDA'S SPRINGS

NEW PROJECTS PLANNED TO IMPROVE WATER QUALITY

By Debra Preble, P.E.

WITH MORE THAN 1,000 freshwater springs located in the north and central part of the state, Florida has the largest concentration of springs in the world. Much of the Sunshine State's development throughout history can be traced to the presence of this unique natural resource. Freshwater springs, a source of drinking water, recreation, and irrigation for farming, have drawn settlers and tourists to Florida for centuries.

Today, these springs continue to provide important economic and recreational benefits while also playing a critical role in the health of local ecosystems. However, for several decades Florida's springs have been threatened by pollution, drought, and increased development. Projects now underway reflect a broad-ranging effort to restore and protect these vital natural resources.

'Old Florida' attractions

Florida's Springs are best known for their recreational value. These "Old Florida" attractions include Weeki Wachee Springs, a freshwater spring that has been a mainstay of Florida tourism since 1947. This first-magnitude spring, which discharges 112 million gallons a day (mgd) on average and feeds the seven-mile-long Weeki Wachee River, is the centerpiece of a 538-acre park near the Gulf Coast.

Warm Mineral Springs, known as "The Fountain of Youth," is the only warm water mineral spring in the state, and the largest in the world. Located in Sarasota County, the spring is on the National Register of Historic Places and is among the state's top tourist attractions. Wakulla Springs State Park near Tallahassee features the world's largest and deepest freshwater spring along with more than 80 additional sinkholes and streams. The park is also listed on the National Register of Historic Places and is a National Natural Landmark.

Ichetucknee Springs State Park, in Columbia County, is a premier site for canoeing, kayaking, and tubing, with the rapidly flowing Ichetucknee River stretching for five miles until it joins the Santa Fe River. Homasassa Springs State Wildlife Park is a showcase zoo for native wildlife, including West Indian manatees, alligators, crocodiles, black bears, and bobcats.



Permeable, Unpaved Roads Offer Fast Site Access—Even Over Soft Subgrades.

The 3D cellular confinement technology was developed by Presto Products Company and the U.S. Army Corp of Engineers in the late 1970's for building roadways over poor subgrades using on-site sand. Ultrasonically-welded strips of High-Density Polyethylene (HDPE) form the 3D GEOWEB® System—transforming infill by giving cohesion and additional strength to non-cohesive soils—through confinement. This translates well for remote areas such as the Canadian Oil Sands and Amazon Basin where soft subgrades and limited access to aggregate resources makes building roads especially challenging.

GEOWEB roads are often the chosen solution for these challenging conditions as they greatly reduce the cross-section required—often replacing a 1.5 m section with a 200 mm section. Additionally, reject screenings from crushing operations (coarse sand <5 mm) can be used as infill rather than having to import expensive aggregate to the site. The road sections are shipped in efficient collapsed bundles, ready for fast deployment and installation on site.

Confined in the GEOWEB cellular network, infill remains extremely stable under heavy loading. With dynamic and static loading surface pressures distributed across the confinement system, concentrated rutting and maintenance requirements are virtually eliminated. Differential and overall settlement impacts are also minimized, even with low-strength subgrades.

Low Environmental Impact Design Solution

Pavement designs requiring highly-permeable surfaces also benefit from the GEOWEB technology. High-porosity aggregate infill promotes stormwater infiltration, reducing surface runoff. On-site stormwater containment systems may be eliminated as the pavement performs double duty as an on-site water detention/retention storage "basin" to manage stormwater at its source.

Permeable pavements are incorporated for problematic soft soil, high traffic areas, such as intermodal yards and auxiliary parking lots, where hard-surface pavements are highly susceptible to degradation and maintenance. With many environmental attributes, permeable pavements also contribute to green building credits—such as the USGBC's LEED® program—and are viable options for sustainable Low Impact Development (LID) and Green Infrastructure (GI) design.

The GEOWEB system improves the load distribution characteristics of unpaved roads and pavements, reducing long-term maintenance requirements and costs and delivering numerous environmental benefits. GEOWEB pavements can handle site challenges—and have been for over 35 years—allowing access even over the toughest site conditions.



Swim ladders and stairs were installed to discourage swimmers from climbing on the shoreline to enter and leave the swimming area, stabilizing the spring banks to control erosion. *Photo: Dewberry*

Adventurous visitors are drawn to parks such as Manatee Springs State Park, Ginnie Springs, and Blue Spring State Park, which are well known for cave diving, scuba diving, and snorkeling. With 28,000 feet of explored passageways, Wes Skiles Peacock Springs State Park in Suwanee County has one of the longest underwater cave systems in the continental U.S., an attraction to many experienced and ambitious cave divers.

Many springs that were originally operated privately are now owned by the state and under the care of the Florida Park Service. Twenty state parks feature freshwater springs. In addition, numerous local parks and recreation areas are centered around springs. Visiting springs in Florida is a way of life for both residents and tourists. Springs protection efforts must take this into account and allow for this continued use while providing protection.

An essential natural resource

While Florida's freshwater springs have long helped to sustain the state's tourism and recreation industries, with an estimated direct economic value of more than \$300 million per year, their most important role lies in their ecological value. The springs, along with the rivers, lakes, and bays that they feed, are home to numerous species of plants and animals, ranging from eelgrass, lilies, and bald cypress trees to freshwater shrimp, birds, turtles, otters, alligators, and Florida's treasured manatees.

Spring are also a vital component of the Floridan Aquifer System, which supplies most of the state's drinking water. This vast groundwater source spans 100,000 square miles in the southeastern U.S., including all of Florida, and supplies potable water to millions of people as well as water for agricultural irrigation and industrial purposes. The Floridan Aquifer System has historically supplied about 10 billion gal-

lons per day of fresh water to Florida's springs. More than 750 Floridian springs are part of the system, and the health of these springs is a strong indicator of the quality of the aquifer.

Florida's unique geology

A freshwater spring occurs where water flows directly from the aquifer to the earth's surface (see Figure 1). When the aquifer fills, the subsurface pressure causes water to flow up to the land surface through openings called spring vents. Florida's unique geology, including its layers of highly porous marine limestone, contributed thousands of years ago to the prevalence of springs in the state. The porous limestone formations hold and transport more water than formations elsewhere in the country. The capacity of these formations, combined with relatively high rainfall amounts and subsurface water flow, resulted in the creation and ongoing sustenance of Florida's freshwater springs.

Water flow can vary considerably, based on aquifer water pressure, rainfall, size of the spring basin, and the size of spaces, including caves, within the rocks. Groundwater withdrawal for consumer use can also greatly impact the flow of springs. Some springs flow only after significant rainfall events, while others flow at the rate of hundreds of millions of gallons per day. Florida has 33 magnitude 1 springs, defined as a spring that discharges water at a rate of 100 cubic feet per second.

Challenges and threats

Healthy springs are typically characterized by adequate flow, water clarity, dense aquatic vegetation, and the abundance and diversity of native wildlife. Unsustainable water consumption, runoff from farms and residences, damaging invasive species, unrestricted recreational use, and the abundance of onsite sewage and disposal systems are among the many threats to the preservation and health of natural springs.

The Florida Department of Environmental Protection (FDEP) created a detailed list of specific threats to Florida's springs, including:

- landscaping and lawn care, including excessive water use and the use of fertilizers and pesticides;
- sprawl and development, including encroachment on natural spaces that serve as important recharge areas for the aquifer and springs;
- stormwater runoff, which often carries clogging sediments and chemical pollutants into waterways;
- water consumption and overuse resulting from the demands of people, agriculture, and industry;
- illegal dumping, including disposal of garbage and chemicals into sinkholes that contaminate springs and the aquifer;
- row crop agriculture, leading to the use of harmful fertilizers and pesticides;
- livestock farming, resulting in tons of animal wastes that contaminate springs and the aquifer;
- golf courses, which occupy approximately 200,000 acres of land in Florida, requiring excessive use of fertilizers and pesticides;
- recreational impacts, including trampling of native vegetation, erosion of shorelines, littering, and damage from motor boats and other vessels; and
- invasive species, often encouraged by nitrates in the water, leading to damage to springs and spring runs.

Degraded springs may have higher water temperatures and nitrate levels and lower levels of dissolved oxygen and water clarity. The most common form of pollution is nitrate, a form of contamination that results from many of these threats, including septic systems, sewage plants, agriculture, and fertilizer.

According to Robert L. Knight, Ph.D., founder and president of the Howard T. Odum Florida Springs Institute, "At higher concentrations [of nitrate], what we see is a flip where the system stops supporting the submerged aquatic vegetation — like the tape grass and the eelgrass — and it starts supporting more and more algae and a different kind of algae: filamentous algae."

More than 60 percent of Florida's springs are currently impaired by nitrate, according to FDEP standards. The overwhelming presence of algae, often in the form of the dense algal mats, can ultimately lead to the demise of the native aquatic plants, fish, and wildlife that typically thrive in the springs-based ecosystems, while also dramatically degrading the quality of water in the aquifer. These environmental degradations also reduce the recreational and economic value of these resources.

Restoring the health of springs

FDEP, the Florida Springs Council (a consortium of 36 organizations), the Florida Springs Institute, and water management districts (WMDs) across the state clearly recognize the critical importance of Florida's springs and the need to pursue a variety of restoration and protection initiatives. Several spring restoration projects have been completed or proposed. These initiatives focus on pollutant reduction, water conservation, and more recently, land purchases, land easements, and agricultural conversions.

Nearly \$270 million has been committed in state and local investment during the last four years to protect the state's springs. Thirty-five projects of all sizes and scopes were identified for FY 2016-2017. While the funding commitment has been encouraging, Florida's springs restoration and protection efforts will be challenged to keep pace with anticipated population growth, increased water use, and growing agricultural fertilizer use.

Funded initiatives currently include measures that fall into three categories:

- projects in and around springs to prevent and repair physical damage, including shoreline stabilization, erosion control efforts, access control, and improving recreational infrastructure;
- projects that are remote from springs but reduce pollution in the springshed, including replacement of septic systems with central sewer systems, improving drainage systems, enhancing groundwater recharge, retrofitting drainage retention areas, replacing stormwater pipes, rehydrating wetlands, water conservation measures, and incentivizing low-nutrient land use; and
- projects that conserve water.

The following case studies represent two of these three types: a septic-to-sewer project near Wakulla Springs and a physical restoration project at Wacissa Springs.

Wakulla Springs

Wakulla Springs, south of Tallahassee, is another Old Florida attraction that has long been a destination for tourists. The spring and its surrounding 2,860 acres were purchased by the state in 1986, creating the Edward Ball Wakulla Springs State Park.

In 1997, the first of the "choking" hydrilla began to appear at the springs. Apple snails and limpkins also began to disappear. The water is now rarely clear enough to permit the park's popular glass bottom boat rides. Since the 1970s, scientists have documented a decline in water quality, particularly with regard to nitrates.

Until 2010, the City of Tallahassee's wastewater treatment plant was the largest source of nitrate pollution in the Wakulla Springs Basin. After a \$200 million upgrade to the wastewater treatment plant and additional water quality improvement projects in the springshed, septic tanks may now be the main contributor to the nitrate pollution in the Wakulla springshed.

In some rural areas with large lots, septic tanks are geographically separated in a way that precludes the economic viability of wastewater collection and transport to a centralized treatment system. In these circumstances, plans are underway for enhanced onsite sewage treatment and disposal methods. These systems can be active or passive. Active systems typically rely on aeration, while passive systems typically involve an enhanced drainfield media.

Four projects in the springshed — two in Wakulla County and two in Leon County — have ongoing springs protection projects to connect homes on septic systems to central sewer. The two neighborhoods in Wakulla County where the density of lots and proximity to centralized



Large boulders are used to prevent vehicles from approaching Wacissa Springs. Similar boulders are used to ring the shoreline and designate access points for swimmers. *Photo: Dewberry*

treatment systems were identified as suitable for a “septic-to-sewer” type of springs protection project are Wakulla Gardens and Magnolia Gardens.

Wakulla Gardens is a residential neighborhood in Wakulla County located in the Wakulla springshed. Some lots have access to city water, but most are on wells, and all 3,000 lots are on septic tanks. The county plans to expand the wastewater collection system in phases to abandon septic tanks and connect these lots to an expanded collection system.

Magnolia Gardens is a similar neighborhood in Wakulla County, also in the Wakulla springshed. Magnolia Gardens is closer to an existing conveyance system, so the project can remove more lots for the same budget since the offsite conveyance system is shorter. Wakulla County, in partnership with the Northwest Florida Water Management District, is working to bring these two neighborhoods into the centralized wastewater treatment plant. The project is being funded in phases. Phases I and II will remove 716 residential lots from septic to a centralized treatment system out of the springshed.

For years, Wakulla County has also been proactively working on plans to improve groundwater quality by reducing pollutant loading. The county is continuing this effort by identifying large sources of potential negative impacts, and working on plans to reduce these impacts. These efforts include wastewater treatment plant upgrades, identification and elimination of inflow/infiltration, implementation of a reclaimed water system, and expansion of the collection system to reduce septic tanks. Three county projects have been identified for the Wakulla Gardens and Magnolia Gardens communities:

Otter Creek Wastewater Treatment Plant Upgrade — This project will upgrade the existing plant capacity from 0.6 mgd to 1.2 mgd, and is currently being designed and permitted. The upgrade will also provide for filtration and disinfection to Public Access Reuse Standards. The existing plant is at capacity and cannot support any new connections, so this project will allow for future development, which will also increase

wastewater system revenues. Additionally, this project will increase the treatment level of the wastewater to provide for a higher level of nutrient removal, which increases the overall environmental benefit.

Shell Point Wastewater Treatment Plant Abandonment — This project includes abandonment of an existing wastewater treatment plant in the coastal community of Shell Point. Talquin Electric Cooperative owns this plant and is constructing a conveyance system to connect to the county’s existing conveyance system. This project, nearly complete, will provide the county additional revenues for the wastewater treatment system and will provide the environmental benefit of removing the wastewater effluent discharge from the sensitive coastal area.

Wildwood Reuse Line — This project includes construction of an 8-inch reuse main from the wastewater treatment plant to a local golf course. The new reuse main will allow for a minimum of 300,000 gallons per day of reuse irrigation water for the golf course. The project reduces groundwater consumption for irrigation and allows for effective disposal of wastewater effluent. The project has been constructed and is awaiting upgrades at the Otter Creek Wastewater Treatment Plant before it can be put into service.

Removal of existing septic systems, stormwater retrofits, and other water quality improvement projects have significantly reduced nitrate concentrations in Wakulla Spring. During the last 20 years, nitrate concentrations have been reduced by about 50 percent. This reduction does not yet include the work at Magnolia Gardens and Wakulla Gardens. In Wakulla County, the Magnolia Gardens and Wakulla Gardens septic-to-sewer projects will help protect Wakulla Spring, one of the largest and deepest freshwater springs in the world.

Wacissa Springs

The Wacissa River Springs project in Jefferson County, located within the Suwannee River Water Management District, reflects another approach to springs protection. Over the years, access to the spring for recreational use has been unlimited. The spring and spring run have

been the sites of “mudding” by locals, a popular activity where trucks enter the water and spin in the mud. This use as well as other typical uses have contributed to the degradation of the spring. There are no stormwater management facilities and the parking lot is dirt. Over time, the banks have eroded and sediments have filled the spring vents from both bank erosion and lack of stormwater management facilities. Invasive species are choking the area, making swimming and boating a challenge.

The Board of County Commissioners created a citizens’ panel to develop an improvement plan, now being implemented in phases. Working in partnership, the Jefferson County and the Suwannee River Water Management District (SRWMD) are removing sediment and stabilizing the spring banks to control erosion. The project involves removal of vegetation, silt, and debris; and protecting the spring bank by defining access points and stabilizing the shoreline in the vicinity of the spring head and run.

Debris was removed from the spring head, including concrete rubble and old railroad ties. Invasive plant species were also removed. Large boulders were used to prevent vehicles from approaching the spring. Similar boulders were used to ring the shoreline and designate access points for swimmers. The shoreline along the spring run was stabilized and a floating dock installed to discourage boaters from climbing on the bank. Swim ladders and stairs were also installed to discourage swimmers from climbing on the shoreline to enter and leave the swimming area. Phase I of the Wacissa Springs restoration was completed in 2015 with funding from both Jefferson County and the SRWMD.

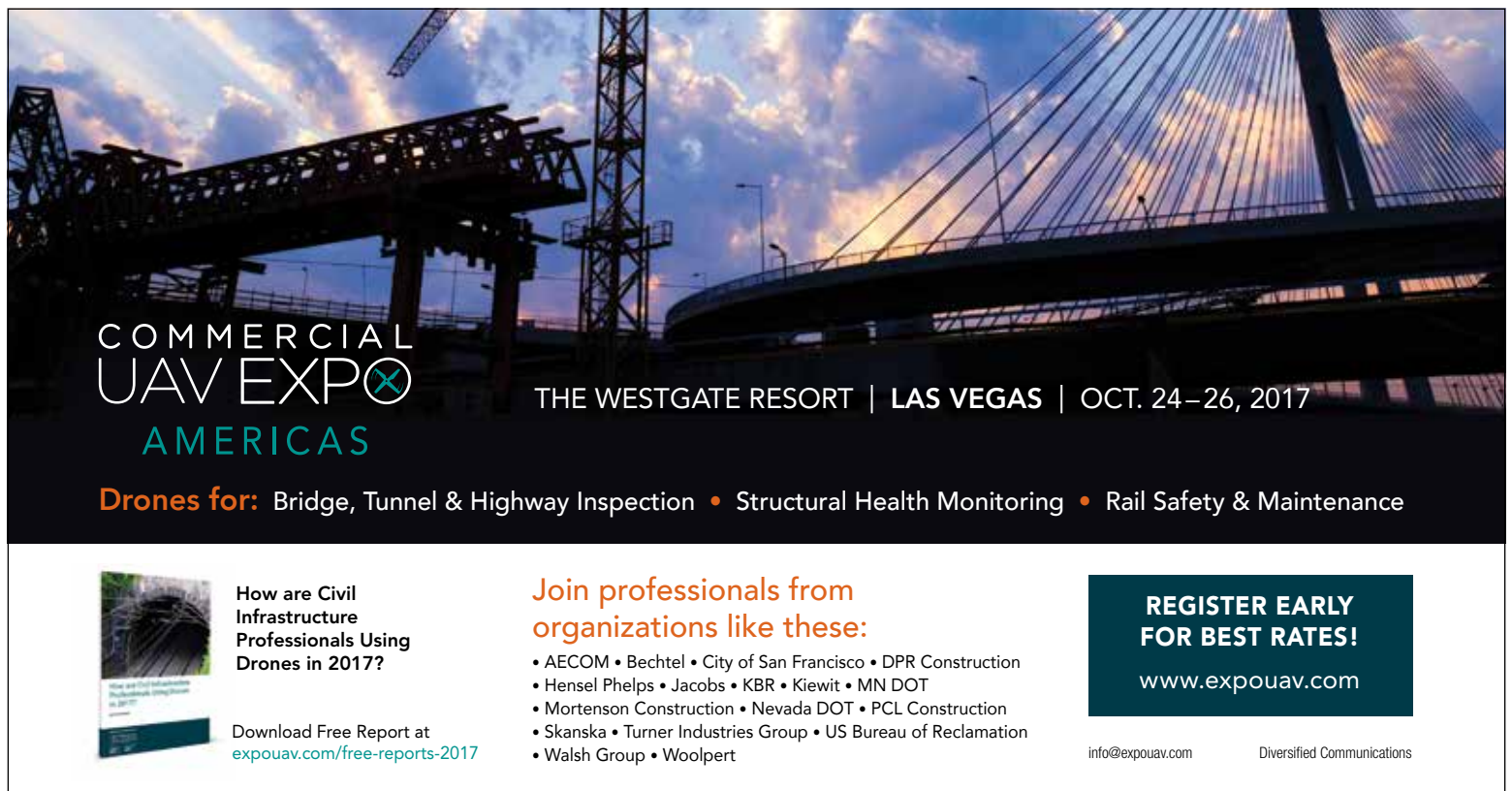
Phase II of the springs restoration has been funded and is expected to begin in the fall of 2017. This phase will include additional shoreline stabilization, sediment removal, exotic plant removal, stormwater management facilities, shoreline boardwalk, and impervious parking. Phase II is estimated to remove 59,431 pounds per year of nutrients. Additional grant funding has been secured to provide composting restrooms, picnic shelters, and additional shoreline boardwalks.

Protecting springs: Florida’s unique legacy

The commitment to funding during the next several years is an opportunity to make substantial and lasting improvements to Florida’s springs. The challenge lies in selecting the most beneficial projects and using resources wisely, while keeping pace with population growth.

Florida is fortunate to have strong alliances between state and local partners, as well as the advocacy and support of groups such as the Florida Springs Council and the Florida Springs Institute. Many water management districts throughout the state are taking the initiative to implement meaningful projects that will restore and protect freshwater springs. These projects will be instructive in continuing this effort and protecting Florida’s vital and unique natural resources for future generations.


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Using advanced computer modeling to integrate the design of the building systems and façade, Arup significantly reduced operational costs and improved energy efficiency. Photo: © Warren Jagger

TOTAL DESIGN FOR SUSTAINABILITY

ARUP IMPLEMENTS COMPREHENSIVE ENERGY STRATEGIES AT NEW
NORTHEASTERN UNIVERSITY INTERDISCIPLINARY SCIENCE COMPLEX.

ARUP RECENTLY CELEBRATED the opening of the Interdisciplinary Science and Engineering Complex (ISEC) at Northeastern University in Boston. Architecture firm Payette selected Arup to provide mechanical, electrical, and plumbing engineering, as well as energy modeling, façade consulting, sustainability, and lighting design services for the 234,000-square-foot project. The integrated design process resulted in a high-performance laboratory facility for Northeastern.

“We are extremely pleased to be a partner in such an extraordinary project at Northeastern University,” said Julian Astbury, Arup project manager. “Sharing Arup’s resources and expertise in sustainability and technology with the team made the experience a true collaborative process — a work of total design.”

Ambitious energy goals

“The facilities department at Northeastern wanted the most energy-efficient building possible,” said Mark Walsh-Cooke, Arup principal in charge. By using advanced energy modeling software and building information modeling (BIM) early in the design process and holding biweekly workshop meetings with the architects and university representatives, Arup empowered the client to make better, more informed decisions about the design, enabling them to reach their sustainability goals.

The Massachusetts Stretch Energy Code calls for new buildings to perform 20 percent better than required by base code. The ISEC surpasses this requirement, achieving 33 percent energy-cost savings over code and 75 percent energy savings compared with typical laboratory performance. To accomplish this, Arup engineered several major energy conservation measures.

The cascade air system is the biggest contributor to energy savings at the ISEC. “This technology was new to the client and contractor, so our advanced energy modeling software studies were critical,” said Astbury.

In a typical scenario, laboratories have a dedicated HVAC system, an expensive feature to construct and operate. At the ISEC, the cascade system recovers conditioned air from the offices and atrium of the building, then transfers it to the lab, saving energy and reducing costs.

Arup used performance and life-cycle analysis to optimize the façade design, ensuring both occupant comfort and energy efficiency. The northern part of the ISEC complex, which houses the energy-intensive labs, is the focus of thermal improvements; at the southern exposure (where low-energy functions such as offices are located), triple-glazed windows and a shading system work to maximize daylight while minimizing energy consumption.

Using active chilled beam technology significantly reduces the energy consumption compared with conventional air conditioning. In this system, supply air to the space is directed through nozzles on either side of a heat exchanger coil, creating a pressure difference. This pressure difference pulls air from the space over the coil, cooling or heating it, and then mixes with the supply air to be delivered to the space. Arup's comfort-modeling software balanced the downdraft and the ambient temperature to ensure a pleasant environment.

Arup designed a hydronic run-around coil system to recover energy from the lab exhaust air to precondition the outdoor air, targeting the heating as needed to either the offices or labs, and optimizing the efficiency of the system. The coils are designed to minimize the size of the fan motor and extract as much energy as practical before the exhaust is discharged.

To optimize the efficiency of the chiller and heating system, Arup installed a heat-recovery chiller, which simultaneously generates heating hot water and chilled water. This reduces the run-time of the boilers for laboratory re-heat in the summer and shoulder seasons and for pre-heat of the domestic and laboratory hot water systems.

The winter outdoor air heating demand to the atrium is reduced by using a passive solar collector to preheat the outdoor air using radiant energy from the sun.

The ISEC will be open to outside researchers in the interrelated fields of computer science, basic sciences, health sciences, and engineering. Attracting talent from beyond the campus raises the university's profile and diversifies the academic leadership and curriculum.

The project benefits the surrounding community as well. A pedestrian bridge (currently in design by Arup's structural engineers in collaboration with Payette) spans the commuter-rail tracks to allow residents, workers, and students to easily and safely navigate their way through the site.

Watch a video about design of the Northeastern University Interdisciplinary Science & Engineering Complex at <https://youtu.be/2OXIuVTaqSk>.

Information provided by Arup (www.arup.com).



A light-filled atrium separates the laboratory space from the main office areas.
Photo: © Warren Jagger

MORE THAN ZERO

A HOLISTIC DESIGN PROCESS IS NECESSARY
TO OPTIMIZE BUILDING ENERGY PERFORMANCE.

By Megan Saunders



Energy modeling software can be used to help to determine the size of a renewable energy system for a project, whether it be photovoltaics, wind turbines, biomass, geothermal, or hydroelectric. Photo: Jud Haggard

BUILDINGS CONSUME almost half of the energy provided in the United States and are responsible for nearly half of the carbon emissions. Sustainable building trends have progressed rapidly since the adoption of LEED in 1993, which set the bar for high-performance buildings. During the last 25 years, more stringent criteria have been adopted with increasing environmental concerns in order to drive the industry. Net-zero buildings are part of the latest movement of building with the future in mind.

The term “net zero” can be used to describe a variety of elements in a building. One of the most common definitions, adopted recently by the U.S. Department of Energy, describes buildings designed to be energy-efficient and produce as much energy as is delivered to the project. Other interpretations make distinctions between site and source energy. Site energy refers to energy used in the building whereas source adds in the cost to deliver energy to the building. Additional standards have also been proposed that would require buildings to be net neutral to the environment as a whole. These often include carbon production and offsets, as well as ensuring water and waste are self-sufficient systems.

To ensure a building achieves net-zero energy status, a holistic design process must be employed. Early in the design phase, a commitment must be made to optimize energy performance. However, this should not focus entirely on the energy-generation part of the equation.

The purpose is to balance production with efficiencies. While there are buildings claiming to be net zero by supplying enough onsite renewable energy to offset their typical loads, a true net-zero building focuses first on tightening the envelope and maximizing efficiency. In fact, several certification bodies require a minimum Energy Use Intensity (EUI) measured by kbtu/square foot/year for the building to be considered for net-zero status.

Over and above the certification aspect of net zero, there are real economic incentives in achieving this goal. Assuming your local electricity grid allows the facility to sell energy back to the grid, the cost of the project can often be offset through energy sales over time. In the long-term, the building can actually generate income for the owner or tenants on the energy side.

Several tools exist to determine the target EUI of the building. One of the most simplistic is the Energy Star Target Finder, a free online tool from the EPA that allows designers to enter basic assumptions about the building and location before a project begins. Target Finder also allows

users to set a goal for reduction in energy compared to the median building or a specific Energy Star score.

More sophisticated modeling techniques can be used throughout the design process to ensure the building maintains the targeted EUI while exploring different measures as the project moves through critical design stages. Energy modeling software can be used to provide an estimate of real world conditions of the building once fully operational. This number will also help to inform the size of the renewable energy system for the project, whether it be photovoltaics, wind turbines, biomass, geothermal, or hydroelectric.

Once a building is constructed, a simplified measurement and verification process can be employed to determine whether net zero has been achieved. At least 12 months of utility bills through the performance period should be collected to review actual energy use compared to the total renewable generation, on an annual basis. In some cases, a third-party auditor is required to certify performance.

Two key organizations in the net-zero movement — the International Living Future Institute (ILFI) and the New Buildings Institute (NBI) — recently joined forces to concentrate their efforts. ILFI, a non-profit organization focused on creating healthy and sustainable design, has created several certification programs and labels for buildings, including the Zero Energy Building (ZEB) certification. NBI, which provides guidance and tools for net-zero buildings, will now act as the lead certification auditor and administrator of the data. Taking it a step further, ILFI also runs a program called the Living Building Challenge, which promotes net-positive buildings that produce 105 percent of the energy use of the building using renewables.

In many parts of the country there are real opportunities for net-zero construction. Areas with abundant sunlight, for instance, should already be prioritizing this kind of construction. As battery technology improves, increasing areas of the country will find this an economically viable alternative to traditional forms of construction, and a pathway to resiliency. Downward pressure on pricing and increasingly accessible technologies will also drive construction in this area.

MEGAN SAUNDERS is the director for sustainability for PBK Architects (www.pbk.com) with nearly 10 years of experience in green building consulting and sustainability leadership, advocating for high-performance and resilient design for building owners and cities.

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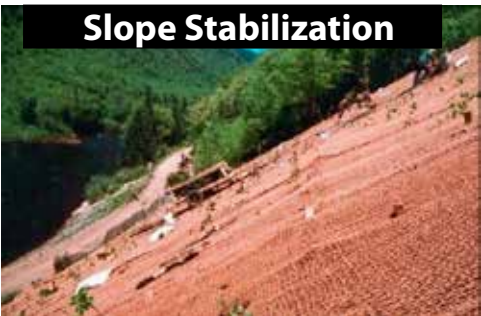
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The rigid inclusion foundation improvement option involved placing a grid of small-diameter grout columns throughout the embankment area. Photo: LAN

SPURRING DEVELOPMENT

CLOSE COORDINATION HELPS CITY OF SUGAR LAND BUILD KEY THOROUGHFARE.

By Lauren Van Andel, P.E.

THE CITY OF SUGAR LAND, TEXAS, was named for the 150-year-old Imperial Sugar Company that is headquartered in the city. This company built the foundation of what is known today as Sugar Land and has influenced the culture of the city. While the headquarters is still located in Sugar Land, the refinery closed in 2003. Since the refinery has long been an integral part of the community, the city and its developers have made it a priority to preserve, enhance, and bring economic development to the area, now known as the Imperial District.

Providing new connectivity is essential to spurring growth in this area. University Boulevard provides access from US 90A into the heart of the Imperial District and to one of the city's biggest attractions, Constellation Field. In addition, University Boulevard is a major north-south connector through the city that provides relief to the congested State Highway 6.

To further improve mobility to this district, the city is currently constructing the University Boulevard North Extension, a \$21 million, 0.5-mile, four-lane, divided connector between US 90A and South Stadium Drive in front of Constellation Field. The road is adjacent to Nalco Champion and crosses Oyster Creek and Union Pacific Railroad (UPRR) tracks in two locations. The project includes reconstruction of a portion of US 90A, track work with UPRR, an at-grade rail crossing with traffic signal preemption near US 90A, a grade-separated overpass over a UPRR spur and Oyster Creek, a side path and sidewalk, retaining walls, and a bridge-supported water line.

With this extension, new opportunities are available to developers. "The property to the west (of University Blvd) was really not looked at by the developer as being really worth a whole lot until the agreement with UP came about and the extension project started," said Chris Steubing, P.E., city engineer with the City of Sugar Land. "Now they have a valuable 16 acres of land that they have been able to put on the market and, from the city's perspective, will be able to draw increased revenues."

Lockwood, Andrews & Newnam, Inc. (LAN), a national civil engineering firm, is the project's engineer-of-record. Harper Brothers is constructing

the road and bridge portions of the project with construction anticipated to be complete in February 2018. Webber completed construction of the rail portion of the project in February 2017.

Stakeholder coordination

From developer to city council, this project was under intense focus and required significant stakeholder coordination to achieve success. Coordination was required with UPRR, Texas Department of Transportation (TxDOT), Nalco Champion, Johnson Development, and various smaller entities.

An agreement was made with UPRR prior to project development. In this agreement, UPRR would gain the easements needed for a new double-track along US 90A and close two crossings while developing a new crossing for University Boulevard. Typically, UPRR requires closing three crossings when opening a new crossing, so this agreement proved to be a pivotal success factor that was mutually beneficial to the city and UPRR.

One of the UPRR crossings that was closed was a private drive into Nalco Champion. To accommodate this loss, the city entered into an agreement with Nalco to locate two driveways on University Boulevard into their new headquarters adjacent to the project.

The UPRR tracks were 60 feet from and 3 feet higher than the edge of US 90A. Since US 90A was built with a standard crown cross-slope, there would be a bump in the road travelling over the tracks unless a major portion of US 90A was reconstructed. Coordination with TxDOT for modifications to US 90A, a major thoroughfare through the city that carries more than 60,000 cars daily, allowed more than 800 feet of US 90A to be reconstructed to reverse the slope of the roadway and provide a smooth ride over the UPRR tracks.

Finally, Johnson Development, the developer of the Imperial District, was committed to working with the city to provide connectivity to the Imperial District and ensure the overall vision of the district was present in the aesthetics of the project. To this end, Johnson was a major funding partner in the project and was consulted on all discussions of project aesthetics.

With all of the stakeholder agreements and coordination, the city expected this project to take as long as 10 years to complete. Due to hard work from city staff and the design team, as well as collaboration with



each of the stakeholders, the project is anticipated to be completed within five years.

“It was a large collaboration and coordination project between several different parties,” said Steubing. “It’s the most expensive stretch of road that I think I’ve ever been a part of, but it’s going to be a great asset to the city when it’s done.”

Sandy soils

The city’s proximity to the Gulf Coast influences geotechnical parameters at the site. The very soft, loose, sandy and silty soils with little to no bearing capacity and high settlement potential makes any civil project complicated. As such, the soils require a robust foundation for the rail, road, and even drainage elements.

Most notable was the soil’s effect on the bridge and retaining wall foundations. The flat terrain and vertical clearance required over the UPRR spur (23 feet, 4 inches) required embankments as tall as 23 feet. If founded on the in situ soils, the embankment would experience as much as 5 inches of settlement over time, causing significant maintenance issues for the city. To mitigate this, two foundation improvement options were evaluated: Remove and replace soil with cement-stabilized sand or use rigid inclusions.

While the cement-stabilized sand option would be the most cost effective, it did not fully mitigate the settlement potential of the embankment and required preloading of the structure, which would delay construction of the project. The rigid inclusion option involved placing a grid of small-diameter grout columns throughout the embankment area. This foundation improvement option penetrates the entire depth of low bearing capacity soils and minimizes long-term settlement of the embankment. To preserve its investment in this structure, the city opted for the rigid inclusions despite the higher cost.

Aesthetics

Aesthetics for this project were a high priority for the client. The vision of the Imperial Redevelopment District featured an aesthetic scheme influenced by the historic Imperial Sugar Plant’s building architecture. The dominant aesthetic features included a dark, earth-tone brick veneer accented with pale precast stone trim elements. These features were most prominent on the exterior bridge and retaining wall columns that were clad with the brick veneer and extended above the deck as pilasters and included lighting features above.

One of the primary challenges with the aesthetics was detailing the precast stone trim elements. The bridge columns were inset into the bridge deck, allowing the pedestrian rails to terminate into the face of the columns at the ends of each span. To accommodate this scenario, special attention was given to the precise dimensions of the trim elements that wrapped around the columns.

A 3D model of the precast stone trim around the columns and along the deck was developed to visualize how each piece would fit together. Furthermore, the deck plans required block-out details to accommodate the column inset. Special consideration was given to ensure the precast stone trim elements wrapping around the columns were isolated from the bridge deck so that the bridge deck could thermally expand and contract without cracking the precast stone trim.

Another challenge with the aesthetics was accommodating the pedestrian rail posts that required anchorage to the bridge deck. To provide the contractor with more flexibility for installation, LAN detailed the rail posts’ anchorage so that the base plates could be post-installed instead of cast-in with the concrete deck. The precast stone trim complicated these details because rail posts had to extend through the trim pieces. Block-outs in the precast stone trim were provided so that the pedestrian rail posts could be installed after the precast trim installation. Close coordination between the contractor, the precast stone fabricator, and the rail fabricator will be required during the construction phase so that these elements tie together appropriately.

Conclusion

LAN’s team of dedicated engineers, in coordination with the city, provided high-quality solutions to the various challenges faced on this project to bring a much needed connection to the city. Once completed, the roadway will improve access from north Sugar Land to south of US 90A while also providing an alternate route to alleviate traffic congestion.

“This approximately 700 acres Northeast of the intersection of SH 6 and US 90A turned out to be a very prime spot and has really stimulated the area,” said Steubing.

LAUREN VAN ANDEL, P.E., is the North Texas Bridge Section leader for Lockwood, Andrews & Newnam, Inc. (LAN; www.lan-inc.com), a national civil engineering firm. She can be reached at lvvanandel@lan-inc.com.



Kiln-processed lightweight aggregate was used as fill on one side of the bridge; geofoam blocks were used on the other side. Photo: Ed Bell Construction

LARGE-SCALE CONSTRUCTION requires making many decisions far in advance of the onsite construction work. Engineers and architects guide clients through many decisions while creating the drawings and specifications during the design phase of the project. Ultimately, successful projects are about making good decisions prior to moving the first shovel of dirt and then putting detailed plans and drawings into the hands of skilled people to do the work.

“Building roads and bridges is often about solving problems,” said Phillippe Falkner, operations manager for Ed Bell Construction, a north Texas heavy/highway and municipal contractor based in Dallas. “Experience is always a great asset in building confidence in the choices we make.”

Ed Bell was working on a highway rehabilitation project for the Texas Department of Transportation (TxDOT) in 2010 when Falkner was presented with a rare opportunity.

“The US 67 bridge over SH 174 outside of Cleburne needed to be rehabilitated and they asked Ed Bell to add it to our scope of work on the adjacent section of highway,” Falkner said.

The bridge header was settling because deteriorating embankments at either end were causing the pavement to bunch up where the road connects to the bridge. TxDOT had already attempted to rehabilitate the embankments using traditional soil stabilization methods but moisture issues and settlement continued.

“Since traditional methods hadn’t worked, they asked us to do a side-by-side comparison of two different fill materials, sort of an R&D project,” Falkner said.

The first task on the add services contract was to rehabilitate the bridge over SH 174, which was being diminished by the failing embankments.

MATERIAL DIFFERENCE

TEXAS ROADWAY REHABILITATION EXPLORES
ALTERNATIVE EMBANKMENT FILLS.

By Tom Huempfer



Geofoam blocks were placed by hand on a sand leveling course in the 6-foot-deep by 120-foot-long trench next to the rehabilitated bridge. Photo: Ed Bell Construction

Once the bridge was sound, the embankments were excavated in sections roughly 6 feet deep and 120 feet long, giving builders a fresh, wide trench on either side of the bridge to fill with the alternative fill materials. After each trench was filled, it was to be paved over with new road, reconnecting both sides to the rehabilitated bridge.

Working with two different structural fills, Ed Bell’s assignment on the embankments was to plan and complete the work on each side of the bridge. They would also install electronic pressure monitors beneath the restructured embankments so any future settlement could be monitored independently on each side. For Falkner, the project seemed like a great learning experience as well as a chance to rethink construction processes he’d completed many times before with soil embankments.

TxDOT indicated it wanted to compare a kiln-processed lightweight clay aggregate and solid, lightweight geofoam blocks as alternative fills. On the surface, Falkner’s early expectation was that the aggregate materials would behave similarly to soil. Thinking about the geofoam block side, however, he had some concerns.

“The lightweight aggregate really only comes from one manufacturer in north Texas, so there wasn’t a lot to consider,” Falkner said. “Using



Workers can customize geofoam blocks using a hand-held hotwire cutter to fill in around the bridge superstructure. Photo: Ed Bell Construction

geofoam, however, seemed so different from typical roadway building that I needed to know quite a bit more before I could order it.”

Falkner engaged two geofoam suppliers to gain as much insight as he could while competitively securing the materials. “The costs between the suppliers was about the same, the big difference was the technical support ACH Foam Technologies offered in response to my concerns about building with geofoam.”

ACH Foam’s in-house drafters produced shop drawings of the block configuration pattern to fill in the embankment for structural soundness and numbered each block to ensure it was easy to place precisely according to the plan.

With traffic diverted, the bridge remediated, and the trenches dug, all that was left to do was build the embankments and document the work. Both trenches were lined with a filter fabric before the new fill materials went in. On the lightweight aggregate side, a truck simply backed up to the hole and dumped in the material, which Falkner said is similar to kitty litter in texture. The aggregate was graded flat and covered with more fabric, performing largely the same way soil would under the grader. Special sensors were placed beneath both types of fill to allow TxDOT to closely monitor each material’s settlement post construction.

On the geofoam side, first a sand leveling course was put down to get a nice flat surface. The geofoam blocks were laid in by hand with no specialized equipment or skilled labor involved. Two men were easily able to move blocks as large as 8 feet by 4 feet, weighing less than 100 pounds. Most of the blocks required no modification, but workers were able to customize blocks quickly to fill in around the superstructure using a hand-held hotwire cutter. With the geofoam stacked and wrapped in fabric just like the aggregate side, Falkner was looking at two ready-to-pave embankments made from very different materials.

“With the embankments built, it was time to lay the road down and that



Electronic pressure monitors were placed beneath the restructured embankments to measure settlement. Photo: Ed Bell Construction

went a lot differently than expected,” Falkner said. The road plan called for a crushed limestone base subgrade, covered with hot mix asphalt and topped with a 10-inch concrete pavement. “I was worried about the geofoam side, but it was rock solid under the equipment as we pushed the base out with a dozer. Then on the aggregate side, everything was kind of squishy and it took a lot longer than we expected to get a smooth surface.”

Falkner, still concerned about damaging the embankments with heavy construction equipment, decided to use a lightweight truss screed bridge paver rather than a traditional concrete paver to put in the final topping.

More than five years since the original embankments were built, data suggests both alternative fills have performed adequately. On the lightweight aggregate side, the fill settled slightly more than was originally expected, but was still within TxDOT’s acceptable tolerances. On the geofoam side, there was a quick initial settlement and then no further movement at all, performing better than originally expected. Falkner said that he continues to work on TxDOT projects with the area engineer and that the department has been satisfied with the work and the lack of need for return maintenance since the rehabilitation was completed in 2012.

Since geofoam comes in several different grades, plank sizes, and can also contain termite-resistant treatment, there are variables that need to be explained when quoting a project. ACH Foam took the time to explain the differences and developed a series of options that helped Falkner select the right materials for the application.

TOM HUEMPFNER is vice president, sales and marketing for ACH Foam Technologies, Inc. (www.achfoam.com).

EARTHQUAKE RESPONSE

FIELD TESTS DEMONSTRATE SURVEILLANCE AND COLLAPSE MODELING TOOLS TO SUPPORT URBAN SEARCH AND RESCUE TEAMS.

THE SECOND INACHUS FIELD TEST, held on May 31, 2017, in Lyon, France, demonstrated the project's wide area surveillance solutions and collapse modeling tools to an audience of more than 16 users specialized in urban search and rescue (USaR) operations and structural engineers from Sweden, Belgium, the Netherlands, and France.

In collaboration with CARDEM demolition company, INACHUS partners identified a building in Saint-Fons appropriate for the second field test and created a scenario for its collapse that mimicked earthquake conditions.

One of the goals of the field test was to demonstrate that INACHUS technological solutions could help USaR professionals improve their situational awareness. This should be achieved by creating 3D models of the target building, which could in return:

- aid in damage assessment,
- identify the location of potential voids in an easier way,
- assess the stability of the structure, and
- aid in determining possible rescue paths.

Surveillance tools and 3D mapping

During the field test, users observed the imagery and 3D models created by INACHUS tools. Two unmanned aerial vehicle (UAV) flights — one with a laser scanner and another with an optical digital camera — took place over the collapsed building. The same set up could easily be applied for wide-area surveillance of an entire affected area following an earthquake. Data was also collected from a ground-based laser scanner. The three data sets were then combined, and each served to highlight different features of the collapsed building.

The laser scanners were using their ability to distinguish between different types of objects, for example, people, various building materials, vegetation, even precipitation, and identifying large pieces of (building) material within the overall rubble pile.

Consequently, users were provided with the ability to identify and highlight items in various colors and thus have a clearer understanding of the rubble pile. This can help rescuers get a clear view of the rubble and assist in determining the stability of the structure.

On the other hand, the UAV imaging tool quickly provides an image of the collapsed building, identifying the damaged areas, establishing a percentage of destruction, and helping to prioritize the zone of intervention for USaR teams.

Building collapse simulation software

In the field test, participants could also get a glimpse of the INACHUS



INACHUS collapse simulation software model (left) and scan of collapsed structure.



Frames from a video sequence of the actual collapse (right) and INACHUS collapse simulation software.

tools that simulate building collapse caused from an earthquake or explosion. INACHUS partner Applied Science International (ASI) created a pre-demolition 3D model of the target building based on precise measurements taken from a site visit. Applying within the INACHUS tools the known variables of the explosion provided by the demolition company led to a model that matched in a very large scale the actual rubble pile. The tool's purpose is to aid USaR teams in finding possible survivable spaces within a collapsed structure when applying the phenomenon variables in the INACHUS simulation tools.

The primary goal of the field test was to determine if INACHUS technological solutions could identify possible voids in the rubble where victims may be able to survive, or which rescuers could use when entering the rubble.

After a visual investigation of the building, users could evaluate whether the pile of rubble and the present voids corresponded with the INACHUS models and simulation results. Participants could experience that the models offered a realistic view of the collapsed building and the possible voids within it. Participants in the event agreed that INACHUS could aid in decisions related to victim localization and structural integrity during USaR missions.

Finally, progress on the Emergency Support System (ESS) was shown, allowing participants to digitally complete the INSARAG forms required during large-scale response missions. With INACHUS, data is shared instantly and can be used by various levels of command to greatly improve situational awareness and response coordination. Further aiding in these

areas is the Common Operational Picture (COP) interface, which shows sectors and corresponding activity within sectors.

Moreover, the 3D point clouds and simulation models could be visualized in the post-processing stage of the pilot demonstration, which demonstrates the effort that is made within the project with regard to integration of the project tools. Participants were interested in development of these tools, which they anticipate adding significant value to their current operations.

Participants reacted positively to project developments shown in Lyon. They offered useful feedback for continued progress and expressed interest in remaining involved in the project's development.

The focus of the first field test, held in Ågesta, Sweden in June 2016, was on victim localization tools. The focus of the second field test was on wide-area assessment tools and collapse modeling tools. A third field test will be held in April 2018 in the Netherlands, demonstrating the first integrated version of the INACHUS tools. The project's final field test, to be held along the French and Italian border in Winter 2018, will demonstrate the fully integrated INACHUS system.

For more information about the INACHUS project, visit www.inachus.eu.

Information provided by Applied Science International, LLC (www.appliedscienceint.com).

CONNECTING FIELD TO OFFICE

TRIMBLE INTRODUCES ANDROID APP AND ANNOUNCES UAS COLLABORATION.



Trimble is collaborating with Propeller Aero to distribute its unmanned aircraft system (UAS) analytics platform to measure surface geometry, track trends and changes across time, and perform visual inspections.

TRIMBLE INTRODUCED Trimble Penmap for Android, a cloud-connected application for field surveying and high-accuracy GIS data collection that works on mobile handhelds, smartphones, and tablets. Trimble Penmap for Android focuses on core survey and mapping tasks such as cadastral and boundary surveys, establishing local control, stake-outs, quality checks, and asset management for utilities. It provides both professional surveyors and field workers with a map-based interface to manage features and attributes for high-accuracy GIS and complete survey documentation.

For example, the application is ideal for use in the energy distribution industry for locating infrastructure and recording critical information on encroachments, clearways, and existing monuments, the company said. The application runs on a variety of Android devices, including the rugged Trimble TDC100 handheld, and supports full-featured Trimble Global Navigation Satellite System (GNSS) receivers such as the Trimble R10, R8s, and R2 receivers.

Trimble Penmap for Android is optimized to integrate with the new Trimble Catalyst service, a software-defined GNSS receiver that connects to the small, inexpensive plug-and-play DA1 antenna, and allows surveyors to choose an accuracy level from meter to centimeters to suit their application needs. Together, Penmap and Trimble Catalyst — both purchased through a fixed monthly subscription — offer an on-demand, lightweight, and low-cost professional surveying system, Trimble said.

“Surveyors using the Penmap application with Trimble Catalyst can easily manage seasonal shifts in survey activity by scaling up or down without a capital investment,” said Matt Delano, general manager of Trimble’s Land Administration solutions. “Survey managers will find it an efficient way to carry out field checks without tying up expensive equipment used by

their field crews. They can simply use a phone, the Penmap application, a Catalyst subscription, and the DA1 antenna.”

Trimble Penmap for Android includes the Penmap Project Manager, which is used to set up projects, create templates, and add team members. Penmap Project Manager works with the Trimble Connect platform for storing and transferring data between the field and office. Trimble Connect, which is also included in the Penmap subscription, is a collaborative cloud-based platform that enables organizations to set up and deploy projects to their field users. Information collected in the field is synced back to the office in real-time where it is stored, managed, and communicated to team members. Data can also be exported from Penmap Project Manager into back-office systems in a variety of file formats for viewing and sharing.

Trimble Penmap for Android is available for download from the Google Play Store. For more information, visit <https://geospatial.trimble.com/products-and-solutions/Penmap-Android>. Trimble Catalyst is available to purchase. For more information, visit www.catalyst.trimble.com.

UAS analytics platform

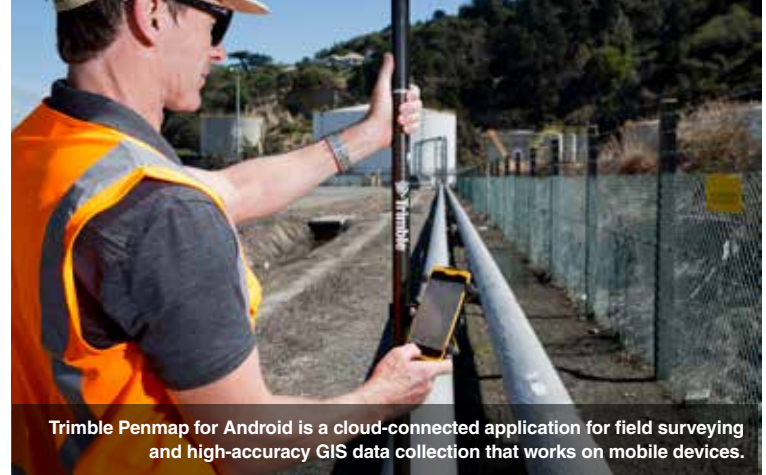
Also in July, Trimble announced that it is collaborating with Propeller Aero to distribute its unmanned aircraft system (UAS) analytics platform. Propeller, based in Sydney and Denver, provides collection, visualization, and analysis of data from UAS. Propeller’s automated ground control targets, cloud-based visualization, and rapid analysis platform will also be integrated with Trimble Connected Site solutions to bring an end-to-end cloud-based UAS solution to civil engineering and construction contractors.

Pairing Propeller’s web-based interface with Trimble Connected Site

solutions gives users access to simple tools to measure surface geometry, track trends and changes across time, and perform visual inspections. Both technical and non-technical professionals are now able to gather insights remotely and collaborate, driving significant improvements in safety, efficiency, and reducing environmental impact across a construction worksite, Trimble said.

For more information, visit www.propelleraero.com/trimble.

Information provided by Trimble (www.trimble.com).



Trimble Penmap for Android is a cloud-connected application for field surveying and high-accuracy GIS data collection that works on mobile devices.

UAV +
SURVEYING

AERIAL ANALYTICS

SITE SCAN NOW PROVIDES CUT AND FILL CALCULATIONS
AND INFRASTRUCTURE INSPECTION.

3D ROBOTICS announced that its Site Scan drone-based aerial analytics platform can now calculate cut and fill volumes directly without exporting drone data into other platforms. Cut and fill analysis provides the information needed to effectively grade and level a jobsite and prepare it for construction. An accurate cut and fill helps save time and money, reduce risk, and better manage resources onsite, the company said.

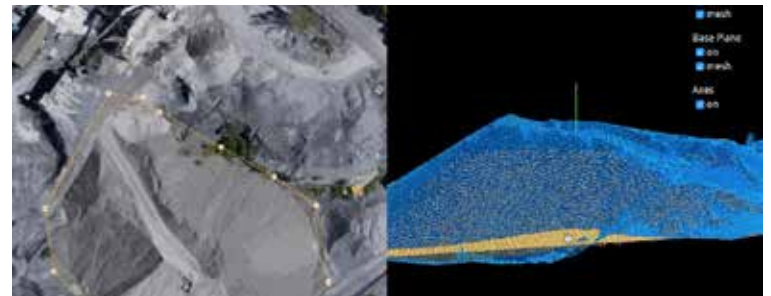
Calculating a cut and fill properly, however, has long been a time-consuming process, with significant time spent in the field performing a topographic survey and back in the office analyzing the data. While drone surveying has significantly reduced time onsite, calculating cut and fill volumes has still been needlessly complex; it requires using multiple tools and specialized earthworks software.

Site Scan users can open the app and with the tap of a button get precise, actionable volume measurements. Site Scan's cut and fill calculations are based on data collected by the Sony R10C drone camera and three base planes available that account for the underlying terrain: lowest point, highest point, and best fit.

The lowest point base plane finds the lowest elevation in the vertexes of a boundary and creates the base plane from that point. This is best suited for stockpiles on a flat surface — or with walls or other stockpiles nearby — that users plan to cut.

The highest point plane will work from the highest vertex of the boundary, and is appropriate in cases where users plan to fill, such as a trench, hole, or ditch.

The best fit base plane, which is the default plane in Site Scan, automatically determines the most appropriate fit for the selected area.



The Site Scan best fit base plane gives precise fill volumes.

Integration with Pix4D

3DR also announced that it integrated Site Scan with Pix4D, a photogrammetry processing engine, to help users create more accurate and detailed data products. Site Scan is already integrated with the Autodesk ReCap processing engine, so with the addition of Pix4D the company is now offering multi-engine photogrammetry processing for data products.

According to 3DR, multi-engine processing, combined with the high-resolution photos from Site Scan's Sony R10C camera, delivers results that consistently rival LiDAR and traditional surveying when it comes to accuracy. With this combination, one of 3DR's customers was able to achieve accuracy levels within a tenth of an inch of terrestrial LiDAR.

The company said that it also made improvements that deliver processed data three times faster, allowing users to process five times more photos at once — 2,500 photos in total.

Infrastructure inspection

A new flight mode called Inspect Mode allows users to fly Site Scan manually and take high-resolution, geotagged photos of infrastructure and assets such as bridges, dams, cell towers, cranes, and more. Inspect Mode keeps fields crews safe on the ground while capturing jobsite details and making it easy to monitor and share progress. The 20.1MP Sony R10C camera includes an E-mount 3X optical zoom lens with image stabilization to help take the best photos possible.

Information provided by 3D Robotics (www.3dr.com).

ARCADIS PRESENTS FREE REMEDIATION EDUCATIONAL SERIES

ARCADIS IS OFFERING a free webinar series on the latest technologies in environmental remediation. Advancements in environmental remediation are happening at an accelerating pace. Outdated scientific techniques have been replaced with unconventional treatment methods and cutting-edge tools to successfully address some of the world's most complex environmental challenges.

To explain how these innovations will affect corporate and community remediation projects, Arcadis developed the following series of free educational webinars that cover emerging issues and evolving investigation and remediation methods:

Innovations in the Management of 1,4-Dioxane describes the impact of this contaminant on public water supplies, what to expect from regulatory agencies, and new cost-effective ways to manage this risk.

This presentation covers the pros and cons of various treatment methods, including Advanced Oxidation Processes, In-Situ Chemical Oxidation, Natural Attenuation, Ex-Situ Bioreactor, Bioremediation, and Synthetic Media. The webinar features Arcadis experts Caitlin Bell, P.E. and Joe Quinnan, P.E., PG.

Smart Characterization Methods that Increase Return on Investigation (ROI) explains new site investigation methods that narrow the focus to expand the impact of remediation methods and provide a significant ROI. This presentation shows how new modeling methods and technology not only improve accuracy, but significantly decrease investigation time and cost. The webinar features Arcadis experts Nick Welty, CPG, PG and Joe Quinnan, P.E., PG.

Successful Innovations for Achieving Large Plume Closure provides an in-depth look at the framework used to evaluate and optimize remedial performance to successfully clean up a large-scale DOD plume in less than

eight years and with substantial cost savings. This presentation describes how dynamic groundwater recirculation can overcome back diffusion. The webinar features Arcadis experts Kelly Houston, P.E.; Scott Potter, Ph.D., P.E.; and Suthan Suthersan, Ph.D., P.E.

Big Data and Environmental Remediation: Gaining Predictive Insights reviews the evolution of data capture and how new analysis methods will reveal patterns, trends, and associations that provide predictive insights about complex environmental issues and identify areas that could deliver additional value to the corporate bottom line. The webinar features Arcadis experts Margy Gentile, Ph.D., P.E. and John Horst, P.E.

These webinars were previously recorded and are available now. For more information and to access this free webinar training series, visit <http://arcad.is/air-webinar-ec>.

Information provided by Arcadis
(www.arcadis-us.com).

ACI CONVENTION INCLUDES FRP CONCRETE SYMPOSIUM

MORE THAN 2,000 engineers, architects, contractors, educators, manufacturers, and material representatives from around the world are expected to convene in Anaheim, Calif., Oct. 15-19, 2017, to collaborate on concrete codes, specifications, and standards. Technical and educational sessions will provide attendees with the latest research, case studies, best practices, and the opportunity to earn Professional Development Hours (PDHs).

The Southern California Chapter of the American Concrete Institute (ACI) will host the convention this fall as an opportunity to showcase the companies, projects, current events, and landmarks that inspired the

convention theme of Making Connections. Convention highlights include:

- International Workshop on Structural Concrete: Technology Advancement and Adoption in the Americas;
- 13th International Symposium on Fiber-Reinforced Polymer Reinforcement of Concrete Structures;
- Women in Concrete Alliance Summit;
- ACI Chapter Fall Roundtable;
- International Lunch with special guests Jae-Hoon Lee and Hong-Gun Park;
- Student Egg Protection Device Competition;
- Inaugural Student Eco Concrete Competition;
- NASA Centennial Challenge Demonstration;
- Student Lunch with speaker Conrad Paulson;
- Contractors' Day Lunch with speaker Kent Estes;

- 10th Anniversary ACI Concrete Sustainability Forum;
- Third-Annual Excellence in Concrete Construction Awards Gala; and
- An industry exhibition showcasing as many as 70 exhibitors.

Throughout the convention, ACI will hold more than 300 committee meetings, 30+ technical sessions, an industry trade exhibition, networking events, and more. Registration is open online through Sept. 25, 2017, and discounted rates are offered until Sept. 17, 2017. To learn more about the ACI Convention and to register, visit www.aciconvention.org.

Information provided by the American Concrete Institute (www.concrete.org).

AISI AND CFSEI CO-SPONSOR 25TH SHORT COURSE ON CFS STRUCTURES

THE AMERICAN IRON AND STEEL INSTITUTE (AISI) and the Cold-Formed Steel Engineers Institute (CFSEI), in cooperation with the Wei-Wen Yu Center for Cold-Formed Steel Structures at the Missouri University of Science and Technology, are co-sponsoring the 25th Short Course on Cold-Formed Steel Structures in St. Louis, Oct. 24-26, 2017. The short course provides information on the behavior of cold-formed steel members and connections for both commercial and residential applications, including wall studs, floor joists, purlins, girts, decks, and panels. It is eligible for 2.4 Continuing Education Units (CEUs). Registration is required by Oct. 10, 2017.

“This comprehensive course benefits all engineers interested in cold-formed steel design,” said Maribeth Rizzuto, LEED AP – BD+C, managing director, CFSEI. “For those unfamiliar with cold-formed steel design,

the course will provide an introduction to the behavior of cold-formed steel members and connections and how that behavior is addressed by AISI S100, North American Specification for the Design of Cold-Formed Steel Structural Members. For experienced engineers, the course will strengthen their understanding of the fundamental behavior of cold-formed steel members and connections.”

The following topics will be covered during the short course:

- Mechanical properties of steel and effect of cold-work of forming;
- Local buckling and postbuckling strength of thin flat elements;
- Flexural members — bending strength, lateral-torsional buckling, and deflection;
- Tension members;
- Compression members — flexural, torsional, and flexural-torsional buckling;
- Bracing requirements;
- Design based on test results;
- Direct strength method; and
- Shear wall design.

The instructors are Roger A. LaBoube, Ph.D., P.E., Curators’ Distinguished Teaching Professor Emeritus of Civil Engineering at the Missouri University of Science and Technology and director of the Wei-Wen Yu Center for Cold-Formed Steel Structures; and Sutton Stephens, Ph.D., P.E., S.E., chief engineer (retired-advisor) at Pacific Northwest Engineering, Inc.

Additional co-sponsors of the Short Course include the Metal Building Manufacturers Association, Metal Construction Association, Rack Manufacturers Institute, Steel Deck Institute, Simpson Strong-Tie, and Steel Framing Industry Association.

For more information or to register online, visit the 25th Short Course on Cold-Formed Steel Structures web page at: <http://ccfssonline.org/cfs-short-course>.

Information provided by the American Iron and Steel Institute (www.steel.org) and the Cold-Formed Steel Engineers Institute (www.cfsei.org).

ASTM INTERNATIONAL UPGRADES ONLINE LEARNING MANAGEMENT SYSTEM

ASTM INTERNATIONAL debuted a new learning management system (LMS) designed to enhance user experience and functionality. Since 2012, the number of learners has grown from 500 to more than 4,000. Usage increased by more than 174 percent last year alone, prompting the need for a more robust platform.

Existing customers will begin seeing a

seamless transition to the new platform. The migration was expected to be completed by Aug. 31. The new LMS features:

- an expanded search tool,
- 24/7 access to ASTM International training content,
- accessibility to training modules from any device,
- enhanced reporting capabilities, and
- customized curriculums.

From the new homepage, learners will be able to find new training modules, access completed training, browse catalogues, and

print certificates. In addition, courses can be downloaded and completed offline.

There will be continued updates to the LMS, including the addition of a “video wall,” where learners will have easier access to training videos.

Learn more at www.astm.org/train or contact the learning management team at lms_support@astm.org.

Information provided by ASTM International (www.astm.org).

AASHTO PUBLISHES LRFD TUNNEL DESIGN AND CONSTRUCTION GUIDE

THE AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO) published new guide specifications on Load

and Resistance Factor Design (LRFD) and construction of road tunnels. The LRFD Tunnel Design and Construction Guide Specifications, available on the AASHTO website (www.aashto.org), is the result of a five-year research effort by WSP USA performed under a task order from the

National Cooperative Highway Research Program (NCHRP).

The specifications are intended for the design, evaluation, and rehabilitation of road tunnels constructed using cut-and-cover, bored, mined, and immersed tunnel

construction methodologies. In developing these specifications, consideration was given to safety and operations, maintenance, and inspection of tunnel systems. The publication, the first national design and construction specifications for road tunnels, represents groundbreaking work to advance and support the professional practice in tunnel and

underground engineering in the United States.

The recommended LRFD-based tunnel design methodology used to develop the guide is presented in the final NCHRP research report. A literature search was performed to review existing design codes and standards, project-specific design criteria, reports, and technical

publications. Limited calibration of the load factors was performed based on results from the analysis of a circular bored tunnel. A summary of the calibration procedure is presented in the report.

Information provided by WSP USA (www.wsp.com).

DFI ANNOUNCES KEYNOTE SPEAKERS FOR 42ND ANNUAL CONFERENCE

DEEP FOUNDATIONS INSTITUTE (DFI) announced four keynote speakers for the 42nd Annual Conference on Deep Foundations, being held in New Orleans, Oct. 24-27, 2017.

David B. Paul, P.E., special assistant for Dam Safety with the U.S. Army Corps of Engineers (USACE), is providing an update on the “USACE Oversight of Remediation of the World’s Highest Risk Dam.” This keynote is a continuation of a lecture that was delivered at the 2016 DFI Annual Conference in New York. Paul is responsible for managing the USACE’s portfolio of 709 dams. He is a national specialist on critical infrastructure design, dam design, levee design, construction engineering, engineering risk assessments, interim risk reduction measures, and dam and

levee safety modifications performed as part of USACE dam safety management activities.

Eric C. Halpin, P.E., special assistant for Dam and Levee Safety for the USACE, references Hurricane Katrina and the recent situations at Oroville Dam and Mosul Dam in the keynote lecture, “Being Approximately Right or Precisely Wrong: Risk Informed Lessons in a Standards-Based Industry.” Halpin leads safety programs for the USACE and is the senior advisor to leadership on all dam and levee safety issues and decisions. He is the primary agency safety representative on interagency, congressional, and international safety organizations. His primary emphasis has been on incorporating concepts of engineering risk into all facets of safety programs.

Deborah D. Keller, P.E., CEO of D.D. Keller & Partners, is sharing insight on “Fostering Multi-Generational Work Teams.” Keller is

a professional civil engineer who served as chief engineer at the Port of New Orleans for 27 years. During her 40-year career, she has directed design and construction of nearly \$1 billion in public works projects.

Ralph W. Junius, Jr., P.E., president of Linfield, Hunter & Junius, is delivering a lecture on legal issues in the industry entitled, “The Intersection of Engineering, Construction, Litigation and Ethics.” Junius has professional experience with a wide range of infrastructure projects, including transportation, water, port and flood protection systems, as well as foundations. As a lawyer, he has served as an engineering expert in appropriate cases.

Visit www.deepfoundations2017.org for more information.

Information provided by the Deep Foundations Institute (www.dfi.org).

ASCE'S NEW BOOK HELPS WITH RISK-RELATED DECISION MAKING IN CONSTRUCTION

A NEW ASCE PRESS BOOK, Quantitative Risk Management and Decision Making in Construction, focuses on identifying, quantifying, and mitigating risks associated with construction projects. The author, Amarjit Singh, Ph.D., P.Eng., C.Eng., professor of civil and environmental engineering at the University of Hawaii, Manoa, introduces valuable techniques for weighing and evaluating alternatives in decision making with a focus on risk analysis.

Topics include probabilistic cost estimating, contingency analysis, cause-effect diagrams, FAST diagrams, and decision trees, as well as information on the available tools to quantify risks such as payoff matrices, Bayes’ theorem, matrix analysis, and analytical hierarchy process. In addition, the author shows how the information gained from analysis can be applied to mitigate risks using a risk analysis card game, monitoring performance, and managing inventory.

Intended for graduate and upper-level undergraduate students, each topic is accompanied by numerous examples,

drawings, and exercises to illustrate and reinforce these concepts. In addition, the common techniques can be executed by business and construction managers for practical construction risk assessment.

To purchase online, visit the ASCE Bookstore at <http://www.asce.org/templates/publications-book-detail.aspx?id=24824>.

Information provided by the American Society of Civil Engineers (www.asce.org).



01. LINEAR SURFACE DRAINS

Advanced Drainage Systems, Inc. (ADS) acquired Duraslot, Inc., a manufacturer of stormwater collection surface drains. Duraslot linear surface drains are made by incorporating a heavy-duty aluminum inlet slot mounted on top of ADS N-12 corrugated HDPE pipe. The slotted inlet at grade intercepts sheet flow across a paved area or is installed against a curb or barrier in a gutter-type application. These high-capacity drains are designed to remove stormwater as it flows across paved or cleared areas, or as it collects in low spots.

ADVANCED DRAINAGE SYSTEMS, INC.
WWW.ADS-PIPE.COM



02. FIRE WALL HANGER

Simpson Strong-Tie said its new DG fire wall hanger series is ideal for Type III multifamily, multi-level building construction and easily installs on a two-hour wood stud fire wall during framing — before the drywall is in place. The new series includes three models of top-flange hangers that connect floor joists to the wood wall and feature enough space for two layers of 5/8-inch drywall to be installed later. The completed fire wall assembly remains continuous from floor to floor. All three fire wall hangers have been tested according to ASTM E814 standards.

SIMPSON STRONG-TIE
WWW.STRONGTIE.COM



03. CORROSION PROTECTION

According to Covestro LLC, during the last decade, more than 150 steel bridges in Virginia have been repainted with two-coat polyaspartic urethane coating technology. The results show the polyaspartic urethane two-coat coating systems offer corrosion protection equivalent to conventional three-coat systems. Two-coat polyaspartic urethane coatings also have the added benefits of providing cost reduction in painting operations, accelerated painting schedules, and less traffic congestion. Studies have shown that the application of these fast-throughput systems can save transportation departments as much as 20 percent on field repainting costs due to productivity advantages, the company said.

COVESTRO LLC
WWW.COVESTRO.COM

Structural Engineers Axiom #7

Professional Liability is Essential. Overpaying is Not.

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