2019 RISING STARS

10-DIMENSIONAL: MIKE DEBACKER
WHAT’S NEW IN ACI 318-19
A MARINA IN NEW YORK HARBOR
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I’m honored to present the 2019 class of Rising Stars, 20 of the industry’s best in civil and structural engineering. This year’s candidate pool, as it has been for eight years now, was wide and deep, and it took our jury weeks to select the winners. With the process complete, I’m comfortable saying that this year’s group is as good as it’s ever been.

While the essential format of submission and judging remained the same, there was one big wrinkle: Fewer engineers made the list. We pared it down from 26 to 20. Six might not seem like a big number, but in this context it is, as the club for Rising Stars became a bit more exclusive to join. If your candidate did not make the list this time around, I encourage you to resubmit for 2020. A lot can happen in a year, like a big promotion or the completion of an important project – something that could give your nominee the superlative he or she needs to stand out in a competitive crowd.

The awards will be conferred at the industry’s largest and most prestigious awards celebration, the ELEVATE AEC Conference and Awards Gala in Las Vegas, October 2-4, 2019.

As I looked at this year’s list, I couldn’t help but feel plenty of pride and validation. In keeping with Zweig Group’s mission to Elevate the Industry, the class of 2019 embodies the mission’s five key tenets – Educate, Diversify, Celebrate, Promote, and Change. Our Rising Stars are based in the big markets of Los Angeles, New York, DC, and Philadelphia, but also in heartland areas like Minnesota, Wisconsin, Kansas, and Kentucky. Fields of expertise include academic research, bridge building, wastewater, landfill, environmental protection, interstate traffic, and earthquake resiliency. Collectively, they do it all. Men and women, those from the United States and abroad, they are mentors, educators, and cheerleaders, as well as hard-nosed doers with monster workloads who know how to deliver. They employ tried-and-true techniques but also have the confidence and ability to chart a new course.

One thing, among many, that caught my attention was the age of the candidates. Due to the award guidelines, nominees must be under the age of 40. That being the case, most were in their 30s while some were in their 20s. Reading through the submittals, I was impressed by everyone’s credentials, but nothing, it seems, beats a resume seasoned by a decade or more of experience. By that I mean those in their 30s. Though still young and with the world still in front of them, they have just enough moss on their backs, and just enough arrows in their quivers, to impress a panel of objective jurors. Reflecting the industry at-large, they are the project managers, the team leaders, and the budding C-suiters, the kind of people that every firm covets, the kind of engineer for which every firm recruits and does their best to retain. My advice to those firms that have a Rising Star: Do whatever it takes to keep them on staff because your competitors know who they are and would love to poach them from you.

What also impressed me about the winners was the focus they showed at the beginning of their careers. Starting off as interns while still in college, they were already experienced by the time they graduated. Some of them remain with the firms that gave them their first chance, and now find themselves at a sweet spot in the org chart. The process of career-building is oftentimes compared to the story about the tortoise and the hare. I agree with that analogy. But even if you run the slow and steady race, it never hurts to get off to an early start.

Join me in congratulating the 2019 class of Rising Stars. Read their stories and celebrate their achievements!

CHAD CLINEHENS, P.E., is Zweig Group’s president and CEO. Contact him at cclinehens@zweiggroup.com.
IF YOU TAKE A CROSS SECTION of the firms in this industry, you’ll inevitably see a couple of things – they describe themselves as innovative, and say they truly care for their people. That’s one reason that so many of the strategic planning clients we work with want to win the Zweig Group Best Firms to Work for Award.

That said, when we interview the leadership, employees, and clients of these firms, a number of issues arise that make it seem like those are just buzzwords that sound good in marketing material. Many firms struggle with the challenges of having a disengaged younger staff and battling “the way we’ve always done things.” The constrained labor pool, the looming economic recession, and a perception that we are not doing what’s needed to elevate our professions in the increasingly evolving technological landscape, also lead to a weak response to changing market conditions. I’m sure if you took an honest look in the mirror at how you and your firm operate, these shortcomings may not just seem like someone else’s problem.

Well, here is your next great idea that may help tackle some of those seemingly unrelated challenges. Consider implementing a “Shadow Board of Directors.” This is a group of non-principal/executive level staff members that work with the principal or executive level leadership on strategic initiatives. What function does this “shadow board” serve? It solicits the younger staff’s insights and diversifies the perspectives the leadership of the firm is normally exposed to. Consider the staff development, employee engagement, mentoring opportunities, and ability to innovate if you have younger staff not only vying for a position on this board, but consistently thinking like a business leader with a real stake in the leadership and direction of the firm. It will help develop two of the most important skillsets – effective communication and strategic thinking – someone will need if they are ever going to make it to the principal level, according to a recent survey of Fortune 500 CEOs. Better yet, this system seems to work. It’s not just a feel-good measure; it’s real action you can use to exemplify your firm’s values. It takes the words off of the website and drives them into the culture.

This shadow board should meet regularly with the senior team and be composed of people from various functions throughout the firm. Research suggests that Millennials crave more visibility and access. That is exactly what a shadow board delivers. It sets you apart in your recruiting and retention efforts. This often becomes your pool of second-tier leaders that end up being identified for future ownership opportunities. So, what are a few of the “next” practices in implementing a shadow board in your firm?

• **Look Beyond the “High-Potential” Group.** As with mentoring, this isn’t simply an exercise for those you’ve already identified as high performers. Allow anyone that meets your pre-defined criteria, and who has a passion to do so, apply for a seat on the board. This will lead to a more diverse set of individuals and the possible discovery of someone within your organization that you hadn’t recognized up until that point. Often, only choosing high performers means you miss out on those with the highest performance in skillsets such as data analytics, complex or strategic thinking (how do the pieces fit together), and team-work.

• **Be Sure it is Vigorously Supported by Firm Leadership and Directly by the “CEO.”** In order for this to work, as with many strategic initiatives, support needs to come from the top. The majority of the execution happens elsewhere, but the firm needs to know that this is important to the managing principals for it to have real impact. Principals should be interacting, interviewing, and playing an active role with potential members.

• **Evaluate, Iterate, and Figure out What Works.** You may not get it right the first time. There will be a learning curve as you seek to implement this into the existing culture of your organization. How long are appointments, who is included, is the group the right size, and is it diverse enough? These are questions that will need answers. We suggest reviewing the program on a semi-annual basis for the first two years and then annually to ensure that it is meeting the goals for which it was established.

If you are interested in forming a shadow board, we’d like to hear from you.

PHIL KEIL is director of Strategy Consulting, Zweig Group. Contact him at pkeil@zweiggroup.com.
In Dallas, a Court Case

In June, a case involving a very big engineering firm was moved from state court in Dallas County to US District Court for the Northern District of Texas, Dallas Division. The case, which originated in 2017, has the Big Firm facing a number of allegations, including racial discrimination, retaliation, fraudulent inducement, and breach of contract, from a former joint venture partner, which we’ll call the Little Firm. The Big Firm has denied the claims. Moreover, the defendant asserts that the plaintiff in the case, the Little Firm, sealed its own doom by repeatedly submitting problematic invoices, and that it repeatedly breached contract protocol by communicating directly with the joint venture’s client, the Texas Department of Transportation.

“Plaintiff’s alleged losses and damages, if any, are the result of, and directly related to, plaintiff’s own conduct, actions and/or failure to act, and not of the Defendant’s conduct, actions or failure to act. Plaintiff’s own acts or omissions were the sole proximate cause or a proximate cause of their damages, if any,” the Big Firm said in one of its filings.

The case was moved from state to federal court because the Little Firm filed a third amended state petition in May adding a new plaintiff, the Little Firm’s owner, and new allegations tied to that person as an individual. The Little Firm’s founder was not party to the original complaint, which was filed by the firm itself. Nonetheless, the Little Firm and its founder are seeking monetary damages of more than $1 million, in addition to punitive, compensatory, and other damages. Trial is currently set for January 2021 at the federal building in Dallas.

So, let’s go back to the beginning. It’s 2015, and the Big Firm, the Little Firm, and a third firm formed a joint venture before bidding on and winning a five-year, $20 million contract with TxDOT, according to court documents. Under the terms of the agreement, as the joint venture’s sponsor, The Big Firm was supposed to get 80 percent of the contract work, and the two smaller firms were supposed to get 10 percent each. But in the court filings, the Little Firm claims that it and the other small firm, both certified Disadvantaged Business Enterprises, were essentially cut out of the work, with the Big Firm getting the lion’s share of TxDOT payouts. According to the complaint, from the beginning of the contract the Big Firm began “assigning the work to itself and some of the subcontractors in excess of the contractually limited entitlement of 80%.”

On top of the alleged problems with the contract and billing, the plaintiff also contends that its minority employees were “subjected to racially disparate treatment/harassment” from the Big Firm’s employees, with instances including denial of access to equipment and office space, and rude comments. This treatment of its employees, the Little Firm claims, only heightened the frequency of the complaints it made about the Big Firm. According to court filings, the Big Firm finally terminated the Little Firm from the joint venture in summer 2017. A few weeks later, the Little Firm sued for breach of contract, and amended the complaint a few months later to include the allegations of racial discrimination and retaliation. A year after the initial filing, the complaint was amended a second time, and included the Little Firm’s take on the state of affairs: “No non-minority company was similarly mistreated by [the Big Firm].”

In subsequent filings, the Big Firm tells a completely different story. In a sworn affidavit from one of the firm’s division vice presidents, the employee says the Little Firm started out, and remained on, the wrong foot. Shoddy invoices, billing for overhead instead of engineering services, and going around the joint venture’s sponsor – the Big Firm – to communicate directly with TxDOT officials, were the norm for the Little Firm, according to court documents. And it’s that behavior, not the minority status of the Little Firm and its owner, that led to the sacking in 2017. Furthermore, the Big Firm says it acted in “good faith, without any improper motive, purpose or means, and/or without any hatred, ill will, malice, intent to injure, or reckless disregard of the rights of the plaintiffs.”

Some joint ventures work out, and some end up in court. As we all know, partnerships can “go south” at anytime for any reason. Obviously, this case is a bit different. You have a really Big Firm, one of the largest DOTs in the United States, and a Little Firm that claims it’s been wronged. This case promises drama. It will eventually go to trial and a jury will decide who’s right and who’s wrong, or if it was all just one big misunderstanding. On the other hand, this case could get settled long before jury selection begins, avoiding a messy public spectacle for a lot of people. Our bet is on the latter.

If you know of an interesting or off-kilter story taking place in the AEC industry, please contact C+S at rmassey@zweiggroup.com.
AUGUST 2019

THE OPERATION & MAINTENANCE OF STORMWATER CONTROL MEASURES
AUG. 4-7 – MINNEAPOLIS, MN

The conference—an outgrowth of more than a decade of international low impact development conferences—addresses the growing need for state and municipal staff, regulators, consultants, and more, to share successes and lessons learned around stormwater operation and maintenance (O&M).
https://www.omswconference.org/about

IDETC-CIE
AUG. 18-21 – ANAHEIM, CA

IDETC/CIE 2019 will highlight emergent technologies that impact the critical engineering issues of product design and development, manufacturing, and the management and integration of information systems throughout the product life-cycle. These events are key international meetings for design and manufacturing engineers in academia, government and industry.
https://event.asme.org/IDETC-CIE

LEARN THE LANGUAGE OF BUSINESS
AUG. 20 – HOUSTON, TX

This course provides an overview of business financial management – specifically tailored to our industry – to help firm leaders make informed decisions.
https://free.zweiggroup.com/events-and-seminars/

STRATEGIC DEVELOPMENT COUNCIL TECHNOLOGY FORUM
AUG. 27 – PITTSBURGH, PA

SDC Technology Forum will include several technology showcases that highlight new and innovative equipment, materials and applications that will have the potential to advance the industry, including are fiber-reinforced polymer composite macro fibers used in precast concrete, strengthening bridges and existing concrete structures using titanium, integrated design of chemical admixture systems via machine learning, opportunity for improved productivity & quality with robotics, machine learning – prediction of concrete performance from mixture proportions and, integrating traditional civil engineering with artificial intelligence.
https://www.acifoundation.org/sdc/forums

HIRING AND KEEPING GREAT TALENT
AUG. 28 – DALLAS, TX

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ELEVATING DOER-SELLERS
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SEPT. 17 – SCOTTSDALE, AZ

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OCT. 2 - 4 – LAS VEGAS, NV

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ELEVATING DOER-SELLERS
OCT. 10 -11 – HOUSTON, TEXAS

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"...SAYS HERE YOU PAY ME BELOW INDUSTRY AVERAGE FOR SOMEONE WITH MY TITLE."

"OK - I'LL CHANGE YOUR TITLE."
Mike DeBacker sees the future of transportation from many different angles. Technology will certainly play a role in the ongoing challenge of moving goods and people from Point A to Point B: Electric vehicles, autonomous vehicles, micro-mobility, and the associated network of smart infrastructure and devices. But DeBacker also sees a more traditional factor – funding – playing a role. A waning federal gas tax, gridlock in Washington, and a crumbling web of roads and bridges, are creating the perfect storm in which decision makers and asset owners will increasingly look to the state and local levels for answers, and will consider alternative forms of financing and project delivery to get their improvements underway. And DeBacker, as the new general manager of the Transportation Global Practice at Burns & McDonnell, will no doubt be part of the unfolding story.

A 30-year veteran of transportation, DeBacker assumed his new position in July, when former general manager Ben Biller retired. Backed by a powerful, 7,000-person firm with a robust culture fueled by employee ownership, DeBacker said he and his team are well equipped to compete and succeed. Here are his thoughts on where we are, where we are going, and how we are going to get there.

Civil + Structural Engineer: You have nearly 30 years of experience in transportation policy, planning and design. What is the critical challenge ahead for this country as it faces deficiencies in transportation infrastructure across the board – land, air and water?

Mike DeBacker: First, I want to say how fortunate I feel to have spent my entire career focused on transportation – one of the biggest drivers of the economy.

There is no question our main challenge is the fact that we are nearing or even past the original design life of most of the surface transportation infrastructure built during the Interstate era. The vast majority now requires replacement or major rehab.

We could have met the maintenance demand for this system if the federal fuel tax levels had been indexed for inflation. But they were not, and the last federal fuel tax increase was in 1993, putting the rate at 18.4 cents per gallon. Since that time, buying power is now about 50 percent of what it was then. We are living in a perfect storm in which government-mandated standards for increased fuel economy are resulting in lower fuel tax revenue. This, combined with a lack of indexing for the fuel tax, is leaving us further and further behind. And now, with electric vehicles on the way, it is obvious we need to look at new ways to fund surface transportation infrastructure.

How this occurs will probably look different in each state and region, depending on how citizens view transportation. Some may fund the improvements with increased fuel taxes; others, with tolling or sales taxes. Transportation development districts also are coming, and some states are turning to general revenue allocations. It’s interesting that most of the momentum is occurring at the state and local levels.

C+S: Trends in transportation are certainly following the arc of technology. In your new role, how are you going to incorporate technology as you partner with clients and policymakers?

MD: Technology will allow us to travel smarter – with both smarter vehicles and smarter transit resulting from efficiencies in signal timing, station stops, etc. We also will have better technology in our hands for smarter routing and shorter travel times, which can relieve congestion and provide more modal choices and integrated choices for transport. Infrastructure is also getting smarter, but technology in our vehicles, in our transit systems, and in our hands will lead the way at this time.

C+S: In terms of policy, what does the federal government need to do to help firms like yours fix the problems plaguing the transportation grid?

MD: Surface transportation is just one of the many challenges and competing interests that policymakers must deal with, and things have become extremely partisan. This is new because infrastructure policy previously has not been particularly partisan. Unfortunately, we are in a hyper-partisan environment right now.

Our policymakers must find the political courage to fund transportation infrastructure or change the model so that it functions more as a public/network utility. This starts with the reality that we will need to pay some catch-up and also acknowledge that the fuel tax is ultimately a declining revenue source. We must look at other user-based options, liking tolling – more of a network utility model moving forward.

Again, we are in a perfect storm with the existing infrastructure that served us well for decades. Back in the early 2000s, it began reaching the end of its life, and now we have deteriorating highways and bridges along with a fuel tax that hasn’t changed at the federal level since 1993. Those factors are combined with federal government mandates for higher fuel economy, which is wonderful in a lot of ways because vehicles are more economical and less-polluting, but it all creates an urgent need for solutions.

So, what we need is some real political courage. In the short term, we need to index fuel taxes. And in the long term we need a new model, such as a user fee model where you pay for what you use. What is interesting is that due to challenges at the federal level, we will see new appropriations at the regional and state levels. Local elected officials and chambers of commerce have come to the conclusion that they must
expect less. So, we are looking to solve our transportation problems locally and at the state level. The challenge with that, of course, is the Interstate system was set up as a network, and without a larger look this will be done piecemeal. There will be funding at those levels long before we see it at the federal level. Even with a new authorization, we still have to have the money, and new revenue will need to be addressed.

C+S: What are a few things you’d like achieve in the next five to 10 years?

MD: One priority is to continue a leadership role in good policy development and to support our clients with our knowledge and experience. We can learn from other industries where Burns & McDonnell plays a leadership role, such as energy and electric transmission and distribution. The public or network utility model is not perfect, but it does provide a level of equity for users, or customers, of transportation to pay for what they use. This is similar to the utility model we use for energy, water, telecommunications, etc., where we pay monthly for what we use, along with some level of fixed payment for being connected to the network.

C+S: You assumed your current role after the retirement of Ben Biller. What did you learn from him, and what’s the importance of having a management succession plan?

MD: Ben continued in a very active leadership role until he left in early July. We have a lot of momentum right now, both as a firm and as a division, and Ben is stepping away with everything in a good spot.

There are a lot of things I’ve learned from Ben, but maybe the most important is to always be consistent in client service. Ask clients what is important. Survey them regularly and make adjustments to bring more value. Ben also has a strong operations capability and taught me a lot about the importance of discipline in project management and expectations for meeting budgets and schedules.

C+S: Since being at Burns & McDonnell, what’s the most challenging project you’ve ever managed and why? What was the lesson learned?

MD: We have many great projects in the portfolio. The ones that stand out are often those with many stakeholders, which means there are different interests that have to be addressed. The projects with the greatest challenges also carry the greatest opportunities. One that stands out is the planning and environmental linkages study, or PEL study, in downtown Kansas City. It brought those opportunities because of its regional impact, involving multiple cities, two states, and many stakeholders. It is a model in which we learned many key lessons about never overlooking any detail when it comes to communications with multiple stakeholders.

It is hard to narrow any particular big milestone project at Burns & McDonnell. There are several big projects that we have been privileged to be a part of. We made a decision several years ago to get into EPC (engineer-procure-construct) and design-build in an intentional and larger way. Now, three years into that strategy, we are really beginning to see the fruits of that labor with project wins and significantly better value for our transportation clients as we take on the entire project under one contract for one owner.

A nice hometown project again is the PEL study, which we called Beyond the Loop, where we did a first-of-its-kind look at the I-70 Loop through downtown Kansas City. It surfaced a wide spectrum of alternatives, from keeping the status quo to completely closing the interstate in downtown and pushing traffic to parallel interstates and repurposing that area for development in the future. This is truly a long-term horizon, looking at years 2030 and 2040 as scenarios. What is interesting is that for the first time in a study I’ve been involved with, we looked at autonomous vehicles, EVs and connected vehicles because we believe those will be quite prevalent then.

C+S: Kansas City is a great American city. You’re part of the Big 5 transportation initiative with the Greater Kansas City Chamber of Commerce. Tell us about giving back to the community where you live.

MD: As co-champion of the Big 5 transportation initiative, I am honored to be in a role that can make a difference. This is an effort with the Greater Kansas City Chamber of Commerce to develop future transportation strategies for the region. It was established in 2011 under our former chairman and CEO, Greg Graves, while he served as chairman of the chamber. The goal of the Big 5 is to focus on critical areas of need in our community – from education to transportation – that can help make Kansas City one of America’s best places to work, live, start a business and grow a business.
It’s been enjoyable to work with my co-champion and the KC Chamber leadership to engage the business community in transportation because we need it and use it every day. One primary initiative is workforce access – connecting people in the central city to job corridors across the metro area. We have some pilot projects under consideration, including looking at how the region can better support transportation investment. We have a strong recent history of supporting transportation ballots for transportation safety, such as education and advocacy on eliminating distracted driving. The community also strongly supports bike and pedestrian corridors and scooter safety. We are working with our delegation of elected leaders and the business community to advocate in those areas.

I have had other leadership roles in the industry, including serving as chairman of the American Council of Engineering Companies for Missouri, participating in the leadership academy of the International Bridge, Tunnel and Turnpike Association and serving in several roles with chambers of commerce and nonprofit organizations.

At Burns & McDonnell, we believe we have an obligation to give back to the communities where we live and work. This goes far beyond serving on committees and boards. It involves corporate and personal giving and volunteer efforts for dozens of organizations across North America.

C+S: Before joining Burns & McDonnell, you were at HNTB for over 16 years. It was your first job out of college. How did your career there prepare you for Burns & McDonnell?

MD: HNTB is a great firm, and I learned a lot during my time there. I gained a good technical background as a young engineer and opportunities for project management on various projects emerged pretty quickly. Young engineers right out of school need to work to build a solid technical knowledge, and I was able to do that there. I was also able to work in several areas of the country, which broadened my perspective in transportation.

Along the way, you decide if you want to continue on a technical track or management. I decided on management, then got my MBA, and it was really a timely degree with what I was doing at HNTB.

C+S: You were recently named general manager of the Transportation Group at Burns & McDonnell. You have been with the firm for nearly 12 years, which means this was a classic example of being promoted from within. What kinds of opportunities exist at a firm like Burns & McDonnell, which is known as a great place to work?

MD: There are truly boundless opportunities at Burns & McDonnell. Our employee ownership culture is real and drives us in many ways. It’s the special sauce that motivates us to make our clients successful. We are entrepreneurial, diverse and can do planning, design and construction. That’s unique in our industry. It’s a special place, and we know it and protect it.

At the industry level, our diversity of business helps us see things across industries. For example, our Transmission & Distribution Group is working on projects that involve building out the electric distribution system in preparation for the wave of EVs that will soon be part of the transportation fleet. Our T&D professionals are working closely with utility clients on battery storage and other trends that have implications for surface transportation. So, we find ourselves working across our entire business to bring owners a lot more value. At Burns & McDonnell, we are 10-dimensional, not just two-dimensional or three-dimensional.

C+S: Personal: spouse, children, hobbies, travel, pets, food, books, music, etc.

MD: I enjoy spending my free time with family – my wife, Darla, and four children: Amy, Josh, Ellie, and Matthew. We enjoy going to games, hiking, skiing, fishing and being on or around the water together. I also spend a lot time on baseball fields and basketball and volleyball courts with the kids’ sports.

Richard Massey is managing editor of Zweig Group publications. He can be reached at massey@zweiggroup.com.
WHAT’S NEW IN ACI 318-19: BUILDING CODE REQUIREMENTS FOR STRUCTURAL CONCRETE
By Jack P. Moehle, PhD, PE

IT’S AN ACKNOWLEDGED FACT that construction practices are changing at a rapid pace. The American Concrete Institute’s recently released ACI 318-19: “Building Code Requirements for Structural Concrete” responds to many of these changes. With a focus on safety, economy and sustainability, it addresses many of the new technologies, products and methods that have become common in recent years.

Seismic Design
New provisions amplify code-prescribed wall design shears based on considerations of wall flexural overstrength and the effects of higher dynamic response modes – the result, in many instances, is a substantial increase in design shears for some walls. The amplified shear forces will better reflect the higher shear forces that have been seen in buildings designed by nonlinear dynamic analysis methods.

Based upon laboratory tests as well as observed behavior of structural walls during seismic events, other changes have been incorporated into the code. For example, to improve concrete confinement and longitudinal bar support, ACI 318-19 limits the aspect ratio of hoops in boundary elements and requires that all crossties have seismic hooks at both ends. To avoid brittle fracture of under-reinforced walls, the code also requires some walls to satisfy minimum longitudinal reinforcement requirements.

New ACI standards (the ACI 550 series) reflect changes made to the 2016 edition of ASCE 7, which incorporated new provisions that called for significant increases in seismic design forces for precast diaphragms. It established new requirements for the design and detailing of precast concrete diaphragms, particularly the connections between precast elements. The ACI 550 documents and standards are referenced in 318-19.

Deep Foundations
ACI 318-19 attempts to eliminate conflicting information in ACI 318, ASCE 7 and IBC regarding design of deep foundations for earthquake-resistant structures, with a goal of having all pertinent concrete-related seismic design and detailing provisions for deep foundations contained in ACI 318.

Among other changes, new provisions on precast concrete piles were incorporated; axial load limitations for deep foundations are now included; and strength design requirements were added that are consistent with ACI 543. This code change will allow designers of deep foundation members to use either the traditional allowable stresses that have been in the general building codes for years or the strength design method using strength reduction factors that is consistent with the rest of ACI 318-19.

Beam Column Joints
ACI 318-19 incorporates design provisions for shear strength and reinforcement detailing of beam-column joints of seismic design category (SDC) A frames, ordinary moment frames, intermediate moment frames, and frames that are not part of the seismic force-resisting system in SDC B, C, D, E, and F. Also, existing design provisions for special moment frames were expanded to include shear strength of roof joints.

Chapter 15 now requires consideration of the presence of opening and closing moments in corner joints. This includes moment transfer across a diagonal section through a corner joint, which is particularly critical where the joint connects a cantilever member for which no redistribution of moments is possible.

Design Verification Using Nonlinear Response History Analysis
The use of nonlinear dynamic analysis methods for design of earthquake-resistant buildings has been increasing recently, especially for design of high-rise buildings. To respond to this change in design practice, ACI 318-19 includes provisions for application of these methods to concrete buildings. The provisions are intended to be fully compatible with Chapter 16 of ASCE 7-16, which contains require-
ments on seismic hazard, selection of earthquake ground motions, load combinations and independent peer review.

High Strength Reinforcement

Current U.S. building codes limit rebar strength based on decades-old research, with most reinforcement used in concrete construction in the United States being Grade 60. Producers are now able to produce rebar, however, that is almost twice as strong as it was several decades ago. ACI 318-19 permits the use of Grade 100 reinforcement to resist moments and axial forces from gravity and wind load combinations. The use of higher-grade reinforcement raised concerns about serviceability (cracking and deflections), which were addressed through a series of changes for slab and beam minimum reinforcement, effective moment of inertia and requirements for deflection calculations for two-way slabs.

Strength and ductility concerns were addressed by introducing new requirements for mechanical properties of reinforcing bars; adjusting the method for calculating the strength reduction factor for moment, combined moment and axial load; revising development length provisions; and limiting the value of fy that can be used for calculating the maximum axial compressive strength, Pn, max, of columns. Grade 100 reinforcement is likely to be used mostly for vertical bars of shear walls and columns, though it might also be used for heavily loaded floor systems.

Substantial new research funded by Pankow Foundation, ACI Foundation and others has demonstrated acceptable performance of members of special seismic systems reinforced with ASTM A706 Grade 80 reinforcement and A706-equivalent Grade 100 reinforcement. Recognizing this, ACI 318-19 now permits special moment frames with A706 Grade 80 reinforcement and special structural walls with A706 Grade 80 and A706-equivalent Grade 100 reinforcement. The provisions allow the use of the higher grades to resist moments, axial forces and shear. To accommodate these higher grades, additional restrictions on hoop spacing, beam-column joint dimensions and lap splice locations have been added that will contribute to more reliable performance of special structural systems.

Thick Slabs and Deep Beams

As more large structures are designed to include thick slabs and other large members that support upper floors, shear provisions have been updated. ACI 318-19 sections on one-way shear and two-way shear (i.e., punching shear) consolidate what were previously a wide range of equations. They also provide a method to include size effect in shear design to avoid issues wherein increasing a member's size can reduce the unit shear strength of a section. The new shear equations also allow the design engineer to take the effect of reinforcement ratio into consideration.

Materials and Technology

Shotcrete, a method of placing concrete by projecting it at high velocity, was not explicitly discussed in previous versions of 318, but is now specifically included. The unification is expected to clarify both the design process and construction requirements for the use of shotcrete.

Post-tensioning updates included clarifications of the construction requirements regarding loss of prestress, use of a new reference document for determining prestress losses, deformed and bonded reinforcement spacing limitations and several clarifications on requirements for anchorage zone reinforcement.

Post-installed concrete screw anchors are increasingly used and this anchor type is recognized in ACI 318-19. The document also introduces provisions for shear lugs comprising a steel element welded to a base plate. Shear lugs are usually used at the base of columns to transfer large shear forces through bearing to a foundation element.

Numerous changes were made to the durability of concrete sections including additional requirements for sulfate exposure classes and concrete exposed to water. Lightweight concrete provisions throughout the code received numerous changes and clarifications based on the new method for determining λ, the lightweight modification factor. The new method calculates λ based on concrete mix proportions.
Updates were also made to strut and tie methodology (STM) that included the removal of bottle-shaped struts from the code and the inclusion of minimum reinforcing requirements in STM. Other STM improvements included curved-bar nodes and knee joints.

**Ease of Use**

While organizational changes were minimal, some new formatting features in ACI 318-19 enhance the document’s usability. Full-color and three-dimensional illustrations are included, improving clarity. The index was expanded and interactive links were added to the online version of the document, in an effort to help users quickly find code provisions.

Chapter 26, “Construction Documents and Inspection,” has seen significant updates since 318-14. Inspection requirements are unified in this chapter, including the relocation of anchor inspection requirements from Chapter 17. The chapter now recognizes that projects may have roles for multiple design engineers and provides a framework for their coordination of work. As higher strength concretes have been developed over time, using the standard definition of modulus of elasticity may not be adequate for certain projects. Therefore, the definition for modulus of elasticity was updated using data from external documents and best practices. For certain materials that are becoming commonplace in the industry (such as alternative cements, crushed hydraulic-cement concrete or recycled aggregates), 318-19 Chapter 26 outlines precautions for designers who are considering their use.

ACI 318-19 also identifies qualification training programs for inspectors/installers and lists certification requirements. By stating certification requirements directly in the code, the information becomes more easily accessible to engineers.

Printed and digital formats of ACI 318-19 are available at concrete.org. Versions are available in inch-pound units, and SI units. ACI 318-19 is also available to subscribers of the online ACI Collection of Concrete Codes, Specifications, and Practices. Additionally, the Institute is hosting public and in-house seminars to introduce users to ACI 318-19 – visit concrete.org for locations and to learn more.

DR. JACK P. MOEHLE is the Chair of ACI 318 Building Code Committee and is the Ed and Diane Wilson Professor of Structural in the Department of Civil and Environmental Engineering at UC Berkeley. He has played a leading role in the development of building codes and professional engineering guidelines on subjects related to reinforced concrete and earthquake engineering. He is a Fellow of the American Concrete Institute, Structural Engineering Institute of ASCE, and the Structural Engineers Association of California, and is an elected member of the U.S. National Academy of Engineering.
EXPERIENCE, KNOWLEDGE, AND STABILITY

VALUE BEATS FIRST COST WHEN BUYING PROFESSIONAL LIABILITY INSURANCE
By Roger L. Ball, PE, FACEC, and Cara Shimkus Hall, FAIA

EVERY ARCHITECTURE OR ENGINEERING FIRM faces the same question annually: in today’s professional liability (PL) insurance marketplace, how do you determine which program is right for your firm? How do you bring a high level of consistency and quality to a decision that impacts your business year after year? Who will be the right partner for your firm?

As the CEOs of multi-disciplined firms tasked with purchasing our PL coverage, we’ve learned to place value first, followed by coverage options, insurer experience and capabilities and, finally, cost. We believe this approach has largely insulated us from the uncertainty and volatility in the insurance marketplace. In talking to our colleagues, we realize that many find the PL market increasingly challenging to navigate, so we thought it might be worthwhile to share our thoughts on the subject.

We’ve watched as dozens of new insurance companies entered (and exited) the PL marketplace over the last 25 years, all vying for our business. Some of these new carriers offered bargain-basement prices – at least for the first year. But when we looked closely, many carriers lacked the support, infrastructure and experience that would help us navigate disputes specific to the design industry, educate our staff, and remind us where the real risk lies in our business. In fact, over time, many have demonstrated a lack of commitment to keep the design profession as a line of business, entering and leaving the market when it was prudent for them to do so, and leaving the insured without their support.

Predictably, when the claims caught up with their pricing, these carriers often raised their rates without a corresponding increase in service or support. Some got out of the PL business entirely. During our tenure in the business, over 50 insurance companies have left the A/E market. And a lot of our design professional colleagues who chose their insurance based mainly on price ended up paying more down the road. We’ve seen friends in the situation of having their insurer exit the market, and scramble to find a new carrier while in the midst of a claim.

Defining Value
What does this mean for A/E firms that are buying professional liability coverage today? As we mentioned, we’ve learned to make the decision based on value. To us, this means we consider the benefits we derive now as well as those we’ll see in the long run – even if we don’t file a claim. Instead of thinking of PL insurance as an expense, like utility bills, we consider it an investment. We learned a long time ago that there’s a difference between the cost of insurance and the cost of risk. While we have relatively little control over the cost of insurance, we can influence our cost of risk. So, we look for a carrier that helps us manage that risk and support our company’s risk management goals.

We liken our decision-making model to qualifications-based selection (QBS). Our clients select us based (we hope) on our experience, skill, knowledge, and stability; we use the same criteria for our professional liability insurer, and believe those criteria apply, regardless of the size of the design firm or insurance carrier.

So, what do we look for? Of course, the insurer must be a financially stable, well-capitalized entity with consistently high credit agency ratings. That’s a given. But it’s also critical that the insurer maintains the desire and ability to manage insurance cycles, and will offer us predictable coverage terms and ongoing support regardless of our claims experience. We want an insurer that is willing to work with us to provide coverage broad enough and flexible enough to meet our needs, one that offers the limits, deductibles and coverage options my firm requires. It’s crucial to us that our professional liability insurer specializes in serving our profession with a legacy in the A/E market.

But these days, you have to know where to look to find these insurers, and your agent or broker owes it to you to help. Many good A/E insurers have been acquired by new parent financial companies. These programs have been around for years and they’re run by specialists in A/E risk. Still, if an insurance company has been recently acquired through a merger or acquisition, you’ll want to know if the new parent company is committed to their A/E program, if they’re investing in it, and if they’re keeping key personnel and programs.

It Only Takes One Claim
To us, great claims handling is a deal-maker. You only need to be involved in a single claim to understand how critical this is. We want to work with claims people who understand our business and who specialize in our type of disputes. We don’t want to have to explain what we do in our profession to someone who also works on life insurance claims. And we want to know how experienced their claims staff is, whether they are licensed attorneys, and if they specialize in A/E defense or are simply general adjusters.
We look for a claims department that will help us resolve problems before they become full-blown claims, that will step forward if the claim is justified but that will not roll over and pay unnecessarily just to settle a case. We look for an insurer that will try to find ways to cover claims, rather than run away from them. And we want claims people who help control legal expenses appropriately, who provide personal service and who communicate with us promptly and frequently.

**A Partner in Risk Management**

We’ve found that professional liability insurance carriers with value offer first-rate training and risk management education programs, and our firm relies on and benefits from these programs. And we expect our professional liability insurance company to provide a high level of service and advice to help us with our professional services agreements.

It’s also important to us that our carrier is actively involved in the professional associations (especially with the AIA, ACEC, and the Engineers Joint Contract Documents Committee, a joint venture of the ACEC, NSPE, and ASCE), that it helps our local, state and national professional associations, and participates in legislative efforts on behalf of our professions.

**A Word About Insurance Brokers**

A properly-selected insurance broker will never let us down. The broker that you select for your professional liability insurance should be an expert in the field, not just the same person that sells car insurance to you. We expect them to recommend a professional liability insurance program rather than a price. In other words, our broker will run through a qualitative vetting process and will show us how a carrier will support our risk management efforts, educate our staff, and treat our time and deductible as if it was their own. As design professionals, we have to stand by the recommendations we make to our clients; as licensed professionals we do not shy away from this responsibility. We expect the same from our broker.

**Value vs. Cost**

The thing is, someone will always offer you a policy for less. But as we are constantly explaining to our own clients, the first cost is not always the lowest cost or the best value. In the end, we want an insurance company that will be there for the long term, one that works hard to preserve our capital, reduce our losses, and that is willing to go to bat for my profession and my business. In other words, the one that offers the best value.

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**Roger L. Ball, PE, FACEC**, is President and CEO of Rick Engineering, headquartered in San Diego, CA.

**Cara Shimkus Hall**, FAIA, is Principal and CBO of GH2 Architects, based in Tulsa, OK.
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New ACI 318-19 Now Available

The newest edition of ACI's 318 Building Code Requirements for Structural Concrete and Commentary is now available. The latest edition includes new and updated code provisions along with updated color illustrations for added clarity.

FIND AN ACI 318-19 SEMINAR NEAR YOU

Learn more about the latest edition of ACI 318 by attending the public seminar "ACI 318-19: Changes to the Concrete Design Standard." Visit concrete.org/ACI318 for a complete list of dates and locations and register today!

Welcome to Rising Stars 2019, presented by Civil + Structural Engineer magazine. The eighth annual celebration of the AEC industry’s top talent features 10 Civil and 10 Structural engineers, all under the age of 40 at the time of their nomination. Though they come from different parts of the United States and the world, went to different schools, and have honed different specialties, they all share a few things in common - leadership, technical ability, and service to their professions, firms, and communities. These 20 recipients have distinguished themselves in an oftentimes thankless world of intense competition, impossible deadlines, confounding problems, and unrealistic client demands. Instead of being undone by obstacles, they overcome them. Their reward? The respect of their peers.
**Jeff Roman**  
Partner, Engineering Practice Leader  
Little  
Charlotte, North Carolina

Roman has led the Engineering Practice at Little to six years of profitable growth, quadrupling staff and revenue while expanding engineering to all offices and adding new service offerings. He created a vision and core values and successfully implemented a culture change to build Little’s national engineering practice. In 2018, he became the first engineer to join the partnership and is currently the youngest partner. In 2019, he was selected for a three-year term on Little’s Board of Directors.

**Accomplishments:**
- Civil engineer of record for multiple projects at Florida Gulf Coast University in Fort Myers.
- Civil engineer of record for most projects within the Forum at Fort Myers, a 700-acre mixed-use development.
- Client relationship manager and project manager for new construction and renovations for automotive dealerships nationwide for Sonic Automotive.

**Public/Professional Service:** Roman gives back to the engineering profession with his passion for STEM education. His outreach efforts have impacted well over 1,000 students during the last 15 years. Roman speaks in K-12 and college classrooms presenting about engineering and facilitating fun hands-on activities. He leads Little’s efforts to host students for field trips and job shadowing, host teachers for externships, and created an Engineering Explorers Post.

**Education:**  
BS Civil Engineering, Lawrence Technological University | Executive MBA, University of Florida

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**Sharareh Kermanshachi**  
Assistant Professor and Director of the Resilient Infrastructure and Sustainable Environment (RISE) Lab  
University of Texas at Arlington  
Arlington, Texas

Dr. Kermanshachi has received several prestigious national and regional awards including the UESI Fellowship, ASCE Outstanding Reviewer, Albert Nelson Marquis Lifetime Achievement Award, ASCE Professional Service Award, ASCE Excellence in Civil Engineering Education (ExCCEEd), OER Research Fellowship, and the Graduate Climate Award. Kermanshachi was the only recipient of the 2018 Design Build Institute of America (DBIA) Distinguished Leadership Award from the Faculty category. Kermanshachi’s areas of expertise are risk management, performance optimization, and post disaster reconstruction.

**Accomplishments:**
- Currently leading the RISE lab, which has more than a dozen Ph.D. and master’s students and teaches various graduate and undergraduate level courses in civil engineering.
- Peer reviewed publications – over 326 citations.
- Has published more than 80 books, scholarly articles, conference proceedings, and research reports and has conducted several national- and state-level research projects with a value of more than $2.3 million.

**Public/Professional Service:** An extensive record as an advisor, organizer, and mentor.

**Education:**  
Ph.D., Civil Engineering, Texas A&M University | MS, Civil Engineering, Mississippi State University | MBA, Eastern Mediterranean University | BS, Architectural Engineering, I.A. University of Tehran
Lambrina Tercala  
Project Manager, Environmental & Water Resources Group 
OHM Advisors 
Detroit, Michigan

Tercala, PE, ENV SP, is one of the firm’s newest shareholders, elected in November 2018 to the now 42-member group of employee owners. Tercala was elected to this important position – a role in which she will contribute to the firm’s leadership and success, elect board members and future shareholders, and exercise voice in the future direction of the company – in just four years since joining OHM Advisors due to her sharp business acumen, eye for advancement opportunities, and candor in strategic conversations.

Accomplishments:
• Developed an odor-control system using new technology in the Midwest for one of the firm’s important, long-term municipal clients.
• Co-manages the oversight and administration of the Downriver Utility Wastewater Authority, a 13-community co-operative serving more than 350,000 people.
• Balances the myriad multitasking responsibilities of parenthood with a robust career that includes substantive client work, heavy involvement in the firm’s Project Manager Forum, and active representation in professional organizations.

Public/Professional Service: Analyzed the results of a firm-wide PM survey collecting ideas and information on how managers can best perform and engage their teams.

Education: BS, Engineering, Civil and Environmental Studies, University of Michigan

Mark Origer  
Head of Environmental Services Group 
ISG 
Mankato, Minnesota

A gifted civil engineer driven to improve water quality in rural Minnesota, Origer works closely with public agencies and private landowners alike to implement projects that provide a marked improvement on water quality. Despite being relatively young in his career, Origer has already established himself as an equally talented designer, project coordinator, and committed mentor to his fellow employee owners. With unique hydrologic and hydraulic modeling expertise with softwares such as HydroCAD and XPSWMM, Origer is able to examine alternative practices and select the most advantageous option tailored to serve each individual project. This technological expertise also allows Origer to perform large-scale hydraulic and hydrological analysis across multiple watersheds.

Accomplishments:
• Serves as a project team member for numerous projects within the Heron Lake Watershed located within portions of Nobles, Jackson, Murray, and Cottonwood Counties in southwestern Minnesota, extending approximately 472 square miles.
• Led hydrological and hydraulic analysis on the 18,000-acre Line Creek Watershed in Chippewa and Swift Joint Counties in Minnesota.
• Led hydraulic analysis on a portion of Limbo Creek in Renville County, Minnesota, to determine the flood damages to the area and the public safety concerns of road crossings. The watershed consists of 9,300 acres of open channel and wetland complexes that serve as an outlet to public drainage systems.

Public/Professional Service: Has led tours at the International Drainage Symposium, frequently presents at water quality workshops and Drainage Authority meetings, was a contributor to the University of Minnesota’s Fields to Streams: Managing Water in Rural Landscapes publication, and serves as a mentor for lucky engineering students at his alma mater, Minnesota State University, Mankato.

Education: BS, Civil Engineering, Minnesota State University, Mankato
Lee Daigle
Senior Project Manager
Cornerstone Environmental Group, A Tetra Tech Company
Madison, Wisconsin

Daigle is a project manager with 12 years of experience in the landfill gas industry. He has managed the design, construction, operation, and monitoring of landfill gas extraction and treatment systems at municipal solid waste landfills throughout North America. He has led the initial start-up and monitoring of collection and control systems and has performed data analysis and interpretation to assist in optimizing overall landfill gas system performance.

Accomplishments:
• Project manager for a multi-disciplinary team on a unique landfill gas to renewable natural gas (LFG-to-RNG) facility at the Dane County Rodefeld Landfill, the first of its kind in the US.
• Has registered numerous landfills for compliance with the United States Environmental Protection Agency's mandatory rules for greenhouse gas reporting. He has also performed construction management and construction quality assurance services during the installation of numerous landfill gas extraction and treatment systems.
• Served as project manager overseeing routine operation and maintenance activities for landfill gas collection and control systems at four landfill facilities with the San Bernardino County Solid Waste Management Division.

Public/Professional Service: Presented at numerous local, regional, state and national conferences and events, including the Global Waste Symposium and the Engineering Society of Detroit.

Education: BA, Environmental Engineering, Rensselaer Polytechnic University

Todd Abrams
Principal-in-Charge, Civil Engineering
WT Group
Hoffman Estates, Illinois

Abrams joined WT Group right out of college as a Project Designer. He rose through the ranks to Project Manager and Vice President, and was then named the youngest President/Principal-in-Charge in the history of the civil engineering division at only 35 years old. His work ethic shows in the number of projects he has successfully completed. In just 15 years he has accumulated experience on projects that would take other professionals decades to acquire.

Accomplishments:
• Regularly hired by the Illinois Department of Transportation as an expert witness.
• Site Design: 10+ residential developments; 20+ truck and trailer facilities; 100+ gas stations throughout the Midwest; 60+ commercial projects; 50+ park district projects; 55+ educational institutions; Eminent Domain Analysis – over 300 reports for State/County and 250 for private owners.
• Redesign of Springfield Park baseball complex in Bloomingdale, Illinois to solve long-standing drainage problem.

Public/Professional Service: He supports the Children’s Advocacy Center, which is dedicated to serving the needs of abused children. He also volunteers with the local park district, painting old playgrounds and making them safe for children. Todd reaches out to young engineers, mentoring them and teaching them how to find the path to success.

Education: BS, Civil Engineering, Valparaiso
Laura Casset  
Associate, Floodplain Management and Project Funding Specialist  
Lockwood, Andrews & Newnam, Inc. (LAN)  
Austin, Texas

Casset has more than a decade of experience serving public clients in stormwater and floodplain management. Her background includes civil engineering design of flood mitigation projects, surface water hydrology/hydraulics, identifying project funding opportunities, grant application development, Federal Emergency Management Agency (FEMA) map revisions and studies, as well as site development, utility relocation, and transportation drainage projects throughout Texas.

Accomplishments:
• An expert on FEMA grant funding and travels throughout Texas meeting with cities and counties to discuss funding solutions for infrastructure planning and construction.
• Erosion Hazard Zone Mapping & Geomorphic Assessment of Eastern Watersheds, Austin.
• Riverfront Bank Stabilization and Disaster Recovery Funding, Beaumont.

Public/Professional Service:  
An avid activist for refugees, Casset volunteers with the Refugee Center of Austin. Volunteers collect donations for refugee families and victims of sex trafficking. Donations include used items, monetary donations, and skill training. She has prepared apartments for refugee families that arrive in Austin with no belongings.

Education:  
BS, Civil Engineering, University of Texas

Steven Abendschein  
Senior Principal  
Stantec Consulting Services Inc.  
New York, New York

Abendschein has always been a driven individual. It is this drive that put him on the leadership fast track from his first days at Stantec. His engineering expertise and leadership style were first noticed early on in his career, as demonstrated on the Route 9A Redevelopment project. Stantec was working to get the roadway to working order after the devastating September 11th terror attacks. Abendschein led the simulation development for West Street, which illustrated various construction alternatives and their impacts. He was recognized by the client for his professionalism, technical expertise, and sensitivity. Shortly thereafter, he obtained his professional engineering license.

Accomplishments:
• At the age of 28, was promoted to managing leader of a 30-person group responsible for traffic engineering and national traffic and revenue studies in New Jersey, New York, and Connecticut.
• Leads Stantec’s Transportation Technology group, focusing on Intelligent Transportation Systems and self-driving vehicle initiatives across the world.
• Since June 2013, has been responsible for 43 investment-grade traffic and revenue studies that have raised $13 billion in revenue bonds.

Public/Professional Service:  
Active in ACEC NY and is currently the Chair for the chapter’s Scholarship Committee. He organizes and oversees the committee, and reviews and scores scholarship applications. Since the program’s inception in 2002, the council has awarded $770,500 collectively to 280 high-achieving engineering students attending New York State colleges and universities.

Education:  
Master of Engineering, Engineering Management, Cornell University  |  BS, Civil Engineering, Cornell University
Cheryl Bornheimer-Kelley
Design Engineer
McClure
Lenexa, Kansas

Bornheimer-Kelley is constantly pursuing and improving her knowledge of transportation engineering, specifically her passion for traffic and safety engineering. Now as lead PTOE for the Kansas City area offices of McClure, she heads the authoring of traffic studies, alignment and safety studies, interchange justification reports (I.J.R.) as well as designing transportation projects. Currently she is managing the design study of improvements to Kansas & Spruce Avenues in Olathe, Kansas. These improvements are spurred from her traffic study for the new Johnson County Courthouse.

Accomplishments:
• Safety expert for the Ford County Safety analysis for the Kansas Department of Transportation.
• Project manager on the bridge replacement on Highway K-9 in Norton County, Kansas.
• The Highway 76 project in Branson, Missouri, where Bornheimer-Kelley worked on the safety features involved with sidewalks, American with Disabilities ACT (ADA) ramps and other appurtenances intended to allow non-vehicular stakeholders to coexist with very congested vehicular traffic.

Public/Professional Service: Heavily involved with the Engineer’s Club of Kansas City, a philanthropic society that provides scholarships to engineering students in the region. The group typically awards over $95,000 in scholarships annually. She is on the Board of Directors as Secretary, and is scheduled to be President in 2021.

Education: MS, Civil Engineering, University of Kansas | BS, Civil Engineering, University of Kansas

Abelardo A. Salinas (Abe)
Associate Vice President; Chief Innovation Officer
LNV, Inc.
San Antonio, Texas

LNV’s first ever CIO, Salinas is responsible for leading and carrying out a critical component of the organization’s Innovations Program by providing decisions and recommendations capable of impacting extensive professional and related activities for the company. He is also LNV’s Stormwater/Flood Control Technical Specialist, and developed career track planning worksheets for the firm.

Accomplishments:
• Edwards Aquifer Authority Director, District 3. The Authority is a political subdivision and regional water management agency that regulates the use of the Edwards Aquifer, one of the most prolific artesian aquifers in the world that serves over 2 million South Texans.
• Project lead for the Multi-modal Transportation plan for Laredo, a project featured in Texas Architect Magazine.
• Project manager and design lead for design of a dam and reservoir that will restore an irrigation network that provides water for approximately 33,000 acres of farmland in the Medina River Valley.

Public/Professional Service: Appointed to the San Antonio Airport Technical Advisory Committee to represent the interests of the Edwards Aquifer.

Education: BS, Civil Engineering, Rice University
Jian Li
Chair’s Council Assistant Professor
University of Kansas
Lawrence, Kansas

Li is a Chair’s Council Assistant Professor in the Department of Civil, Environmental and Architectural Engineering (CEAE) at the University of Kansas and has been selected for promotion to Associate Professor. His research focuses on both theoretical and experimental developments of advanced sensing and health monitoring techniques to improve the resiliency and sustainability of civil infrastructure under operational and extreme loading conditions. His specific research interests include vibration-based damage detection, uncertainty quantification, innovative sensing techniques and wireless smart sensor networks, computer vision, fatigue and fracture, earthquake risk assessment and mitigation.

Accomplishments:
• Since 2013, has served as principle investigator of research projects with a total funding of $1.52 million, of which he is responsible for $1.06 million as PI.
• Has made significant contributions to advanced structural inspection by creating innovative algorithms for detecting various structural defects such as fatigue cracks and bolt loosening using computer vision. This work has so far led to three provisional patents and one international patent application.
• Has published 38 journal papers and 37 conference papers, and has delivered 13 invited seminars and 25 conference/workshop presentations.

Public/Professional Service: As the secretary and a member of the Board of Directors of the US-China Earthquake Foundation, Li has been actively involved in promoting cooperation between the US and China in earthquake engineering. The foundation is a non-profit organization established in 2002 in Pasadena, California.

Education: Ph.D., Civil Engineering, University of Illinois at Urbana-Champaign | MS, Civil Engineering, Harbin Institute of Technology | BS, Civil Engineering, Harbin Institute of Technology

Benny Lujan
Project Manager
CTL | Thompson
Denver, Colorado

Lujan joined CTL | Thompson in 2006 while still a student at the Colorado School of Mines and is now a project engineer and manager in its Denver office. He performs preliminary and design-level geologic and geotechnical investigations and consultations, as well as post-construction geotechnical engineering consultations. During his tenure, he has authored more than 1,000 engineering reports for a variety of structures and has been the engineer of record on nearly 30 significant CTL projects, designing structural engineering solutions that have improved geotechnical project design and management practices.

Accomplishments:
• Successfully co-managed the effort, that included a team of geotechnical and environmental engineers, to transform a city block into the foundation for 1144 15th, a 42-story, 603-foot-high office tower in Denver.
• Helped design a passive dewatering system for a new development at the Colorado Rockies Major League Baseball stadium that saves the team $200,000 per year throughout the life of the building.
• Denver-area projects include: Denver World Trade Center; Globeville Landing Park/40th Street Outfall; Latino Cultural Arts Center; Metro State Sports Complex; Colorado School of Mines Elm Hall; and CU Systems Biotechnology Building.

Public/Professional Service: Lujan is actively involved in causes supporting Hispanics and Hispanic-owned businesses. He is a member of the Denver Hispanic Chamber of Commerce, and works alongside the Latin American Educational Foundation and the Denver Hispanic Coalition. He is the geotechnical engineer for the new six-story Denver Latino Cultural Arts Center.

Education: BS, Civil Engineering, Colorado School of Mines
Ali Ashrafi  
Associate Principal  
Thornton Tomasetti  
New York, New York

Ashrafi joined Thornton Tomasetti in 2006 and is now an associate principal with extensive experience in structural design, investigation and demolition, emergency response to structural failures, façade preservation of historic structures, renovation, and performance-based design for earthquake, fire and wind. Through active participation and leadership in a wide range of projects, membership in professional associations, active research, publication of papers, presentation at conferences, organizing mini-symposia, teaching, and mentorship of young professionals, Ashrafi consistently helps shape the direction of the AEC industry and provides leadership for his profession.

Accomplishments:
• Led performance-based seismic design for Soyak Tower, a 550-ft high-rise with eight basement levels in Turkey. The building’s concrete core was designed to withstand the forces of a dramatic seismic event in a highly earthquake-prone region.
• Led the complex analysis of the seismic soil-structure interactions for the Salesforce Transit Center in San Francisco. Because of the structure’s long length, deep basement and different soil structures, seismic movements of the ground at one end of it can be very different from the other end.
• Led the fire modeling and structural analysis for the Shed at Hudson Yards, showing that the wheels carrying it could resist the effects of fire without fireproofing.

Public/Professional Service: Ashrafi teaches Earthquake and Wind Engineering at Columbia University, serves on two committees on the Engineering Mechanics Institute, reviews papers for several professional journals, and mentors engineers and students inside and outside the company to help build the next generation.

Education: Ph.D., Civil Engineering and Engineering Mechanics, Columbia University | MS, Civil Engineering, New Jersey Institute of Technology | BS, Civil Engineering, Sharif University of Technology

Taylor Perkins  
Senior Structural Engineer  
Stantec Consulting Services Inc.  
Lexington, Kentucky

Perkins has developed a diverse project portfolio focused on evaluation and design of long-span and complex bridges, including post-tensioned segmental bridges, curved steel girders, trusses, tied arches, cable-stayed structures, and long span suspension bridges, as well as evaluation and retrofit of large concrete gravity dams. He serves as a corporate expert on advanced numerical modeling and simulation. His finite element modeling expertise extends to non-linear, dynamic, soil-structure interaction, time-dependent, and staged construction considerations. For complex bridge and dam projects, he has performed non-linear simulations incorporating geometric and material non-linearity based on both elastic and plastic theories. His dynamic analysis experience ranges from simple modal analysis to explicit time-history simulations. Perkins is familiar with a wide variety of structural analysis software packages and serves as a Stantec corporate resource for the use and implementation of these programs.

Accomplishments:
• Serves as the structures discipline lead for the quality assurance management team on the Wellsburg Bridge, a $131 million design-build project constructing a new Ohio River crossing in Wellsburg, West Virginia.
• Serves as deputy project manager and lead designer for the $50 million US 60 Cumberland River Bridge Replacement in Smithland, Kentucky.
• He has inspected over 35 bridges, the majority of which are major crossings requiring rope access techniques. Perkins has completed SPRAT Level 1 rope access training.

Public/Professional Service: Perkins is a mentor to several junior structural engineers in his office and several students at the University of Kentucky. Early on in his career, Perkins had an excellent mentor that helped him grow professionally and personally. To pay it forward, he has taken on this mentor role to provide invaluable lessons and structural knowledge to help foster growth in the young engineers he works with.

Education: Ph.D., Structural Engineering, University of Kentucky | MS, Civil Engineering, Structures, University of Kentucky | BS, Civil Engineering, University of Kentucky
Michael Mendenhall
Structural Engineer
Hanson Professional Services Inc.
Springfield, Illinois

During his nearly 17-year career, Mendenhall has provided engineering, planning and design services for numerous bridges, structures and retaining walls across Illinois and the U.S., including Alaska. Award-winning Alaskan projects Mendenhall has been involved with include the $42.5 million Glenn Highway capacity improvements in Eagle River and the $187 million Tanana River Bridge in Salcha. He also has performed project management responsibilities for multiple projects, including the $315 million Springfield Rail Improvements for the city of Springfield, and the $75 million Illinois Route 104 bridge over the Illinois River in Meredosia, for IDOT.

Accomplishments:
• As Hanson’s lead structural engineer responsible for studying the effect of skew and continuity of reinforced concrete slab bridges for IDOT, Mendenhall has used his experience to develop structural engineering equations and design code that is used to design reinforced concrete slab bridges throughout Illinois.
• Helps drive Hanson’s largest market, infrastructure, which earned $37 million in gross revenue in 2018. Clients include DOTs in Florida, Illinois, and Missouri, the city of Springfield, Illinois, and the Illinois Tollway.
• Provided Phase I and II engineering services for replacement of the McClugage Bridge in Peoria and Tazewell counties, Illinois. For the $200 million project, he was the lead structural engineer and task manager for the east bridge approach unit design, main span foundation design, vessel collisions study, and independent review of the 650-foot-long, tied-arch main span.

Public/Professional Service: As an active member of the Illinois Society of Professional Engineers since 2006, Mendenhall has served as the chapter’s president, vice president, treasurer and secretary. He was also chairman of the chapter’s annual fish fry committee for six years, as well as MATHCOUNTS and Engineers Week.

Education: BS, Civil Engineering, University of Illinois at Urbana-Champaign

Ross Stuart
Structural Division Manager
Pennoni
Philadelphia, Pennsylvania

Stuart has more than 12 years of experience in the structural engineering profession. He has assisted with the design, coordination, administration and management of the structural engineering for a diverse spectrum of projects, including new construction, rehabilitation, adaptive reuse, inspection, condition assessment, construction engineering and repair projects covering a wide range of project types and materials including cast in place, precast and post tensioned concrete, structural steel, cold formed metal framing, masonry, and timber. Since 2007, Stuart has been involved with more than 339 individual projects and is licensed in 11 states.

Accomplishments:
• As Division Manager, Stuart is responsible for the technical and financial performance of the structural department, managing work load, networking, client development, proposals, billing, and evaluating employee performance. The structural division is consistently recognized as one of the firm’s Top 10 financially performing groups.
• Project Engineer for the design, documentation and construction administration of an $18 million, 70,000-SF office building with composite steel framed mezzanine and 145-foot span of 66-inch deep glue laminated arches supporting SIP roofing system on glulam purlins. Building achieved LEED Platinum certification.
• Project Engineer and manager responsible for the structural design of the $90 million, 235,000-SF Paul VI High School West.

Public/Professional Service: Stuart is a member of the Delaware Valley Association of Structural Engineers and the Structural Engineers Association of Pennsylvania, a local and national member of the American Society of Civil Engineers, and a national member of the American Concrete Institute, the American Institute of Steel Construction and the National Council of Structural Engineers Association. Stuart also volunteers his time as an ACE Mentor.

Education: BS, Civil/Environmental Engineering, Rutgers University
Lauren Wingo  
Senior Structural Engineer  
Arup  
Washington, DC

Wingo is a licensed structural engineer in Arup’s Washington, DC office. Her experience includes both conventional and innovative structural materials, with a focus on incorporating sustainable strategies into structural design. She has worked on a number of large scale renovation projects, further influencing the sustainability of projects by adaptively reusing existing structures. Wingo is deeply involved in structural sustainability within the design profession. She is an expert in and an early adopter of whole building life cycle assessment. She advocates for considering environmental impacts embodied within structural materials equally alongside operating impacts when evaluating the overall sustainability of a project. She has performed whole building life cycle assessment for several projects, including a new airport terminal and a high-rise timber residential building.

Accomplishments:
• Lead project engineer for Whittle School & Studios located in Washington, DC. In this capacity, she leads the delivery of the structural work for this large-scale renovation spanning over 900,000 square feet, managing a team of engineers.
• Lead project engineer for the Concourse Modernization project at Union Station in Washington, DC. This project, also a large-scale renovation, includes numerous structural interventions that interact with different historic phases of construction and span numerous material types.
• Was the lead project engineer for Washington Latin Public Charter School, the first cross-laminated timber building in the District of Columbia.

Public/Professional Service: Wingo’s volunteer work focuses on promoting STEM fields for younger students. She volunteers with ACE Mentors through Arup’s involvement at Dunbar High School. Wingo recently participated in a day-long workshop Arup put together for the Design Like a Girl mentorship program. The program is designed for girls in the DC metro area aged 11-13, who are passionate about architecture to learn about the profession first-hand from successful women mentors in the architecture, construction, and engineering fields.

Education: MS, Civil Engineering, George Washington University | BS, Civil Engineering, Johns Hopkins University

Vartan Chilingaryan  
Associate Vice President, Director of Structural Engineering  
HDR  
Los Angeles, California

Chilingaryan has accomplished a great deal in a short amount of time. He started with HDR 15 years ago in the Los Angeles office as a structural intern. He joined the firm when he was only a junior in college and balanced school and work in a very pressurized schedule. By the time he graduated college, he was already independently leading small structural projects. During his professional career, he has successfully led highly technical projects through design, engaged in project management, and taken on different leadership roles within the firm.

Accomplishments:
• Recently named HDR’s National Director of Structural Engineering, making him the youngest person ever to hold the position at HDR.
• Project Structural Engineer: Fort Bliss Replacement Hospital, a 1.13 million SF medical facility replacing the current William Beaumont Army Medical Center (WBAMC) in Texas.
• Project Structural Engineer: Cleveland Clinic Abu Dhabi, a 1.8 million SF underground parking structure located directly below the main tower. Project was awarded a 2015 Merit Award in the Built category from the American Institute of Architects (AIA) Middle East.

Public/Professional Service: Chilingaryan is very active within his local community. For the last few years he has served on the planning board for Art Swagger, which is a well-recognized annual walking art gallery hosted by a handful of architectural design firms, located in the heart of downtown Los Angeles. He is also active with the Structural Engineering Association of Southern California.

Education: BS, Civil Engineering with emphasis in Structural Engineering, California State University, Northridge
Joelle Nelson
Practice Leader, New York Downtown Construction Engineering
Thornton Tomasetti
New York, New York

Nelson joined Thornton Tomasetti in 2004 and quickly rose to project director, taking on complicated projects such as the Roosevelt Island Tramway Rehabilitation Project, the U.S. Capitol Dome Restoration Project, and the 95-foot high pivoting doors at U.S. Bank Stadium. She has investigated major structural collapses, lending her expertise in wind loads and cranes. Now a partner at Thornton Tomasetti, she established and leads the firm’s crane and erection engineering practice in New York City, opening doors for women in a typically male-dominated sector. With her experience from forensic investigations of crane collapses, she is working to get in front of the problem and improve site safety.

Accomplishments:
• Restoration of the U.S. Capitol Dome in Washington, D.C.: Performed the structural analysis of the existing cast iron dome structure and analyzed it for modern code prescribed loading requirements and for loading applied from the scaffolding.
• Rehabilitation of the Roosevelt Island Tramway in New York City: Designed new head frames to support the replacement tram, rope, and mechanical/electrical system and analyzed the existing towers for the new increased loading.
• U.S. Bank Stadium, home of the Minnesota Vikings: Performed the structural design and kinetic coordination for the stadium’s operable glass panels, the tallest pivoting glass doors in the world.

Public/Professional Service: Serves on the Wind Load Subcommittee for the referenced standard ASCE 7: Design Loads and Associated Criteria for Buildings and Other Structures. Served on the subcommittee for the published ASCE 7-16, and continues to serve on the subcommittee for the in-progress ASCE 7-22. She also currently serves on the committee for the referenced standard ASCE 37: Design Loads on Structures During Construction.

Education: MS, Civil Engineering, Columbia University | BS, Civil Engineering, Columbia University

Matthew Murray
Project Manager
CE Solutions, Inc.
Carmel, Indiana

Murray brings a unique, research-based perspective to CE Solutions. His graduate research gave him hands-on experience in the design, construction, and testing of reinforced concrete beams, and was published in the January 2018 edition of the ACI Structural Journal. Murray demonstrates a commitment to his projects and a deliberate approach in making important decisions and anticipating obstacles. Due to his outstanding technical capabilities, he serves as Project Manager on the firm’s more challenging projects. His depth of experience with various materials is a great asset for teaching young and seasoned engineers. When Murray shares his knowledge, people listen.

Accomplishments:
• Project Manager for two high-profile pieces of public art: “VOSS” (Visiting our Solar System) at Purdue University in Indiana, and “Rocket” in Richardson, Texas.
• Project Manager for Hooverwood (assisted living), CityWay Phase II Building D (mixed use), and Hinge (mixed use). Murray used his technical expertise to provide structural systems to support a green roof, increased loading and removal of load-bearing walls, and custom bracing systems on a pedestrian connector bridge.
• Project Manager for the Duke Energy Central Stores Building. The unique challenge was the need to strengthen the existing floor to double its load-carrying capacity. This creative solution involved a combination of additional columns in the basement and welding new headed studs on existing steel beams. A new composite slab was poured, and the overall capacity of the floor system was increased.

Public/Professional Service: Murray has given his time and talents to various community organizations and initiatives. He has volunteered for Construction, an event where teams build a structure using only food cans. The cans are then donated to a local food pantry. He has also volunteered for the annual Passport to Hi-Tech, an event that introduces young children to the STEM fields. He and his family also volunteer their time preparing and serving monthly meals at Neighborhood Fellowship, a church that provides for the homeless in downtown Indianapolis.

Education: MS, Civil Engineering, Purdue University | BS, Civil Engineering, Purdue University
ONE°15
BROOKLYN MARINA
A ROBUST SYSTEM OF STEEL WAVE ATTENUATORS MAKES FOR SMOOTH WATERS IN NEW YORK HARBOR.
By Editorial Staff

NEW YORK CITY’S FIRST NEW MARINA in over 50 years had its soft opening in May, with the design team working out the final touches over the following weeks. With over 100 berths for vessels up to 200 feet, a Sailing Club and School, and community programs, the facility offers the calmest waters in New York Harbor thanks to advanced technology and design.

Located just south of the Brooklyn Bridge, across the East River from Wall Street and South Street Seaport, the marina offers incredible views and easy access to Manhattan. Part of the vibrant Brooklyn Bridge Park, ONE°15 Brooklyn is home to the city’s largest community dock.

Civil + Plus Structural Engineer asked Estelle Lau, ONE°15 Brooklyn Marina’s deputy CEO, about a few of the challenges of building on such a busy waterway.

C+S: Looking at the press surrounding the opening of the marina, it seems that this was the second time around for this project. The fact that any shortcomings with the original facility were rectified speaks to the resiliency among the project’s planners. Tell us about the process of “going back to the drawing board” on such a high-profile project.

EL: The decision to redesign the marina was a thoughtful process that took into account the desired wave climate and amenities that our ownership group had envisioned for the project. Changes in the use of the waterways in front of the marina have seen an increase in traffic at high speeds which impacted the original design and would continue to worsen. Obviously budget and time to accomplish the redesign were factors but we moved quickly to commission new studies to find a solution. This led us to build a team with long histories of waterway expertise in the NYC area to work on the project with strong input from the operational team, so that we could achieve the desired results. We worked closely with permitting agencies to find the most effective solution that would have the least environmental impact and meet our goals and be able to reuse the original design elements to contain costs and limit waste and time. This whole process was complicated by the fact that we continued to be operational during the boating season and had to work to maintain the original infrastructure and minimize disruption to the boating community using the marina. While work along the waterfront in NYC is a complicated endeavor, we feel that we’ve managed the process well and are pleased with the results we are seeing.

C+S: The sub-grade R train tunnels had to be taken into consideration for this project. Talk about the regulatory and design challenges associated with a commuter tunnel running beneath the project.

EL: Our original design used a newer system of elastic moorings which did not impact the sub-grade train tunnels, but proved to be insufficient to provide the wave protection needed for the marina. A number of options were considered, but ultimately a more robust series of steel wave attenuators set on steel pilings was the most effective and least environmentally impactful. Internal to the marina we continued to use the elastic mooring system wherever possible so as to minimize impacts over the tunnels. The placement of the piles along the attenuators (and the design of the attenuation system) was carefully laid out to avoid the impact area of the tunnels – requiring a longer attenuator which spans the actual tunnels. The permitting process with the SBS, Army Corp, Environmental Agency and finally MTA was lengthy, requiring us to set up a sophisticated monitoring system when the piles would be driven, but overall the professionalism and knowledge of the agencies’ staff helped the process move as quickly as possible.

C+S: The wave attenuators were critical to the success of this project. Tell us about the design, manufacture, and installation of the attenuators.

EL: No doubt the biggest challenge was the design, build and installation of the attenuation system to defend against the increased waterway traffic wave climate. We looked at off-the-shelf, third party attenuators and found few companies that have a record of building them for recreational boating locations in these conditions. Ultimately we found that designing and building our own system made the most sense and brought the process in-house. For such a large production, we chose to have the attenuators built in Texas and towed up from there. Unfortunately, the manufacture of the system was met head on with a couple of issues: First, the larger political environment caused delays during the sourcing process for the steel needed for the attenuators; and then man-
power issues due to temporary labor shortages. We were fortunate to have found a shipyard that we trusted and worked closely with during the build; our engineers, project managers and operational team visited during the process. Secondly, extreme, inclement weather impacted the build as materials were waylaid in various locations due to weather and the transport of the attenuators was elongated. Ultimately, once the attenuators arrived, the installation went smoothly and we have seen the performance enhancement that we had hoped to achieve.

Sustainable, Environmentally Friendly and ADA Compliant:
• The team used a variety of materials to build the marina which considered environmental, maintenance and durability concerns – as ONE°15 Brooklyn Marina is subject to challenging New York City weather and harbor conditions. 
• The marina’s internal docks for small- to medium-sized vessels were made from light-weight frame aluminum docks with a lattice decking to permit light to transmit to the water below. While larger concrete docks were used elsewhere in the marina, where possible, these environmentally sustainable docks and decking were deployed. 
• Additionally, a majority of the marina was moored using an elastic mooring system instead of the traditional metal chain system. By doing so, the team was able to deploy concrete blocks to anchor the docks that have a lower footprint on the seabed. 
• Due to the natural conditions in the harbor, as well as increased traffic from ferries and high-speed boats, the team determined that to create the calmest marina in the New York Harbor and protect and provide its customers with the best water experience, the use of piles in certain locations – most notably for its wave attenuator and large craft berthing areas – would be advantageous. 
• The team worked with city officials and the Brooklyn Bridge Park on a set of large steel wave attenuators which were ballasted down on piles to protect the marina. A smaller set of concrete attenuators, anchored on the elastic mooring system, was deployed along Pier 5 to protect the marina from waves beneath the open pier. 
• Integration (and protection) of anchoring and dock materials remained a priority for ONE15. While larger boats and areas needing more protection had concrete docks and piling deployed, smaller boats and less exposed areas utilize lighter weight materials. Finally, the community dock has sturdier concrete docks for stability and ease of access for larger groups. 
• The team also installed a solar-powered lighting system within its docks to provide additional safety and considered ADA needs to create the only handicap-accessible marina on the New York Harbor.
FOUR WAYS TO TAKE ON THE LIVING BUILDING CHALLENGE

By Barry Stiles

THE LIVING BUILDING CHALLENGE calls on engineers, architects, and designers to create buildings that have a positive net effect on their surroundings. Built using only nontoxic, low-impact materials, living buildings are meant to be both healthy and beautiful. They produce more energy than they consume, collect and treat all water on-site, and incorporate elements of the local culture and natural surroundings in an aesthetically pleasing design.

The Frick Environmental Center in Pittsburgh is the most recent of only 22 buildings worldwide to earn the International Living Future Institute's Living Building Challenge certification, a classification that requires more sustainability work and documented performance than even the Leadership in Energy and Environmental Design (LEED) Platinum designation. In addition to net-zero energy and water, LBC building standards include nontoxic construction materials – a significant challenge, given that there's only one source in the world for nontoxic carpet. Still, the project leads have found the arduous process worthwhile, and so has the city of Pittsburgh.

Rethinking how buildings are constructed has a major impact on the environment. Today, buildings consume 41% of the total energy in the U.S. and are responsible for almost 40% of carbon dioxide emissions – outpacing the industrial and transportation sectors in both categories. However, in recent years, the market is driving a dramatic change. LEED-certified buildings consume 25% less energy, reduce carbon dioxide emissions by one-third, and have kept 80 million tons of waste out of landfills.

As green building activity continues to increase, almost half of industry respondents from around the world anticipate that most of their upcoming projects will be green buildings. It's worth noting that the financial returns are proving to be worth the investment. The average increase in value for a green building is 4%, while maintenance costs for LEED buildings are nearly 20% less than non-green commercial properties.

Four Ways to Bring Buildings to Life

With eco-friendly building on the rise, architects, engineers, and builders are taking on the challenge of combining the ecological and financial benefits with aesthetically pleasing designs. Increasingly, engineers and designers are turning to a range of green construction strategies starting with these:

1. Control the Light.

Custom sunshades and light shelves add to a building’s curb appeal, but their main purpose is lowering energy costs and reducing a building’s carbon footprint. The shades are also part of “daylighting strategies” that enable occupants to rely on natural light.

2. Help the Building Breathe.

Clay plasters are a high-performance building product that combine unfired clay and sand to add an attractive element to a building’s design. At the same time, they bring breathability to a structure by maintaining relative humidity between 40% and 70%, significantly reducing airborne bacteria.

3. Add Warmth, Literally and Figuratively.

As the best mainstream material for thermal insulation, wood outperforms concrete, brick, and steel. Using Forest Stewardship Council-certified wood for a building’s exteriors and interiors does more than increase the environmental benefits: Research shows that wood is perceived as warm and welcoming, which enhances feelings of well-being.

4. Pave with Style.

Think of paving requirements as more than just an infrastructural component of a project. With the range of permeable pavement solutions available, today’s pavers are designed to add to a building’s aesthetic appeal. In addition, many municipalities provide incentives to use permeable pavers because they offer an economical, functional way to meet building code requirements for on-site stormwater capture.

By embracing the challenge of meeting and exceeding environmental building standards, the building industry plays a vital role in how people view their surroundings. With a unique combination of imagination and practicality, green buildings are transforming the built environment.

BARRY STILES is the founder and CEO of TRUEGRID Pavers, the 100 percent permeable paving alternative to concrete and asphalt that instantly absorbs stormwater and detains water below the surface. TRUEGRID is a green, permeable Lego-like paver system for the real world, made in the United States from 100 percent post-consumer recycled plastic and filled with gravel or grass for a natural aesthetic. As an engineer and as a dad, Barry is passionate about TRUEGRID’s mission to provide green paving solutions to build a safer and cleaner environment for our kids. For a complete guide to managing stormwater with permeable paving, download TRUEGRID’s whitepaper.
Fire Design of Mass Timber Members - Part 2
Code Applications, Construction Types and Fire Ratings

By Richard McLain, PE, SE and Scott Breneman, PhD, PE, SE

This is Part 2 of a three-part paper on fire design written to support architects and engineers exploring the use of mass timber for commercial and multi-family construction.

Comparing Construction Types
As noted in Part 1, selection of construction type for mass timber projects is one of the more significant design considerations. Table 4 summarizes the main differences between Types III, IV and V, as well as the different types of wood systems permitted in each. These allowances are shown in IBC Section 602, Table 601 and Section 2304.11.

**TABLE 4:**
Comparison of Construction Types III, IV and V

<table>
<thead>
<tr>
<th>Construction Type</th>
<th>III-A</th>
<th>III-B</th>
<th>IV</th>
<th>V-A</th>
<th>V-B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exterior wall materials</td>
<td>FRTW</td>
<td>FRTW</td>
<td>FRTW or CLT</td>
<td>Any wood including mass timber</td>
<td>Any wood including mass timber</td>
</tr>
<tr>
<td>Exterior bearing wall FRR</td>
<td>2-hour</td>
<td>2-hour</td>
<td>2-hour</td>
<td>1-hour</td>
<td>0-hour</td>
</tr>
<tr>
<td>Interior framing materials</td>
<td>Any wood including mass timber</td>
<td>Any wood including mass timber</td>
<td>Heavy timber including mass timber</td>
<td>Any wood including mass timber</td>
<td>Any wood including mass timber</td>
</tr>
</tbody>
</table>

Sources: IBC Section 602, Table 601 and Section 2304.11
When looking to maximize the code's current allowances in terms of building size for mass timber structures, considering the differences between Type III-A and IV construction is important. For example:

- Type IV does not allow concealed spaces in floor or roof assemblies (e.g., dropped ceilings, soffits, chases, etc.), but 1-hour fire resistance-rated interior partitions are permitted. All other construction types including III-A allow concealed spaces. Note that requirements for sprinklers and draft stopping/fire blocking apply within concealed spaces per IBC Section 718 and the applicable NFPA sprinkler standard.
- Except for exterior bearing walls, Type IV does not require demonstration of fire-resistance ratings for structural elements. This is a requirement for all other construction types including III-A (but only when a fire-resistance rating is required).
- Type IV construction allows the use of CLT in exterior walls; Type III does not.

Table 5 illustrates these differences and others for a group B occupancy building.

**TABLE 5:**

**Comparison of Construction Types III and IV: Group B Occupancy**

<table>
<thead>
<tr>
<th>Allowable Height/Area</th>
<th>Type III-A</th>
<th>Type IV</th>
<th>IBC 2018 (IBC 2015) Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base allowable area per story&lt;sup&gt;1&lt;/sup&gt;</td>
<td>85,500</td>
<td>108,000</td>
<td>Table 506.2</td>
</tr>
<tr>
<td>Allowable stories&lt;sup&gt;1&lt;/sup&gt;</td>
<td>6</td>
<td>6</td>
<td>Table 504.4</td>
</tr>
<tr>
<td>Allowable building height&lt;sup&gt;1&lt;/sup&gt;</td>
<td>85'</td>
<td>85'</td>
<td>Table 504.3</td>
</tr>
</tbody>
</table>

<sup>1</sup>NFPA 13 sprinklered throughout building per IBC Section 903.3.1.1

<sup>2</sup>No frontage increase included

<table>
<thead>
<tr>
<th>Rating Requirements</th>
<th>Type III-A</th>
<th>Type IV</th>
<th>IBC 2018 (IBC 2015) Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary structural frame</td>
<td>1-hour</td>
<td>HT</td>
<td>Table 601</td>
</tr>
<tr>
<td>Exterior bearing walls</td>
<td>2-hours</td>
<td>2-hours</td>
<td></td>
</tr>
<tr>
<td>Interior bearing walls</td>
<td>1-hour</td>
<td>1-hour-HT</td>
<td></td>
</tr>
<tr>
<td>Nonbearing exterior walls</td>
<td>Table 602</td>
<td>Table 602</td>
<td></td>
</tr>
<tr>
<td>Nonbearing interior walls</td>
<td>0-hour</td>
<td>1-hour or per 602.4.8.1</td>
<td></td>
</tr>
<tr>
<td>Floor construction &amp; associated secondary members</td>
<td>1-hour</td>
<td>HT</td>
<td></td>
</tr>
<tr>
<td>Roof construction &amp; associated secondary members</td>
<td>1-hour&lt;sup&gt;3&lt;/sup&gt;</td>
<td>HT</td>
<td></td>
</tr>
</tbody>
</table>

<sup>3</sup>Note ability to use heavy timber in Type III-A roof construction in lieu of FRR

HT = Heavy Timber – See minimum wood member sizes per IBC 2018 2304.11 (IBC 2015 602.4)

<table>
<thead>
<tr>
<th>Other Considerations</th>
<th>Type III-A</th>
<th>Type IV</th>
<th>IBC 2018 (IBC 2015) Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRTW required in exterior walls</td>
<td>Yes</td>
<td>Yes</td>
<td>Sections 602.3 &amp; 602.4.1</td>
</tr>
<tr>
<td>CLT allowed in exterior walls</td>
<td>No</td>
<td>Yes with stipulations</td>
<td>Section 602.4.2</td>
</tr>
<tr>
<td>Concealed spaces in floor systems allowed</td>
<td>Yes</td>
<td>No&lt;sup&gt;4&lt;/sup&gt;</td>
<td>Sections 602.3 &amp; 2304.11.3 (602.4.6)</td>
</tr>
<tr>
<td>Exterior wall projections</td>
<td>Any approved material</td>
<td>Any approved material</td>
<td>Section 705.2.2</td>
</tr>
<tr>
<td>Interior finish requirements</td>
<td>Table 803.11</td>
<td>Exempt</td>
<td>Section 803.3</td>
</tr>
<tr>
<td>Minimum roof covering classification</td>
<td>B</td>
<td>B</td>
<td>Section 1505.1</td>
</tr>
</tbody>
</table>

<sup>4</sup>2021 IBC will allow concealed spaces in type IV-HT under certain conditions as noted
The requirements of Type IV construction to have no concealed spaces in floors or roofs and for all interior partition walls to be solid wood or 1-hour rated can significantly impact its utility for some applications. The alternative of using Type III construction (or Type V where building size permits) avoids this limitation; however, the processes for demonstrating fire-resistance ratings also vary between Type IV and Types III and V. Methods for meeting fire-resistance rating requirements for mass timber elements in buildings other than Type IV construction are the focus of the rest of this paper.

**Methods to Demonstrate Fire-Resistance Ratings of Mass Timber**

When a mass timber building element or assembly is required to have a fire-resistance rating, IBC Section 703.2 requires the rating to be determined by testing in accordance with ASTM E 119 (or UL 263) or via one of six alternatives listed in IBC Section 703.3:

The required fire resistance of a building element, component or assembly shall be permitted to be established by any of the following methods or procedures:
1. Fire-resistance designs documented in approved sources
2. Prescriptive designs of fire-resistance-rated building elements, components or assemblies as prescribed in Section 721
3. Calculations in accordance with Section 722
4. Engineering analysis based on a comparison of building element, component or assemblies designs having fire-resistance ratings as determined by the test procedures set forth in ASTM E119 or UL 263
5. Alternative protection methods as allowed by Section 104.11
6. Fire-resistance designs certified by an approved agency

These alternatives are options when the exact assembly has not been tested per ASTM E 119 and a test report is therefore not available. They are all founded on ASTM E 119 testing.

There are currently limited options for fire resistance-rated mass timber assemblies from approved sources (e.g., Gypsum Association GA-600, American Wood Council’s Design for Code Acceptance 3 – Fire Resistance-Rated Wood Floor and Wall Assemblies, [DCA 3]) or certification agencies (e.g., UL listings). However, an increasing number of assemblies have been tested according to the ASTM E119 standard and are available publicly or on request from manufacturers. The number of available tested assemblies can be expanded using comparative engineering analysis described in Item 4 of IBC Section 703.3. Such an analysis, which seeks to justify the fire-resistance rating of an assembly or component similar to one that has passed an E119 test, can be performed by a fire protection engineer.

Item 3 of IBC Section 703.3, which permits the use of calculations in accordance with Section 722, is also frequently used to demonstrate the fire-resistance rating of exposed mass timber. IBC Section 722.1 states: The calculated fire resistance of exposed wood members and wood decking shall be permitted in accordance with Chapter 16 of ANSI/AWC National Design Specification® for Wood Construction (NDS®). Chapter 16 of the NDS can be used to calculate up to a 2-hour fire-resistance rating for a variety of exposed wood members including solid sawn, glulam, SCL, and CLT.

**ASTM E119 Testing Method**

According to Section 4.2 of ASTM E119-18, the fire test procedure is intended to do the following:

*The test exposes a test specimen to a standard fire controlled to achieve specified temperatures throughout a specified time period. When required, the fire exposure is followed by the application of a specified standard fire hose stream applied in accordance with Practice E2226. The test provides a relative measure of the fire-test-response of comparable building elements under these fire exposure conditions. The exposure is not representative of all fire conditions because conditions vary with changes in the amount, nature and distribution of fire loading, ventilation, compartment size and configuration, and heat sink characteristics of the compartment. Variation from the test conditions or test specimen construction, such as size, materials, method of assembly, also affects the fire-test-response. For these reasons, evaluation of the variation is required for application to construction in the field.*

Successful fire tests have been completed on numerous mass timber elements and assemblies, achieving fire-resistance ratings of 3 hours or more. Additional tests by manufacturers and others are ongoing. Most tests are conducted according to ASTM E119 or its Canadian equivalent, ULC S101. Both utilize the same time-temperature curve and performance criteria and, as such, ULC S101 fire tests are usually acceptable to U.S. building officials. However, each project’s building official should be consulted if choosing this design route.

To help building designers compare options, WoodWorks has compiled a web-based inventory of completed mass timber fire tests. The Inventory of Fire Resistance-Tested Mass Timber Assemblies & Penetrations as new tests become available, and can be found at http://bit.ly/2FRwAPG.
Calculation-Based Method
As referenced in IBC Section 722.1, NDS Chapter 16 can be used to calculate the structural fire-resistance rating of various wood products, including solid sawn, glulam, SCL, and CLT.

As noted by Douglas and Smart in Structure magazine (July 2014), “The design procedure allows calculation of the capacity of exposed wood members using basic wood engineering mechanics. Actual mechanical and physical properties of the wood are used, and member capacity is directly calculated for a given period of time—up to 2 hours. Section properties are computed assuming an effective char depth, \( \beta_{eff} \), at a given time, \( t \). Reductions of strength and stiffness of wood directly adjacent to the char layer are addressed by accelerating the char rate by 20 percent. Average member strength properties are approximated from existing accepted procedures used to calculate design properties. Finally, wood members are designed using accepted engineering procedures found in NDS for allowable stress design.”

The American Wood Council’s (AWC’s) Technical Report 10 – Calculating the Fire Resistance of Wood Members and Assemblies (TR 10) provides an in-depth explanation of the concepts and background associated with exposed wood fire design. This document also includes a number of design examples for exposed structural wood members utilizing the provisions of NDS Chapter 16.

Structural Design Calculations under Fire Conditions
When utilizing the char calculation option of NDS Chapter 16 to demonstrate fire-resistance ratings, a structural design check must also be done to determine structural adequacy of framing members under fire conditions. One of the main benefits of the char calculation method is that it accounts for the ability that heavy and mass timber have to form a char zone, which insulates the remaining wood cross-section, allowing it to retain structural capacity.

NDS Section 16.2.2 states that, under fire design conditions, the average member strength can be approximated by multiplying reference design values such as \( F_b \) by the adjustment factors specified in Table 16.2.2. As indicated in Table 7, an increase in allowable design stresses by a factor of 2.03 to 2.85 is allowed, depending on the stress under consideration.

For example, a 6-3/4-inch x 13-1/2-inch glulam beam with an unadjusted allowable bending stress of 2,400 psi would first be checked for all structural loading conditions and limit states (bending, shear deflection, vibration and others as applicable) using the full cross-sectional dimensions and adjustment factors per NDS Chapter 5. If this beam were required to have a 1-hour fire-resistance rating (perhaps as a floor beam in a Type V-A structure) then its effective char depth on all three exposed sides would be 1.8 inches (per NDS Table 16.2.1A). Its cross-sectional dimensions under fire conditions would be:

\[
\text{Width} = 6.75" - (2)(1.8") = 3.15"
\]
\[
\text{Depth} = 13.5" - 1.8" = 11.7"
\]
This reduced cross-section would then be checked under fire conditions, with allowable design stresses increased by the factors given in NDS Table 16.2.2. For example, a 2.85 increase factor could be applied to allowable bending stresses. AWC’s TR 10 provides design examples for a number of exposed timber applications under fire conditions.

The stress adjustment factor, K, to increase the reference design stress is for use when performing a structural capacity check under the fire load condition with allowable stress design (ASD) load combinations (e.g., D + L, etc.). This stress adjustment factor is not intended to be used with load and resistance factor design (LRFD) load combinations, including those intended for extraordinary events such as in ASCE 7-16 Section 2.5.

Appendix A of TR 10 provides design tools for beams and columns of solid sawn, glulam or SCL materials under fire design scenarios using the char calculation provisions of NDS Chapter 16. Table A1 provides a method to quickly check if a beam exposed on three sides passes the structural fire condition check provided the designer knows the beam’s size and maximum demand to capacity ratio (Rs) under the required non-fire condition using ASD load combinations. Table A2 provides a similar design table for columns exposed on all four sides.

For more information, the complete paper can be downloaded from the WoodWorks website, along with an Inventory of Fire Resistance-Tested Mass Timber Assemblies and Penetrations.

WoodWorks – Wood Products Council provides free technical support as well as education and resources related to the code-compliant design of commercial and multi-family wood buildings. A non-profit organization staffed with architects, structural engineers and construction experts, WoodWorks has the expertise to assist with all aspects of wood building. For assistance with a project, visit www.woodworks.org/project-assistance or email help@woodworks.org.
Municipal and investor-owned utilities often rely on subjective criteria to determine which water mains in their system need replacing. To add to the inaccuracy, the decisions are often made when opportunity strikes, like where street paving will happen in the near future. This process leads to inefficient spending of limited resource dollars, leaving utilities extremely vulnerable to financial and structural risk.

This is unwanted pressure for utilities, as they’re facing increased state and federal regulatory pressures to create efficient, comprehensive asset management plans.

Asset management practices combined with Artificial Intelligence, specifically Machine Learning, provide a new method for assessing the condition of buried water mains. Specifically, AI and Machine Learning allow utilities to properly align maintenance, rehabilitation, and replacement strategies to better allocate limited resources.

Digital Condition Assessment Using AI and Machine Learning

Machine Learning-based condition assessment tools are relatively new, but are now commercially available. Machine Learning, a category of AI, provides computers the ability to learn without being programmed. It uses automated and iterative models to learn about patterns in big data, detecting anomalies and identifying a structure that may be new and previously unknown. Through this capability, Machine Learning supports a new way of aligning maintenance and, in turn, asset management planning by creating more accurate analysis despite using less data.

Fracta offers a fast, accurate and affordable digital condition assessment solution to predict the Likelihood of Failure (LOF) of water distribution mains.

Fracta is also fully integrated with Esri’s market-leading ArcGIS software. The integrated Fracta and Esri platforms provide an architectural framework to readily integrate with other important software applications used by water utilities such as Enterprise Asset Management (EAM), Computerized Maintenance Management Systems (CMMS), and Hydraulic Modeling.

Many utilities, public utility commissions, and consulting engineers still view the Fracta Machine Learning and GIS approach as a “black box,” as happens with any new technology, with the primary concern being accuracy.

Balanced Accuracy for LOF Predictions

The data that comes out of a Machine Learning model is only as accurate as the data that goes into the model (i.e., “garbage in, garbage out”). Fracta uses a Supervised Machine Learning model with input variables (x) and an output variable (Y). The model uses an algorithm to learn the mapping function from the input to the output, \( Y = f(x) \). The goal is to approximate the mapping function so well that for new input data (x) the algorithm can predict the output variables (Y) for that data.

It is supervised learning because the process of algorithm learning from the training dataset is similar to a teacher supervising the learning process. By using a training data set with the correct answers known, the algorithm iteratively makes predictions on the training data and is corrected by the teacher. Learning stops when the algorithm achieves an acceptable level of performance. Generally, 80% of the historical data are used to train, and 20% are used to validate the Machine Learning model.

Assessing a water distribution system with a Machine Learning model requires an understanding of both failures and non-failures. True Positive Rate (TPR) measures the proportion of correctly identified real positives. In the Fracta solution, that means correctly identifying the high probability failures. True Negative Rate (TNR) measures the proportion of correctly identified actual negatives. This methodology focuses on correctly identifying the segments that have low LOF. The accuracy is a balance between high LOF and low LOF results. Because the training and validation of the model are based on 80% of the data, the maximum Balanced Accuracy that it can achieve is 80%.
The Next Generation of Condition Assessments: Fast, Accurate and Cost Effective

Traditionally, condition assessments of buried water mains typically fall into two categories: indirect and direct. An indirect desktop study method should always occur first. A direct or physical inspection and condition assessment are accurate for the pipe tested, but it tends to be slow, very expensive, and labor intensive. Multiple physical measurements are required for correlation and confirmation. The results are difficult to extrapolate to system-wide recommendations, which could be based on arbitrary assumptions and weights (i.e., older pipes are more in need of replacement than newer pipes).

A performance-based buried infrastructure asset management approach involves a detailed inventory by pipeline segment and monitoring how well individual pipelines are meeting the level of service that is required of them. Since buried infrastructure is not readily accessible, performance-based management of these buried assets has historically not been performed in the water industry.

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

Due to the large amount of historical and geospatial data needed to run Machine Learning algorithms, water main condition assessments contain all the necessary components of an ideal application for water utilities. Pipe data and the surrounding environmental data covering installation year, pipe material, break history, pressure class, geographical location, elevation, pipe diameter, proximity to other infrastructure systems, and soil composition can all be taken into consideration while also assessing hundreds of other variables unique to a specific utility and pipe location. Consistently analyzing this data can uncover trends, gain insight on pipeline health, and offer data-driven assessments.

New pipe data strengthens the predictive power of a Machine Learning algorithm. Machine Learning can also benefit utilities with a limited asset or breakage data by “filling in the gaps.” Machine Learning can utilize many streams of data to perform certain predictions and begins to learn patterns that can inform situations where many of the common data points may not be available creating a new digital revolution in advanced asset management practices. The more data a model contains, the more robust the model. As utilities are constantly collecting data such as new breaks and installed pipes, that data can continually be fed into a Machine Learning model.

In February 2019, Fracta launched its next wave of capabilities. They couple its fast, accurate, and affordable LOF predictions with Consequence of Failure (COF) to calculate a monetized Business Risk Exposure (BRE) and an estimated replacement cost for every buried water main in a distribution system. Fracta COF determines the consequences, or severity, of the failure.

Utilities can calculate the BRE in terms of risk ranking and direct and indirect costs. This approach gives an objective assessment and translates the results into financial terms that water engineers, planners, and finance professionals can use to make fast, accurate and capital-efficient risk mitigation decisions about buried water main infrastructure.

Incorporating a Machine Learning condition assessment like Fracta into a proper infrastructure and asset management program will enable utilities to meet the Modified Approach under GASB 34 for reporting the value of buried water mains. This will contribute to a more accurate accounting of the value of the assets. It also contributes to the reduction of economic impacts incurred from water main breaks and more efficient allocation of funding 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 and accountability to the planning process and refine the investment strategy so a utility will be in a better position to defend planning efforts and justify pipe replacement projects.

DOUG HATLER is Chief Revenue Officer at Fracta.
**IS A STORMWATER UTILITY RIGHT FOR YOU?**

**MANAGING STORMWATER QUALITY IS AN UNFUNDED MANDATE.**

**THE COST FOR CAPITAL AND OPERATIONS WILL HAVE TO BE FUNDED AT THE LOCAL LEVEL, THROUGH TAXES OR A FEE.**

By Michael Schober

*BY NOW,* most municipalities are familiar with the many acronyms associated with stormwater. They have permits for their Municipal Separate Storm Sewer (MS4) systems and have completed their Pollution Reduction Plans (PRP). Regardless of which acronym chosen, municipalities are faced with increasing regulatory requirements and diminishing budgets with which to address them. Let’s face it, with local municipal / political priorities, parks and roads will always get funded before projects for reducing sediment to our streams. Therefore, many municipalities are turning to alternative revenue models to fund stormwater projects.

Rather than competing for funds from the municipality’s general fund, some municipalities are forming either stormwater utilities (a department within the municipality, much like sewer or water) or stormwater authorities. In both cases, the utility or authority charges a user fee dedicated strictly to stormwater quantity and / or quality projects which then eliminates competition for scarce revenues.

The decision to keep the stormwater utility within your municipality, or form a separate authority, will depend on several factors. Each municipality will have to evaluate its operation, and determine its goals and desired outcomes. Before doing so, consider the following:

**Stormwater Department** – Forming a stormwater department is typically easier because the framework of employees and policies are already in place. There is also the ability to cross-train employees and use existing equipment as dual-purpose. Of course, since the funding mechanisms are separate, keeping close account of where all costs (labor and equipment) are incurred, and are being charged to the correct accounts, is paramount. Although the revenue funds are kept separate, it still may be difficult to prioritize where municipal employees and equipment focus their efforts.

**Stormwater Authority** – The advantage of a stormwater authority is the separation of funds and employees from any competing interests. All funds and employees are dedicated to stormwater-related projects. The authority can plan and prioritize projects without political influences. An authority can borrow funds without incumbering the borrowing capacity of the municipality. An authority has the capability to do projects outside the jurisdiction of the municipality which can result in economies of scale, as well as increased grant opportunities. However, forming a stormwater authority can be a complex process and will require seed money to get it up and running.

Whether it’s a stormwater department or stormwater authority, there will be a need to establish a fair and equitable stormwater rate. There are several ways to do this and most equitable methods are based on the amount of stormwater a property produces. This makes it a user fee; not a tax. Ultimately, the stormwater fee will be based on your municipality’s land use characteristics, resources and preferences.

Most fee structures begin with the Equivalent Residential Unit (ERU). Much like the EDU for sewer or water, the ERU is based on the amount of impervious area on a property. Impervious areas are typically rooftops, driveways and sidewalks. An average square footage of impervious area is calculated for residential properties. For instance, the average impervious area could be 3,000-square-feet (SF), representing one (1) ERU. If a commercial property in the same municipality consisted of 9,000-SF impervious, it would be charged for three (3) ERU’s. It should be noted that non-profits such as schools, universities and churches would pay the fee based on their calculated ERU (remember, it’s a user fee; not a tax). There are several variations to this type of fee structure:

The Residential Tier System is similar to the ERU, but it divides residential properties into different rate tiers based on the amount of impervious cover. While this system offers more equity, it is more difficult to manage and may be more vulnerable to legal challenges than the ERU method.
The Intensity Development Factor adds a land use component by allocating cost based on the percentage of impervious area relative to the entire parcel size. This system recognizes that stormwater from a farm house on 20 acres has a different impact than a house in a densely populated neighborhood. These land use categories can be broad, difficult to implement and even more difficult to explain to the public.

The Residential Equivalent Factor (REF) uses a highly-scientific approach to determining stormwater impacts from each parcel. For each parcel, REF considers soil types, land use and ground slope to predict the expected amount of stormwater discharge for a given storm intensity. While this approach is arguably the most exact, performing these calculations for each property is very time-consuming and explaining this to the public is a significant challenge.

Regardless of the rate structure selected, it may be viable to consider offering a credit program that can reduce the stormwater fee for installing or conducting practices that reduce stormwater runoff or improve stormwater quality. These are generally referred to as Best Management Practices (BMP’s). Each municipality will have to decide who is eligible for credits and the amount of reduction for a given BMP. Some municipalities offer credits to only non-residential properties as a means to limit the complexity of managing the credit program.

Finally, a robust public education program is essential for gaining public and stakeholder approval. This should include involving key stakeholders early in the process. Key stakeholders may include elected officials, non-profits, schools / universities and the business community. Typically, these are the properties that will be seeing the larger stormwater bills. Getting their input early will help them plan for this and will provide valuable feedback for moving forward.

Managing stormwater quality is yet another unfunded mandate from the EPA. The cost for capital and operations will have to be paid for at the local level, whether it’s via taxes or a stormwater fee. Once the public understands this, and that a stormwater fee can be applied equally among all property owners, then there is general acceptance. Residents want to know that the fees they pay are going toward the intended projects. A stormwater fee is one way to ensure that happens.

Michael Schober

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Michael Schober, PE, BCEE, T&M Associates. Mr. Schober has over 33 years of experience in the field of water resource engineering. He has been involved in dozens of water, wastewater and stormwater projects and has worked with municipalities and authorities to develop stormwater utilities. He has a BS, Civil Engineering, from Villanova University.
The MoPac Expressway intersections at Slaughter Lane and La Crosse Avenue in southwest Austin were originally constructed in 1992. Since that time, Austin’s population has nearly doubled, according to the U.S. Census. Average daily traffic on the MoPac Expressway, which was 21,000 in 2010, is projected to reach 66,700 by 2030.

As a result, the intersections at Slaughter Lane and La Crosse Avenue became congested over the years, creating operational problems, causing travel delays, and affecting access, safety and mobility. In 2013, the Central Texas Regional Mobility Authority and the Texas Department of Transportation (TxDOT) initiated an environmental study to analyze and determine options for reducing travel delay and enhancing safety at these intersections.

“During the morning and evening peak hours, motorists had to wait through multiple traffic signal cycles at these two intersections,” said Lucas Short, P.E., TxDOT’s project manager.

Following the study and public review, TxDOT decided to construct underpasses at Slaughter Lane and La Crosse Avenue and extend the MoPac main lanes under these two intersections. The MoPac main lanes, two in each direction and approximately two miles long, would be constructed inside the existing MoPac lanes. The existing MoPac lanes would be reconstructed and serve as ramps to carry main lane traffic to Slaughter Lane and La Crosse Avenue.

The grade separation at La Crosse Avenue and MoPac was configured as a standard diamond interchange while the grade separation at Slaughter Lane and MoPac was configured as a diverging diamond interchange (DDI) – the first in the city of Austin and the second in the Austin area. Other improvements include constructing an additional 10-foot-wide shared-use path on the west side of MoPac from Slaughter Lane to La Crosse Avenue, retaining walls at the bridges, a storm sewer system, traffic signals, new pavement, and striping and signing throughout the project limits.

“The improvements will reduce delays for northbound and southbound traffic in the MoPac Expressway as commuters don’t have to stop at a signalized intersection to travel through the area,” said Short. “Also, constructing the DDI at Slaughter Lane will allow for more efficient left turn movements.”

To implement these improvements, TxDOT selected Lockwood, Andrews & Newnam, Inc. (LAN), a national planning, engineering and program management firm, as the lead design engineer. Kimley-Horn and Associates, Inc. was selected as the traffic control plan and temporary signals sub-consultant, Cobb Fendley and Associates, Inc. as the illumination sub-consultant, and IDCUS, Inc. as the drainage, signing and striping sub-consultant. In August 2017, the project went to letting and Webber was awarded the contract as the low bid.
To expedite the construction, TxDOT has also employed a disincentive/incentive strategy. Photo: LAN

**Diverging Diamond Interchange**

A DDI is an innovative design solution that addresses congestion by allowing vehicles to travel more quickly through an intersection. Though a relative rarity in the United States, it is gaining popularity because of its efficiency and safety. The first DDI was constructed a decade ago in Springfield, Missouri. Since then, 88 have been built. DDIs are particularly effective at locations that have a high volume of left-turn traffic. In a DDI, traffic is temporarily shifted to the left side of the road to increase traffic flow by allowing through-traffic and intersecting traffic turning left to proceed through the intersection simultaneously. Consequently, this configuration can accommodate 40 percent more left-turning vehicles than a standard diamond interchange with the same number of lanes.

Additionally, a DDI enhances safety by reducing potential crash points at intersections. Compared to a conventional diamond interchange, the DDI reduces vehicle-to-vehicle conflict points by nearly 50 percent, according to the Federal Highway Administration. Other DDI benefits include additional green time at traffic signals to allow more vehicles to pass through the intersection, increased safety for pedestrians and bicyclists due to additional sidewalks, and low-cost construction.

“Our traffic analysis showed that in the morning peak hours, the predominant movement is east-bound Slaughter Lane to north-bound MoPac,” said Short. “In the afternoon rush hour, the predominant movement is south-bound MoPac to east-bound Slaughter Lane. We considered a variety of intersection types for Slaughter Lane, including a standard diamond intersection, single-point urban intersection, grade-separated roundabout, and the DDI. Ultimately, we chose the DDI because it can handle substantial left-turn volumes.”

**Environmental Protections**

The MoPAC Intersections project is located over the Barton Springs segment of the Edwards Aquifer Recharge Zone. The Barton Springs segment of the Edwards Aquifer supplies water to between 50,000 and 60,000 people, provides habitat for two endangered salamander species, discharges at the Barton Springs complex, and is one of the most studied karst aquifer areas in Texas (the word karst describes an area of irregular limestone in which erosion has produced fissures, sinkholes, underground streams and caverns).

To protect the Edwards Aquifer, TxDOT and the project team implemented rigorous environmental measures that met, or even exceeded, the Texas Commission on Environmental Quality (TCEQ) compliance requirements. The measures included four categories of environmental controls: environmental compliance management, karst void mitigation, temporary construction controls, and permanent post-construction controls.

- **Environmental Compliance Management** — TxDOT hired an independent environmental compliance manager to monitor construction and ensure that Best Management Practices (BMPs) for environmental protection are implemented and function as designed. This is in addition to construction management and environmental compliance personnel provided by the contractor. This level of environmental compliance oversight is atypical for TxDOT projects and exceeds TCEQ requirements.
- **Karst Void Mitigation** — Construction plans and specifications provide construction details and notes directing the contractor on how to proceed if a karst feature is encountered. In addition to specific construction details, the contractor is directed to notify the TxDOT project manager, environmental compliance manager, TCEQ and the City of Austin.
- **Temporary Construction Controls** — The project incorporates erosion and sedimentation controls such as silt fences for perimeter control, rock berms for concentrated flow and construction exits to control sediment onto roadways.
- **Permanent Water Quality Controls** — The project includes a suite of storm water quality measures that, in combination, will exceed the 80 percent Total Suspended Solids (TSS) removal requirement of the TCEQ Edwards Aquifer Protection Program rules. These measures include vegetated filter strips, permeable friction course, and retrofit of the existing vertical sand filters. In addition, the project includes seven batch detention ponds functioning primarily as hazardous material traps, but also providing extended detention to remove the Total Suspended Solids.

**Accelerated Construction**

Due to the high traffic volumes in the two intersections, TxDOT wanted to minimize the impact to the traveling public during construction. To this end, the project team employed a number of strategies to expedite construction. One such strategy was implementing Accelerated Bridge Construction (ABC) techniques such as precast bent/abutment caps and post-installed column aesthetic features.

“On conventional bridges, you excavate to the top of the foundation, which in many cases are the drilled shafts,” said Mario Rosino, Webber’s project manager. “Then you build the columns up, build the cap in place, set beams and then pour the deck. On Slaughter Lane, we built the bridges essentially at-grade. We built the drilled shafts and the columns through the existing pavement under nightly lane closures. Then we pushed traffic into a new detour section and excavated down to sub-grade, exposing the drilled shafts and then set the pre-cast caps in place.”

By using pre-cast elements, Webber was able to find savings in concrete cure time, thereby reducing the total schedule. After completing the bridge, the contractor dressed-up the columns with Class K concrete so they had a smooth finish with the appropriate form liner. Also, by using a new detour section, Webber was able to build the bridges in Slaughter Lane in one phase instead of two, which accelerated the construction process.
To expedite the construction, TxDOT also employed a disincentive/incentive strategy. As part of this strategy, TxDOT set the contractor three milestones with penalties for exceeding the timeline and bonuses for early completion. The first milestone, which had to be substantially completed in 150 working days, required opening the two new bridges for Slaughter Lane, opening one MoPac main lane in each direction, and closing a single frontage road lane in each direction. This milestone also required opening the DDI in temporary configuration. TxDOT set the disincentive/incentive for late/early completion at $20,000 per day. The second milestone, which required substantial completion in 70 working days with a disincentive/incentive of $15,000 per day, involved opening Slaughter Lane and all the frontage roads within 300 feet of Slaughter Lane in the final DDI configuration. The third and final milestone required opening La Crosse Avenue bridge and a single MoPac main lane in each direction in 70 working days, with a disincentive/incentive of $10,000 per day.

“The goal is to motivate the contractor to complete the project ahead of schedule,” said Ralph Condra, P.E., LAN’s project manager for construction engineering and inspection services. “TxDOT employs this strategy for critical projects where traffic inconvenience and delays need to be held to a minimum.”

Thanks to these innovative design and construction strategies, TxDOT and the project team have kept the project on schedule and under budget. The construction of the $53.5 million project began in January 2018 and is expected to be completed in winter 2020.

“The Slaughter Lane and La Crosse Avenue intersections are the only remaining at-grade intersections in the entire MoPac corridor,” said Short. “This project will help us remove a critical bottleneck and go a long way toward reducing congestion in southwest Austin.”

BOB AUSTIN, P.E., is a vice president at Lockwood, Andrews & Newnam, Inc. (LAN), a national planning, engineering and program management firm. He can be reached at RDAustin@lan-inc.com.

STAYING ON TRACK
MAINTAINING RAILWAY RESILIENCY: A STRATEGIC ASSET MANAGEMENT APPROACH TO LIFECYCLE OPTIMIZATION
By Meg Vermillion

INCREASING VARIABILITY AND EXTREMES IN WEATHER create increased operational risk for critical defense installations. These extreme weather events test the infrastructure resilience, degrade infrastructure, and lead to delays as well as concerns about continuing operations.

According to the US Department of Homeland Security, Infrastructure resilience is the ability to reduce the magnitude and/or duration of disruptive events. The effectiveness of a resilient infrastructure or enterprise depends upon its ability to anticipate, absorb, adapt to, and/or rapidly recover from a potentially disruptive event.

The impacts of Hurricane Florence on Military Ocean Terminal Sunny Point (MOTSU) helped identify vulnerabilities in its infrastructure and more specifically in its railway network. In a resource limited environment, the emphasis on repairing the railway infrastructure is summed up in one word – capacity. One railcar can hold the equivalent of roughly four truck loads. Additionally, one train can haul the equivalent of over 400 trucks. In order to move 400 trucks on the road,
the pressure of rapidly rising flood waters, Sanford Dam gave way. Railways were inundated by floodwaters during the hurricane. Under nize, and store large amounts of inventory for global distribution. The MOTSU’s railways are the installation’s primary means to move, orga-

...ed many times since originally built. The remainder of the rail is a series of internal rails (dip yards, class yards, holding yards) which support the movement, storage and sorting of train cars. The railways were constructed in the 1950s and have been

MOTSU’s ability to continue mission, although compromised, demonstrated the resiliency of its multi-modal infrastructure. Additionally, only a relatively short period of time, two months, was necessary to conduct critical repairs and bring the installation back to full operational capability (FOC). This further demonstrated resiliency and highlights the role a strategic asset management program has in improving infrastructure resiliency.

scope of work development:
The U.S. Army Corps of Engineers (USACE) was assigned the mission to assess all damage caused by Hurricane Florence to MOTSU and contract the repairs. USACE brought the entire enterprise of expertise and assets to bear on this national security problem in order to return MOTSU to FOC by November 26, 2018. With more than 100 miles of railways to assess in addition to other infrastructure damage, the Savannah District USACE leveraged the expertise of its railway subject matter experts (SME) from USACE’s Engineer Research and Development Center (ERDC) and a Rail Assessment Team (RAT) provided by the 757th Expeditionary Rail Center (ERC). They supplemented MOTSU’s Department of Public Works (DPW) Railway Maintenance Department’s inspection capability of rail infrastructure and rail equipment. Together, the USACE teams rapidly evaluated and prioritized repairs.

With the exception of extensive wash outs, the overall condition of the MOTSU rail system rated as good. The entire MOTSU rail system had undergone a complete upgrade within the past 10 years. As a result of these upgrades, a majority of MOTSU tracks could absorb Hurricane Florence’s impact.

The assessment team provided a framework upon which to evaluate, prioritize, and estimate repairs. The team formed recommendations to align with codes and standards. A risk matrix identified areas of deficiencies and recommendations for mitigation which they used to prioritize repairs and provided the template to develop a cost estimate. Repairs fell into two categories: (1) minimal spot repairs that MOTSU’s Department of Public Works (DPW) Railway Maintenance Department could correct and (2) extensive repairs requiring USACE contracts.

Focus on Repairs:
Up against the clock, the USACE teams and MOTSU DPW collaborated to more finely delineate the project’s scope of work and priorities. The institutional knowledge of the USACE railway SMEs and MOTSU’s own railway maintenance team, formed through their training and years of service proved invaluable.

Together, the teams delineated the critical components of the railway necessary to safely support a fully loaded train. The railway consists of rails which are supported by ties and held in place with plates, spikes and anchors. The entire railway rests upon ballast which supports, stabilizes and distributes the load of the train. In addition, this ballast serves to shed water away from the timber crossties to prevent premature deterioration. Furthermore, rails must be level and aligned

Washed out section of railway – structural fill and ballast absent leaving rail and ties suspended. Photo: Meg Vermillion

it would require 400 drivers compared to the two engineers that could run one train.

MOTSU’s rail network exceeds 100 miles of track which consists of 300 individual tracks, switches, bridges, and highway crossings. Of the 100 miles of track, the external rail is approximately 18.25 miles long. The remainder of the rail is a series of internal rails (dip yards, class yards, holding yards) which support the movement, storage and sorting of train cars. The railways were constructed in the 1950s and have been added to and renovated many times since originally built.

MOTSU’s railways are the installation’s primary means to move, organize, and store large amounts of inventory for global distribution. The railways were inundated by floodwaters during the hurricane. Under the pressure of rapidly rising flood waters, Sanford Dam gave way. Waters coursed over MOTSU’s network of railways, washed out tons of ballast, destabilized hundreds of feet of culvert, undermined the integrity of miles of track, and left multiple areas of track rails exposed with railroad ties dangling.

MOTSU’s railway network supports a mixture of military and commercial traffic. After the storm, external military and commercial railway operations completely halted due to the washouts. Internally, however, railway operations still continued due to redundancies built into the rail network.
to ensure trains travel with as little harmonic rocking as possible to prevent the train from derailing. All these systems must be in place to ensure the safety of a train and its operators.

The finalized scope of work consisted of replacing damaged crossties, adding ballast to return the railroad to grade, cleaning out drainage ditches of debris, repairing culverts, re-surface and aligning tracks, and testing any electrical grade crossing signals.

The USACE awarded a contract to Eagle Eye Electric, LLC with Civil Works Contracting (CWC) as their subcontractor. Construction started on October 2, 2018, and by November 26, 2018, the installation was back to FOC. The contractors worked seven days a week in order to reach FOC within this period. This massive effort used specialized equipment and operators brought in from all regions of the country. A total of 7,891,760 lbs. (390 tons) of crossties were disposed of at a local energy plant and recycled for energy. In addition, workers replaced more than 4,190 cross ties using approximately 36,000 rail spikes amounting to nine tons of spikes. Furthermore, 150 linear feet (LF) of 36-inch to 60-inch concrete culvert pipe was replaced from under and alongside of the tracks. The repairs of the washouts required 2,245 cubic yards of structural fill, 521 tons of aggregate base, and 1,753 tons of ballast. To finish off, a total of 60,000 LF or 11.36 miles of track was re-surfaced and aligned to level the track over the repairs.

Focus on the Future:
An asset management plan for railways includes the maintenance of the rails, ties, plates, spikes, anchors, ballast, drainage structures, maintenance equipment, and personnel. The road to railway resiliency starts with a strategic asset management plan that seeks to optimize each asset’s life cycle. The first step of this process is to establish asset condition indexes, identify the manufacturer’s recommended lifecycle for each asset, and develop a comprehensive maintenance plan.

The framework used the railway condition index to prioritize, plan and budget repairs and capital improvements. This labor intensive process enabled USACE to expedite work following Hurricane Florence by utilizing UAVs and an influx of SMEs. During normal operation, however, MOTSU has two track inspectors who average 30 days to complete the task of walking all tracks in order to deem them in or out of service. MOTSU’s tracks are required to have a monthly “walking inspection.”

The maintenance team must develop a comprehensive maintenance plan which clearly communicates maintenance priorities in terms of risk, levels of severity and likelihood of impacting operations. A comprehensive maintenance plan projects reoccurring repairs into the future, at least five and ten years out, in order to visualize efforts and distribute costs. Together, a multiyear maintenance plan and a well-defined prioritization matrix communicates urgency during the funding process.

Another consideration when developing the budget and maintenance plan is whether to routinely maintain an asset or run it to failure. This helps to identify funding needs as expense or capital improvement. In addition, a substantial financial and time investment is equipment, training, and establishing redundancy in the system. When it’s not feasible to conduct repairs due to time or budgetary constraints, it may be more feasible to out-source the work.

To illustrate the magnitude of specialized equipment necessary for railway maintenance, MOTSU’s inventory of equipment consists of rail motor cars (to haul personnel and materials), spike extractors/inserters, tie extractors/inserters, a tie crane (to clean up loose ties and lift switch ties), an aerial lifter (to insert plates), high rail dump trucks (ballast), tampers (to surface and align rail, and tamp ballast), regulators (to dress up the ballast on railroad shoulders and sweep excess ballast from the tracks), brush cutters (vegetative maintenance), loaders and fork lifts. MOTSU faces a challenge to balance the budget and schedule in order to maintain equipment, cross-train personnel, and conduct repairs. Putting the components of strategic asset management in perspective, MOTSU’s railway maintenance supervisor shared his vision for the future of MOTSU’s railway maintenance plan. His strategy focuses on six primary components: inspections, crossties, switches, ballast, ditches and culverts, and OTM – other track materials.
Another factor to maintaining proper drainage is the design and main-

A well-drained rail-roadbed is essential to good track maintenance. Another factor to maintaining proper drainage is the design and main-

doline of the track and trains to prevent overstressing the subgrade. The railroad consists of tons of ballast. Ballast must be properly maintained at adequate levels and replaced when fouled. Fouled ballast is full of dirt which prevents proper drainage. MOTSU maintains rail-roadbeds using its inventory of specialized equipment.

A well-drained rail-roadbed is essential to good track maintenance. Another factor to maintaining proper drainage is the design and main-

tenance of ditches and drainage structures along the railway. Ditches and other drainage structures (culverts, drains, and drop inlets) must be of sufficient size and construction to handle the expected flow of water; and maintained at least annually to ensure the free passage of water. Following Hurricane Florence, most of the culverts along the railway required replacement. MOTSU must now keep them free of debris.

OTM – other track materials – forms the final component of MOTSU’s railway asset management plan. Other track materials include tie plates, anchors, and rail fastenings such as bolts, joints, spikes, and gauge rods. The maintenance of OTM is scheduled based on manufacturers’ recommended lifecycle, condition indexes and deficiencies identified during monthly, quarterly, semi-annual or annual inspections.

Moving Forward:
In the months since the railway assessment, USACE contracts for railway repairs are complete, and MOTSU’s DPW railway maintenance department is moving forward, adapting its maintenance plan with a focus on strategic asset management to tackle the prioritized risks. The assessment team provided a report which clearly identified deficiencies, exact locations, and rated the severity of each deficiency. As a result, MOTSU now has a comprehensive view of current railway conditions for planning and budgeting – making the railway more resilient, compliant, efficient, and capable of supporting MOTSU’s overall mission even in the event of a natural disaster.

According to the National Tie Association, MOTSU’s crossties have an 18 year life cycle based on the region’s relative moisture, rainfall and the material composition of the crossties. MOTSU has 100 miles of track which equates to 300,000 ties of which 16,700 ties should be replaced per year. In this respect, efficient management of the budget, personnel and equipment is crucial to stay on schedule. Proper crosstie maintenance prevents track closures. As such, MOTSU’s tie crew sets and adjusts weekly goals. Recruiting, training, and retaining personnel is also a challenge. Out-sourcing this portion of the maintenance plan every five years may help maintain the replacement rate.

Railroad switches are critical points of failure on any railway. MOTSU has 302 switches. Switch maintenance consists of the maintenance of the switches, turnout components, and switch ties. Around switches there is an average of 70 ties per switch which are 16 ft. long as opposed to the 8.5 ft. long crossties along the remainder of the track. At MOTSU, there are approximately 6 miles of switches which also have an 18 year life cycle. Maintenance personnel use a tie extractor/inserter to replace crossties everywhere except around rail frogs. The rail frog is a piece of the track in a turnout designed to divert trains from one track to another. Since the tie-crew cannot use equipment, the work is manual which slows progress.

In addition, classification yards are composed of numerous switches to move trains from one track to another. Classification yards at MOTSU consist of 7-11 sets of rails per yard. These rails are in close proximity to each other which compounds the maintenance timeline. Replacing the classification yard switch ties requires additional equipment and problem solving skills. In addition, switches require monthly or quarterly inspections and lubrication based on the operational demand. MOTSU has out-sourced the replacement of switch ties in classification yards in order to keep up with maintenance demands.

Ballast is another important asset of a railroad. According to UFC 4-860-03, there must be adequate ballast to restrain the track laterally, longitudinally, and vertically under dynamic loads; and to distribute the load of the track and trains to prevent over stressing the subgrade. The railroad consists of tons of ballast. Ballast must be properly maintained at adequate levels and replaced when fouled. Fouled ballast is full of dirt which prevents proper drainage. MOTSU maintains rail-roadbeds using its inventory of specialized equipment.

MEG VERMILLION, CPT, EN, is a project engineer with the U.S. Army Corps of Engineers, Savannah District.
A Massive Reconstruction Initiative
The only east-west interstate through Birmingham central business district, the I-59/I-20 interchange is Alabama’s heaviest traveled corridor, accommodating more than 160,000 vehicles per day. Built in the 1960s, the six-lane divided highway has minimal shoulder width and has more than tripled its original traffic capacity. As a result, more than 600 accidents have occurred within the past four years. The infrastructure has become functionally obsolete, with structurally deficient bridges and inefficient roadway alignment. To improve functionality, safety, and overall capacity of the 3.5-mile city interchange, the Alabama Department of Transportation (ALDOT) initiated a USD 750 million reconstruction project.

“This is the largest amount of money and largest amount of traffic ALDOT has ever dealt with in one place,” said John Cooper, director at ALDOT.

The massive renovation included construction work for 36 bridges, roadway widening, and utility work. Subject to a fast-paced schedule, the project presented numerous coordination challenges and changes in the overall design scheme. ALDOT Visualization Group was tasked with coordinating data access and information exchange among multiple offices and utilities, as well as communicating with the public and stakeholders, to quickly deliver an accurate 3D model that could be provided to contractors for precise cost estimates. These models were then referenced to complete phased construction within 14 months.

Collaborative Digital Engineering
To optimize information exchange and meet the fast-paced schedule, ALDOT implemented a collaborative 3D BIM process. With no precedent for developing the digital engineering model, the team relied on Bentley’s integrated 3D design, collaboration, and visualization applications to facilitate the BIM strategy. ALDOT first modeled the existing site and infrastructure from more than 2.3 million data survey points using Descartes and MicroStation®. Then, they established an open, connected data environment using ProjectWise as the collaborative platform to seamlessly share and exchange models and information. The team used OpenRoads™ to create the digital terrain models and StormCAD, CulvertMaster, and FlowMaster to address drainage and utilities design. All 3D models were imported into MicroStation for design verification and clash detection to generate a comprehensive 3D model.

To support precise cost estimation and lower bids for the project, it was critical that the 3D digital engineering model include accurate and timely data to support multiple uses. ProjectWise allowed designers, department heads, drafters, reviewers, and consulting teams to have real-time, electronic access to all project files, and ensured that everyone was working on the right data. The software provided an open, connected data environment to streamline information exchange throughout the project lifecycle, accelerating accurate, integrated 3D modeling.

“This was the biggest game changer. Using ProjectWise for data and information exchange worked fantastic,” said Matt Taylor, P.E., state engineer at ALDOT.

Model accuracy also played a critical role in avoiding construction delays. Using Bentley’s 3D engineering design and construction analysis applications enabled ALDOT to identify potential issues and potential construction delays before the project broke ground, eliminating costly on-site errors and keeping the project on schedule. Integrating LumenRT to produce and present animated renderings of the 3D model through Live Cubes to city officials, stakeholders, and the public brought visualization and understanding of project impact, alleviating concerns and accelerating project approval.

Maximizing Model Potential
ALDOT sought to maximize the potential of the digital engineering model for multiple uses, including visualization, design checks, construction analysis, clash detection, right-of-way (ROW) negotiation, lawsuits, and aesthetics. Using the 3D model
facilitated design verification, which allowed the team to check horizontal and vertical clearances and bridge elevations and identify exposed footings and elevation issues prior to construction. Utility companies examined the model to ensure there were no clashes. Utilities are a critical element in any construction project and ALDOT invested millions into locating and relocating them. Having a visual 3D representation of the utility infrastructure enabled ALDOT to perform clash detection. For instance, the model showed one of the utility companies that the new roadway would not adversely impact their equipment, preventing expensive utility relocation. Overall, the ability to perform clash analysis on the 3D model using MicroStation resulted in ALDOT identifying more than 1,100 design and construction clashes.

“One great thing is that we were able to provide everything to the contractors to pre-bid. Every contractor that bid got a full 3D model,” Taylor explained. As ALDOT’s first project submitting 3D models for bidding, model accuracy was significant to support precise cost estimation and meet the organization’s goal of lowering construction bids. Using Bentley’s integrated modeling technology accelerated design and improved quality to deliver accurate models to construction bidders for more informed cost and time estimates. The contractors maximized usability of the BIM model by clicking on specific items within the model to determine precise quantities for creating cost estimates.

Lastly, the 3D BIM model along with Bentley’s reality modeling technology maximized visualization potential necessary to demonstrate project impact to all stakeholders and the public. With Live Cubes in LumenRT, ALDOT generated animated renderings that facilitated visual understanding of the design and its effect on the surrounding environment and community to optimize ROW negotiations and enable more informed decision making.

**Integrated Applications Deliver Savings**

This highly sensitive project had to be designed quickly, efficiently, and accurately. Using Bentley’s design and collaboration applications allowed all parties to achieve this goal and save millions. ProjectWise established an open, connected data environment that helped consulting firms save tens of thousands of hours creating the 3D models to meet the rigorous scheduling de-
mands of the project. The collaborative software provided inspectors and contractors real-time access to design files on tablets, eliminating lengthy meetings and manual review and workflows, saving hundreds of hours. Coordinating information sharing through ProjectWise saved ALDOT an estimated USD 50,000 and 40,000 resource hours.

“MicroStation clash detection was hands down the most effective technology utilized in the project,” commented Taylor. ALDOT saved over USD 10 million by implementing this software feature. The reports generated from this BIM review methodology allowed designers to fix costly design and construction errors prior to project bidding, ensuring utilities were properly located and eliminating construction change orders. Having an automated and optimal design review process avoided construction delays and reduced construction time by 65 days.

Integrating LumenRT with MicroStation visualization capabilities allowed ALDOT to provide dynamic visual representation of the project rather than traditional 2D drawings to optimize project understanding. This facilitated public and stakeholder communication as well as saved ALDOT USD 2 million in lawsuits filed based on misinterpretation of ROW lines. The animated renderings demonstrated how ROW lines were not only legitimate but also improved surrounding properties.

Rejuvenating Downtown Birmingham
Currently under construction, the project continues to use ProjectWise as the method for sharing and exchanging information in real time with on-site teams through mobile devices. The 3D BIM model produced with Bentley’s digital design applications enabled ALDOT to effectively convey the design to the people of Birmingham, meeting its responsibility to the public to not only build safe infrastructure but also save the public money. Bentley provided ALDOT an integrated technology solution to meet developmental needs of the city of Birmingham while reducing environmental impact by minimizing noise levels in the developed urban area. The new, structurally safe and functional roadway infrastructure provides better interstate access by consolidating ramp locations, creating an area for improved park space beneath the bridges.

This mega-reconstruction project is reuniting the north and south sides of central Birmingham where they once were divided by the urban I-59/I-20 interstate. It has provided the catalyst for rejuvenating Birmingham with the new City Walk initiative, which will add parks, walking paths, cafes, and music venues, increasing commerce and economic growth within the community.

Project Summary
Organization: Alabama Department of Transportation
Solution: Roads and Highways
Location: Birmingham, Alabama, United States

Project Objectives:
• To implement digital workflows to coordinate information exchange and meet the 14-month construction schedule for the reconstruction of Alabama’s I-59/I-20 corridor.
• To develop an accurate 3D BIM model to optimize design and cost estimates.
• To effectively convey design and project impact to stakeholders and the public.

Products Used:
CulvertMaster, Descartes, FlowMaster, LumenRT, MicroStation, OpenRoads, ProjectWise, StormCAD

FAST FACTS:
• ALDOT initiated a USD 750 million reconstruction project to improve safety and functionality of the I-59/I-20 interchange in central Birmingham.
• The visualization group delivered a 3D digital engineering model for multiple uses to meet the 14-month construction schedule.

ROI:
• Using ProjectWise to coordinate information exchange streamlined workflows among the numerous consultants to save 36 days in delivery time.
• Performing clash detection in MicroStation identified 1,100 errors, saving USD 10 million and 65 days in construction time.
• Bentley’s integrated applications enabled ALDOT to produce an interactive 3D model for contractors to optimize cost estimates.

AMY HEFFNER is a manager of civil product marketing at Bentley Systems, focused on the promotion of Bentley’s civil design applications, including OpenBridge, OpenRail, OpenRoads, and OpenSite.
Collaborating with Confidence
Cloud-Based Solutions Democratize 3D Deliverables
By John Fomby

When Jarrod Black PLS, a surveying and mapping director for Georgia-based Rochester & Associates Inc., wants to get project data into a client’s hands, he considers a few questions: What level of detail do they require? How much skill do they have dealing with 3D data files? Are they set up with the right kind of software/hardware?

The answers help Black determine if a simpler and quicker report can satisfy their needs, especially if the client – often a structural engineer or architect – only wants to visualize the space, get a sense of scale and go a bit beyond 2D plan sheets.

Black’s thought process underscores the challenge surveyors face when they want to share information from massive data sets collected from their optical, photogrammetry and scanning systems. That is, the powerful data and software can be too cumbersome and technical for some stakeholders to work with.

In these situations, having a just-right tool to satisfy a minimal requirement can make all the difference in fast, efficient communication.

Easier viewing, sharing
In 2016 during the Trimble Dimensions user conference, Black talked with Trimble software developers about the need for a software-agnostic viewer that could run on a browser. Last summer, Trimble invited him to take a sneak peek at its solution, Trimble Clarity, a cloud-based application included in the Trimble Connect collaboration platform, before it was released at the INTERGEO conference.

Trimble Clarity makes it possible for industry professionals, whether land surveyors, civil engineers, land developers or site managers, to easily visualize and share three-dimensional point cloud data with clients. It also directly integrates with Trimble Business Center, enabling users to publish their 3D point cloud and imaging deliverables from the Trimble SX10 Scanning Total Station or other Trimble VISION instruments.

“I used to spend hours creating a zip drive, FedExing it over, or uploading the data,” Black says. “Clarity makes it extremely easy for a client who just wants to peruse the data without having a whole lot of skill in doing anything point-cloud based. I can email them a link, they click on the link, and within a couple of minutes they are looking at the data. It also has some nice tools.”

These include the ability to perform 3D measurements, annotate objects and quickly collaborate with project stakeholders, such as the structural engineers and architects with whom Black typically uses the software.

“The other thing that’s nice is if I do make some changes or any type of revision, the site is automatically updated,” Black said. “So, I’m not constantly needing to upload these massive files.”

Avoiding a data-sharing headache
The growth of 3D data in geospatial and related industries is creating a pressing need for tools that increase utilization of the large data files to move data analysis from the specialist to the generalist.

As hardware has become less expensive, more surveyors are making use of the wide range of data capture technologies, and as a result, are collecting massive data sets. But while the process of collecting the data may be straightforward, what to do with the data is not.

At a recent Trimble Business Center user group, many of the pain points shared by 40 attendees centered on one theme: “We have successfully collected a bunch of data, but we don’t really know what to do with it.”
When data becomes too massive to store, process and share, it becomes an intellectual property problem. For example, one customer won’t let their surveyors use the mobile mapping scanners because they are running out of hard-drive space.

Technology, however, continues to improve around connectivity, cloud computing and Application Programming Interfaces (APIs), which is easing storage challenges and empowering more seamless information and data exchanges between disparate groups.

**Leaping into the cloud**

Geospatial technology providers are moving to the cloud to help customers avoid the need for massive $10K computers and $8K desktop licenses needed to store and process data. The cloud allows data to stay in place so users can work on it from different browsers and devices. The cloud also serves to lower the barrier of entry by keeping the data in one place and available through the web. Once the data is stored in the cloud, it should not have to move again, which also reduces time needed to make it deliverable.

Because Trimble Clarity is housed in the cloud, users can create station-based views of their point cloud data. The point clouds created in Clarity do not require heavy Graphics Processing Unit (GPU) local processors to run. Instead, Clarity manipulates the point cloud data into a 2.5-dimension view with depth in the image to enable accurate measurement.

“It’s invaluable to the end user because it’s bringing a scale into your computer,” Black said. “Whereas if you’re just looking at plan sheets, it’s very hard for you to visualize the space. This tool allows you to visualize the space and also get a sense of the scale.”

This is possible because Clarity places the user in a view that is very light weight and easy to understand, with the goal of any user being able to successfully navigate the software in the first minute. Clarity also lowers the barrier of entry by working on any platform or device.

“If we use it for nothing else than to check our survey drawings,” Black said, “it’s a very good tool for that.”

One of Black’s recent projects included gathering point cloud data for multiple levels of a historic building. Using Clarity, Black was able to share just enough 3D information so the architect could get dimensions to order and place new furniture and understand the placement of certain utilities.

“It gave them a good sense of the scale spatially,” Black said. “It brought the spatial realm into their computer.”

**Tools for Chasing BIM**

In addition to needing a way to share complicated data sets simply, more geomatics professionals are also interested in aligning with Building Information Modeling, the information-centric process for improving efficiency and productivity of construction projects. BIM offers many opportunities for surveyors to provide more and richer deliverables to professionals across the design, build and operate lifecycle.

But the act of purchasing a laser scanner doesn’t turn a surveyor into a BIM service provider. That level of service requires the surveyor to provide deeper understanding of the data to improve process and project outcomes.

With tools such as Trimble Connect and Trimble Clarity, surveyors now have the ability to communicate with multiple trades through a single project management environment. These types of software are part of software fleets that connect a surveyor to the entire virtual BIM process so they can go beyond measuring property lines and building foundation footprints to provide rich, BIM-ready deliverables, and be rewarded by contractors for bringing more to the entire process.

**Choosing a 3D viewer**

With so much riding on data utilization, it’s important to consider the various features and support for any 3D viewer. These can include:

- communication tools, such as annotations and markups
- measurement tools, such as “snapping to” for measuring on the vertical without any horizontal movements
- navigation tools to move around within the viewer
- file formats, and whether the software is flexible in handling different kinds
- pricing models, whether subscription-based or desktop point of sale
- data security, such as how data is stored, whether it can be stored in the cloud, what happens to data when it is erased, and what local governance laws allow
- privacy, such as whether data is being collected on your software use and how it will be used, such as with cookies

Probably one of the greatest advantages to a cloud-based 3D viewing software is its ability to be automatically updated.

Whatever the features, the overarching goal needs to be solving collaboration problems.

“The potential for our clients is that we don’t have to give them huge dumps of data,” Black said. “They are just pointing to a web browser and going forward.”

JOHN FOMBY is product manager, cloud strategies, for Trimble.
ALIGNMENT THAT IMPACTS THE BOTTOM LINE

MARKETING AND BUSINESS DEVELOPMENT ARE TWO DIFFERENT THINGS, BUT THEY NEED TO WORK TOGETHER IF EITHER ARE TO SUCCEED

By Jen Newman, CPSM and Doug Parker, FSMPS, CPSM

JUST OVER HALF OF PROFESSIONAL SERVICE FIRMS say that their marketing and business development groups coordinate efforts. A lack of integration can result in redundancies, waste, and lost opportunities. Without a strategy, all your marketing and business development activities and tactics might be for nothing. Success starts with alignment – heading in the same direction toward focusing on promising prospects, closing deals, and generating revenue. True alignment involves collaboration and integration. We achieve this with a jointly developed strategy to connect with, engage, and convert prospects to clients to raving fans by working together throughout the client life-cycle.

Why is marketing and business development alignment critical?

1. **We Are Better Together.** They work best when they work together. Despite their differences, they still orbit around the same sun with the same mission. Marketers require a business development mentality to produce powerful messages and content, while business development teams need a marketing mentality to approach clients in a compelling way.

2. **Client Focus.** Alignment is really about the CLIENT. We have to look at everything we do through the eyes of the client.

3. **Process.** They are both integral to the business development process. Alignment improves tracking as it is far easier to track results and make high-impact changes.

4. **Culture.** Alignment leads to a better internal culture, which leads to improved employee retention. With alignment comes greater clarity, a better understanding of strategies, and an improved perception of one’s job and colleagues.

5. **Bottom Line.** Not only are internally aligned organizations more profitable and efficient, but they also provide a better workflow for employees.

Strategies for marketing and business development alignment?

1. **Plan Together.** When marketing & business development plan together, this fosters buy-in and allows business development leaders to work with marketing to create initiatives, and a strategic marketing plan that directly aligns with the strategic direction of the firm.

2. **Develop a Cohesive Strategy.** By creating a shared strategy for building a business, all team members buy in. Prioritize the issues you’ve identified and develop a phased approach to tackling them together and holding each other accountable.

3. **Identify Each Team's High-Impact Activities.** The reason business goals become detached from marketing & business development efforts is simple: leadership doesn’t align those goals with daily activities. Clarify the roles and functions of each department and determine which activities make the highest impact.

4. **Agree on a Client Persona.** Not clarifying who the ideal client is can lead to ineffective strategies and team disconnect. Marketing may create a campaign targeting one group of clients, whereas the business development team may target a different group. The collaboration will lead to understanding who your ideal clients are, what they are looking for, and what their big-
gest challenges are so that your content and messaging is on point.

5. **Create a Single Client Journey.** The client journey does not separate the experiences from marketing, business development, or even operations and project delivery. Work together with everyone that touches a client to develop a Client Experience Journey Map starting from the awareness to decision to delivery and feedback to brand loyalty — everything should be tied together as an experience.

6. **Gather & Use Client Feedback.** One of the most powerful things that you can do together is to develop a client feedback program that allows you to gather, review, and act upon feedback from your clients. Client feedback should not just take place at the end of the project. Utilize your Client Experience Journey Map to identify feedback points along the way.

7. **Join Forces on Client Growth and Retention.** Attracting new clients is up to 6 to 7 times more expensive than retaining them. By only focusing on new clients, you could be missing out on profits you should be making from existing clients. Marketing and business development should be working closely together to increase the lifetime value of your clients. For example, once you’ve acquired a new client, content and communication should shift from attracting to growing and influencing a client to stay.

8. **Lean Heavily on Your Brand.** As marketing and business development alignment gains steam, brand makes even more of a difference. It gives both sides a common understanding and shared language as they essentially co-create their brand experience. The most successful business development and marketing partnerships align in their commitment from top to bottom — from their brand’s highest-level vision to its most tactical tools.

9. **Keep Marketing Messages Consistent.** You’ve experienced it before — the marketing team explains the organizational differentiators in one way, and the business development team does it completely different. With mismatched messaging, you run the risk of a confusing, uncomfortable, and inconsistent journey for your clients leading to a poor first impression of your company. Therefore, a client is less likely to trust you. Alignment leads to messages that are consistent and true to your brand.

10. **Coordinate Content Creation and Campaigns Between Teams.** When marketing and business development teams are aligned, content is used far more strategically — rather than being shared sporadically and without reason. Business development knows the client’s needs, and marketing knows what gets people excited. Coordinating will ensure content is relevant and utilized.

11. **Prioritize Open Communication.** Create an internal communication strategy to make sure everyone is on the same page. Regular meetings within and between teams create the foundation. Examples of this are team and client onboarding, business development, and client capture plan meetings.

12. **Track Joint KPI’s.** Shared KPI’s does not mean the same KPI’s. It means that you should strive to devise KPI’s that depend on each other to achieve the goals of each separate team. Collaborate and agree on shared metrics and review frequently. Incentivize collaboration — reward the achievement of shared targets. For example, both business development and marketing teams could have a “conversion rate” KPI. For each of the teams, this will mean something different, although related to the other team’s KPI.

13. **Analyze Departmental Data.** Work together to understand what content and campaigns have been performing best. Dig in and analyze them, and then integrate that information into business development efforts.

14. **Those Who Learn Together, Produce Together.** Training together will empower both teams and create an understanding of their shared goals, help them build on their core competencies, and have the added benefit of bringing teams closer and circulating information and know-how.

15. **Walk in Their Shoes.** It takes mutual respect flowing both ways to leverage the strengths of both marketing and business development fully — so everyone can reap the benefits of these opportunities.

Co-Author by Jen Newman, CPSM, Managing Director, and Doug Parker, FSMPS, CPSM, Managing Principal & CMO, Zweig Group.

Zweig Group is proud to offer marketing and business development services. Contact Jen Newman, CPSM for more information jnewman@zweiggroup.com.

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As Managing Director at ZWEIG GROUP, JEN NEWMAN, CPSM utilizes her 20+ years of AEC specific experience to help firms grow their people and profits while ELEVATING THE INDUSTRY.

DOUG PARKER, FSMPS, CPSM brings a unique combination of operations and marketing experience specializing in professional services firm management to his role as Managing Principal and CMO at ZWEIG GROUP. He has developed award-winning brand strategies to position firms and key stakeholders to gain market share and increase revenue.
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Concrete Innovations
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Learning Objectives:
1. Understand new technologies used in concrete manufacturing
2. Discover how innovative concrete products can improve project performance
3. Learn how to implement the latest concrete innovations in building and infrastructure projects
4. Demonstrate the importance of incorporating new technologies to enhance resilience and sustainability in the built environment

Introduction
What do the Jubilee Church and the Pantheon have in common? They are both places of worship in Rome. But besides that, they are both built with innovative concrete. The Romans mastered the use of concrete 2,000 years ago to build some of the most iconic structures ever built. Although different than today’s concrete, Roman concrete used the same principals, combining aggregate with a hydraulic binder. The aggregate included pieces of rock, ceramic tile and brick rubble often recycled from demolished buildings. Volcanic ash, called pozzolana, was the favored binder where it was available. Gypsum and quicklime were used as binders also. And even 3,000 years before, the Egyptians used a form of concrete made with mud and straw to build the pyramids. Today of course, most concrete is made with portland cement, invented in 1824, and combined with high quality quarried aggregate. Most modern concrete is augmented with innovative products and additives to enhance both plastic and hardened properties.

Innovative supplementary cementitious materials (SCMs) such as fly ash, slag cement and silica fume are used to increase strength, durability and workability. Chemical admixtures affect set time, freeze thaw resistance and flowability. Tiny fibers are added to increase ductility and control cracking. Carbon dioxide is injected into concrete to improve strength and capture greenhouse
Concrete is the most widely used building product in the world. It’s mostly made locally with local materials. It’s cost effective, available everywhere, strong and durable. Although conventional concrete can tackle most jobs, it is also the material of choice for the tallest buildings in the world and infrastructure designed to last centuries. Although concrete is not always synonymous with innovation, new products and manufacturing methods are enhancing concrete’s performance to tackle modern challenges. This article explores some of these latest innovations.

**Self-cleaning Concrete**

Imagine concrete that can clean itself and even the surrounding air of harmful pollutants. That’s what concrete made with titanium dioxide (TiO₂) can do. The function of TiO₂ cement is to break down harmful pollutants in the air via a reaction catalyzed by light, or photocatalysis due to titanium dioxide which is added to the cement during its production. This capability of TiO₂ cements was inspired by the ability of certain microbes to break down harmful chemicals by modifying their oxidation state, also through photocatalysis. However, in photocatalytic cements the reaction is carried out by the titanium whereas microbes rely on natural enzymes. The cement breaks down organic as well as inorganic pollutants, and it is intended to be used for projects in urban centers where air pollution and poor air quality are most pronounced.

An example of how TiO₂ cements break down pollutants can be seen in its conversion of nitrogen dioxide (NO₂), a harmful compound mostly produced by burning fuels in cars and trucks. Nitrogen dioxide is one of the compounds responsible for acid rain, smog, respiratory problems and staining of buildings and pavements. The reaction with sunlight produces hydroxyl radicals which react with NO₂ to produce NO₃ which is dissolved by water after reacting with the cement surface.

Research data of TX Active®, a TiO₂ cement marketed by Lehigh Hanson (a division of HeidelbergCement Group) in the US, indicates that “up to 50% of these atmospheric pollutants could be reduced in some cities if only 15% of the buildings and roads were resurfaced with TX Active® cement.” TX Active® was first used for the curved panels on the Jubilee church (also known as Dives in Misericordia Church) in Rome, which used the photocatalytic cement panels for its stylistic shells. Since then, Italcementi (a division of HeidelbergCement Group) has dedicated decades of research to photocatalytic cement products. This cement is promising in its potential to greatly improve urban life and the environment.
Case Study: Jubilee Church, Rome, Italy

According to architects Richard Meier and partners, the Jubilee Church in Rome was “conceived as part of Pope John Paul II’s millennium initiative to rejuvenate parish life within Italy.” The project consists of the church itself as well as both secular housing and housing for the clergy. The church is most easily distinguished by the three large concrete shells which are meant to represent the Holy Trinity. Given the symbolic importance of the shells, their appearance is an absolute priority. Thus, due to the fact that the shells need to remain in pristine condition, it was only natural that “self-cleaning” TX Active® photocatalytic concrete was used to ensure that the shells would not accumulate stains due to smog. Completed in 2003, the photocatalytic shells have notably remained clean and white, performing constant self-maintenance.

Bendable Concrete

Bendable concrete presents an efficient alternative primarily in the construction and maintenance of infrastructure, where concrete is subject to harsh weather conditions and extreme loading. The design which gives bendable concrete, or engineered cementitious composite (ECC), its impressive ductility is based off nacre, the substance that coats the inside of abalone shells. Nacre is composed of small aragonite platelets that are held together by natural polymers, allowing it to be both hard and flexible as platelets are free to slide side to side under stress. This effect is mimicked in bendable concrete by dispersing tiny fibers throughout. Victor C. Li of the University of Michigan, where ECC was first researched and invented, states that bendable concrete “can deform up to 3 to 5 percent in tension before it fails, which gives it 300 to 500 times more tensile strain capacity than normal concrete.” It is of course this incredible ability to tolerate tensile strain that makes bendable concrete unique.

This enormous increase in ductility suggests various potential applications. Firstly, in roads as well as other paved surfaces which must bear repeated loading of heavy vehicles, bendable concrete would crack less often, preventing further weathering primarily from road salts which corrodes steel reinforcement. Further, due to ECC’s capacity to absorb greater quantities of energy without being damaged, it can be used to make reinforcing elements such as the dampers on the Seisho Bypass Viaduct in Japan, which is roughly 28 kilometers long. Dr. Li also states that ECC has been employed as earthquake resistance in tall buildings in Tokyo and Osaka and further suggests that ECC would be useful in underground construction as well as the construction of water infrastructure.

However, before it can be more widely commercialized for such large-scale projects, bendable concrete must become more readily available. To be economically viable, it must be supplied efficiently and not overused on projects. But, it is paramount that design professionals be made aware of the product and its potential as they might otherwise overlook a promising concrete option for structures that require the ability to deal with considerable tensile strain.

Bendable concrete also has self-healing capabilities. Because bendable concrete keeps cracks relatively small, natural reactions within the hardened concrete generate “healing” products through carbon mineralization and continuous hydration which repairs the cracks and restores the durability of the concrete. Bendable concrete is a promising technology that already has proven itself through commercialization by several companies.
In fact, fiber reinforced concrete is not new. Many companies supply fibers for use in concrete with the objective of improving strength and durability of concrete in some way. Fiber reinforced concrete accomplishes this by incorporating fibers made of steel, glass or organic polymers (plastics). Sometimes naturally occurring fibers such as sisal and jute have been used as well. These fibers are primarily used to combat plastic shrinkage and drying shrinkage which can otherwise crack and damage the concrete. This resistance to shrinkage and subsequent cracking is the key to extending the lifespan of concrete, decreasing the frequency of costly repairs. Fibers also keep existing cracks from widening and further damaging the concrete when they do appear. And more recently, steel fibers are being used in structural applications to reduce the amount of traditional steel reinforcing bars, saving time and labor.

**Case Study: 42 Broad, Fleetwood, New York**

42 Broad is a 16-story mixed-use development near New York City being built with Insulating Concrete Forms (ICF). ICF construction is becoming more mainstream with thousands of projects built in the US, but still considered innovative by many. ICFs sandwich a reinforced concrete wall between forms made of rigid polystyrene insulation that stay in place after the concrete hardens. There are several taller ICF buildings in Canada, but at 16 stories, 42 Broad will be the tallest in the US.

The real innovation on this project is panelizing the Amvic ICF blocks and using Helix™ steel fiber reinforcement. The ICFs are assembled off-site in a nearby plant and arrive at the jobsite as custom panels up to 50 feet long which results in labor and time savings on the job site, meaning the owner can occupy the building earlier. Part of what makes this process possible is the use of steel fibers in the ready mixed concrete to replace the horizontal reinforcing steel which eliminates costly horizontal rebar slices.

LafargeHolcim is one of the first companies to commercialize bendable concrete with a product called Ductal®. Ductal® is an ultra-high-performance concrete (UHPC) that incorporates fibers into the concrete mixture in order to improve strength and ductility along with a host of other benefits. LafargeHolcim distributes the premix powder, fibers and admixtures necessary to produce Ductal® to their partners, who then mix it into concrete. LafargeHolcim states that they use “high carbon metallic fibers, stainless fibers, poly-vinyl alcohol (PVA) fibers or glass fibers” to increase the concrete’s ability to withstand tensile loads and deformation.

Ductal® is also less porous than conventional concrete, making it more resistant to chlorides, acids, and sulfates. It is also generally much more impermeable to water, making it ideal for roofing as well. In addition, Ductal® has self-healing properties. This bendable concrete has been thoroughly researched and is commercialized. Read more here
Concrete Innovations Quiz

1. Bendable concrete uses fibers to improve:
   a) Color
   b) Ductility
   c) Flowability
   d) Slump

2. The primary benefit of concrete made with titanium dioxide cement is:
   a) Increased strength
   b) Improved flowability
   c) Staying clean
   d) High early strength

3. Steel fibers have been used in concrete to:
   a) Improve color uniformity
   b) Replace steel reinforcing bars
   c) Increase set times
   d) Improve surface appearance

4. In addition to increased ductility, bendable concrete also has the benefit of:
   a) Staying clean
   b) Resisting extremely high temperatures
   c) Reduces surface friction
   d) Self-healing

5. Graphene concrete is made by:
   a) Suspending flakes of graphene in mixing water
   b) Wrapping concrete with graphene sheets
   c) Recycling pencil lead into concrete
   d) Using graphite cement

6. Carbon dioxide is absorbed by concrete in a process called:
   a) Hydration
   b) Carbonation
   c) Calcination
   d) Photocatalysis

7. Carbonation of concrete is higher when:
   a) Surface-to-volume ratio is higher
   b) Surfaces are painted
   c) Concrete is buried
   d) Concrete is more dense

8. Carbon dioxide injection reduced carbon footprint of concrete in two ways:
   a) Reduces strength and increase cement demand
   b) Sequesters CO₂ and increases strength
   c) Eliminates the need for portland cement and increases need for water
   d) Reduces labor and set times

9. One company makes artificial limestone by:
   a) Crushing sea shells under high pressure
   b) Growing and harvesting coral
   c) Mining coal ash from landfills
   d) Combining CO₂ with metal oxides

10. Self-consolidating concrete (SCC) is often used to:
    a) Eliminate mechanical vibration
    b) Reduce on-site labor
    c) Improve surface appearance
    d) All the above

11. Which of the following has NOT been commercialized to any great degree?
    a) SCC
    b) SCMs
    c) Geopolymer concrete
    d) Fiber reinforced concrete

12. Beneficiation of fly ash involves:
    a) Recovering and processing fly ash from landfills
    b) Creating fly ash bricks
    c) Spreading fly ash on the surface of concrete
    d) Converting fly ash to portland cement

Click Here to Take the Quiz!
Every New Yorker knows the frustration of subway delays caused by signal failures. The MTA’s train signal system is outdated—it’s the same fixed-block signal system that was originally used when the subway system opened in 1904, and it’s prone to signal failures that cost New Yorkers time and money every day.

In a fixed-block system, if a block of track is occupied by an entire train or a single car, the entire block is signaled as unavailable to every other train operator. But, when a signal switcher fails mechanically, the track is signaled as unavailable to train operators even when there is no train, leading to extra track congestion and delays as operators must use other lines until the mechanical issue is located and corrected.

One common cause for signal failures is voltage sag. The MTA has three times as many trains running as the system was designed to optimally handle, drawing more power through lines and signal systems. When the power supply drops, the power draw increases, and unless the supply rises to stabilize the current, signal switchers can malfunction and close blocks of track. As part of the governor’s initiative to rehabilitate the subways, contracts went out to install voltage sag correctors at all of the signal switchers, a relatively simple but time-consuming operation due to the immense scale of the NYC subway system. E-J Electric Installation Co., one of New York’s largest electrical contracting companies and a regular contractor for the MTA, won the work to install sag correctors across 96 stations. Those stations encompassed all of Brooklyn, as well as parts of Manhattan, the Bronx and Queens.

Inglima’s task was to survey signal switchers, take pictures and document measurements, then create blueprints for the installation of the sag correctors. Traditionally, a job like this would require at least two days for each blueprint, but the team decided to try Bluebeam Revu, a PDF based platform for editing, marking up and sharing blueprints, on a Microsoft Surface tablet to see if they could save any time.

The experiment worked. “We did 96 stations in 96 working days,” Inglima said proudly. “I was able to use [Revu’s] signature tools that day, and everything got signed and sent out for production immediately. There was no turnover time, there was no going back to the office. I figure we saved ourselves another 96 days.”

There was a learning curve, Inglima mentioned, but he was pleased to discover deeper and more intuitive functionality in Revu than he had known before this project. “Once I was kind of comfortable doing a couple things, I’d ask, ’I wonder if there’s any way to do that?’ And boom, there it was.”

Even when the technology exists, someone has to be the first to try it out beyond the lab and discover the practical applications. Inglima noted that “The older guys have been doing it with a pen, paper, rulers and colored pencils for years and years. And I show up with my tablet, and I’m in and out… it took me eight hours for the first one, but once you get it, 15-20 stations in, I’m done in five hours.”

There are still many challenges ahead for the NYC subways, but at least for Inglima and E-J Electric Co., they’re taking advantage of the cost-saving solutions that modern technology offers and making the daily commute of millions of New Yorkers that much faster.
RECOGNITION IS GROWING across the construction industry about the importance of collaboration. However, the reliance on anecdotal experience to demonstrate that importance makes it much more difficult to drive the change needed in the process of building design and construction to encourage more collaboration. A pair of studies conducted by Dodge Data & Analytics for the Lean Construction Institute help fill that gap, by providing quantitative research that makes a compelling case that the industry needs to make the fundamental change of embracing collaboration if it is going to improve project performance. The studies asked owners and architects to consider two recently completed building projects: their best recent project in terms of its overall performance and their own satisfaction with it, and one that they would describe as a typical example of the work they conduct. Then, they were asked two series of questions about those projects; the first set revealed the difference in performance between best and typical projects and the second looked at differences in how those projects were conducted, including the use of various lean and industry-leading practices.

The differences in performance between best and typical projects reported by the owners were quite stark. Sixty-one percent reported that their typical projects have schedule delays, whereas 79 percent said that their best projects finished on-time or early. Similarly, nearly half of owners (49 percent) reported that their typical projects exceeded budget, but only 17 percent of them found that budgets were exceeded on their best projects. These findings demonstrate that many building owners believe that the delays and overruns are a typical part of doing a construction project.

The findings from the owner study were used to set minimum thresholds of schedule and budget performance for the typical projects in the architect study, which led to less dramatic differences. Instead, architects were selecting the difference between best and typical based on their own experiences with the projects. But even with these minimum standards in place, best projects were more likely to finish ahead of schedule (18 versus 3 percent of typical projects).

While the studies could not look directly at all the factors that caused these differences in performance, they did look for some correlations based on what happened more frequently on best than on typical projects. The most compelling correlation was between team building, collaboration and improved performance. One factor is the engagement of key stakeholders, including the entire design team, the prime contractor and the most important trade contractors. On the best performing projects, 76 percent of owners reported that these stakeholders were engaged before schematic design, but that early engagement was only reported by 34 percent of owners on their typical projects.

In the architect study, the engagement of the various key stakeholders was looked at in more detail. On their best projects, 74 percent of architects reported that the primary consultants were engaged before schematic design, compared to 56 percent on typical project, again demonstrating the importance of early engagement.

Team chemistry was also closely correlated to performance. Over two thirds (68 percent) of the owners rated the team chemistry on their projects at the highest level possible, compared to just 10 percent of owners on their typical projects. The designers report a similar disparity, with only 16 percent finding excellent team chemistry on their typical projects, compared with 58 percent on their best projects.

The study also looked at several lean practices, and those that encourage more collaborative practices—such as Co-Location/Big Room, Target Value Design, and Full-Team Onboarding—consistently correlated with better overall project performance.

The findings of the two studies are clear—prioritizing greater collaboration and team chemistry is critical to help improve project performance in the construction industry.

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