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How construction businesses are using advanced technologies:

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<th>Technology</th>
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<td>Drones</td>
<td>18%</td>
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<td>Autonomous equipment</td>
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<td>AR / VR</td>
<td>6%</td>
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<td>3D Printing</td>
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Source: Software Connect survey
Stewart helps plan and design its new headquarters in a landmark building. PAGE 38
The American Concrete Institute announces a new all-access subscription to ACI University webinars and on-demand courses. This 12-month subscription includes all ACI monthly webinars and ACI’s 175+ on-demand courses. Multi-user options are also available. Visit www.aciuniversity.com to subscribe.

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IN RECOGNITION OF VETERANS DAY, this issue of Civil + Structural Engineer focuses on veterans of the U.S Armed Forces.

See “AEC veterans: Tested in combat, those who served the country are proven leaders in the engineering field” (page 16) and “Hiring veterans: Vet Centers can help firms find skilled and experienced professionals” (page 19).

As an employer of literally hundreds of veterans during my 38-year career, I can say that — with only a few exceptions — they have all been calm, balanced, hard-working, disciplined, and responsible employees. Something about the military experience — putting the “team” above your own needs — makes for a very good employee.

As a professor, I have had the privilege of teaching some career military people as well as those who did a couple-year stint in the military. Without exception, all have been good students who did their assignments without excuse, produced quality work, and did well working in small groups — many assuming leadership of their groups in group projects. I have to say that I am favorably disposed toward veterans!

These brave and self-sacrificing men and women deserve all our support. Often traveling to foreign countries where they get shot at, bombed, injured, and killed, they give up time away from their families while putting their lives on the line.

Enjoy this November issue of Civil + Structural Engineer magazine! We’re here to elevate you, celebrate you, and honor and promote the engineering profession and the work you do. Please let me know any way you think we could improve our publication. We — and our advertisers and sponsors — depend on your input and support.

MARK C. ZWEIG
mzweig@zweiggroup.com
SURVEYING HISTORY

During World War I, some 120,000 New Zealanders were sent overseas. Among them were the men of the New Zealand Engineers Tunneling Company, a tough bunch made up of miners, quarrymen, and laborers with a secret mission to help underground warfare and thwart the advances of enemy forces.

Working ahead of a major battle planned by the allied forces to break the German front in April 1917, the tunnellers were tasked with connecting a network of abandoned chalk quarries, some dating back to the Middle Ages. They created a 2.3-kilometer-long subterranean passage where allied soldiers could easily move underground and eventually take the enemy by surprise on the morning of the battle. The tunnels and quarries could accommodate 24,000 men and included a light rail system, fully equipped hospital, electric lights, kitchens, latrines, running water, and living quarters.

Dr. Pascal Sirguey and his colleague Richard Hemi, both from the National School of Surveying at the University of Otago in New Zealand, devised a project, LiDARRAS, to use LiDAR technology and capture a permanent digital record of the tunnels.

Read the entire article at http://tinyurl.com/surveying-nov18.

PROJECT PROFITABILITY: PROJECT CLOSEOUT

By Howard Birnberg, Association for Project Managers

For many project managers, by the time a project is substantially complete, little budget, time, or interest remains for the project closeout process. Unfortunately, this is a lost opportunity to compile important data, cement a relationship with a client, and tie up loose ends on a project’s scope.

Read the entire article at http://tinyurl.com/projectprofit-nov18.

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AN ESTIMATED 250,000 VETERANS LEAVE THE MILITARY every year and are projected to do so at the same rate for years to come. These outstanding individuals will be looking for work. I was in this very situation when I left the Air Force in 2010. Being a veteran myself, I know the transition from military life to civilian life can be difficult.

While working with firms on their strategic plans, inevitably one of the top three concerns principals face is hiring and retention of good, qualified talent. With the current job outlook, this problem will only get more difficult over the next several years. Veterans provide a tremendous resource if we know how to attract, retain, and reward them.

A cornucopia of initiatives help veterans get hired, such as Hiring our Heroes, Operation IMPACT Network of Champions, and Veterans Jobs Mission. They are doing great work along with those that are assisting us in translating and communicating the leadership and technical skillset we’ve developed while serving that is so valuable to firms. Unfortunately, nearly half of all veterans leave their first civilian job within a year and as many as 80 percent will leave before they finish their second work anniversary. What does that mean to us? We need to do a better job retaining veterans and have a larger conversation around retaining employees in general.

According to VetAdvisor and Syracuse University’s Institute for Veterans and Military Families, the top reasons that veterans are departing their first jobs include a lack of career advancement/development, work that lacks meaning, limited professional development opportunities, or an unfamiliar work culture. You’ll notice that many of these explanations are the same that departing non-veteran employees give. So as leaders within organizations, what do we do to hold onto this vital group?

Educate firm leaders, recruiters, and managers about military culture and language. We need championship from the principal level down that allows leadership to bridge gaps in communication. We can’t expect veterans to do all of the adapting. Other veterans within your firm can help.

Design a specific onboarding and integration program for veterans. A more thorough examination of your onboarding process for every employee may be a good idea. One helpful suggestion is to develop a glossary of common terminology, acronyms, and jargon.

Help veterans establish connections and relationships within the firm.

Find a way to connect role responsibilities to the firm’s overall strategy and purpose.

A few more suggestions for retention that are applicable to every great team member you have include:

• **Responsibility** — Push tasks and duties as far down in the org chart as possible. Strive to give ownership and responsibility to everyone and allow mentor relationships to help develop the necessary skillset.
• **Respect** — This one is obvious. Everyone wants to know they are respected and appreciated.
• **Revenue sharing** — Tie a part of employee compensation to the firm’s performance.
• **Reward** — Reward goes beyond monetary compensation. Celebrate wins, give recognition, and build an intentionally positive workplace culture. Give people a purpose to work toward; provide them a “why.”
• **Flexibility** — Some form of flexible work environment and allowing employees to relax are key to retention.

Long-term commitment requires work from both the top and bottom of the organization. There is a lot of discussion around “job hoppers,” but if you want to keep people, it is vital that you give them good reasons to stay.

**Phil Keil** is director of Strategy Consulting, Zweig Group. Contact him at pkeil@zweiggroup.com.
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IT’S SUNDAY MORNING IN MEXICO CITY. I am in a small dark conference room packed with people from all walks of life. Their facial expressions are earnest and distressed. They are owners of apartments in a high-rise building that was really badly damaged and, in some cases, collapsed, in last year’s earthquake. One by one, they start to ask me questions.

Last year on Sept. 19, a 7.1-M earthquake affected thousands of buildings in Mexico City, even though the epicenter was hundreds of miles away. After the Spanish conquest of the Aztec empire, the Spanish turned a large lake into one of the largest megacities in the Americas. The city is essentially sitting on deep soft soil. This soil resonates with long-distance earthquakes and creates dangerous motion for taller construction.

The earthquake collapsed 44 buildings and the city estimates that more than 800 buildings were severely damaged and need to be taken down. More than 400 people died, and thousands more lost homes and their investments. Most of these buildings are older nonductile concrete structures, which are well known for earthquake risk. Most of the damaged buildings are mid-rise apartment buildings that housed tens of thousands of people.

Our mission is to not only reconstruct safer buildings but provide financially feasible solutions for people who lost their homes. The city has a plan that allows home owners to reconstruct 35 percent taller than what zoning allows. This is a smart concept. Mexico City is developing fast and the value of housing is rising exponentially. It even sometimes matches property prices in U.S. cities.

This enables a developer to rebuild a whole building and sell the 35 percent additional condominiums. Existing owners can return to their newly constructed apartment with little or no cost, and they are safer and architecturally more suited for modern city life. Developers make a decent return on investment for their capital investment. I call this a private-sector driven approach to disaster reconstruction.

Strategy — a similar concept was applied in the aftermath of the 1995 Kobe Earthquake and the city was rebuilt bigger, better, and safer. Fast — I really feel this will be a successful program, judging by the entrepreneurial spirit of the Mexican people and robust engineering capacity.

The energy of this city is something else. Its vivid culture, music, history, and food is everywhere. You may not have had the chance to visit Mexico City; it is often overlooked by international tourism for Mexico’s mega beach resorts. But I highly recommend it. Its historical center rivals any ancient European city and, on top of it, Mexico has unbelievably good food and music.

An elderly homeowner raised a hand and said thoughtfully, “I appreciate you coming here to talk to us. We needed good information on engineering and financial solutions. It is still a long way to go, but I am hopeful.”

A comment like that keeps us going through a long day in a post-disaster zone.

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.
Awards, promotions, and new hires

Freese and Nichols, Inc., welcomed Jorge A. Arroyo, P.E., an international authority on alternative water supplies and innovative water treatment, to expand the firm’s work in helping meet Texas’ future water needs. Keith Beatty, P.E., joined Freese and Nichols to lead the firm’s Tulsa, Okla. office. He has more than 20 years of experience in roadway design, water/wastewater, stormwater, site development, and structural forensics. Naveen Chil lara, P.E., joined the firm’s Water Resources Design Division as a senior project manager and water resources design engineer serving the Southeast Texas and Louisiana markets.

Janine La Marca, CPSM, director of business development, was named an associate at The Harman Group. She has 25 years of experience in the AEC industry.

Passero Associates welcomed four professionals: Bruce Bradley as an aviation engineer; Robert J. Bilyo, P.E., as a project manager; Chase LeBrun as a structural engineer; and Joshua Case to the Aviation Services Team as an owner construction representative.

Christina LeGros was promoted to executive vice president at CT Consultants. She will oversee implementation of the firm’s newly adopted 7 Leadership Principles. Justin Haselton, LEED AP, joined CT Consultants as Cleveland Regional leader with responsibilities for project management, technical support, and business development.

Brenton Jenkins, P.E., joined Cardno as a project engineer in the company’s Baton Rouge, La., office. Bruce Moreira, PWS, GISP, joined Cardno as an environmental project scientist in the firm’s Portland, Ore., office. Jim Godfrey, PLS, joined the firm as branch manager of Cardno’s Tampa, Fla., office. He has more than 30 years of utility engineering and surveying experience.

Carla Thompson, senior director of marketing, Core States Group, received the Weld-Coxe Marketing Achievement Award from the Society of Marketing for Professional Services. This tribute is the highest honor given by the organization and is only awarded when it identifies a deserving candidate.

Mark Fuhrmann joined HDR’s transit practice as a senior project manager based in the Minneapolis engineering office. His first assignment is serving as program manager for the Northern Indiana Commuter Transportation District West Lake and Double Track projects.

Jay Mezher, AIA, joined Mott MacDonald as digital delivery leader for the North American region. Based in Seattle, Mezher will expand Mott MacDonald’s project delivery capabilities through implementation of new and emerging tools and progressive workflows. L. Matthew Gwinn, RA, joined Mott MacDonald as a vice president and Eastern U.S. regional leader for the Aviation Practice. Based in New York City, he will be responsible for management oversight of the JFK Master Plan/Development Program.

Heather Reed, Ph.D., a senior associate in the New York, Wall Street office of Thornton Tomasetti, was invited by the National Academy of Engineering to attend the 2018 U.S. Frontiers of Engineering (US-FOE) Symposium at the MIT Lincoln Laboratory in Lexington, Mass. Each year, the USFOE brings together 100 innovative engineers under the age of 45 from U.S. companies, universities, and government labs to discuss leading-edge research and technical work across a range of engineering fields.

Jay Simonds, P.G., joined V3 Companies’ Columbus, Ohio, office as senior environmental project manager. A former U.S. Army Corps of Engineers service member, he will focus on delivering projects for the commercial development, power and energy, and industry markets, along with V3’s full spectrum of services.

Eric Ross joined DPS Group as virtual design and construction (VDC) manager for U.S. operations in the firm’s Albany, N.Y., office. He will oversee VDC and BIM for all DPS projects within the U.S.
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NOVEMBER 2018

VECTORWORKS DESIGN SUMMIT
NOV. 4-6 — PHOENIX
One-on-one sessions with Vectorworks software experts and breakout sessions exploring detailed workflows and best practices.
www.vectorworks.net/design-summit

TRIMBLE DIMENSIONS INTERNATIONAL USER CONFERENCE
NOV. 5-7 — LAS VEGAS
Learn how Trimble hardware, software, and service solutions maximize productivity and boost profitability across agriculture, construction, geospatial solutions, transportation and logistics, and multiple emerging industries.
https://trimbledimensions.com

ASBI 30TH ANNUAL CONVENTION
NOV. 5-7 — CHICAGO
Forum to further refine current design, construction, and construction management procedures, and evolve new techniques that will advance the quality and use of concrete segmental bridges.
www.asbi-assoc.org/index.cfm/events/30th-annual-convention

CEO ROUNDTABLE BOURBON EXPERIENCE
NOV. 7-9 — LOUISVILLE, KY.
Exclusive event for top leaders to discuss the highest-level issues facing CEOs and the C-suite of today’s AEC firms.
https://zweiggroup.com/seminars/ceo-roundtable

DBIA DESIGN-BUILD CONFERENCE AND EXPO 2018
NOV. 7-9 — NEW ORLEANS
Workshops, panel discussions, and keynotes by industry leaders addressing the real-world challenges that America’s design-build teams and owners face across all sectors.
www.designbuildexpo.com

NATIONAL DISASTER RESILIENCE CONFERENCE
NOV. 7-9 — CLEARWATER BEACH, FLA.
Focus on the latest in science, policy, and practice to create more resilient buildings and disaster-resilient communities in the face of earthquakes, floods, hail, hurricanes, lightning, tornadoes, and wildfires, as well as human-caused disasters.
http://flash.org/nationaldisasterresilienceconference

AUTODESK UNIVERSITY
NOV. 13-15 — LAS VEGAS
Annual Autodesk users conference attracts 10,000 professionals from the architecture, design, manufacturing, and media industries for classes, workshops, presentations, and interactive galleries.
http://au.autodesk.com

DECEMBER 2018

LEADERSHIP SKILLS FOR AEC PROFESSIONALS
NOV. 14-15 — SAN FRANCISCO
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.
https://zweiggroup.com/seminars/leadership-skills-for-aec-professionals

EXCELLENCE IN PROJECT MANAGEMENT
NOV. 28 — ATLANTA
Tutorial and case study workshop sessions present critical areas every project manager should know from the perspective of architecture, engineering, and environmental consulting firms.
https://zweiggroup.com/seminars/excellence-in-project-management

JANUARY 2019

BUILDING INNOVATION 2019 CONFERENCE & EXPO
JAN. 7-10 — WASHINGTON, D.C.
Examine processes, communities, workforces, structures, resources, practices, communications, and collaboration aimed at “Optimizing for Tomorrow.”
www.nibs.org/page/Conference2019

2019 TRB ANNUAL MEETING
JAN. 13-17 — WASHINGTON, D.C.
Meeting program will cover all transportation modes, with more than 5,000 presentations in nearly 800 sessions and workshops.
www.trb.org/AnnualMeeting/AnnualMeeting.aspx

INTERNATIONAL LIDAR MAPPING FORUM
JAN. 28-30 — DENVER
Technical conference and exhibition showcasing the latest airborne, terrestrial, and underwater LiDAR as well as emerging remote-sensing and data-collection tools and technologies.
www.lidarmap.org
FEBRUARY 2019

**GEOSYNTHETICS CONFERENCE**
**FEB. 10-13 — HOUSTON**
More than 1,300 geotechnical practitioners, designers, regulators, contractors, and installers gather to learn the latest research, materials, applications, and case studies.
https://geosyntheticsconference.com

**IECA ANNUAL CONFERENCE**
**FEB. 19-22 — DENVER**
Learn the latest updates and advancements in the erosion and sediment control and stormwater industry and gain insight to critical issues facing the profession.
http://www.ieca.org/IECA/IECA_Events/2019_Annual_Conference.aspx

**PCI CONVENTION**
**FEB. 26-MARCH 2 — LOUISVILLE, KY.**
Precast/Prestressed Concrete Institute 2019 Convention includes education sessions, committee and council meetings, and The Precast Show exhibition. National Bridge Conference and all peer-reviewed paper presentations are moved to the PCI fall conference.
www.pci.org

MARCH 2019

**SUCCESSFUL SUCCESSOR SEMINAR**
**MARCH 13-15 — NEW ORLEANS**
Discuss issues facing newcomers to the c-suite and individuals who are preparing to take on a high-level management role in today’s AEC firm.
www.zweiggroup.com/seminars/successful-successor-seminar

**EXCELLENCE IN PROJECT MANAGEMENT**
**MARCH 27 — KANSAS CITY, MO.**
Tutorial and case study workshop sessions present critical areas every project manager should know from the perspective of architecture, engineering, and environmental consulting firms.
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APRIL 2019

**NASCC: THE STEEL CONFERENCE**
**APRIL 3-5 — ST. LOUIS**
Educational and networking event for the structural steel industry, bringing together structural engineers, structural steel fabricators, erectors, detailers, and architects.
www.aisc.org/nascc

**DESIGN-BUILD FOR TRANSPORTATION**
**APRIL 8-10 — CINCINNATI**
Only U.S. event targeted to the rapidly growing design-build transportation industry.
https://dbia.org/conferences/design-build-for-transportation-conference

MAY 2019

**WEF STORMWATER AND GREEN INFRASTRUCTURE SYMPOSIUM**
**MAY 8-10 — FORT LAUDERDALE, FLA.**
Inaugural symposium crafted to deepen the technical knowledge of professionals involved with stormwater management and provide forums to discuss leading issues.

**3CCONNECT**
**MAY 16-16 — DENVER**
National Conference for Public-Private Partnerships offers this event for public-sector officials and private-sector innovators focused on advancing public-private partnerships (P3s) nationwide.
https://thep3connect.org

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U.S. Army Reserve Col. Jack Otteson, P.E., knows how to make a great pot of coffee — strong and served black in a porcelain mug at the kitchen table at his house on Lake Benbrook south of Fort Worth. It might seem like a small thing, a pot of coffee, but it can spark a big day when great things happen.

And that’s what Otteson’s hoping for. Working to establish a firm he founded in July 2017, he needs big things, positive things, to happen every day. And if it’s not big, then it at least needs to be a small step in the right direction.

So far, things seem to be working out, as Otteson and his firm, JAX Engineering, Inc., have landed a series of contracts, both large and small, throughout Texas. But that’s not necessarily surprising. At 54, Otteson knows how to grind, knows the AEC industry like the back of his hand, and has what it takes to run a successful business.

“At a minimum, a company should have a vision and goals that are clearly understood by every person in the organization,” he said. “And the first goal should be making a profit — this is the only responsible way to run a business. If you don’t make it a goal to make money and direct efforts and resources into making money, it probably won’t happen. This puts the company — and its employees’ livelihoods — at risk.”

And there you have it. Otteson wants to win, not merely survive, a recurring theme that started early in life. He served as student council president his senior year of high school in Sanford, Colo. He was captain of the football team, playing offense and defense. And he built bridges for the Denver & Rio Grande Western Railroad when he was just a teen.

After a year as a Mormon missionary in Brazil, where he learned Portuguese, the seed of command germinated at the U.S. Military Academy at West Point, where Otteson got his degree in civil engineering. Now in his 29th year of service, Otteson has earned, among many others, three bronze stars, four meritorious service medals, and two Army Commendation medals. He served in Saudi Arabia, Iraq, and Afghanistan, and is currently the operations officer for the 100th Training Division at Fort Knox, Ky.

As a warzone engineer, Otteson’s prime duty was to plan and procure for base camps, something he did with the 1st Armored Division in Iraq and with the 420th Engineer Brigade in Afghanistan. Prior to those two
deployments, he served as a platoon leader, providing security for construction of supply routes into Iraq during Desert Storm. Having tasted the dust, endured the heat, and heard the mortars raining down, Otteson knows the difference between what it’s like over there and over here.

“Every time I’ve deployed for contingency operations or training missions, I’ve come back with a greater appreciation for the blessings we enjoy by living in the U.S. — freedom, security, and opportunity,” Otteson said. “That’s what serving is all about and that’s why I’m proud to be a part of the greatest military on earth.”

His service comes to a mandatory end next year, in May, putting a well-deserved exclamation point on a distinguished military career. But even if he could rest on his laurels, Otteson isn’t going to do it. Instead, he has his AEC firm and is consumed with the competition for contracts, overhead, hiring the right people, diversifying his service lines, stressing over cash flow and capital, and figuring out how to grow his company to where it generates $10 million per year in revenue.

“It wasn’t panic, but it was a sense of urgency,” he said, referring to the process of founding JAX. “You need a bit of stress to function at your optimum level.”

The incorporation of JAX came after more than 16 years with a Fort Worth-based multidiscipline firm where Otteson was a partner. He and the firm, however, decided to part ways in July 2017. But Otteson, who shrugged off multiple offers from other firms, was prepared. Less than a month after leaving his old firm, his new one was open for business. Equipped with licensure in more than 20 states, a proven background in railroad engineering, and hard-won industry connections, Otteson spent little time looking in the rearview mirror.

He works out of his 3,000-square-foot home on Lake Benbrook, has a satellite office in Kansas City, and five full-time and four part-time employees. To Otteson’s advantage, four of his full-time people came over from his previous firm, giving him a near-instant team of trusted engineers.

“They liked my leadership style,” he said, referring to his method of rewarding competence, and to his inclination to treat people with dignity.

It didn’t take long for JAX to gain traction in the market. Just a month after opening his firm, monster Hurricane Harvey struck the Texas and Louisiana coasts, killing around 100 people and causing an astounding $125 billion in property damage.

By October 2017, Otteson had his first contract for oversight of a debris removal program in Aransas County and the city of Rockport, Texas, ground zero for Harvey’s first landfall. But Otteson, who shrugged off multiple offers from other firms, was prepared. Less than a month after leaving his old firm, his new one was open for business. Equipped with licensure in more than 20 states, a proven background in railroad engineering, and hard-won industry connections, Otteson spent little time looking in the rearview mirror.

By October 2017, Otteson had his first contract for oversight of a debris removal program in Aransas County and the city of Rockport, Texas, ground zero for Harvey’s first landfall. In November, Otteson was hired as a subcontractor for assessments and structural reviews at Naval Air Station Corpus Christi, a project tied to Harvey. The prime on this contract was CH2M, which has since been acquired by Jacobs. Otteson, just a few months into his new endeavor, was subcontracting with one of the largest AEC firms in the world.

“[The Corpus Christi contract] gave me a toehold with the big dogs,” Otteson said.

In December 2017, the U.S. Department of Veterans Affairs verified JAX as a Service Disabled Veteran Owned Small Business (SDVOSB); Otteson has a worn out back and knees, and hearing loss related to his military career. This is an important designation for JAX because government agencies have set asides for SDVOSB firms, and large companies such as Jacobs have goals to hire them for a certain amount of their contracts.

So, 2017 was good, but 2018 looks to be even better. In January, JAX won a piece — that of lead inspector — of Union Pacific’s ($550 million Brazos Yard project in Robertson County, Texas. The new yard represents the largest capital investment in a single facility in UP’s 155-year history and will create the capacity to switch as many as 1,300 rail cars per day, making it one of UP’s largest yards in the company’s 23-state network. JAX’s contract, as the lead inspector for the entire project — grading, utilities, and construction — amounts to $400,000 in revenue.

For Otteson, Brazos Yard is particularly sweet. Pat Greenwood, one of the engineers who came over with Otteson from their former employer, had good connections with the Brazos Yard prime, Wilson & Company, where Greenwood had worked years earlier. And it is Greenwood who is at the Brazos Yard project full-time, serving as a liaison for the engineer-in-residence.

An expert in railroad engineering, Otteson sees funds opening up for capacity projects across the country, an industry trend that could feed his firm for years to come. Seeing what’s on the horizon, and how his firm fits into the equation, Otteson is optimistic.

“There’s money out there in the private and public sectors,” he said.

With his entrepreneurial career gearing up and his military career winding down, Otteson has no regrets. On the Army side of his life, he’s pretty much done it all, from West Point to Kabul, from mailing letters home to talking with family through Skype. Once his stint in
the reserves is over, he’ll have all his weekends to himself. More time, perhaps, to go fishing, play his guitar, do a bit of wing shooting, or to read books.

“I’m looking forward to retirement,” he said. “I’ve had a good career and enjoyed every minute of it.”

A long and dangerous road

The Iraq-Afghanistan maelstrom is what Otteson went into and out of, all while juggling a family and a career. The same maelstrom also forever changed the life of now-rising civil engineer Shaun Theriot-Smith.

He’s 32, married, and a father of three. He works as a project engineer for Big Red Dog Engineering|Consulting’s commercial services team in Houston. Embedded in the commercial real estate development scene in one of the nation’s largest cities, Theriot-Smith is a busy man. And on top of that, he hosts the firm’s Unleashed podcast (http://bigreddog.com/category/podcast), which highlights the people, projects, and culture of Austin-based Big Red Dog.

A great family and a great job in a dynamic market, all with the added benefit of folding a personal passion — the podcast — into his professional life. Theriot-Smith, it seems, has it all, but he took a long and dangerous road to get there.

He was a sophomore in high school on Sept. 11, 2001, when the World Trade Center Towers came down. Like millions worldwide, the attack had a profound impact on Theriot-Smith, who has a history of military service in his family. But at first, a civilian life beckoned. He graduated high school, studied computer science in Florida, and worked an assortment of odd jobs — IT specialist, line chef, and video game tester. But he needed something more, and in 2007 an opportunity emerged. Then-President George W. Bush, mired in the Iraq War and facing harsh criticism at home, announced a troop surge of 20,000 reinforcements, the vast majority of which went to Baghdad.

“That galvanized my desire to enlist in the military,” Theriot-Smith said.

He joined the Army in November as a fire support specialist, and in May 2008, deployed to Baghdad, where he provided security for Civil Affairs and Psychological Operations until 2009. He returned to the United States, trained for his next deployment, and then went to Afghanistan, where he served in the Wardak and Logar provinces in 2010-2011.

While he was not destined to become a career soldier, in a way he found his life’s calling in Iraq and Afghanistan. Working alongside the U.S. State Department and USAID, an independent government agency, Theriot-Smith saw firsthand how infrastructure could improve lives. In Afghanistan, in particular, he provided security for those who were building schools, roads, mosques, and water wells. The experience — described by Theriot-Smith as what took place between the firefights — was profound.

“Working directly with civil engineers in these programs, I was able to see an idea grow from design to reality,” he said. “It was tremendously rewarding to watch as a rural village cut the ribbon on a piece of vital infrastructure. I knew I wanted to chase this passion for improving the quality of life for communities at home, much like we did overseas.”

In January 2012, when his active duty was over, Theriot-Smith honorably separated from the Army. He returned to his hometown of Houston and immediately started his engineering coursework at the University of Houston. With service to others at his core, he said it was a natural step to join student government and, ultimately, be elected student body president of a school with 43,000 students.

“Although I do not have any intentions or aspirations to public office, my passion for public service is still very much alive and will continue...
to play a major part of my career,” he said.

Theriot-Smith has been with Big Red Dog since May 2017. A progressive firm with a pronounced focus on the client, the firm also demands a high standard of care for fellow employees. Fittingly, when he was being recruited to join the firm, an Army veteran already on staff was the one who started the conversation between him and firm management.

Soon after the interview, he got the job. Now two-and-a-half years out of college and in his chosen field, Theriot-Smith knows what he and other veterans bring to the table.

“I believe all veterans carry unique skills that they acquire, either wittingly or unwittingly, during their service,” he said. “The power of ownership, thorough and precise communication, and the initiative to operate decisively in the absence of orders, can create powerful impacts on team and organizational dynamics. Coupling these skills with a deep commitment and focus on completing the mission and taking care of the team often make veterans excellent job candidates.”

Hiring Veterans

Vet Centers Can Help Firms Find Skilled and Experienced Professionals.

By Bernie Siben, CPSM

Let’s assume the U.S. Army Corps of Engineers (USACE) needs to survey the runway and taxiway systems at multiple military facilities across a broad geographic area to determine their actual length and width, and the locations of ring roads, electrical conduits and vaults, water/wastewater pipelines that run beneath those runways, and runway lighting and signage. The chances are that the USACE will issue a Request for Qualifications (RFQ) or a Request for Proposals (RFP) for Indefinite Delivery/Indefinite Quantity (ID/IQ) or On-Call surveying services.

Now let’s assume that a single military base needs to have surveys done in order to extend a few streets in its base housing area, identifying any water, wastewater, or electrical utilities alongside or crossing the right-of-way, and determining locations for manholes and fire hydrants. The chances are that the base civil engineering office will look for surveying skills right there on base before looking off base for surveying firms.

Because of the way such services are often needed, in bits and pieces, the military search out a wide variety of technical and other skills in their on-base personnel. These servicemen and women can perform the required services, and many of them are sufficiently skilled and experienced that they can train others as well.

As my firm is growing, one of my current job responsibilities involves identification of new locations for the placement of job notices for survey personnel — especially field crew, party chiefs, and survey

Veteran business owners

- Service Disabled Veteran Owned Small Businesses: 10,791
- Veteran Owned Small Businesses: 3,777
- Total: 14,568
- Engineering firms registered as SDVOSB or VOSB: 2,275

Source: Department of Veterans Affairs, Office of Small & Disadvantaged Business Utilization

Society of American Military Engineers

National Security Through Infrastructure

- Membership, both military and non-military: 1,542 companies, 30,000 individual members

Veteran facts

Beginning in 2016, Gulf War Era veterans became the largest veteran population in the United States.

2018 Veteran population/2028 projection

- Gulf War Era: 7.4 million/8.2 million
- Vietnam: 6.4 million/4.2 million
- Korean Conflict: 1.3 million/214,000
- World War II: 496,777/18,849
- Total Veteran population: 19.6 million/16 million

Source: Department of Veterans Affairs
technicians. While I was looking at all the “usual” places, one of my firm’s owners said, “There have to be a lot of veterans with the kinds of skills we need, and I’d really love it if we could hire some veterans for our open positions.”

That made a lot of sense to me. Every veteran I knew was generally responsible, reliable, and knew how to follow instructions, so they got the job done efficiently, on time, and on budget. And most important to a firm like ours, they already understood the concept of deadlines, had experience working long hours, and knew how to work well under even the most extreme pressure.

Many years ago, in my first “real” job, I worked with a senior executive who had a framed sign on his office wall that read: Stronger than all the establishments of man is an idea whose time has come!

Hiring veterans was definitely an idea whose time had come, and an idea that I could really get behind. So I said, “Okay. Let me look.”

My first stop was the website of the U.S. Department of Veterans Affairs (VA), where I learned that the VA can support veterans in every stage of their job searches — including getting more training to take advantage of new job opportunities and getting access to employers who want to hire veterans and military spouses.

On the department’s home page, there is a navigation button labeled “Locations,” and under that the second link is “Vet Centers.” There are at least 200 Vet Centers across the United States, and each has at least one bulletin board where they can post — among other things — current local job notices.

I called the Austin Vet Center and spoke with Jane Olien, the center’s director. I told her that my firm was looking for multiple survey party chiefs and technicians, and was interested in exploring the possibility of hiring veterans.

Sounding pleased and excited to hear that, she said, “We actually have a lot of veterans with surveying skills who come through this facility looking for many of the resources we provide, including job postings. And some of them were trained by the very best!”

The next day, I spoke with Angela Young, the outreach specialist at the center. She also sounded excited about the prospect of putting more local veterans to work, and said she’d be happy to post my notices. She also asked if she could hang my notices in other locations where veterans would see them, as well as their job board.

I sent her the notices for two positions later that day and she confirmed receipt and posting. A few days later, I sent her updated notices, including more information on the firm’s benefits package and our Equal Opportunity statement. She confirmed receipt of these updates and said that the notices would go up the next morning.

Initial response was not what we anticipated or hoped for, but we are eagerly looking forward to significant growth in responses as time passes. Meanwhile, kudos and thanks to the Austin Vet Center and all the other such facilities across the United States that help our veterans and their families get back to living normal lives when they leave the military.

Bernie Siben, CPSM, is director of Marketing & Business Development at Chaparral Professional Land Surveying, Inc., in Austin, Texas. Contact him at bernie@chapsurvey.com, 512-443-1724, or 559 901 9596 (cell).

SAFETY BY DESIGN
MASER CONSULTING DEVELOPS SAFETY TRAINING AND COMMUNICATION PROGRAMS SPECIFICALLY FOR ITS FIELD ACTIVITIES.
By Lisa DeBenedetto with Maraliese Beveridge

According to the Occupational Safety and Health Administration’s (OSHA) website, its mission is “to assure safe and healthful working conditions for working men and women by setting and enforcing standards and by providing training, outreach, education, and assistance.” This is a mission that is necessary, regarded by all, and vital to the successful wellbeing of everyone in the workplace.

Because Maser Consulting is a multidiscipline engineering firm, we have field staff working within a wide variety of jobsite environments...
performing very specific tasks. While OSHA guidelines cover workers in the field environment at large, they don’t drill down to some of the details of specific standard operating procedures (SOPs) for engineers operating within that space. Any violation they witness, that they haven’t formally designated, falls to the responsibility of the contractor/engineer onsite who can be cited by OSHA’s General Duty Clause. Our goal was to minimize our potential for safety violations through a system of onsite self-governance that we developed from the ground-up specifically for our field activities.

History
Many industries have struggled over years of navigating through the ongoing development of technology and migrating data and workflow process from handwritten paper systems to ever-changing electronic platforms. We were no different. After investigating different platforms, our Safety Advocate Committee utilized Microsoft Infopath, a design application that enabled us to create our own customized, service-specific forms. But this was still generally a paper system that wasn’t user friendly, was time-intensive, and eventually became outdated. By today’s standards, this type of system might not be good enough to help the field technician who sustained an injury onsite requiring immediate directions to the closest hospital.

What we did
In 2016, I was hired as the first full-time, dedicated Health and Safety manager. One of my first duties was working with the committee to perform a complete audit, examining and assessing the history of our safety records, procedures, and near misses. Together, we took it upon ourselves to take our worker safety to a higher level by developing our own internal hazard assessment based on each department’s service and project site type.

After analyzing the collected information and many brainstorming meetings, we developed a two-fold process. It included development of a customized, internal website that facilitated a workflow enabling field personnel to access safety requirements and information about the project site in real time from the field. It also allowed them to feed data into the system about site changes such as additional hazards encountered. Because this information was live and accessible by all field staff, it increased communication between field team members themselves, as well as from field to office.

The other half of the program was creation of a designated Site Safety Leader (SSL) for each project. The SSL is a person identified by the project manager, as soon as the project number has been opened, to be responsible for the safety of our employees and our subcontractor teams on the site.

The SSL goes through specific training we developed for the program. The minute they open a checklist and pick the appropriate hazards, the system automatically uploads the associated SOPs and hazard controls. Once the team has been formed, every member is automatically notified that they’ve been assigned to a checklist that they are to review and acknowledge prior to the first day on the job. This ensures that the entire team has access to the same information.

Real-time checklist
The checklist is a web-based program that consists of fillable drop-down boxes containing a list of a variety of project site types, including buildings/structures, active roadways, construction sites, trenching/excavation, waterfront/bridgework, hazardous waste/chemicals, confined spaces, scaffolds, pipeline, large chemical/petrochemical sites, wastewater treatment facilities, etc. Each project site has a sub-checklist of many possible hazard types related to the site environment (waterfront, wooded, paved, etc.).

For example, if you are working on a pipeline site, you have potential to encounter:
- excavation/trench collapse,
- slips/trips/falls,
• injured by vehicle/equipment,
• ionizing radiation,
• hot work/welding, and
• gas leaks/explosions.

Once in the field, if additional hazards are present, there is a check box that allows you to upload a new site hazard. Because the program is web-based, it is accessible from a phone or other mobile device anywhere in the field where a cell signal can be reached. Each time a new hazard or message is entered into the system, it generates a notification to all team members in real time.

The checklist also includes a section for personal protection equipment (PPE) required for each site environment, and emergency information including coordinator, contact, and signal, evacuation route, muster point, and medical facilities and addresses. All of this can be pre-loaded into the application.

The website also provides sections for Lessons Learned, office information, training opportunities, and Health and Safety documents:

• Health & Safety Documents H&S Plan
• Standard Operating Procedures
• Office Safety Coordinators
• Training Library
• Hospital Locator
• Incident Report Form
• Injury & Illness Prevention Program
• Return-To-Work Program
• Vehicular Accident Reporting Form

Once the SSL submits the initial checklist, it provides ownership of the project by making them responsible for site hazards throughout the life of the project.

In the office
The website is available to all personnel from any computer, smart-phone, or mobile device with internet access. We also developed a Health and Safety section on our intranet that has a wealth of additional information that contains Emergency Action Plans for each of the firm’s 26 offices, fire drill information, floor plans, evacuation routes, Lunch and Learn presentations, office inspections, PPE, vehicle inspections, site inspections, SOPs, training opportunities, safety moments and tips, and meeting minutes.

The launch of the website also coincided with the roll-out of a mandatory internal Near Miss Training initiative that was presented to all employees. A Near Miss Newsletter has also been added to the firm’s intranet that displays near miss reports and corrective actions taken from employees monthly, both in the office and field. The competitive nature of many employees has contributed to an increase in awareness and submission of near miss events that have ranged from the location of poison ivy to bread left unattended in a toaster.

Creation of an SOP
While our near miss policy is at one end of the safety spectrum, creating an SOP to address a specific task is at the other. Recognizing the need for uniformity in his teams’ safety protocols, Clay Wygant, PLS, Geospatial/LiDAR manager took a proactive stance to develop an SOP for the entire mobile LiDAR scanning process focused on protecting the crew and a host of highly sensitive and costly survey instrumentation.

This protocol addresses every step of the process from the deployment of the LiDAR equipment to the withdrawal and securing of equipment at the end of each scanning session.

Because this process is performed daily, it became apparent that re-thinking procedures already in place should be looked at more closely. Working in accordance with myself and his team, we standardized every segment of the process. The program includes establishing a safety perimeter around the off-loading area, physically removing the high-level scan gear from inside the vehicle, staging it for use, lifting and securing the LiDAR unit to the top of the vehicle for deployment, then returning all gear (scanner, cameras, cables, antennas, tools, and fittings) back into the vehicle once the scan is complete, with no issues such as tripping and lifting hazards or damage to the apparatus.

These mechanics were broken down individually to identify any hazards and then eliminate them. Based in safety, this process also helped to confirm all inventory was intact, accounted for, and secured at the end of each deployment. As the firm has grown and more mobile Li-
Hard hats, high visibility safety vests, safety glasses, and steel-toed boots are required personal protection equipment on most jobsites.

DAR teams are working in the field, it was important to ensure everyone was trained to do the same job the same way.

Future
Still in progress, all forms in the program will be fully electronic. Once complete, this last segment will give employees the ability to fill out and submit all forms, paperwork, and assessments onsite, feed them into the system, and send electronically to the health and safety manager and appropriate supervisor.

A company’s safety rating is a necessary indicator of a firm’s well-being and relied upon more today than ever before. As a multidiscipline design firm, our employees are faced with operating within a wide variety of working environments. It’s essential to be proactive in protecting them in the field through safety training and communication programs designed specifically for the services they provide.

LISA DEBENETTO, health and safety manager for Maser Consulting PA (www.maserconsulting.com), is an OSHA General Industry Authorized Instructor with more than a decade of experience developing and facilitating training courses for employees. She is responsible for employing standard operating procedures, training the firm’s employees, reviewing safety risk assessments, and performing office and field safety inspections.

MARALIESE BEVERIDGE, senior technical writer and public relations specialist for Maser Consulting PA, has more than 25 years of experience in journalism and is a nationally published writer within the engineering industry. Her expertise is focused on transforming complex technical ideas into comprehensible articles on trending subjects.

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CONSTRUCTION SITE SAFETY

FIVE REASONS IOT WIRELESS GEOTECHNICAL MONITORING IS KEY TO REDUCING SAFETY RISKS.
By Juan Perez

CONSTRUCTION SITES ARE DANGEROUS PLACES. With so much heavy machinery and a lot going on in one place, it’s no surprise that one in 10 construction workers is injured every year (https://blog.capterra.com/13-shocking-construction-injury-statistics). Most construction sites already have safety measures in place — such as training, worker uniforms, signage, and strict procedures — but in spite of all this, accidents still happen (www.ehstoday.com/construction/construction-accidents-risks-facts-and-repercussions-infographic).

Some risks are unavoidable, but others — those provoked by geotechnical problems for example — can easily be predicted and prevented with the right technologies in place.

Research suggests that the construction industry is not using these technologies and is lagging behind in the adoption of information systems. This is reflected in the fact that 47 percent of construction managers still use manual methods to collect important project information (https://link.springer.com/chapter/10.1007/978-3-642-35548-6_104). This increases site risks, as project managers do not have access to the necessary real-time data to predict and prevent incidents from happening — either because they are using manual or non-remote data-gathering, or because the internet of things (IoT) system they’re employing is not up to scratch.

Effective IoT wireless monitoring (http://blog.worldsensing.com/industrial-iot/digitizingtunnelmonitoring) could significantly improve site safety if it was more widely adopted by the construction industry. Remote site monitoring based on IoT works by using several technologies to wirelessly and remotely collect data about the status of the project from nodes installed at key points on the construction site. Considering the size, different phases of construction, rate of change of the measured parameters, and difficulties to externally power the sensors, low-power wide-area networks (LPWAN) are the most suitable technologies, enabling deployment of nodes powered by internal batteries and allowing long-range communication.

Table 1 compares some of the wireless options available in the geotechnical monitoring market today.

The nodes “sense” what is going on around them, transmit this information remotely to a gateway, and then to a server, where the information can be processed by the appropriate software and turned into actionable insights. Monitoring based on LPWAN technologies is a key geotechnical innovation that, when high quality and used properly, can help prevent accidents on construction sites. Following are five reasons why it is essential for construction site safety.

Real-time, remote data collection — Real-time data collection, now a standard part of most infrastructure or site-monitoring solutions, is essential to site safety because it allows anomalies in the status of different parts of the site to be flagged as soon as they occur. This means that something that might be a minor change can be dealt with immediately rather than turning into an incident — such as a landslide — that costs both money and human lives.
Accidents can happen anytime, so data from sensors has to be collected regularly to anticipate any issues. Remote data collection adds to increased site safety because areas of the site that are difficult or dangerous for workers to reach can be monitored at a distance. Monitoring systems that use LPWAN network technologies ensure that little to no monitoring system maintenance is needed.

In France, wireless monitoring is being used to greatly increase site safety for the Grand Paris Metro Project (https://www.vinci.com/vinci.nsf/en/news-update/pages/grand_paris_express_the_biggest_infrastructure_project_in_europe.htm), significantly reducing risks to employees and citizens through deployment of more than 400 Loadsensing wireless data nodes installed deep in the basements of the surrounding structures.

**Remediation and predictive maintenance** — Wireless monitoring systems constantly collect data about the status of the project. While construction site managers can more accurately plan maintenance to make sure that no incidents occur, the data collected gives details of the causes, not just the early warning signs, of changes or incidents.

A retaining wall in an excavation may collapse anytime due to poor drainage. Through wireless monitoring, the stability of the wall as well as the water pressure that can affect the structure can both be monitored to anticipate any accidents.

Being able to build up a picture over time of the key causes of incidents helps construction site managers predict accidents even before detecting any disturbances and allows them to develop a long-term maintenance strategy that more accurately prevents accidents.

**Engineering design validation** — Data gathered about the status of the construction site through wireless sensors helps validate the design of the structure and the retaining system. Engineers study all possible outcomes and scenarios, but no plans can ever be 100 percent foolproof. Supported by a wireless monitoring system, engineers can spot potential flaws in the design or any changes or unexpected factors in the surrounding environment that were not originally factored in. This means that the design can be changed or remedial actions implemented at the beginning of the project, before any problems are so entrenched that lives are put at risk, accidents occur, or it costs a lot of money to resolve them.

By measuring the load of ground anchors in a construction site, construction engineers and managers can see if they have been designed properly or not, and in turn if they need to modify the design or perform remedial actions — such as placing a berm — before they get too far into the project or before an accident occurs.

Being able to validate a design is particularly important for large infrastructure projects, such as the Cisomang Bridge Refurbishment in Indonesia where wireless data nodes are monitoring strain gauges on the bridge pillars, which had to be refurbished after they were deformed, posing a huge safety risk. These nodes not only ensure the safety of the workers and motorists but also help validate the new, safer design for the pillars.

**Easy installation** — Wireless data nodes are plug and play and also are compatible with most sensors. They can be installed at the beginning of a project and may be relocated or expanded through the course of the project. This offers an advantage compared with other types of monitoring systems, such as cable monitoring, which require frequent maintenance and are difficult to move around, interfering with a rapidly changing construction site.

With wireless sensors, even if the construction moves forward or the site changes, they can adapt to the changing environment. As soon as they are installed, they begin collecting data; this means that operators and managers can know about the status of the project without needing to maintain the monitoring equipment from the very beginning to the very end of the project, allowing for a comprehensive picture of what is happening.

Before, gathering this much data comprehensively with cables or sporadic manual readings was expensive and tedious. But with a wireless system, it is rendered much easier and cheaper. Construction site managers can use the data from one project to build models and plan better for future projects.

One example is the LA Purple Line Metro Extension Project (https://www.worldsensing.com/success-story/tunnel-monitoring-north-america), where data nodes are placed in boreholes on the sidewalk. These nodes measure ground displacements induced by tunneling at different depths and in real time, ensuring that the surrounding area, where people live, is always safe.

**Safety** — In many projects, monitoring through cabling or wireless means is non-existent, and this is where the risks and potential costs are the highest. Wireless monitoring is logistically more practical for a dynamic site than monitoring with cabling. It is also a much more cost-efficient way to ensure safety onsite. Each day a project is delayed costs a lot financially. For example, a project that has a contract value of $50 million with a duration of three years has a value per day

<table>
<thead>
<tr>
<th>Wireless</th>
<th>Frequency</th>
<th>Network type</th>
<th>Power</th>
<th>Data rate</th>
<th>Sensitivity</th>
<th>Range**</th>
</tr>
</thead>
<tbody>
<tr>
<td>SmartMesh</td>
<td>2.4 GHz</td>
<td>Mesh</td>
<td>Medium</td>
<td>250 kbps</td>
<td>-95 dBm</td>
<td>40-150 m</td>
</tr>
<tr>
<td>XBees</td>
<td>0.98 GHz</td>
<td>Star</td>
<td>Medium</td>
<td>10 kbps</td>
<td>-110 dBm</td>
<td>150-400 m</td>
</tr>
</tbody>
</table>

*Table 1: Performance of available wireless geotechnical monitoring systems. **Range considered for typical installation on site and with standard antenna.*
of $45,662. If the average delay is 30 percent, the average cost of delay is just less than $15 million.

Accidents and incidents are the main cause of work stoppage and delays, so if they can be prevented and predicted, a construction project can smoothly reach completion with the least number of delays, meaning less extra costs — both in terms of budget and human lives. There is no price tag for a person’s life, so the aim is for a project to be completed without any health hazards or casualties; wireless monitoring can help alleviate this common concern.

Projects that can prove that there will be fewer risks through implementing a remote system with proof-of-concept will also have lower insurance costs. When an insurance company sees that a construction project has such monitoring systems in place, it gives them a sense that the management team will be able to anticipate accidents and therefore comply better with their insurance policies.

Conclusion
Many engineers and construction site managers have had bad experiences with wireless monitoring because of poor implementation or equipment, but this doesn’t have to be the way. With the right IoT-based system and provider, construction sites can be rendered a lot safer for minimum costs. The “right” provider is one who offers to tailor its monitoring system to the project’s specific needs, who has proven experience in the field, whose technologies are well-reputed, who offers proof-of-concept before full deployment, and who guides implementation of their solution from start to finish, offering advice and consultation along the way.

Overall, insights into the status of each part of the construction site provided by wireless sensors — particularly in terms of validating the design — allow construction site managers to go even deeper into their project, allowing them to do a better job of keeping their sites safe, efficient, and productive places.

JUAN PEREZ is a geotechnical engineer with more than 14 years of experience and knowledge of geotechnics, construction site management, instrumentation, data management, data acquisition systems, and LPWANs. The product owner of the globally recognized wireless monitoring system Loadsensing has been leading the product development of wireless monitoring at IoT pioneer Worldsensing (www.worldsensing.com) since 2013.

NORTH AMERICAN CONSTRUCTION TECHNOLOGY TRENDS
2017 SURVEY OF INDUSTRY PROFESSIONALS REVEALS CURRENT USES AND FUTURE PLANS.
By David Budiac

WE SPEAK WITH A WIDE RANGE of contractors and construction companies to help in their technology sourcing decisions. These regular discussions help us spot construction technology trends (mostly in the United States and Canada).

In September 2017, we surveyed 158 construction industry professionals from small to midsize businesses (SMBs) in North America about their current technology and software uses — as well as future plans. Key findings include the following:
• Expect drones to be commonplace — 26 percent of SMB construction professionals were already using or plan to use drones by 2020.
• Expect larger tech budgets — 81 percent of respondents planned to spend more on technology during the coming year compared with the previous year.
• Project tracking, estimating, and job costing are the most commonly required software functions.

• Software ease-of-use is king — cited as the most important factor when purchasing new software, even more than software functionality and cost.
• Construction software buyers are more willing to review cloud-hosted software — 5 percent more than all other industries.

New construction tech trends
We asked construction businesses about new tools they are using. Drones and autonomous equipment are the clear leaders (see Figure 1).

Drones — Drones emerged as the leading trend. Nearly one in five (18 percent) of SMB construction professionals are currently using drones for photogrammetry and mapping.

Drone technology is capable of dramatically reducing time and resources needed for such tasks. For instance, while a traditional surveyor would spend as long as a month to survey a construction jobsite in detail, a company called Identified Technologies uses self-flying drones to complete the same work within minutes, greatly expediting project timeframes and reducing physical labor costs.

Goldman Sachs estimates that the construction industry will adopt drone use more rapidly than any other commercial industry. Looking ahead, 9 percent of survey respondents said they would implement drone use in the coming three years.

Autonomous equipment — The construction industry is adopting robots and autonomous equipment at a similar rate to drones. Twenty-
four percent of construction industry professionals said they will implement autonomous equipment by 2020. Self-driving equipment brings a number of benefits such as reduced costs, increased uptime, and even saving lives. In fact, 21.4 percent of worker fatalities in private industry in 2015 were in construction.

Augmented/virtual reality — The buzz surrounding virtual reality is evident in the construction industry; it was named by Construction Dive as one of the top 10 construction industry trends to watch in 2017. Yet despite all the potential benefits — improved collaboration, 3D modeling, as well as increased worker safety — the technology remains fairly cost-prohibitive.

Only a relatively small percentage of respondents said they are using augmented or virtual reality (6 percent). That said, in the coming three years, 10 percent will begin to use augmented or virtual reality tools.

3D printing — 3D printing had the lowest adoption rate in the survey. Only 4 percent of contractors use the technology today, and an additional 7 percent plan to adopt it by 2020.

Construction management software
Technology spending is projected to rise. Eighty-two percent planned to spend the same or more during the next year. Some budget will be allocated to new tech discussed above. However, two out of five (41 percent) of respondents said they planned to buy or upgrade their construction management software (CMS).

SMB construction professionals want a lot out of their software. When assessing options, the majority of SMB construction professionals are looking for features related to project tracking (73 percent), job costing (72 percent), and project estimating (66 percent) (see Figure 2).

Still, functionality is only one factor when it comes to investing in new technology. Respondents cited “ease of use” (37 percent) as the most important purchase consideration, even over functionality and cost. As construction companies often need to train staff and contractors across many field sites, it’s crucial that they can quickly train and onboard new users in any technology that’s used in widespread operations.

The majority of SMB construction professionals use CMS (56 percent). Unsurprisingly, CMS users are much less likely to rely on manual methods for business operations (spreadsheets, pen, and paper).

However, even when construction companies do invest in technologies, they often run into problems that may prevent widespread adoption within the company. Most commonly, the challenges they face include the following:

Insufficient commitment of resources — While companies may initially invest in technologies, they don’t always plan a sustainable, long-term budget to manage and update the technology and train staff on its use. As a result, ROI is lower than expected, and companies don’t maintain the commitment.

Obstacles in large-scale implementation — While a technology initiative may be a high priority in the head office, field staff and contractors are not always sufficiently trained in the tool’s use and importance. Even if they are trained in the technology, crew members may consider the tools a hindrance to their established methods of labor. Construction professionals are demanding software ease-of-use likely to help bridge this gap.

Incompatibility with legacy systems — Construction companies often have an established technology framework for planning, modeling, and managing jobs, and their legacy systems may not be compatible
with new integrations. As a result, such implementations are delayed until the point that it makes sense to replace the legacy tools.

A 2016 study from the UK-based BRE Academy (www.bre.co.uk/academy/skills_survey) found that a digital skills gap was a significant cause of concern, with respondents claiming that management skills were lacking at both an industry- and organization-wide level.

More than two-thirds of respondents to the BRE study said that institutions should do more to promote the technical and digital aspects of the industry. In the coming years, it’s clear that hiring employees with the ability to engage with technology tools in the construction field will be a key differentiator for leading companies.

Cloud software
With every firm we speak to, we ask if they’re “open to reviewing cloud/hosted software.” The proportion has changed over the years. As of late, construction businesses are especially open to cloud/hosted software (typically 5 percent more likely than other industries):

<table>
<thead>
<tr>
<th>Open to cloud software</th>
<th>2015</th>
<th>2016</th>
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<tr>
<td>Construction industry</td>
<td>78%</td>
<td>84%</td>
<td>87%</td>
</tr>
<tr>
<td>All other industries</td>
<td>77%</td>
<td>79%</td>
<td>82%</td>
</tr>
</tbody>
</table>

Why are construction companies more likely to look for cloud software? Perhaps due to changing job sites, or the need for mobile tech.

Mobile tech
Fifty-eight percent of SMB construction professionals say their business at least “sometimes” relies on mobile or tablet-based applications. Also unsurprising, cloud/hosted software users were more likely to depend on mobile. Hosted software and mobile tech go together like two peas in a pod, especially when you throw in multiple devices and real-time reporting.

BIM software
Fifty-one percent of respondents currently use building information modeling (BIM) software, but more than half (59 percent) of BIM adopters reported that they are less than thrilled with their software (see Figure 3).

In some cases, the dissatisfaction may be based on the respondents’ lack of commitment to engaging with the BIM tool and encouraging widespread adoption throughout the company.

The McGraw-Hill Construction Report found that the more invested construction professionals were in making BIM software a key part of their processes, the more ROI they saw from the tool. According to their stats, just 13 percent of BIM users demonstrated very high engagement with the software — but 65 percent of this select subgroup saw ROI of 25 percent or greater on the software, as compared with just 20 percent of less-engaged users. Of the less-engaged group, two-thirds had negative or break-even returns on their BIM investment.

DAVID BUDIAC is a managing partner at Software Connect (https://softwareconnect.com). He’s been helping software buyers make informed investments in business software since 1996. Conducted in September 2017, the Construction Industry Technology Trends Report is based on a survey completed by 158 construction industry professionals from SMBs in North America. The bulk of respondents came from the United States and 97 percent from companies with fewer than 500 employees.

MORE THAN JUST A WEBCAM
IP CONSTRUCTION CAMERA TECHNOLOGY CONTINUES TO Evolve.
By Ken Pittman

IN THE DECADES SINCE REMOTE MONITORING TECHNOLOGY became available to the public, it has evolved beyond simple webcams to become a high-tech construction management tool.

Development of internet-enabled (IP) construction cameras has its roots in the 1990s with the widespread adoption of webcam technology. Basic webcams had limited functionality, allowing live pictures or video to be streamed remotely. That began changing as innovative companies integrated webcams into the cloud, allowing pictures and footage to be saved on remote servers. The technology continued to be refined and new functionality added.

At first glance, webcams and IP construction cameras might seem alike. A webcam is a simple camera that connects to a computer and allows users to record or stream video over the internet. An IP construction camera also gives users access to live video from anywhere in the world.

Since being introduced as a dedicated tool for the construction industry, though, IP construction cameras have evolved into sophisticated tools that offer powerful new features. They can capture images, create time-lapse video, record security footage, and offer interactive features. Some cameras are robotic or integrate drone services.
Most construction cameras are accessible through web and smartphone apps that provide users a suite of management and informational tools. Construction cameras can allow unlimited users to view the camera’s footage in real-time.

**Always connected**
The massive adoption of cell phones over the decades and the related increase in cellular data coverage and speed changed the game for construction cameras, which can now be installed as turnkey units. Without the need for a fixed internet connection, construction cameras just need power to operate — whether electrical or solar. This means there is much greater flexibility in where the cameras can be placed.

As the data speed has increased, construction cameras have been able to offer higher resolution, meaning increasingly better image and video quality. Some internet-enabled cameras can surpass 20 megapixels in resolution.

Because they’re also connected to the internet, manufacturers can future-proof the cameras by remotely updating them with new capabilities and software fixes in real time. Construction camera systems can be set up to flag events based on specific circumstances, such as a motion detector being triggered. Some IP construction systems can send out real-time alerts, keeping stakeholders informed of any suspicious or criminal activity at any hour of the day.

**Management capabilities**
Cloud technologies have allowed some construction camera manufacturers to evolve into large-scale image-hosting providers, allowing live product management, data archives, and image documentation. This allows construction cameras to effectively supplement traditional construction reporting, recording and indexing visual documentation about any detail of jobsite conditions.

IP construction cameras don’t just provide after-the-fact documentation of jobsite conditions. Project managers can use them proactively to find and correct safety issues before they turn into accidents.

A growing trend in construction camera technology is integration with popular project management software platforms. This allows the recorded images to be viewed, stored, and shared within the project management software, allowing construction companies to seamlessly save, document, and find images of specific projects or events. Contractors can pull up an image, mark it up with notes, and then share it with fellow contractors or subcontractors.

**The future**
Construction camera technology continues to get smaller and faster with higher resolution. This is leading to more indoor applications for the units. Traditionally, once interior work begins on a jobsite, construction supervisors can be at a disadvantage trying to keep track of workflow.

Indoor construction cameras allow project managers to remotely monitor interior construction on multiple jobsites. The photo documentation can also be useful further in the life cycle of the project. For example, if a year goes by after a building is completed and electrical or plumbing work is required, archived photos can be consulted to show the exact location of wiring or plumbing.

As cloud-based computing lowers the cost of large-scale data analytics, construction cameras can begin to integrate machine learning and smart tagging capabilities. This means that someday, cameras could automatically detect safety issues while scanning a jobsite.

Since the first construction cameras appeared, they have evolved far beyond simple recording devices and their webcam roots. Advances in cellular technology, data analysis, cloud-based computing, web apps, and robotics continue to drive further innovation in the construction camera industry. Tomorrow’s cameras promise exciting features that can only be imagined today.

**KEN PITTMAN** is the chief marketing officer for Winston-Salem, N.C.-based TrueLook (www.truelook.com), which provides construction cameras that combine live jobsite viewing, project time-lapsing, and HD security, as well as webcams for various other industry applications. TrueLook has been providing camera technology for more than 20 years.
DIGITAL COLLABORATION FOR EFFECTIVE PROJECT DELIVERY

INDUSTRY TRENDS AND RISKS ASSOCIATED WITH AN INABILITY TO SUCCESSFULLY SEIZE THE OPPORTUNITIES OF GOING DIGITAL.

THE GOALS OF ENGINEERING FIRMS HAVE CHANGED relatively little during the last decade. Winning new contracts — and retaining existing clientele — are still the most critical objectives. Therefore, design and engineering firms try to continually improve efficiency and meet every deadline. However, accessing information quickly is only half of the solution. Firms must dramatically improve how they manage their data and collaborate across projects to work smarter, work faster, and be more competitive.

Facing the deluge of data
By some estimates, the digital universe will double every two years, showing a 50-fold growth from 2010 to 2020 (The Exponential Growth of Big Data, Insidebigdata.com, February 2017). Due to the nature of the work, this surge in data profoundly affects how firms design, build, and execute on projects. Given that engineers often deal with multiple projects at a time, the sheer amount of information flowing in and out for a project can be overwhelming. It can be a stumbling block on a company’s path to win new work, especially considering all the steps in any given project.

Designing, reviewing, and approving plans generates a high volume of data and introduces many potential points of error along the way. New technologies, including BIM processes, laser scan point clouds, and reality modeling meshes, mean that big data is now an important factor in the engineering world. However, big data can be a double-edged sword, requiring more hours and effort to usher in its benefits, if not managed properly.

Improve productivity
These changes are amplifying the amount of information that firms need to store, share, and manipulate. Firms face two distinct information-related challenges: finding the necessary information and confirming that the information is correct. By some estimates, 40 percent of an engineer’s day is spent looking for data. This problem can be exacerbated if information is spread throughout the company in email chains, hard drives, or generic file-sharing solutions such as Microsoft SharePoint or Dropbox.

With no single, central repository of data, teams run the risk of overwriting files, using out-of-date information, and slowing down the reviews and approvals and supply chain communications. A siloed approach to data management can also have long-term negative effects, including errors, delays, budget overruns, and an inability to take on more work due to inefficiencies.

Twenty-five percent of engineering firms said that inaccurate project paperwork or too many versions of documents contribute to a construction delay (AEC Survey Calls for Industry-Specific Cloud-Based Document Management, Construction Executive, February 2015).

Accelerate collaboration
Despite the challenges, firms can improve their ability to avoid risk and stay competitive by managing engineering information, automating business processes, and accelerating collaboration across all disciplines and locations for effective project delivery.

As the digital transformation reshapes how projects are designed and managed in the industry, firms need to embrace innovation as they evolve and grow. By aligning design teams with a connected data environment for improved collaboration, firms can work smarter, work faster, and be more competitive in the industry.

Information provided by Bentley Systems (www.bentley.com).
The most competitive project delivery organizations, no matter what their size, know that success depends on efficient project collaboration, streamlined work processes, and disciplined information management. And the numbers tell the story – they rely on ProjectWise.

Industry-leading Digital Project Collaboration

Connect and empower your team with ProjectWise. Learn how a connected data environment will help you achieve better project outcomes: www.bentley.com/CONNECTwithProjectWise
The highly anticipated Platte Fifteen multi-use mid-rise structure, located at 15th and Platte streets in Denver, has reached its final depth of 28 feet below ground surface. Installation of a temporary dewatering system by TerraFirma Earth Technologies is complete and is in the maintenance phase. General contractor Adolfson & Peterson Construction continued excavation in preparation for pouring concrete slabs in late June.

Besides being Denver’s first mid-rise building made from cross-laminated timber (CLT) and offering a reduced carbon footprint, Platte Fifteen is the site of a rarely utilized means of groundwater control known as ejector well dewatering. David Giles, president of TerraFirma Earth Technologies, explained, “Though more costly up front, in the long run, this unusual use of ejector dewatering wells in controlling the groundwater within soils typical to downtown Denver has proven more reliable, and more cost efficient.”

The added benefit of this unique use of the ejector well dewatering system was the lowering of groundwater to the maximum extent possible, allowing excavation and installation of the foundation mat slabs and water proofing membrane in “near-dry” conditions.

“The proper installation of the foundation slabs and waterproofing membrane under near-dry conditions is extremely important to the structure,” said Shiloh Hicks, project engineer. “The concrete slabs and waterproofing membrane create a water-tight foundation, commonly referred to as a ‘bath tub’ foundation. The bath tub-like foundation eliminates the need for the often costly and maintenance-intensive permanent foundation dewatering system typical of Denver’s downtown buildings.”

There are generally three means employed by the dewatering contractor in controlling groundwater: vacuum wellpoints, deep wells, and ejector wells. The most commonly known in the Denver area are deep wells (sometimes referred to as sump wells).

“Most contractors shy away from the ejector wells due to up-front costs; however, they are more often the best solution for Denver soil conditions (water-bearing alluvial soils over shallow bedrock),” Giles said. “We are glad to see that the general contractor, Adolfson & Peterson Construction (AP), made the best decision for dewatering this project. Though ejector wells are typically utilized in much deeper excavations, they are well suited here because of the necessity to lower the groundwater to the very top of the confining bedrock.

“Vacuum wellpoints, though versatile, were ruled out because of the suction limitation, generally 15 feet or less,” Giles said. “Because ejector wells use a continuous, recirculating supply of water through an ejector body to create a vacuum at the bottom of each well, suction limits are not a concern (water is pushed up). Deep wells, though suited for deeper excavations, would have proven ineffective because of the proximity of the relatively shallow bedrock (20 feet below ground surface) in relation to the much deeper subgrade (28 feet below ground surface). Deep wells would have to be so closely spaced to achieve the desired results; they quickly would become cost-inefficient. Additionally, deep wells, which rely on the continuous flow of groundwater to cool the electrically driven submersible pump located near each well bottom, would quickly run dry under the Platte 15 soil conditions, making them a maintenance nightmare. The ejector well, on the other hand, is a self-priming pump. If it runs out of groundwater, it will proceed to pump air without interruption until the groundwater returns.”

According to AP’s Project Manager Shawn Brannon, Platte Fifteen is using the construction manager/general contractor (CM/GC) delivery method, which gave AP the opportunity to employ the “choosing by advantage” process when hiring contractors.

“This ensures a collaborative project team offering the best solutions for the particular project’s requirements, rather than choosing contractors simply by cost,” Brannon said. “TerraFirma was consulted well in advance of groundbreaking. Getting the project on firm ground is critical to the success of a project. We needed TerraFirma’s expertise early in the preconstruction phase. They were able to give us a detailed solution to the site conditions that we could detail out before we broke ground.”

He added that the owner, Crescent Real Estate, applauded the “choosing by advantage” process and that it made the entire team engage
wholeheartedly in the preconstruction problem-solving effort, which was a year in the making.

The Platte Fifteen property is being built out right to the property lines. TerraFirma’s Giles said that dewatering of the site was further complicated by the fact that one entire side of the site was inaccessible. “The excavation has a perimeter footprint of approximately 800 linear feet (approximately 200 feet by 200 feet). Two levels of underground parking are planned; the excavation extends up to 28 feet below ground surface.”

TerraFirma installed 64 ejector wells around the site’s three accessible sides — one every 10 linear feet.

Also unique to the project was TerraFirma’s use of the sonic drilling methodology in advancing each borehole several feet into the bedrock. “By employing the use of sonic drilling technology, not only were we able to fully penetrate the water-bearing alluvium overburden, we also were able to penetrate the highly weathered portion of the bedrock, which can often be another source of groundwater,” Giles said. “With the sonic drilling methodology, the 64 ejector wells were installed and ready for operation just three weeks after mobilizing.”

From the ejector wells, the groundwater was directed through a storm drain leading to the Platte River; however, as is true of many construction sites in the downtown Denver area, the preliminary geotechnical and environmental sampling reports revealed groundwater that was contaminated.

“To deal with the contaminated groundwater, TerraFirma teamed up with BakerCorp,” Giles said. “Their extensive experience in the downtown area and knowledge of its groundwater chemistry, as well as their working relationship with the various regulatory agencies involved, has proven invaluable.”

Following approval of the Remedial Discharging Permit Surface Water Permit from the Colorado Department of Public Health and Environment (CDPHE), BakerCorp, in close conjunction with TerraFirma, developed a Remedial Activities Management Plan to reduce the pollutants of concern to below the limits set forth in the permit issued by the CDPHE.

The groundwater treatment plan included introduction of a 10 percent solution of sodium hydroxide into the dewatering influent water to oxidize the metals iron (Fe) and manganese (Mn). This reaction took place in a single, 21,000-gallon flocculation tank. From the flocculation tank, the water was pumped through two, four-unit bag filtration pods to capture the flocculated metals. In addition to Fe and Mn, the permit also required to treat for arsenic and selenium. An ion exchange medium known as Purolite was utilized to reduce the elevated levels of selenium and arsenic. Granular activated carbon was added to the treatment train to remove any volatile compounds encountered, as well as for removal of any residual chlorine in the treated water.

“In the end, pure, drinkable water discharged into the Platte River,” Giles said.

Cory Christensen, project superintendent, said, “The sonic drilling rig utilized by TerraFirma was extremely compact — perfect for the site’s limited accessibility issues. In addition to the rig’s maneuverability, it was quickly able to complete a borehole that extended several feet below the top of the bedrock and easily penetrated the gravelly cobbles overlying the bedrock.”

Platte Fifteen is part one of a three-part development for Crescent Real Estate near the Platte and 15th Street intersection. This first phase is scheduled to open in fall of 2019.
In September, Fluor Corporation and IBM announced the use of artificial intelligence-based systems to predict, monitor, and measure the status of engineering, procurement, fabrication, and construction (EPC) megaprojects from inception to completion. Fluor’s extensive engineering, fabrication, construction, and deep supply chain expertise, coupled with artificial intelligence and analytic technologies from IBM Watson, forms the foundation for big data analytics and diagnostic systems that help predict critical project outcomes and provide early insights into the health of projects.

To gain insights from project data in nearly real time and to understand the implications of changing factors, Fluor is introducing the EPC Project Health Diagnostics (EPHD) and the Market Dynamics/Spend Analytics (MD/SA) systems. Developed with IBM Research and IBM Services, working collaboratively with Fluor, these tools help to identify dependencies and provide actionable insights by fusing thousands of data points across the entire life cycle of capital projects.

Fluor selected IBM Research and IBM Services to assist in the development of these advanced systems as part of its global data-centric transformation strategy. Fluor said it can now leverage a wealth of experience from across its entire historical data store and global workforce to quickly understand markets and monitor project factors impacting cost and schedule to drive improved certainty and cost efficiency across the entire project scope.

“Harnessing the power of data to make meaningful insights will alter how megaprojects around the world are designed, built, and maintained,” said Arvind Krishna, senior vice president and director of IBM Research. “Together with IBM, Fluor is embracing artificial intelligence as an engine for transformation in data-driven industries that are ripe for innovation, including energy and chemicals, and mining and metals construction projects.”
“The ability to rapidly analyze and comprehend big data that drives decisions at any point throughout the engineering, procurement, fabrication, and construction of today’s megaprojects is imperative for the success of our company and the protection of our clients’ capital investments,” said Ray Barnard, Fluor’s senior executive vice president of Systems and Supply Chain. “And to be the best at predictive analytics and project execution in our industry, we teamed with IBM to create EPHD and MD/SA, an advanced and effective set of diagnostic tools and capabilities that rapidly predict best-in-class pricing globally, project status, and outcomes, and improves the quality of services and decision-making as we serve our clients around the globe.”

The EPHD and MD/SA systems are designed to transform complex data into actionable business insights using domain-driven semantic models to guide artificial intelligence-based predictive and diagnostics modeling. A unique feature of the systems is the blending of data with domain expertise to learn models that are operationally insightful. An advanced cognitive user interface provides seamless access to the data, reports, and results of the analysis, using EPC domain-sensitive natural language conversational interface. The underlying domain understanding is used to guide project diagnostics and provide natural language summaries based on the reports, with data visualization techniques to ease its quick consumption and understanding.

These tools assess the status of a project by:

• predicting issues such as rising costs or schedule delays based on historical trends and patterns;
• gaining earlier insights from many sets of complex factors across project execution; and
• identifying the root causes of issues and the potential impacts of changes as input to the decision-making process, including estimate analysis, forecast evaluation, project risk assessment, and critical path analysis.

“Besides the work Fluor was already doing on predictive maintenance and construction sequencing, five years ago we began investing in predictive analytics and artificial intelligence capabilities to further evaluate performance and determine critical project outcomes as a part of our data-centric journey,” said Leslie Lindgren, Fluor’s vice president of Information Management. “We will be using these innovations on select large and megaprojects to quickly discover trends, patterns, and meaning in our structured and unstructured data that deliver competitive advantage through the digital transformation of data into critical information with significant benefits to our clients, other stakeholders, and our company.”

As Fluor continues on its global data-centric transformation journey, the company plans to further develop and expand EPHD and MD/SA using analytics and artificial intelligence capabilities from IBM Watson and integrate them into Fluor’s processes.

Fluor announces financial close on Gordie Howe International Bridge

Fluor Corporation announced that Bridging North America, a partnership of Fluor, ACS Infrastructure Canada, and Aecon Group Inc., reached financial close to design, build, finance, operate, and maintain the Gordie Howe International Bridge Project for Windsor-Detroit Bridge Authority. Fluor is participating in the entire 36-year life cycle of the $4.4 billion project.

The project includes approximately $900 million of financing in a combination of bonds, bank debt, and equity from Fluor and its partners. The contract includes milestone payments for design and construction progress, as well as availability payments for operating and maintaining the project over the 30-year concession period.

When complete, the crossing will be the longest cable-stayed bridge in North America. The scope also includes building new, state-of-the-art ports of entry on both the U.S. and Canadian sides of the Detroit River as well as improvements to existing infrastructure in both Michigan and Ontario.

Artist rendering of the Gordie Howe International Bridge. Photo: Business Wire

Information provided by Fluor Corporation (www.fluor.com), a global engineering, procurement, fabrication, construction and maintenance company.
ANALYSIS OF IRREGULAR-SHAPED DIAPHRAGMS

ADDRESS DESIGN ISSUES TO ENSURE COMPLETE LOAD PATHS THROUGHOUT STRUCTURES.

By R. Terry Malone, P.E., S.E.

THE STRUCTURAL CONFIGURATIONS OF MANY MODERN BUILDINGS require complex lateral load paths that incorporate diaphragms at different elevations, multiple re-entrant corners, multiple irregularities, and fewer vertical lateral force-resisting elements. It is important to address these design issues and irregularities to ensure complete load paths throughout the structure; however, this doesn’t have to be a daunting task.

Knowledge regarding the analysis of complex diaphragm layouts varies greatly within engineering and code enforcement communities. In some cases, it has become standard practice to treat all structures as if they were simple rectangular diaphragms, and the absence of continuous load paths, presence of discontinuities, and missing elements such as chords, collectors, and drag struts are commonly overlooked. This is largely due to the lack of concise information on how to design complex diaphragms.

The purpose of this article is to bridge that information gap by providing an overview of a method, based on simple statics, that can be used to analyze complex diaphragm structures, while guiding readers to more detailed information through the references.

Principles of effective diaphragm design

For simple and complex buildings, the load path for lateral loads typically includes:

• development of the seismic or wind loads in the roof or floor diaphragms;
• transfer of loads acting on the diaphragms to diaphragm boundary members and internal collectors;
• collection of loads along the length of boundary members to the shear walls;
• transfer of forces within the diaphragm across areas of discontinuity;
• transfer of loads through shear walls to the resisting elements; and
• resistance of loads at foundation to soil interface.

Integral parts of the load path for even simple rectangular buildings are chord elements, which resist the bending or moment action within a diaphragm, and struts and collectors, which collect and transfer the diaphragm shears to the shear walls or frames as shown in Figure 1. All edges of diaphragms must have boundary members consisting of drag struts, chords, collectors, or vertical lateral force-resisting elements. Boundary members include chords and drag struts at diaphragms and shear wall perimeters, interior openings, discontinuities, and re-entrant corners. Collector elements must be capable of transferring the seismic or wind forces originating in other portions of the structure to the elements providing resistance to those forces.

Following are two key definitions relative to establishing complete load paths and the analysis and design of complex diaphragms and shear walls:

Diaphragm boundary — In light-frame construction, a location where shear is transferred into or out of the diaphragm sheathing. Transfer is to either a boundary element or to another force-resisting element.

Drag strut; collector — A diaphragm or shear wall element parallel and in line with the applied load that collects and transfers diaphragm shear forces to the vertical elements of the lateral force-resisting system and/or distributes forces within the diaphragm.

All of these components of the load path, including connections, help to ensure effective performance during a significant wind or seismic loading event.
For the purpose of clarification on the use within this paper, drag struts and collectors function in the same manner and are therefore the same thing — collector elements. It is the author’s preference to designate a collector element that receives shears from one side as a “drag strut.” A collector element that receives shears from both sides is designated as a “collector.”

**Discontinuities and irregularities**

Discontinuities in diaphragms are often created when a portion of an exterior wall line is offset from the main wall line, causing a disruption in the diaphragm chord or strut. When this occurs, the disrupted chord or strut force must be transferred across the discontinuity through an alternate load path. It is important to remember that, at diaphragm discontinuities such as offsets, openings, or re-entrant corners, the design must assure that the dissipation or transfer of edge (chord) forces combined with other forces in the diaphragm is within the shear and tension capacity of the diaphragm. All irregularities and/or discontinuities within a system of diaphragms and shear walls must be addressed.

The term “combined with other forces” is frequently misunderstood. The main diaphragm is already under shear force from the applied loads. Additional shear force is applied at the transfer area from the discontinuous member force. These shears must be combined with the basic diaphragm shear to be in compliance with code.

The example diaphragm shown in Figure 2 contains many discontinuities and irregularities commonly seen in modern designs. When highly irregular diaphragms are viewed as a whole, a rational design of the lateral force-resisting paths may seem daunting; however, when approached one section at a time, keeping in mind the statics approach outlined below, a robust design can be developed.

**Method of analysis**

For practical purposes and ease of demonstrating the method, the simple diaphragm shown in Figure 3 will be reviewed. For those same reasons, the orientation of the main framing members must also be ignored. Diaphragm dimensions and loading are provided in the figure along with a complete set of calculations in the full article at www.woodworks.org/irregular_diaphragms. The diaphragm shown has a single horizontal (end) offset at the left support. The offset causes a discontinuity in the diaphragm chord.

To successfully transfer forces through areas of discontinuity, it is important to understand how shears are distributed into and out of a diaphragm. The discontinuous chord shown at grid line B/2 is typically extended into the main body of the diaphragm with the use of a continuous light-gauge steel strap and flat blocking between the framing members. The intent is to overlap and transfer the disrupted chord force into the main chord at grid line C. The strap is lapped onto the discontinuous chord and is then applied over the sheathing and blocking within the main diaphragm. The distance the strap is extended into the diaphragm will depend on the results of the calculations (discussed later in this paper), practicality, and engineering judgment.

When the chord along line C is under tension, the transfer area lying between grid lines B/2 and C/3, shown as a dashed rectangle in Figure 3, could rotate if there is no means to resolve the rotational movement from the chord forces. Framing members at grid lines 2 and 3 can be designed to oppose the rotating couple forces. Local over-stressing and deformation in this area of the diaphragm can occur if resolution of the rotational forces is omitted. The free-body diagram at the right of the figure illustrates a simple method that not only eliminates rotational problems but also provides a complete load path that complies with code requirements.

Briefly, the method utilizes a portion of the diaphragm to the right of the discontinuity as a sub-diaphragm, or transfer diaphragm (TD), which receives the disrupted chord force and distributes it out to the main diaphragm chords at grid lines A and C by beam action. The transfer diaphragm acts like a beam with a concentrated load applied as depicted by the inset diagram. This method of analyzing diaphragms with offsets and openings was developed in the early 1980s.

Figure 4 provides an overview of the method of analysis. Typical symbols for 1-foot by 1-foot pieces of sheathing called “sheathing...
element symbols” are shown on the lower left. The directions of the shears applied at each edge of the elements indicate whether the shears are positive or negative. The basic shear diagram, expressed in pounds per linear foot (plf), is plotted below the diaphragm. The diaphragm unit shears (plf) at grid lines 1, 2, and 3 are determined and designated as positive or negative by placing the appropriate sheathing element symbols on the basic shear diagram as shown in the figure.

The main diaphragm and transfer diaphragm area are already under shear from the uniform load, as calculated in the basic shear diagram. Additional transfer diaphragm shears are created by the disrupted chord force. The transfer diaphragm shears must be added to or subtracted from the basic diaphragm shears to accurately account for the combined localized effects within the transfer diaphragm, resulting in net shears occurring within the transfer diaphragm area. This is what is intended by the ASCE 7 requirement of “combined with other forces.” The transfer diaphragm is the only area affected by combined shears. The unit shears in the areas outside the transfer diaphragm remain unchanged.

The transfer diaphragm shears are determined by analyzing the transfer diaphragm as a simple span beam with a concentrated load. Since the disrupted chord force acts to the left, the reactions of the analogous beam will act to the right as shown on the right side of the figure. The unit shears in the transfer diaphragm caused by the disrupted chord force are equal to the calculated reactions divided by the depth of the transfer diaphragm (DTD). The key in determining if the shears in the transfer diaphragm are positive or negative is to understand that the unit shears just determined and the direction of the arrows are acting on the edge of the sheathing element and not on the outer diaphragm chords. Placing the sheathing element symbols next to the unit shears at the transfer diaphragm reaction area and completing the direction of the shears acting on the other edges of the sheathing element symbol will determine whether the shears are positive or negative.

The final transfer diaphragm shears are determined by adding or subtracting the transfer diaphragm shears from the basic diaphragm shears.

R. TERRY MALONE, P.E., S.E., is senior technical director, WoodWorks – Wood Products Council. Read the rest of this article at www.woodworks.org/irregular_diaphragms. WoodWorks offers free project support as well as education and resources related to the code-compliant design of commercial and multifamily wood buildings across the U.S. Visit www.woodworks.org to find the technical expert nearest you or email the WoodWorks Project Assistance Help Desk at help@woodworks.org.

REVITALIZING DOWNTOWN RALEIGH, ONE BUILDING AT A TIME
STEWART HELPS PLAN AND DESIGN ITS NEW HEADQUARTERS IN A LANDMARK BUILDING.

FREQUENTLY RECOGNIZED AS A TOP CITY on “best of” lists for places to live and work, such as Best Places to Live by U.S. News & World Report, the city of Raleigh, N.C., continues to grow year over year. In fact, Raleigh and its surrounding area in Wake County added an estimated 63 residents per day in 2017. With Raleigh’s rapid rise has come a revitalization of the downtown neighborhoods and buildings, bringing more places to live, work, and play within the city center.

In recent years, much attention has turned to the Warehouse District, a rapidly expanding and vibrant area in downtown Raleigh. Optimizing development efforts in the area is The Dillon, the first mixed-use development of its kind in the district. First conceptualized in 2015, the project has become the landmark for the area and has forever changed downtown Raleigh’s skyline.

Behind the scenes of The Dillon
The 18-story mixed-use project is a Kane Realty property located on
2.5-acre city blocks with three buildings — two residential and one office building — including a total of 214,000 square feet of office space and 40,000 square feet of retail and restaurant space.

The two residential buildings consist of wood-framed construction supported by a composite steel-framed podium slab and include a total of 260 units with easy pedestrian access and central parking. The residential buildings also feature a wood sundeck with a pool and two outdoor courtyards.

The office building, featuring post-tensioned concrete construction, includes a preserved warehouse façade with an open-air portico, ground floor retail, 980-parking-space cast-in-place parking garage, and an eight-story office building tower with a public roof terrace on the 9th floor, overlooking vibrant downtown Raleigh.

An engineer's dream: Design your own headquarters

In June 2018, Stewart, an interdisciplinary design, engineering, and planning firm, relocated its headquarters to The Dillon. Before moving in, the firm had the unique opportunity to play numerous key roles in the planning and design of the landmark building that would later become its home.

With the hiring of Stewart’s landscape architecture, civil and structural engineering, geomatics, geotechnical, and construction services, the firm’s interdisciplinary collaboration helped streamline communication between practice areas and with partners, from the design phase through execution.

Originally built in 1914, the historic Dillon Supply Company sat as a vacated warehouse for many years before Stewart supported its renovation and modernization. Throughout the design process, Stewart was tasked with preserving the essence and historic value of the original Dillon Supply Company, while maintaining ties to the surrounding Warehouse District and downtown Raleigh area.

One key stipulation by the Raleigh City Council significantly impacted engineering and design of the building; the original Dillon Supply Company signage on the façade was to be preserved on two sides of the office building. The design team agreed that beyond the requirement, keeping parts of the original façade felt right for the project as it sought to tie the property into the history of the Warehouse District while ushering new technology and industry into the area.

To preserve as much of the historic building and its relics as possible, Stewart’s geomatics practice area used 3D laser scanning technology to map the exterior and interior of the original building, capturing all the existing data in an easy-to-reference 3D model.

The structural engineering team then used that information to identify how to preserve the façade in a way that would maintain the unique personality of the former warehouse while reinforcing the existing infrastructure. Using calculations from the 3D model, the façade measured a full 2 feet thick. Preserving this structure required temporary bracing with columns set back from the wall at the lower level to allow contractors to reach the foundation while the building was under construction. Deep transfer beams were then required to support the seven stories of parking over this level.

Other salvaged artifacts and parts of the original building were identified within the 3D model and repurposed throughout the design of The Dillon. Stewart’s planning and design team identified a crane and castellated beams which they later used in the property’s most popular outdoor spaces, including the 9th floor public terrace. Castellated beams serve as a trellis over the portico, 9th floor terrace, and residential courtyard. Swing-arm cranes once welded to building columns and used to move heavy materials from one bay to the next, now hold lighting elements.

To preserve as much of the historic building and its relics as possible, Stewart’s geomatics practice area used 3D laser scanning technology to map the exterior and interior of the original building.

Engineering ingenuity

Additional regulations set by the City of Raleigh helped facilitate a further dose of creativity and engineering ingenuity from Stewart.
That’s because the 9th floor public terrace, the entrance portico, and other outdoor features are more than just aesthetically pleasing features of the building. They allow The Dillon to meet the City of Raleigh’s open sky regulation (a.k.a., amenity area) dictating that 10 percent of a project’s usable space must have open sky above it.

While it may be challenging to accommodate these features on a skyscraper in the middle of a downtown area, it can also offer additional engineering opportunities. Stewart’s planning and design team took advantage of the space, layering multiple uses for the same area. The portico is the main entry to the building and is also the amenity area, and the permeable pavers serve as the stormwater control measure for the property.

In downtown areas, it is especially important to layer multiple uses wherever possible to create an efficient use of high-cost land area. Leveraging soil infiltration rate data collected during tests by the firm’s geotechnical and construction services team, the front portico surrounding The Dillon signage façade was designed to ensure safe water runoff and prevent flooding at its main entrance. The final design consists of several customized permeable layers. The top brick layer design is a permeable paver filled with washed stone, followed by multiple layers of washed stone.

In addition to requirements from the City of Raleigh, Stewart collaborated with two architectural partners on the project — Duda Paine Architects on the office building and JDavis Architects on the two residential buildings — as well as property owner Kane Realty. With strategic collaboration, Stewart served as the common structural engineer, civil engineer, and landscape architect for both properties, blending the vision of the two architects together to produce a final product with an intentional design. Known throughout the region, each of these partners hold high standards for their work and the work of their consultants.

Where Duda Paine incorporated unique sloping walls into the architecture, Kane Realty idealized a further distinctive characteristic that every corner throughout the building would be column-free, increasing panoramic views and natural lighting. To mimic the sloping walls, Stewart’s structural engineering group engineered sloping columns to match the architecture while providing sweeping views of downtown Raleigh.

Part of the community
As a new landmark in the Warehouse District, it was paramount to make The Dillon feel like a natural addition to the neighborhood. That includes its surrounding roadways and sidewalks.

The City of Raleigh’s Comprehensive Transportation Plan clearly defines ideal paths for cyclists throughout the city. The Dillon lies directly on a main bicycle thoroughfare, connecting one side of the city to the other. Stewart’s planning and design team was intentional about the bike lane configuration to keep bicycle traffic flowing properly with lanes consistent with the city plan. Sidewalks were also designed to mimic what existed in areas on either side of the building, while main-}

Sometimes it’s the aesthetically unpleasing parts of a project that are the most challenging, yet important to consider. The sanitary system in downtown Raleigh is more than 100 years old in some places and was designed for a substantially smaller city. Stewart designed the replacement of all the sanitary construction connected to the building and upsized the main for a growing downtown community by employing a unique sanitary construction strategy. While pipes are typically replaced and installed with an open cut trench excavation, cutting into and removing existing pavement, this project utilized pipe bursting, a trenchless method.

A hole was opened on the street corner, sending an expander head into the existing pipe. The expander head consists of two components: a leading end designed to guide the equipment through the pipe, and a trailing end with four pneumatic arms to “burst” — or break — the pipe apart. A machine then pulls in a much larger new pipe. As in any downtown location, Raleigh has multiple utilities below the street including natural gas, telecommunications and storm drainage lines, power, water, and sewer all within a 60-foot space between buildings. This technique avoided the need to uproot or relocate any other utilities along the block, saving time and money.

Landmark change
Already making its name as an iconic property in downtown Raleigh, The Dillon’s intention to preserve the history of the district while ushering in a new era of technology firms, art museums, restaurants, and destination retail is evident throughout the execution of the building’s design, as well as the tenants moving in.

Stewart was not only the first office tenant to move in, but also the first to commit to The Dillon as its new home, well before the revitalization
was underway. This forward-thinking decision is paying off, placing Stewart in the center of an entrepreneurial and pioneering atmosphere that matches its company culture.

The innovative and appealing design of The Dillon — merging old and new — is attracting a diverse array of retailers and new businesses to the Warehouse District. In addition to Stewart, technology firms and co-working spaces are quickly filling the office space. Urban Outfitters, Heirloom Brewshop, Weaver Street Market, and Barcelona Wine Bar are scheduled to open in the retail space.

Information provided by Stewart (www.stewartinc.com).

**BALCONY DESIGN**

**IBC CHANGES AND WOOD DURABILITY CONSIDERATIONS.**

By Frank Woeste, Ph.D., P.E. and Don Bender, Ph.D., P.E.

**WOOD CONSTRUCTION** for mixed-use has always been popular in the western U.S. and is growing in popularity throughout the country due to favorable cost, availability, ease of construction, thermal performance, less embodied energy, and carbon sequestration. All building materials have advantages and disadvantages, and wood is no different. For example, wood is susceptible to deterioration from moisture exposure, but this risk can be mitigated through proper design and detailing.

Buildings such as the one shown in Figure 1 often include balconies as shown in the background. Cantilevered balconies have limited structural redundancy and have exposure to weather that requires special attention by design professionals, related contractors, permitting and inspection department, and maintenance by owners in-service. Figure 2 shows a different example of balcony framing for an apartment building constructed in 2018.

Balconies can add considerable value but require special attention to ensure public safety. A case in point: On June 16, 2015, a balcony on a wood-framed apartment building collapsed, causing six fatalities and injuring at least seven others, precipitating emergency changes to the 2016 California Building Code, effective Jan. 30, 2017, and motivated changes to the 2018 IBC that address waterproofing measures and “special inspections” during construction.

Lessons learned from the Berkeley tragedy include:

- Balconies have limited structural redundancy so special attention to design, construction, material selection, and inspection are critical.
- Moisture usually finds a way into enclosed spaces, so there needs to be a way for moisture to exit the spaces.
- Periodic inspections are needed to ensure the integrity of the balcony structure. Some means of access is needed to inspect the enclosed space (e.g., removable access panel).

![Figure 1: Example of mixed-use podium wood construction utilizing structural concrete for the first floor and wood framing for the upper five floors. Photo: courtesy of Construction Science and Engineering, Inc.](image-url)
The objectives of this article are to alert design and construction professionals about changes in the 2018 IBC that address occupant safety of wood-frame balconies, and to provide guidance on improving balcony safety through durable material selection and considerations for in-service inspections.

**2018 IBC change: Impervious moisture barrier system**

The new code requires an “impervious moisture barrier system” when the wood structural framing is “exposed to the weather, such as concrete or masonry slabs,” as an alternative to preservative-treated or naturally durable wood. 2018 IBC Section 2304.12.2.5 follows (changes indicated in bold):

“IBC 2304.12.2.5 Supporting members for permeable floors and roofs. Wood structural members that support moisture-permeable floors or roofs that are exposed to the weather, such as concrete or masonry slabs, shall be of naturally durable or preservative-treated wood unless separated from such floors or roofs by an impervious moisture barrier. The impervious moisture barrier system protecting the structure supporting floors shall provide positive drainage of water that infiltrates the moisture-permeable floor topping.”

Positive drainage — One critically important element for protecting untreated structural framing is the requirement for the impervious moisture barrier system to have positive drainage of water that infiltrates the floor topping. This change makes sense since hard surfaces can form cracks in-service and allow the passage of water by gravity and capillary action. Without the free drainage of water from the surface of the moisture barrier system, water can back up due to hydrostatic pressure even though the in-service (drainage) slope of a waterproofing element is positive.

Impervious moisture barrier system — The key word is “system,” as the system required per the 2018 IBC to have “shall provide positive drainage of water that infiltrates the moisture-permeable floor topping.” A 2016 publication by Joseph Lstiburek, Ph.D., P.Eng., reviewed the issues involved and presented excellent stepwise details of a system installation that incorporates a “drainage mat” above the “waterproof membrane.”

Lstiburek’s publication and details merit careful study by design and construction professionals as the integrity of the wood framing is conditioned on the proper installation of a waterproofing system that meets the requirements of IBC 2304.12.2.5.

Commentary on impervious moisture barriers — In our experience, it is entirely possible that moisture will find a way into the enclosed balcony space, as no barrier system is perfect. As such, it is important to provide a way for the moisture to exit the space. Next, we will cover another IBC change that calls for “free cross-ventilation.” Finally, given the limited structural redundancy of balconies, designers should consider using preservative-treated wood even for the case of impervious moisture barriers. Guidance on durable wood selection and fasteners is provided later in this article.

**Durable wood options**

Naturally durable wood versus preservative-treated (PT) wood — The IBC allows for both options, but practically speaking, PT wood is a better choice for balcony framing.

The IBC defines “naturally durable wood” as the heartwood of decay-resistant species except for the occasional piece with corner sapwood, provided 90 percent or more of the width of each side on which it occurs is heartwood. Decay-resistant species listed include redwood, cedar, black locust, and black walnut.

The reason for the 90 percent heartwood requirement is that sapwood of species listed is not decay resistant. From the 2010 USDA Wood Handbook, “Untreated sapwood of essentially all species has low re-
sistance to decay and usually has a short service life under conditions favoring decay.” Visit www.fpl.fs.fed.us/ documnts/fplgtr/fpl_gtr190.pdf for more information on wood as an engineering material.

We have never seen black locust or black walnut used in building framing, so we examine the remaining choices. Redwood and cedar (with the stated heartwood requirements) generally have lower design values and are more expensive than other common framing lumber choices. These species are good choices for lower structural demand applications such as deck boards where the natural beauty of the wood is left exposed. However, for balcony framing, we favor PT lumber that has been treated and certified according to the specifications in IBC 2303.1.9 Preservative-treated wood.

PT wood — The proper and adequate specification of PT wood requires a knowledge and use of the 2018 IBC, Chapter 35 Referenced Standard for PT Wood: AWPA U1 — 16: USE CATEGORY SYSTEM: User Specification for Treated Wood. As discussed next, a PT wood specification such as “all balcony framing lumber shall be PT wood” by a project designer is extremely vague and not sufficient for balcony framing that is critical for life safety.

Referring to AWPA U1-16, Table 2.1 Service Conditions for Use Category Designations review of the table for “Above Ground” and “Ground Contact” yields 10 Use Categories and Service Conditions. In Table 1, the Use Categories are tabulated with reference to whether or not the Service Condition applies to “critical components” or could involve a “difficult replacement.”

Our interpretation of Table 1 (see page 44) leads to the conclusion that while a balcony is clearly “Above Ground” based on the elevation of the balcony framing, the application of PT structural wood-framing per the AWPA U1-16 Standard is “Ground Contact” UC4A, 4B, or 4C. The choice of UC4A, 4B, or 4C is the responsibility of the design professional and should be clearly stated in the construction documents to enable the general and framing contractors to use the proper preservative treatment.

The most recent version of the code-referenced AWPA U1-18 Standard Excerpt can be downloaded at www.awpa.com/standards/U1excerpt.pdf.

PT structural composite lumber — Structural composite lumber (SCL), which includes laminated veneer lumber (LVL), parallel strand lumber (PSL), laminated strand lumber (LSL), and oriented strand lumber (OSL), are engineered wood composites with excellent engineering properties. However, other than Parallam Plus PSL, we are not aware of any SCL that is treated to decay protection levels above AWPA Use Category UC2.

Fasteners in PT wood — Some of the chemical formulations in wood preservatives can accelerate corrosion of fasteners and flashing. IBC 2304.5 specifies requirements for zinc-coated and stainless-steel fasteners and connectors in contact with PT wood. Simpson Strong-Tie provides excellent information about corrosion risks and solutions at their site (www.strongtie.com/products/product-use-information/corrosion-information).

2018 IBC change: Enclosed balcony framing must be ventilated
The 2018 IBC has a new provision requiring ventilation of enclosed balcony framing as follows:

“Well, 12.2.6 Ventilation beneath balcony or elevated walking surfaces. Enclosed framing in exterior balconies and elevated walking surfaces that are exposed to rain, snow or drainage from irrigation shall be provided with openings that provide a net free cross-ventilation area not less than 1/150 of the area of each separate space.”

This addition to the code guards against the accumulation of water vapor (for any reason) through natural drying. Balcony ventilation openings should be visible to an inspector, and the inspector should report if they are not present or are deficient. In addition, we recommend that the ventilation covers, or some other access panel, be removable to allow for periodic inspections.

A special case: Open framed cantilevered balconies
PT wood framing for balconies that rely solely on cantilever beams for structural support as depicted in Figure 4 is not recommended due to several structural and in-service issues. We are not aware of any method to inspect or determine the structural integrity of the cantilevered joist section embedded in the wall. It should be noted that even “early decay,” not visible or detectable by physical means, significantly reduces the strength properties of wood. In addition, the water trapping joints/surfaces created by the entry of the framing into the wall cavity creates a decay hazard as it is very difficult to prevent the movement of moisture into the contact areas between the joists and masonry wall.
Summary recommendations

We believe the impervious moisture barrier system option is a best practice for balconies when coupled with ventilation per 2018 IBC 2304.12.2.6 and Special Inspection of the “manufacturer’s installation instructions” specified by the design professional and contained in the construction documents. In addition, we recommend using UC4A, UC4B, or UC4C PT wood (and appropriately protected fasteners) even though an impervious moisture barrier system is used, and we recommend access panels that facilitate periodic inspections. This redundant protection against decay is appropriate given the limited structural redundancy of a cantilever balcony system and the importance for life safety.

In the words of the late Professor Stan Suddarth (Purdue University), the focus of the impervious moisture barrier system option is to protect wood framing from decay by the most fundamental way: “Keep wood dry. Don’t let wood get wet. Keep water away from wood.” If installed properly, the life of the wood framing is only limited by the service life of the impervious moisture barrier system.

We recognize that Special Inspections of the manufacturer’s installation instructions are not part of the new IBC, only given in the 2018 IBC Chapter 1 Scope and Administration, and thus may not be adopted by states and local jurisdictions when the IBC is officially adopted. The inspection provisions follow:

“[A]107.2.5 Exterior balconies and elevated walking surfaces. Where balconies or other elevated walking surfaces are exposed to water from direct or blowing rain, snow, or irrigation, and the structural framing is protected by an impervious moisture barrier, the construction documents shall include details for all elements of the impervious moisture barrier system. The construction documents shall include manufacturer’s installation instructions.”

“[A]110.3.6 Weather-exposed balcony and walking surface waterproofing. Where balconies or other elevated walking surfaces are exposed to water from direct or blowing rain, snow, or irrigation, and the structural framing is protected by an impervious moisture barrier, all elements of the impervious moisture barrier system shall not be concealed until inspected and approved.

Exception: Where special inspections are provided in accordance with Section 1705.1.1, Item 3.”

Conclusions

We view the new balcony code provisions to be an opportunity to proactively address the safety and reliability of balconies in-service. In the interest of public safety, design professionals are encouraged to adopt the new 2018 balcony provisions before they are adopted by the governing jurisdiction or state code. At a minimum, we believe that owners of new construction projections should be advised of the balcony safety issue, the new IBC provisions that address water-related issues, and the need for periodic inspections to ensure the balcony framing is being protected from moisture conditions that can compromise structural integrity.

FRANK WOESTE, PH.D., P.E., is Professor Emeritus, Virginia Tech, and frequently consults with the public, design professionals, contractors, and building code officials on various aspects of engineered wood construction and residential construction, including decks and balconies. Along with his colleagues, Woeste continues to offer continuing education programs at Virginia Tech annually. Contact him at fwoeste@vt.edu.

DON BENDER, PH.D., P.E., is Weyerhaeuser Professor of Civil Engineering and director of the Composite Materials & Engineering Center at WSU-Pullman. He is an expert in testing, design, and construction of timber structures. Bender teaches university and outreach courses in structural engineering and is active in national building code and standards development. Contact him at bender@wsu.edu.
The **Charles Pankow Foundation** tackles ideas and issues that no single company or person can solve alone. We challenge you to join in with like-minded champions. Transform the way our world is designed and built. Change the status quo!

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The Great Lakes region was blessed with abundant fresh water for its rivers and lakes. Water as a resource and method of transportation were an important factor in Akron, Ohio, blossoming as one of America’s early manufacturing hubs during the late 1800s and early 1900s.

But it was this industrial past that led to the pollution that brought the U.S. Environmental Protection Agency to issue a federal mandate for the City of Akron to comply with the Clean Water Act of 1972 to end pollution in local waterways. Because about a quarter of Akron’s existing sewer system had been designed as combined sewers when constructed in the early 1900s, frequent overflows mixed stormwater with sanitary sewage. This mix ultimately emptied into the Cuyahoga River, the Little Cuyahoga River, the Ohio & Erie Canal, and Lake Erie.

As part of the solution, The City of Akron created a program — Akron Waterways Renewed! — to control combined sewer overflow (CSO) and improve water quality in nearby rivers. A portion of that plan was to create a 6,240-foot-long Ohio Canal Interceptor Tunnel (OCIT), three new storage basins, upgrade CSO racks, and upsize and reinforce the main outfall sewer cap. The 27-foot-diameter OCIT sections were a feat in themselves, dug with a tunnel boring machine and constructed of reinforced concrete. The basins will hold combined sanitary and stormwater overflow until it can be released safely to Akron’s wastewater treatment facility.

Of particular interest is design and construction of the influent line to the new Howard Storage Basin (CSO Rack 22) at the intersection of Howard and Cuyahoga Streets, which will provide temporary storage of combined sewer flow from the North Hill tributary area. With a 2.4-million-gallon capacity, it is the largest of the three new storage basins.

HM Miller Construction was subcontracted for the site work for CSO Rack 22, one of Akron’s 34 sewer separation units, as well as relocating the existing waterline to accommodate influent piping. The HM Miller engineering staff saw a potential problem with the original design that called for an elliptical reinforced concrete pipe (RCP) influent line to run beneath Cuyahoga Street. They realized that there would be difficulty in achieving clearance under the public road, even though the RCP line would be elliptical, and that could lead to inability of the RCP line to pass the required pressure test specification, according to John Smith, president of HM Miller Construction.

Smith called upon his resources at Hobas Pipe USA to assist in devising an alternate plan for CSO 22 that would resolve the inherent difficulties surrounding installation and testing using the RCP. Together they came up with a design that saved time and money tying the Howard Storage Basin into the main line. In place of the elliptical RCP originally specified to be installed under Cayahoga Street, the new design called for twin, 57-inch Hobas centrifugally cast fiberglass-reinforced polymer mortar (CCFRPM) pipe that would tie into the OCIT-1 main line with

**Last-minute design change benefits Akron CSO project**

TWIN, 57-INCH CENTRIFUGALLY CAST FIBERGLASS-REINFORCED POLYMER MORTAR PIPES SOLVE UNDER-ROAD CLEARANCE ISSUE.

By Liz Moucka
In the next 25 to 30 years, most water distribution mains in the United States will need to be replaced. The American Water Works Association (AWWA) forecasts it will cost nearly $1 trillion to address the problem.

The task of addressing water main replacement needs, including funding, is daunting, but according to the Water Research Foundation (WRF), 75 percent of water utilities cited pipe breaks as a key criterion in pipe replacement decisions. In 2007, the U.S. Conference of Mayors noted that 86.2 percent of cities use the number of water main breaks per unit length to evaluate drinking water pipe performance.

Literature reviews indicate that between 250,000 and 300,000 breaks occur every year in the U.S., which corresponds to a rate of 25 to 30 breaks per 100 miles of pipeline per year (breaks/100 miles/year). According to another WRF publication, the average pipe break rate (regardless of cause) for water utilities is between 21 and 27 breaks/100 miles/year. The AWWA Partnership for Safe Water Distribution System Optimization Program goal for a fully optimized distribution system is 15 breaks/100 miles/year.

Recent studies
In 2018, the Utah State University Buried Structures Laboratory released a study on water main breaks in the United States and Canada. It surveyed more than 300 utilities and focused on water main breaks related to pipe material type, separating out main breaks caused by third-party and maintenance damage. The results answer many important questions. Overall water main pipe break rates have increased 27 percent during the last six years. In aggregate, it was estimated the pipe break rate is 14 breaks/100 miles/year.

Another 2018 report from WRF based on research by Purdue University and Louisiana Tech — Practical Condition Assessment and Failure Probability Analysis of Small Diameter Ductile Iron Pipe — focused on the break rates of ductile iron (DI) pipe less than 12 inches in diameter, taking into consideration that many newer pipes, which are thinner, may be failing at a higher rate than older pipes or larger-diameter DI pipes. The research found that, on average, DI pipes are breaking at a rate of 15.1 breaks/100 miles/year. During the last 10 years on average, the direct cost of failure of small-diameter DI pipe was $12,600 per occurrence, while the indirect cost was estimated at $5,600 per occurrence. On average, the total cost was $18,200 per break or $274,820/100 miles/year.

Condition assessments
The water industry has seen many types of academic surveys and studies on water main replacement programs and the benefits of asset...
management, condition assessment, and prioritization. During the last 20 years, utilities have begun to track all aspects of their infrastructure in a GIS-centric platform, and have collected records on the types, sizes, and repair histories of their pipes. In addition, asset inventory, condition assessment, and asset management planning practices provide valuable information to enable utilities to more efficiently determine which pipes to repair and replace, taking into consideration relevant variables unique to the water utility.

Condition assessments of buried water mains typically fall into two categories: physical and desktop. Physical condition assessments are accurate for the pipe tested but tend to be slow, expensive, and labor intensive. Multiple physical measurements are required for correlation and confirmation. The results are difficult to extrapolate to system-wide recommendations.

Desktop methods are more straightforward, but many of these methods are based on arbitrary assumptions and weights (i.e., older pipes are more in need of replacement than newer pipes). More advanced statistical modeling may help decipher differences between various variables, although many of these approaches may not have the ability to consider the importance of some adjacent details such as proximity to light rails or the contribution of elevation or pipe material, therefore impacting accuracy.

A new paradigm
A more robust approach would be a large-scale comparison of these various factors to generate a more refined and accurate prediction based on the disparate interactions between component variables. Artificial intelligence, specifically machine learning (AI-Machine Learning), has emerged as a technology to make a significant impact in buried water infrastructure asset management. AI-Machine Learning consumes large, complex data sets containing more variables than humans can process with current tools. This objective, data-driven method overcomes inherent subjectivity and biases and provides results that help utilities make better replacement decisions.

Due to the large amount of historical and geospatial data needed to run AI-Machine Learning algorithms, water main condition assessments contain all the necessary components of an ideal application for water utilities:

- years of historical data covering installation year, pipe material, and break history;
- categorical data including pressure class, geographical location, elevation, and pipe diameter; and
- contingent data including proximity to rail systems and soil composition.

The volume of data is a unique opportunity for water utilities. Analyzing this data consistently can uncover trends, gain insight on pipeline health, and offer data-driven assessments.

Fracta (www.fracta.ai), a Redwood City, Calif., technology company, is using machine learning to help water utilities make pipe replacement decisions. Fracta’s machine-learning algorithms use vast amounts of historical data to quickly solve complex pipe problems using the likelihood of failure (LoF). In the water main industry, the LoF, also known as condition assessment, provides the most valuable actionable predictions.

The Fracta condition assessment solution calculates and visualizes the LoF for every water main across infrastructure. A water main’s LoF score is the result of more than 1,000 data variables for every pipe segment. Fracta uses the following types of data:
- Asset data — pipe ID, location, diameter, length, material, installation date
- Historical data — break history
- Geographical information — location, elevation, slope
- Environmental data — soil, climate, water bodies, structures, population density, etc.

Analyzing this data consistently uncovers trends, gains insight on pipeline health, and offers data-driven assessments. Coupling the LoF with consequence of failure analysis can then accurately pinpoint areas that are most in need of replacement.

AI-Machine Learning process
Data acquisition, assessment, and cleaning for any AI-Machine Learning process is roughly 60 to 80 percent of the work — also known as pre-processing or data wrangling — with the remaining percentage being the machine learning itself. Once the data is assessed, cleaned, and imputed where needed, it is ready to be fed into a machine-learning algorithm where it is subsequently “trained” to learn the patterns that predict breakage events. Figure 1 illustrates the process.
Data quality is critically important. The data used in the analysis must be collected, organized, and normalized. Main data sources Fracta uses are the utility water main asset data and information about historical breaks. A software-led approach to data cleaning and normalizing aids in the challenge of using real-life data from city- and community-specific utilities that varies in its quality.

The more data a model contains, the more robust the model. As utilities collect new data over time, recording new activity, data is continually fed into a machine-learning mode. This subsequently enhances the model by either strengthening previously learned rules around break predictions or from encountering additional circumstances around which new rules can be built.

Financial benefits
Analyzing water main condition data consistently uncovers trends, gains insight on pipeline health, and offers data-driven assessments. Incorporating a machine learning condition assessment solution like Fracta into a proper infrastructure asset management program will lower condition assessment costs while helping reduce water main breaks and more efficiently allocate pipe replacement capital investment.

Coupling LoF with consequence of failure analysis can then accurately pinpoint the pipes and areas of highest risk. A risk-based asset management program relies on accurate predictions of the most vulnerable water mains. An inflated or deflated LoF score could dramatically over or under estimate risk and lead to replacing low-risk pipe or ignoring high-risk pipe. Use of machine learning to determine LoF is a fast, accurate, and affordable way to improve confidence that risk ratings are accurate and reliable.

Industry data says that as much as 30 to 40 percent of replaced pipe has useful remaining life. If capital spending on pipe replacement is $10 million per year, a utility could be wasting $3 million to $4 million per year replacing the wrong pipe.

Conclusion
Incorporating AI-Machine Learning condition assessments into a proper infrastructure and asset management program will contribute to reduction of the economic impacts incurred from water main breaks and more efficient allocation of capital by water utilities. Use of best practices and a more accurate, objective tool will align maintenance and capital repair and replacement strategies to more efficiently leverage scarce financial and human resources. They also inject financial integrity to the planning process and refine the investment strategy so a utility will be in a better position to defend planning efforts and fund needed capital pipe replacement projects.

DOUG HATLER is environmental engineer and chief revenue officer at Fracta (https://fracta.ai), a Redwood City, Calif., technology company “Bringing Artificial Intelligence to Infrastructure.” He has more than 30 years of experience managing water, waste, and EHS compliance.
Wastewater infrastructure inspection offers some obvious challenges. Because almost all of the system is hidden from view, the ways to inspect the pipes without a drone is either to dig them up — only done in the case of an emergency — use small cameras attached to ground-based robots, or send people inside.

In Barcelona, inspectors and engineers faced an immediate challenge. A critical piece of the infrastructure, a wastewater interceptor serving five municipalities in the Barcelona area and transporting a large volume of waste to the treatment plant, suffered a break during recent storms. Running along the shore of the Mediterranean, the pipe had been damaged by heavy surf and was leaking 500 cubic meters per second of raw sewage into the sea.

Construction of a bypass was started immediately, but until inspectors could determine the exact location and extent of the structural damage, they could not know how long of a bypass was required. While part of the break was exposed and visible, engineers could not know if there was additional damage either upstream or downstream from the break. Without good data, the bypass would have to be built unnecessarily long; or might join the existing infrastructure too soon, risking another breakage downstream.

There was no way to introduce human inspectors into the pipe — a vaulted half circle concrete pipe of approximately 3 meters in diameter and 1.8 meters high. At 500 cubic meters per second, sewage was flowing through the pipe nearly waist high at a speed that would have washed a person away. It also made use of a ground robot impossible.

In addition, findings later showed that the pipe had a large crack across the top. Liable to cave in, it would have been life threatening to send a human inspector into the area.

**Solution**

“Aigües de Barcelona and Suez met the emergency with all of the necessary and modern technology available,” said Kövessi. The expert pilots at Flind used the Elios collision-proof drone to fly into the damaged pipe. They were able to access the area through the closest intact manhole both upstream and downstream of the visible break, surveying the entire area.

Footage from Elios was able to show the exact extent of the damage. Engineers were able to see that an additional area of the pipe, not visible from the surface, had also been damaged as the sand retreated from under the pipe. With this information, experts were able to ensure that the bypass was connected at the correct place to quickly stop the flow of waste into the sea and to avoid the risk of a future break downstream of the join.

While the collision-tolerant Elios is often used in inspection of inaccessible spaces because of the cost and time benefits, in this case there truly was no other way to evaluate the systems without significant risk to human life — and the mission was of paramount importance to the community.

While this was an extreme example, Kövessi said that the efficiencies of using Elios in normal sewer inspection cases are clear: “Typically, the drone inspection is twice as efficient as human inspectors — and 40 percent less expensive per meter of inspection.”

**Conclusion**

Drone inspection in sewers offers significant cost savings and efficiencies, and in an emergency situation, may offer the only solution. The Suez group works to be an innovative and forward thinking company: they employed Elios to give the best environmental service possible to the community, dealing with a potential disaster by using the best and most advanced tools available to them.

Information provided by Flyability (www.flyability.com), a Swiss company that builds drones for operating indoors, in complex and confined spaces, and in contact with people.
Built in 1913, the historic Ballville Dam sits on the Sandusky River in the heart of Fremont, Ohio, previously serving as a source for hydroelectric power generation and later as the city’s water supply. In 2013, the role of the dam was eliminated when the City of Fremont opted to build an off-line, up-ground drinking water reservoir to serve as the primary source of water for city residents and businesses, addressing environmental concerns related to the dam’s deterioration, the associated sea wall, and fluctuating nitrates and other pollutants along the Sandusky River.

The City of Fremont needed to develop a plan for how to address and potentially remove the 407-foot-long and 34-foot-high structure. During the next few years, various studies from state and national agencies analyzed the disposition of the Ballville Dam, and in 2014, Fremont city council passed an ordinance to remove the dam, with city voters approving the decision the following year.

The Challenge
Conversations among local, state, and federal agencies about the future of the 105-year-old Ballville Dam lasted for more than 20 years — to remove or refurbish the dam was controversial for groups, including Fremont residents and officials, wildlife conservation organizations, the Ohio Department of Natural Resources, and the U.S. Fish & Wildlife Service. Concerns were largely on water quality and the environmental impacts that releasing the built-up sediment behind the dam would cause. Others recognized the clear benefits of a free-flowing, newly exposed 22 miles of river and the subsequent positive impact on recreational activities and fish populations.

First, the design and demolition process needed to address the more than 800,000 cubic yards of stored sediment so that the release was structured to minimize the impact on downstream aquatic ecosystems. Additionally, the U.S. Army Corps of Engineers (USACE) concluded that Ballville Dam was collecting river ice that would otherwise accumulate in the City of Fremont and potentially cause flooding.

Lastly, creating an area that was accessible and attractive to the community into the future was a top concern for Fremont.

The Solution
Working in partnership with design firm Stantec, MWH Constructors utilized the design plan for removing the dam and restoring the river to its natural free-flowing form while mitigating the impacts of releasing the sediment. Project goals included improving water quality, managing impoundment sediment, and minimizing ecological impacts.

Previous project success as the construction manager at-risk on the City of Fremont’s Water Pollution Control Center, an upgrade to the city’s wastewater system, led to the city’s selection of MWH Constructors as the general contractor and construction manager for the Ballville Dam removal. MWH Constructors was responsible for deconstructing the dam and seawall, constructing a permanent fence at the seawall site, and managing complete restoration of the riverbank, including seeding, tree and wetland planting upstream and at the dam, and ensuring the project was completed on time and on budget.

Addressing flooding concerns — An initial step in the project was to create an ice-control structure (ICS) that would mitigate the ice control function of the dam once it was removed in order to protect the floodwall and potential flooding in downtown Fremont which is downstream of the dam. Stantec and the City of Fremont worked with the USACE to design and permit the ICS utilizing the USACE’s design guidance document developed by the USACE Cold Regions Research and Engineering Laboratory (CRREL).

Fifteen piers that are 6 feet in diameter and 15 feet on center were installed across a portion of the Sandusky river approximately 200 feet downstream of the dam. These piers make up the new ICS and were installed in the fall of 2016.
Most of the concrete from the old dam was processed onsite and used to fill scour holes at the bottom of the dam and as fill for stabilizing the bank during restoration.

Choosing the team — An extensive process was used to select the dam demolition and riverbank restoration subcontractor. A request for qualifications was issued and six contractors responded. The submissions were shortlisted to three contractors, with the final selection process determined by a combination of price and project approach. After review of the proposals, MWH Constructors recommended, and the owner agreed, to award the contract to The Great Lakes Construction Co. (TGLCC).

Notching the dam — The dam was removed in two stages in accordance with the approved U.S. Fish and Wildlife Service (USFWS) Environmental Impact Statement (EIS), beginning with a notch in October 2017 and complete removal of the dam in 2018. The intent of the two-stage removal was to attempt to control the amount of sediment exported from the impoundment over time instead of a sudden large release. The timing of the notching and dam removal was also designed to coincide with historic lower flow times, again in attempt to mitigate the amount and timing of the sediment release.

MWH Constructors led construction of the notch — a 10-foot-deep and 20-foot-wide cut in the dam’s southern side. The notch allowed the river to take its natural course, forcing the water level in the dam’s impoundment to drop. Lowered water levels allowed for dewatering of a large portion of the sediment collected behind the dam. This dewatering strategy was included in the construction plan to directly address concerns regarding the release of built-up sediment into the Sandusky Bay and Lake Erie. Using specialized equipment, dewatered sediment was successfully removed from the river channel and incorporated into the restoration efforts above the normal water level.

Removing the dam — In July 2018, MWH Constructors and TGLCC began deconstruction of the Ballville Dam, removing large portions of the dam in phases. Phase one, completed in June, involved establishing safe access and staging for demolition. During phase two, the team enlarged the previously installed notch on the south side of the dam down to bedrock. The balance of the dam was removed from the south to the north. All scour holes were filled and the concrete was processed onsite and used for bank stabilization. Following demolition, the Stantec engineering team gathered post-demolition data and provided the construction team with direction in restoring the river and bank.

MWH Constructors worked closely with TGLCC and the City of Fremont to ensure all aspects of the removal ran smoothly and on schedule. The demolition portion of the project took approximately one month, leaving only a small portion of the northern part of the dam intact, to memorialize the location of the dam. Additionally, a permanent observation platform will be constructed as part of the final restoration.

Riverfront restoration — The City of Fremont envisioned a park-like setting for the new Sandusky Riverfront that included walking pathways, permanent observation decks, and areas for residents to drop in kayaks and canoes. The updated area will bring life back to the riverfront and likely become a highly sought-after spot for fishing in Fremont. Following project completion in 2019, the Ohio Department of Natural Resources plans to study the river to determine the overall environmental impact of the dam’s removal.

As part of riverfront restoration efforts, the project team identified opportunities to reduce landfill waste and repurpose materials. Most of the concrete from the old dam was processed onsite and used to fill scour holes at the bottom of the dam and as fill for stabilizing the bank during restoration. MWH Constructors managed the restoration process of permanent seeding and tree and wetland planting. Approximately 52 acres around the dam and upstream will be reseeded with 9,400 bare root trees, 10,900 live stakes, and 210 containerized trees also planted. The seeding and planting are intended to beautify and stabilize the river bank and surrounding area and develop the wetlands as required by the USACE 404 and Ohio EPA 401 permits. The complete restoration of the river banks and remaining sediment will help manage erosion in the future and fully restore and improve the Sandusky river habitat.

Community engagement — Local interest from past and present Fremont residents ran high throughout the project and specifically during deconstruction of the dam. To address this public interest in a safe way, MWH Constructors and TGLCC built a designated viewing platform near the construction site entrance. Livestream video of the demolition and progression of the project were also posted online.

The multi-phased approach to removing the Ballville Dam proved to be the most efficient, economical, and effective approach to restoring the Sandusky River. Project teams worked together to shape project goals, timeline, and budgets to this deconstruction model, ultimately keeping the project under budget and completed one month ahead of schedule. Following completion in 2019, the area will experience more consistent flow and is expected to be a popular recreational attraction for residents and visitors for years to come.

KURT KOEPF, project manager, MWH Constructors, has 36 years of experience in the water and wastewater industry and has successfully managed numerous water or wastewater treatment projects in Ohio. He works closely with owners and project teams to develop, coordinate, and monitor all aspects of a project. He provides valuable insight into local and regional resources and capabilities.

TUCKER FREDERICKSEN, city engineer, City of Fremont, Ohio, has more than 20 years of experience as a civil and municipal engineer. He specializes in design, project and construction management, and planning of the city’s infrastructure systems including water, sanitary, storm, streets, intersections, multi-use trials, and other critical systems.
‘LEEDING’ THE WAY IN BUILDING CERTIFICATION

U.S. GREEN BUILDING COUNCIL CELEBRATES 25 YEARS OF PROMOTING ENVIRONMENTALLY SOUND DESIGN AND CONSTRUCTION.

YOU KNOW YOUR CERTIFICATION PROGRAM IS MAINSTREAM when a green building graces your country’s currency. When the U.S. Green Building Council (USGBC) was founded in 1993, architects and engineers might not have imagined that conversations about greening their respective professions would blossom seven years later into a full-fledged building rating system.

“Architects and engineers had been looking at efficiency since the seventies, and how to have a better building,” said Melissa Baker, a senior vice-president with the USGBC.

Appealing initially to early adopters willing to participate in pilot projects, Leadership in Energy and Environmental Design (LEED) took a holistic, multi-attribute approach, Baker said. “We wanted to look at how to define a high-performance green building, which encompasses a number of different things, including occupant experience, indoor environmental quality, water savings, energy savings, siting, location, and materials.”

The federal government was one of the earliest participants in the U.S. “We got some early-days grant funding from the Department of Energy, got the rating system up and running, and over time released versions 1, 2, 2.1, 2.2, and then 3 and 4,” Baker said.

With version 4.1 (LEED v4.1) now in beta mode, LEED is recognized in 167 countries with more than 90,000 projects registered or certified. In many locales, the program is so entrenched it’s almost a given that an owner will register for at least some degree of recognition.

“In the D.C. area, for example, we see the LEED logo on almost any new building that’s constructed and on many existing buildings as well,” Baker said.

While LEED was initially limited to new constructions, demand from building owners and professionals, as well as environmental advocates, spurred the USGBC to create a category for existing buildings.

Look at the back of a U.S. $10 bill and you’ll spot a LEED-certified building. The U.S. Treasury Building, completed in 1869, earned LEED Gold in 2011 by increasing daylighting, installing advanced HVAC controls, auditing its waste, greening its procurement, enhancing metering for utilities, and decreasing consumption of electricity and potable water, even while adding workstations.

Indeed, LEED has grown through evolution. While initially focused on office buildings, the scope broadened to include schools, health care, residential, and other verticals. In 2009, the USGBC added key pieces like putting weightings behind the point distribution for the rating system. This more heavily supported actions providing a bigger impact.

One key factor in attaining certification that has gained momentum is building materials. LEED v4, released in 2013, raised the bar even higher in terms of credits for materials and performance.

Strengthened energy codes and strong interest in benchmarking and public disclosure have proven key drivers, as have renewable technology developments in areas such as solar.

Core to LEED’s evolution has been the ability to compare performance through Arc, a new online platform launched in 2016 by Green Business Certification Inc. (GBCI), the certifying body for LEED. Arc lets proponents calculate performance and identify opportunities based on measuring energy, water, waste, transportation, and human experience metrics.

GreenCircle data online

Want to know if the ingredient or product you’re purchasing passes environmental muster? GreenCircle Certified maintains a database itemizing products for which it has provided independent, third-party verification.

“We have a lot of building products,” Certification Officer Tad Radzinski said, offering carpeting, door, and hardware products as examples. “We do a lot with plastics and plastic lumber.”

Green Circle’s database is online at www.greencirclecertified.com/database.
Arc allows them to see their data in real time, use that score to benchmark against other buildings both locally and globally, and see how their buildings are performing,” Baker said. “Driving that performance, driving that data, and letting data do the talking is a key piece of 4.1.”

LEED has always recognized that buildings require high-performance materials to achieve efficiencies in energy and water consumption, recycled content, and localized sourcing. Now, credits can be earned for multiple attributes within particular materials, enhanced transparency of information about ingredients and carbon and energy footprints, and acknowledgement of impacts over an entire building life cycle.

“We’re touching more markets, we have more flexibility within the rating system, and we’re continuing to integrate performance by moving into the operations and maintenance side to track ongoing performance of buildings through data,” Baker said, pointing to developments introduced with LEED v4.1 that stand to further drive data-driven measurement of actual building performance.

“We’re using that data to provide an ongoing certification so that we know for sure buildings are performing as designed,” Baker said. “Rather than providing prescriptive strategies, we’re creating a rating system that’s more about outcomes and performance.”

Baker said the current beta testing is intended to ensure v4.1 is properly tweaked and reflects ongoing trends such as Net Zero without eclipsing current abilities of building owners and professionals. “If we move too fast or jump ahead, we’re not actually executing market transformation,” she explained. “We need the market to come with us and to continue to push.”

GreenCircle Certified
A key bridge between LEED and performance materials is another program, GreenCircle Certified. As Baker put it, LEED is a standard of standards and therefore references other complementary standards.

“GreenCircle is really looking at product life cycles,” Baker said. “In our materials and resources credit we reference a number of different bodies that provide product certification and validation of information. We reference ASHRAE standards for energy, for instance, and WaterSense that the Environmental Protection Agency has created for water fixtures. This allows us to be broader across those different categories.”

Tad Radzinski, certification officer with GreenCircle, described the organization as a third-party auditor and certifier. “If someone claims recycled content in their products, we would certify that. Or if someone needed a third-party-verified material ingredient report, we have a system for certifying which we’ve worked out with the U.S. Green Building Council.”

GreenCircle also examines operations claims such as zero waste to landfill. Radzinski said products meeting GreenCircle criteria are allowed to display the organization’s mark of certification, which, in turn, can be used to help qualify for LEED credits.

“There was a lot of coordination back and forth and development of the process to do it,” Radzinski said, adding that GreenCircle was born in 2009, in part from unhappy experiences a sister company, Sustainable Solutions, had with misleading product claims. Once, when Sustainable Solutions was sourcing office furniture, Radzinski noticed the product label included glue as an ingredient yet claimed 100 percent recycled content. The manufacturer later acknowledged the recycled content at only 72 percent. The second incident involved a flooring product the company was installing for a client whose green building was vying for LEED recognition.

“We installed it, and when we went to get the documentation the manufacturer came back to us and said, ‘Oh sorry, that product is not certified.’ We almost lost our Platinum certification. That prompted us to start thinking about this,” Radzinski said.

As manager of applied sustainability with BASF Construction Chemicals, David Green tracks performance materials and building certifica-
tion programs. He singled out LEED v4, with its focus on product attributes based on life-cycle assessment, as a key development in increasing the transparency of environmental and human health information.

Data includes locale of manufacture, levels of recycled content and biomass ingredients, and overall impact on carbon footprint. “To improve transparency, we’re looking at full life-cycle aspects of products and how we quantify their overall environmental performance,” Green said.

BASF is actively involved in environmental product declaration (EPD) development to provide externally validated results for quantifying environmental impacts. “They’re similar to what a nutrition label would provide on a box of cereal,” Green said. “If an architect, designer, or contractor wants a specific baseline on the carbon footprint, for example, the EPD may provide that information.”

A similar approach for communicating the potential impacts on human health from installed products should also be considered. Green said product manufacturers can meet LEED v4 requirements by complying with the GreenCircle Certified program for manufacturer inventory reporting. He added that BASF evaluates 100 percent of ingredients, including impurities, in products such as Neopor and WALLTITE.

“We’re moving forward by providing transparent information on our product solutions and innovations to support the increasing needs in the construction industry,” Green said. “Transparent information based on scientific results is key to helping people make educated decisions for healthier, environmentally conscious buildings.”

With the USGBC celebrating 25 years, and 18 years of LEED, all eyes are on the future. USGBC’s Baker anticipates data continuing to hold sway. “We’ll keep evolving our rating system development process,” she said, pointing to Net Zero buildings, which produce as much clean energy as they consume. “Net Zero from a carbon perspective is much more accessible. I think that will really drive some of the choices that are made.”

The way buildings are certified, by achieving a specific number of LEED credits, is not expected to change in the near future. Still, Baker acknowledged interest in measuring a building’s actual efficiency to determine the level of certification. “We’re certainly trending in that direction and trying to do that through the benchmarking we’re offering,” Baker said. “There’s a real interest in refining information and making it easier to understand, so it’s obviously critical that we understand how a building is performing and that we keep pushing for more efficiency.”

At GreenCircle, Radzinski foresees further activity around transparency and disclosure. “A lot of companies are conducting life cycle assessments of their products and disclosing the environmental impacts through an environmental product declaration,” he said. “There’s also a large demand right now by many architecture and design firms to understand the chemicals in products. So we’re going to see a lot more demand for material ingredient reports.”

BASF’s Green said significant strides have been made voluntarily and, as certification programs continue to evolve, a next step might lie in their ability to increase their influence on rules and regulations. “If LEED continues to push, and additional voluntary sustainable construction practices are accepted, and it leads to code changes, then we’re better for that.”

Might the ways materials are certified change going forward? “People have much more interest today in the products that are going into their buildings,” Green said. “The demand for greater transparency and better, more sustainable construction products is going to continue to grow.”
We owe a great deal to the Romans. Not only did they leave us with the basis for our legal system in the U.S. and much of Europe, but they also were the first to understand the benefits of a high-quality road network, laying the foundation for modern road design and construction. Roman roads were the best in the world at the time, but today, through technologies such as interlayers, we’ve learned how to greatly improve on their legacy and build stronger roads that can last for decades, while carrying traffic that would have been unimaginable to the Romans.

Everyone knows America’s transportation infrastructure could use a little help, to say the least. Highways and interstates that were once the envy of the developed world are now fading into disrepair in many places, and it’s becoming increasingly expensive to maintain road quality. When cracks and potholes form, contractors are often hired to repave roads with a fresh overlay of hot mix asphalt. But applying a new overlay is like applying a Band-Aid to a deep wound because the damage in the underlying pavement will quickly come to the surface. Cracked pavements repaired with a new asphalt overlay are susceptible to reflective cracking, where the original cracks migrate upward to the surface. Cracks return at a rate of about 1 inch per year, so a 1- or 2-inch-thick overlay does not deliver a long-term solution.

Engineers are increasing the use of interlayer technology that can arrest reflective cracking, lengthening the lifespan of a road while reducing routine maintenance work on fixing potholes and cracks. For example, two kinds of interlayers from Tensar — the GlasGrid pavement reinforcement system and the GlasPave waterproofing paving mat — do just that.

GlasGrid is an interlayer comprised of a grid structure made from fiberglass strands coated with an elastomeric polymer. This design makes for greatly increased tensile strength and a higher modulus of elasticity that works to prevent the spread of reflective cracking in pavement. The interlayer has proven to be effective across geographic regions, from hot, dry deserts to cold, wet subarctic areas.

Waterproofing roads also improves durability, and Tensar’s GlasPave interlayer adds the waterproofing function. Like GlasGrid, GlasPave also uses fiberglass fibers for improved tensile strength, but instead of forming a grid, the fiberglass strands in GlasPave are embedded into high-performance polyester mats. This results in a system that allows the tack coat to saturate the mat, creating a membrane that prevents water from penetrating and damaging the pavement structure.

Geosynthetic reinforcement has seen significant strides in recent years. The Romans may have given us a solid foundation for building modern roads, but we’ve come a long way from a technological standpoint from merely milling old pavement surfaces and adding new overlays. The use of interlayers can do wonders for our infrastructure problem, building roads that will last for the next generation of Americans.

Information provided by Tensar International (www.tensarcorp.com), a full-service provider of specialty products and engineering services based on advanced soil stabilization and reinforcement technologies that offer cost-effective alternatives to traditional construction methods.
THE FUTURE OF URBAN MOBILITY

CONNECTED AND AUTONOMOUS VEHICLES AND SHARED STREETS CAN HELP MEET CITIES’ TRANSPORTATION GOALS.

THE FUTURE WITH DRIVERLESS CARS IS FAST APPROACHING, and how cities around the world respond depends greatly on a variety of factors such as their unique cultural heritage and types of infrastructure. According to Arcadis, a global design and consultancy firm for natural and built assets, a “one size fits all” approach is to be avoided because it would not deliver the full extent of the opportunities available and may not ensure that the special character of a city is protected.

Arcadis released a report — Citizens in Motion (www.arcadis.com/en/global/our-perspectives/connected-and-autonomous-vehicles/citizens-in-motion) — that looks at the mobility needs in 14 global cities and to what extent connected and autonomous vehicles (CAVs) can be leveraged to meet transportation goals. According to Arcadis, while CAVs have the potential to vastly improve urban mobility, they can also possibly make congestion worse, or threaten the viability of vital public transport services, thus affecting citizens’ ability to travel.

When cities design solutions that leverage new technology in transportation, inclusivity and accessibility for all citizens is paramount to avoid creating a two-tier public transport society, Arcadis said. The established mobility blend in any city represents huge investment from the private or public sector, but a disruption like CAVs could threaten to deprive existing providers, like taxi or bus companies, of income. City governments must engage with the private sector to find a solution that strengthens, not weakens, the whole network.

The Citizens in Motion report refers to levels 4 and 5 of autonomy in electric vehicles (EV), where vehicles communicate with each other as well as with the environment around them without the need for a human driver to intervene. It provides an individual profile of 14 global cities and analyses each city’s urban mobility objectives, infrastructure readiness, CAV initiatives in place, and citizens’ openness to their adoption.

Specifically, the three areas examined in each city were citizen connection, governance platforms, and enabling infrastructure. Key points were identified as elements that may or may not support the development of CAV-based solutions as a means of achieving a city’s mobility objectives. Progress toward a fully operational CAV environment is currently at different levels of maturity across the globe.

The fundamental commonality among the 14 cities evaluated in the report is an aim to have urban mobility functions that are healthy and safe, citizen-centric, green and sustainable, accessible, investible, and smart. The degree to which CAVs can help solve mobility challenges varies per city, and Citizens in Motion outlines recommendations for each to progress toward this.

“Cities across the world are grappling with congestion, overcrowded transport, poor air quality, and the need to drive greater prosperity, competitiveness, and improve the citizen-experience,” said John Batten, Global Cities director at Arcadis. “The emerging CAV revolution opens a new frontier of disruption in transportation and urban living, beyond existing examples such as Uber. For our cities, exclusively electric connected and autonomous vehicles will present a huge opportunity to radically transform urban mobility.”

Shared streets
In late September, Ford Motor Company, Uber, and Lyft announced a commitment to SharedStreets (https://sharedstreets.io), a new data platform designed to make it easier for the private sector to work with cities around the world and leverage data to improve urban mobility. The data sets pledged by the companies will provide the public and private sectors with new tools to manage curb space in order to reduce congestion and emissions, improve the efficiency of city streets by making it easier for everyone to get around, and save lives by preventing traffic crashes, the companies said.

The public-private partnership is the result of a collaboration with the National Association of City Transportation Officials (NACTO), the Open Transport Partnership, and Bloomberg Philanthropies, the consortium behind the SharedStreets data platform. Launched earlier this year with funding from Bloomberg Philanthropies, SharedStreets is a universal data language for sharing information about city streets and a launching pad for public-private collaboration to manage streets, reduce traffic deaths, and prepare cities for emerging technological advancements. Already operating in more than 30 cities around the world, the SharedStreets platform and this new partnership will provide city leaders with new instruments for managing transportation networks.

“This is a once in a lifetime opportunity for business and government to work together to rethink transportation,” said Jim Hackett, president and CEO, Ford Motor Company. “Collaborating through initiatives such as SharedStreets will enable us to use vehicles, road systems, and data together to create a new roadmap for mobility. We are working toward a future where all cities are smart and curb space is actively managed, increasing efficiency and safety, while reducing driver stress and pollution.”

Information provided by Arcadis (www.arcadis.com) and the National Association of City Transportation Officials (www.nacto.org).
IMPLEMENTING A BIM PROCESS FOR EXISTING BUILDING PROJECTS

3D MODELING APPLICATIONS HELPED COPENHAGEN AIRPORT A/S ACHIEVE A 4.46 PERCENT COST SAVINGS

THE COPENHAGEN AIRPORT A/S wanted to implement building information modeling (BIM) processes on its upcoming projects to prove that utilizing BIM methodologies would be a beneficial investment. Most of the airport’s projects are the operation, maintenance, and refurbishment of existing buildings, but the airport still wanted to see the benefits of BIM workflows.

The DKK 10 million initiative included producing information-rich 3D models of the facilities based on a combination of 2D drawings, surveys, and field inspections. The project also called for creating BIM process standards, including specification of a level of detail (LOD) for new building projects.

The project team wanted to prove that using BIM processes throughout the project would benefit the building owner by saving cost. According to a 2012 report from the Danish Technical University, building owners who implemented a BIM process achieved a cost savings of approximately 12 percent. To prove that they could also achieve savings, team members set a goal to save at least 4 percent of the entire project’s budget, as their BIM processes would not be as mature as others in the study.

The main challenge for the Copenhagen Airport project team was that BIM processes in Denmark were not well established. To overcome this challenge, the organization collaborated with different companies to hear other views on the best way to implement BIM methodologies. By speaking with these different organizations, the project team produced a standard for future BIM process creation that would help it and other Danish organizations prepare for and benefit from BIM adoption.

Setting standards
To create an effective model, Copenhagen Airport looked at existing LOD definitions to create their models, making sure to include the right amount of information to benefit both operators and consultants. Many of the existing definitions lacked the idea that much information can be obtained with data on less detailed objects. The project team decided to include graphical and non-graphical information in the definitions, with more non-graphical information than seen in other standards.

The team created a 3D model that included the important information from the 2D drawings, which it used as a baseline. Engineers also visited the sites and added any 2D information that was missed or incorrect. The team adopted its new BIM processes on this model, including the parameters on all surveyed objects. Additionally, all project participants were taught how to accurately use the model to gather information.

By using Bentley applications to help create a 3D model and an innovative BIM process, Copenhagen Airport’s project team saw significant time savings. The team quickly extracted heights with MicroStation’s...
The project came with a built-in challenge — a key component of Germany’s industrial and clean power infrastructure that was due for maintenance and repairs. Normally, such an effort would involve detailed inspection and planning prior to the work. But in this case, the worksite was a canal filled with fast-flowing water — and it needed to stay that way as much as possible.

The canal operators faced a paradox: How do you develop a strategy to repair and maintain something that you can’t see or access? The answer would come from a small group of surveyors and engineers using an array of geospatial technologies.

Bentley applications also helped improve collaboration with stakeholders, creating a web platform to exchange information and invite external people to participate in collision and consistency control. With weekly updates, everyone involved in the project knew its status and could easily access the necessary information. Bentley’s applications made it easy to manage contributions from all involved parties while still working to coordinate systems issues.

Preparing for future projects
By incorporating BIM processes for all projects at Copenhagen Airport, the project team used the model to extract quantities for the contractors, which reduced the risk, and thereby the bidding. Together with detecting and correcting unhandled collisions before completions, the team could calculate the benefits.

The organization calculated the difference between using the BIM process and not, and realized a benefit of 4.46 percent cost savings. Since 4 percent was its goal, the organization proved the effectiveness of a BIM process and received a mandate to continue using the process for all projects.

The surrounding community will also see the benefits of Copenhagen Airport’s project, providing insight into how Denmark might use BIM processes for future endeavors — especially since Copenhagen Airport is one of the largest building sites in Denmark. Therefore, if the airport could realize major benefits, then other organizations would realize the benefits as well. The airport set a goal in actively contributing to helping other large building owners mature their BIM processes and increase their level of implementation.

MAINTAINING A SMOOTH FLOW

Bavarian Surveyors Use a Multi-Pronged Approach to Support Critical Infrastructure.

By Erik Dahlberg

THE PROJECT CAME WITH A BUILT-IN CHALLENGE — a key component of Germany’s industrial and clean power infrastructure that was due for maintenance and repairs. Normally, such an effort would involve detailed inspection and planning prior to the work. But in this case, the worksite was a canal filled with fast-flowing water — and it needed to stay that way as much as possible.

The canal operators faced a paradox: How do you develop a strategy to repair and maintain something that you can’t see or access? The answer would come from a small group of surveyors and engineers using an array of geospatial technologies.

Existing level of detail definitions were used to create the models.

ability to handle large point clouds, even when the surveyor was not present on the construction site. Users also joined IFC and DGN files, which helped execute the project faster because the original 2D drawings were in DGN format. There was also greater quality control over the information because the 2D data was included in the 3D models.

The team used ProjectWise to house all relevant information, including the 2D data, which helped users easily find information. Previously, team members would have spent unnecessary time searching through thousands of documents.

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Information provided by Bentley Systems (www.bentley.com).
Located in southern Bavaria, the Alzkanal carries water from the Alz River to the Danube River in the city of Burghausen on the Austrian border. The 40-km (26-mile) canal was commissioned in 1923 to supply water for three hydroelectric power stations. The stations are the primary power source for industrial facilities along its route. In addition to hydropower, the canal’s water provides fire protection for the surrounding communities.

Like any large infrastructure, the Alzkanal requires periodic maintenance. Canal operators have performed inspection and maintenance at roughly 20-year intervals, with the last major work taking place in 1998. During maintenance, the canal is cleaned and any cracks or damaged areas are filled and sealed.

But the maintenance is costly. In addition to the expense of materials and labor for repairs, the canal must be shut down and drained during the work. During that time, electricity users must purchase power from other — more costly — sources, and municipalities need to find alternative sources for fire protection water. As a result, it’s imperative to keep the shutdowns as brief as possible.

Maintenance was scheduled for a 16.8-kilometer (10.4-mile) section of the canal. The shutdown was planned to last eight weeks. The schedule was inflexible due to the cost of the shutdown. Because the canal was kept full, it wasn’t possible to perform any pre-shutdown inspections. The uncertainty and strict time constraints put pressure on the contractors tasked with inspection and repair. It was especially intense for the surveying teams, which needed to quickly provide comprehensive information on the condition of the canal and surrounding features and structures.

The canal operators selected SAK Ingenieurgesellschaft GmbH, an engineering and surveying consultancy located in nearby Traunstein, to provide surveying and related services for the canal refurbishment. According to SAK’s Christian Fendt, the company was responsible for surveying the canal before and after the renovation. Prior to starting the work, SAK consulted with the owner to determine the scope and requirements for the survey, which would document existing conditions and provide data for structural analyses and construction planning.

The survey needed to provide precise measurements of the channel surface at a point density of 2 cm (0.06 foot). In addition to surveying the channel, SAK was asked to provide 3D data extending out 100 meters (330 feet) along both sides of the canal. The work would involve technologies including aerial imaging, photogrammetry, total stations, and static and mobile laser scanning.

“Preplanning for construction was very limited because the channel is always full of water,” Fendt said. “The owner and contractors needed detailed information to perform the repairs. We had a very tight time frame to survey the channel to produce the required data.”

**Coordinated actions**

Surveying began with a combination of GNSS and optical surveys to establish fixed control points for horizontal and vertical positioning. Two weeks before the shutdown, SAK used Trimble R10 GNSS receivers and a Trimble S8 1” total station to set points that would control aerial imaging and ground-based measurements. They installed 156 control points at intervals of roughly 300 meters (1,000 feet) on both sides of the canal. Additional control was created near bridges over the canal.

The canal gates were closed on a Friday afternoon and the water level dropped rapidly. By Monday morning, much of the channel was exposed. SAK started work using a Trimble UX5-HP unmanned aerial system (UAS). They completed eight missions over two days and captured nearly 5,100 images covering the entire length of the project.

SAK had designed the aerial work to move quickly. For example, the first mission covered 3.2 kilometers (10,500 feet) in one flight and captured 810 images at a height of 100 meters (330 feet) above the ground. When the UX5 landed, data was downloaded and immediately taken by motorcycle to the SAK office while the aircraft was cycled to start its next flight.
The data was loaded into Trimble UASMaster software as soon as it reached the SAK office. Technicians extracted tie points and created and stitched together multiple point clouds. Fendt said they could produce finished orthoprojections of the site in roughly seven hours after the raw data arrived. SAK technicians also produced digital terrain models of the canal at the required 2-cm ground density. In areas where the channel wasn’t visible from the air (the channel passed through two tunnels), they used a Trimble TX8 laser scanner to capture detailed data. By Tuesday afternoon, SAK had captured comprehensive data for the entire channel.

When the aerial work was complete, contractors swarmed over the channel to repair cracks and damage to the concrete and asphalt surface. SAK again turned to their TX8 laser scanner. As construction progressed, SAK scanned each completed segment, complementing the scanning with total station measurements to georeference the scans and capture parts of the channel that were beneath bridges or still underwater. They used Trimble RealWorks software to combine UAS, scanning, and point data and to manage and analyze the survey results.

**Optimized results**
The scanning data provided precise “before and after” models of the channel and supported analysis of the work. Because the contractors were paid according to the size of cracks and volume of materials, they needed rapid, accurate results.

“We were on the construction site every day and included in most of the project meetings. This resulted in a demand for additional surveying services from the contractors including mass calculations, preservation of evidence, and layout.”

After the eight-week shutdown was completed, SAK surveyed the surrounding above-ground elements (fences, canal stationing, and related data). In addition to the static scanner and total station for this work, SAK tested mobile mapping solutions using vehicle and cart-mounted technologies. “The mobile scanning solution from Trimble (TIMMS) shortens the time for scanning and would have been a good option in the channel,” Fendt said.

Finished deliverables included point clouds, digital terrain models, cross sections, and georeferenced raw scanning data. In reviewing the work, Fendt attributed the project’s success to their ability to blend multiple technologies (UAS, scanning, GNSS, and total stations) into a single solution. “Since the project worked well, we would use the same approach again,” he said. “Through good planning and cooperation, small teams can handle huge projects and tight schedules.”

**THREE GPS BENEFITS**
LOCATION AND SPATIAL DATA CAN IMPROVE PRODUCTIVITY, SAFETY, AND SURVEYING FOR HEAVY CIVIL CONSTRUCTION.
By Joshua Progar

**DOES THE PHRASE “OVER SCHEDULE AND OVER BUDGET” sound familiar to you?** Unfortunately, if you work in heavy civil construction, it probably does. While the segment struggles with issues that plague the entire construction industry — such as labor shortage and slow technology adoption — it also has unique challenges arising from the nature of infrastructure work. Projects often take place across very large distances and in environments that lack internet access for connectivity such as underground, outside, or underwater. In these situations, workers typically need more connectivity to their offices and to their managers than say, commercial builders, but they usually have less of it.

This dynamic might help explain why large infrastructure projects cost 80 percent more than budgeted and run 20 months late on average, according to IHS Markit. With taxpayer dollars helping fund these projects, the additional time and money spent has to be minimized.

**ERIK DAHLBERG** is a writer specializing in the geomatics, civil engineering, and construction industries. Drawing on extensive training and industry experience, Dahlberg focuses on applications and innovation in equipment, software, and techniques.
The heavy civil segment can recapture some of that time and money with the latent communication capabilities GPS provides. GPS signatures provide coordinates pinpointing the exact location of a given subject. This location tracking, which works offline as well, can help create a record of where project workers and equipment are at any given time, and enables a wealth of time and money-saving capabilities.

There are at least three reasons why GPS is important for heavy civil construction.

**Increase productivity**
Understanding the link between GPS and productivity can be a bit of a head scratcher. How can just knowing where people and equipment are increase efficiency and output?

For one, managers and workers can better maintain budgets. Contract workers like those on civil infrastructure projects are often paid by the hour, and if each worker is identifiable through a GPS signature, both parties can maintain an automated record of how many hours are worked onsite; managers can ensure workers are paid accurately for their time onsite, and workers can ensure they are paid thoroughly. The transparency and accountability that GPS helps establish for payments also helps strengthen working relationships to reduce time and money spent on conflict resolution related to payments.

Additionally, project teams can save time using GPS. By coupling GPS with sensors, project managers and field workers can view where equipment and vehicles are located at all times. This tracking can help them ensure equipment and vehicles are readily available whenever and wherever they are needed, avoid traffic, and maximize fuel economy on large projects where long distance travel is required.

**Enhance safety measures**
Conditions in heavy civil construction are often dangerous for workers and others who may come in contact with the project. Jobsites can include major earthmoving, exposed electric and gas lines, threats of potential collapse underwater and underground, inclement weather, and lack of mobile or internet connectivity.

In conditions where communication capabilities are stifled, safety measures are imperative. GPS, which also works offline, can serve as a communication tool enabling safety. Having access to site workers’ location and movement data can help alert office staff when workers encounter emergency or dangerous conditions. It can also help facilitate the use of alerts for workers themselves, notifying them when approaching hazardous areas such as structures that haven’t been reinforced, or traveling too far away from areas that potentially require timely attention, such as concrete pour sites requiring periodic adjustments.

**Improve site surveying and recording**
Given the sheer size of many heavy civil projects, it can be difficult to chart progress. This is particularly true during the preconstruction phase when there aren’t any visual markers identifying locations across the work site. GPS provides the spatial context needed to pinpoint a particular location.

For example, imagine a highway project where teams have to identify unique locations across tens of miles that have many visual similarities. If teams are able to reference GPS signatures on digital site images, they can easily recognize where work needs to take place on the ground during the preconstruction phase, and then where work has been completed during the construction phase. What’s more, construction software can automatically link the images as references in digital plans so what might otherwise be guesswork becomes a useful system for showcasing specific areas of progress.

Images with GPS signatures also help workers and management avoid traveling hundreds of miles to survey remote jobsites because they can do so digitally and adjust plans as necessary from wherever they are.

Additionally, gathering a record of images appended with GPS signatures is useful for project hand-off. These records, also known as as-builts, are necessary for auditors to conduct ongoing maintenance on infrastructure during facilities management — tunnels and bridges, for example. GPS’s accuracy helps relieve auditor frustrations around comparing outdated drawings to existing infrastructure, and trying to solve for location-related discrepancies, especially when so much of the infrastructure gets buried or covered in concrete. As-builts also become easier to create because site images can automatically be grouped together by their GPS signatures.

**Bottom line about GPS**
Like professionals in other industries and other construction segments, heavy civil construction experts need the best value on the shortest timelines. In fact, they need this more than other industries and segments, given that funding often comes at the expense of taxpayers. GPS enables them to do just that. When applied appropriately to construction technology, GPS is critical to improving project efficacy through productivity, safety, and detail-tracking.

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**Joshua Progar** is the lead customer advocate at PlanGrid (www.plangrid.com). He studied architectural engineering, joined the construction industry as an architect, and later became a construction manager. His passion for technology, innovation, and process improvement for the construction industry led him to PlanGrid, where he works with the sales team to ensure clients are using the product to its full potential.
THE AMERICAN INSTITUTE OF STEEL CONSTRUCTION’s (AISC’s) new Night School course, Steel Construction: From the Mill to Topping Out, takes an in-depth look at the entire steel construction process, from the manufacturing of steel to completion of the structure. Each session covers a distinct topic related to steel construction, presented by an expert on that particular phase of construction. Design engineers will come away with the knowledge of all phases and of the roles of all players in the steel construction process, so that they can be more efficient in their own role. This eight-session course began Oct. 15 and runs through Dec. 10.

The course opens with a look at the practical aspects of steel production and continues with an in-depth view of steel fabrication and erection, as well as the engineering aspects of both of these critical construction operations. The course finishes with sessions on field fixes, quality control, and quality assurance.

Night School is a curriculum of courses on various structural steel design and construction topics. Each course consists of eight sessions presented as 90-minute webinars. Attendees can either register for the entire eight-session package ($500 for AISC members, one attendee per connection) and earn up to 1.2 CEUs/12 PDHs upon passing a series of quizzes and a final exam; or they can register for individual webinars ($185 per session for AISC members), with an unlimited number of attendees per connection, and receive 0.15 CEUs/1.5 PDHs per session.

For more information and to register, go to www.aisc.org/nightschool.

Seismic design


Part 1 now includes a sample set of plan and detail drawings showing how the designer can indicate the SFRS to the steel fabricator and erector. The tables in this part also incorporate the latest in larger rolled steel shapes and high-strength steel grades.

Design examples have been developed in Part 4 for special moment frame systems to reflect updates to the Seismic Provisions. These examples provide guidance for bracing a beam in a moment frame, designing a bolted flange plate connection, and designing a special truss moment frame system.

The new design examples in Part 5 address multi-tiered ordinary concentric braced frames and connection design for buckling-restrained braced frames. The Seismic Provisions updates to ordinary and special composite shear wall systems are reflected in Part 7.


The 2016 Seismic Provisions and Prequalified Connections documents, along with all other AISC standards, are available for free download at www.aisc.org/specifications.

Designers also can visit the technical resources page that is specific to seismic applications at www.aisc.org/technical-resources/seismic. A number of other useful resources that supplement the use of the Seismic Design Manual and the Steel Construction Manual are available at www.aisc.org/publications/steel-construction-manual-resources. AISC also posts archival NASCC conference proceedings, many of which are on the topic of seismic design, at www.aisc.org/educationarchives.

Information provided by the American Institute of Steel Construction (www.aisc.org).
01. SLUDGE THICKENER FOR WASTEWATER

Centrisys Corporation said its Centrisys/CNP THK sludge thickener offers lower life cycle costs, less or zero polymer, higher G-volume for higher capacity, and less redundancy, as well as up to 50 percent less power consumption compared with standard dewatering centrifuges. The THK sludge thickener is designed and built specifically to thicken both primary and waste activated sludge using the fundamental principles of a centrifuge, dissolved air flotation thickener (DAFT), and rotary drum thickener. According to Kenosha Water Utility, a THK200 installed in 2011 replaced four DAFT units, operated 24/7 using no polymer, and achieved 5 percent TS cake and 95 percent capture.

CENTRISYS CORPORATION
WWW.CENTRISYS.COM

02. STRUCTURAL STEEL CONNECTIONS

Simpson Strong-Tie introduced the Yield-Link connection to simplify and streamline structural steel connections made in the field without compromising structural strength. The Yield-Link connection requires no field welding, resulting in reduced onsite labor costs, licensing fees, and construction time. The Yield-Link is designed to absorb forces in a seismic event, and as a bolted connection, is easier to replace than welded beams and posts, greatly simplifying repairs following a natural disaster. Software plugins and design support services are available. The Yield-Link is a prequalified connection for steel special moment frames in ANSI/AISC 358-16 and is code listed in ICC-ES ESR-2802.

SIMPSON STRONG-TIE
WWW.STRONGTIE.COM/YIELDLINK

03. THIN-ASPHALT OVERLAY GUIDE

The National Asphalt Pavement Association’s Thinlays for Pavement Preservation provides guidance on the use of thin asphalt overlays as part of a pavement preservation program. Thinlays, a suite of thin-asphalt overlays designed specifically for pavement preservation, provide road owners with a cost-effective way to preserve pavement life, correct minor distresses, and improve the performance and life of a road. Thinlays for Pavement Preservation provides guidance on the proper use of Thinlays, including how they fit within pavement management systems, when and how they should be used based on existing pavement condition, how Thinlay mixes should be developed and specified, and best practices for Thinlay construction.

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FOR MANY YEARS, the water sector has lagged significantly in the use of building information modeling (BIM) behind the vertical building sector. However, a new study published in The Business Value of BIM for Water Projects SmartMarket Report demonstrates that the tide is turning as owners and project teams begin to experience the benefits of BIM.

In the landmark 2012 study, The Business Value of BIM for Infrastructure SmartMarket Report, Dodge Data & Analytics looked at the emergence of BIM use in the infrastructure sector. While the sector lagged in BIM use behind the building sector at that time, water was particularly slow to embrace BIM — with only 30 percent of respondents reporting that they implement BIM on over half of their water projects — significantly fewer than those in other infrastructure sectors.

However, the new Business Value of BIM for Water Projects SmartMarket Report (www.construction.com/toolkit/reports/business-value-bim-water-projects), published in spring 2018 by Dodge Data & Analytics in partnership with Autodesk and Black & Veatch, with additional support from e-Builder and Pinnacle Infotech, reveals that high BIM implementation is now quite common for at least two types of projects: water/wastewater treatment facilities and mining/industrial projects. In fact, nearly half of engineers, contractors, and owners using BIM for these two project types do so on the majority of these projects (more than 75 percent). In addition, water/wastewater treatment facilities will see even higher levels of implementation within two years, with almost two thirds (61 percent) of those using BIM on these facilities expecting to use it on more than 75 percent of these projects.

This high level of BIM implementation, though, is not universal across the water sector. Tunneling, linear infrastructure, and hydroelectric projects lag significantly behind water/wastewater treatment facilities and mining/industrial projects, both in terms of BIM use in general and in levels of high implementation. However, those using BIM in these lagging project types expect to dramatically ramp up their level of BIM use within the next two years.

To be clear, these findings are not an indication of the level of adoption of BIM in this sector; they only represent the responses of those already using BIM for water projects. However, understanding the degree to which those currently using BIM for water projects find that it adds value is particularly helpful, given the challenges this sector has faced in embracing BIM. The findings reveal that BIM users in this sector are deeply committed to completing water projects with BIM, a commitment that grows as they are exposed to the benefits of working with BIM.

The study also demonstrates that BIM users report a lot of project and business benefits from using BIM for water projects. The top business benefit is the way that BIM enhances the ability for teams to work collaboratively, and the study shows that this enables benefits such as better design solutions, reduced errors and omissions, better ability to maintain quality, and increased client satisfaction.

One surprising finding in this study is the degree to which owners of water facilities are already interested in the ways in which they can capitalize on the 3D model during the operations phase, even though BIM use is still maturing in this sector. The use of BIM in the operations phase of these facilities suggests that facility owners may be the most important drivers of wider BIM adoption for water projects in the future. Right now, its appeal to owners means that BIM can offer a competitive advantage to engineers and contractors in the water sector. Eventually, it may become increasingly necessary to do work in this sector at all.

DONNA LAQUIDARA-CARR, PH.D., LEED AP, is Industry Insights research director, Dodge Data & Analytics (www.construction.com), North America’s leading provider of analytics and software-based workflow integration solutions for the construction industry.
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