

December 2018 Vol. 5 Issue 9

civil + structural ENGINEER

CELEBRATING THE DESIGNERS OF THE WORLD AROUND US

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Combining technologies for comprehensive surveys



Insurance market outlook
Making diversity and inclusion work
Green infrastructure
New bridge form



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AG Surveys raced against the tides and weather to survey 80 beaches along England's southwest coast. — story on page 57.
Photo: AG Surveys

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PUBLISHER

Mark C. Zweig | 508.380.0469 | mzweig@zweiggroup.com

DIRECTOR OF SALES

Beth Brooks | 479.502.2972 | bbrooks@zweiggroup.com

PRODUCTION & CIRCULATION MANAGER

Anna Finley | 479.435.6850 | afinley@zweiggroup.com

EDITOR-IN-CHIEF

Bob Drake | 616.741.9852 | bdrake@zweiggroup.com

EDITORIAL

Chad Clinehens, P.E. | 501.551.2659 | cclinehens@zweiggroup.com

H. Kit Miyamoto, PH.D., S.E. | miyamotointernational.com

Richard Massey | 479.856.6122 | rmassey@zweiggroup.com

ART DIRECTOR

Maisie Johnson | 479.435.6978 | mjohnson@zweiggroup.com

**For subscriptions or change of address,
please visit our website**

csengineermag.com/subscribe/

or call 800-466-6275



800-466-6275

1200 North College Avenue, Fayetteville, AR 72703

PO BOX 1528, Fayetteville, AR 72702-1528

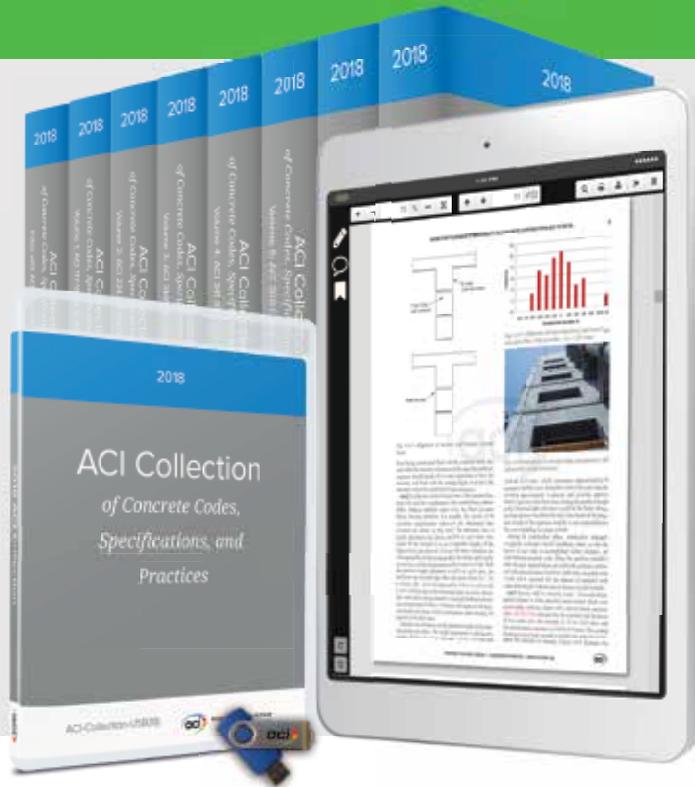
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OVERCOMMITTED?

IT MIGHT BE TIME TO REDUCE
DISTRACTIONS AND SIMPLIFY.

MOST OF US HAVE TOO MUCH TO DO. We're overcommitted and don't know how to say "no." The result of that can be that we aren't doing anything very well.

It's taken me a long time to come to this awareness, but I recently decided it was time to simplify — reduce my distractions and spend my time better than I have been. Since many Civil + Structural Engineer readers are about the same age as me, I thought I would share with you some of the changes I'm making:

I got off social media entirely. It's one of the best decisions I ever made. Like many other people, I too got sucked into Facebook, Instagram, and Twitter. I tried LinkedIn early on but decided I didn't like it soon after getting all the requests to join my network from people I had never heard of. After years of wasting loads of my time posting and reacting to those who reacted to my posts and my reactions to their posts, I have been completely out of all social media for about four months. And I can tell you, I'm more relaxed, my mental state is better, and I have more time.

I am selling off most of my old cars and motorcycles. At times I have had as many as 20 of each (though never 20 cars and 20 bikes at the same time). It has been a huge time drain for me. There's always an ongoing project. Parts need to be located; something needs fixing; something always needs to be redone; something always needs to be bought or sold. It's too much. And it is nothing but a huge distraction and waste of time. When I really look at myself, it has been driven in large part by my personal ego gratification. I don't need the time drain and hassle of it all.

I am going to sell my big house with a pool and move to a condo. It's crazy. It costs a small fortune in yard maintenance, pool maintenance, and utilities, not to mention constant improvements, upkeep, and property taxes (when I pay for my youngest kids to go to private school anyway). I don't need a 400+-foot-long driveway anymore. A nice new condo close to everything will reduce my commute time and free up more time and mental capacity.

I am creating some phone downtime. This one is especially hard for me because being ultra-responsive has been such a big part of any success I've enjoyed, but it has to end. I must be better about paying attention to people and listening to them and being in the moment, versus constantly being distracted. I have ruined my own ability to concentrate on anything and completely justified the constant distraction that my phone provides.

While these changes may hurt a little and annoy some of those around me, I'm confident that in the long run I will be a better person because of them — a better businessperson, mentor, seller, consultant, teacher, parent, friend, partner — all of those will be enhanced.

Enjoy this issue of Civil + Structural Engineer. There is always something good in these pages that we can learn from. And have a safe and happy holiday season!

MARK C. ZWEIG
mzweig@zweiggroup.com

Civil + Structural Engineer provides news and articles online to supplement content in this print issue. Visit cseengineermag.com daily for the latest news and check out the following articles posted online with the December 2018 issue:

DIVERSIONS: SMART ENOUGH

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

Engineers are bred not born. Most of us had to be taught to be an engineer. We may have had what it took to become an engineer. We may have had good engineering “bones.” We may even have had engineering “smarts.”

I heard it a lot in my youth and throughout my career: “You’re smart. You should be an engineer.” Or, “You’re an engineer. You must be smart.” But how smart do you need to be, to be an engineer? Well, I’m no genius. I think I’m just “smart enough.” Smart enough to have picked a profession where I get to help people.

Read the entire article at <http://tinyurl.com/diversions-dec18>.

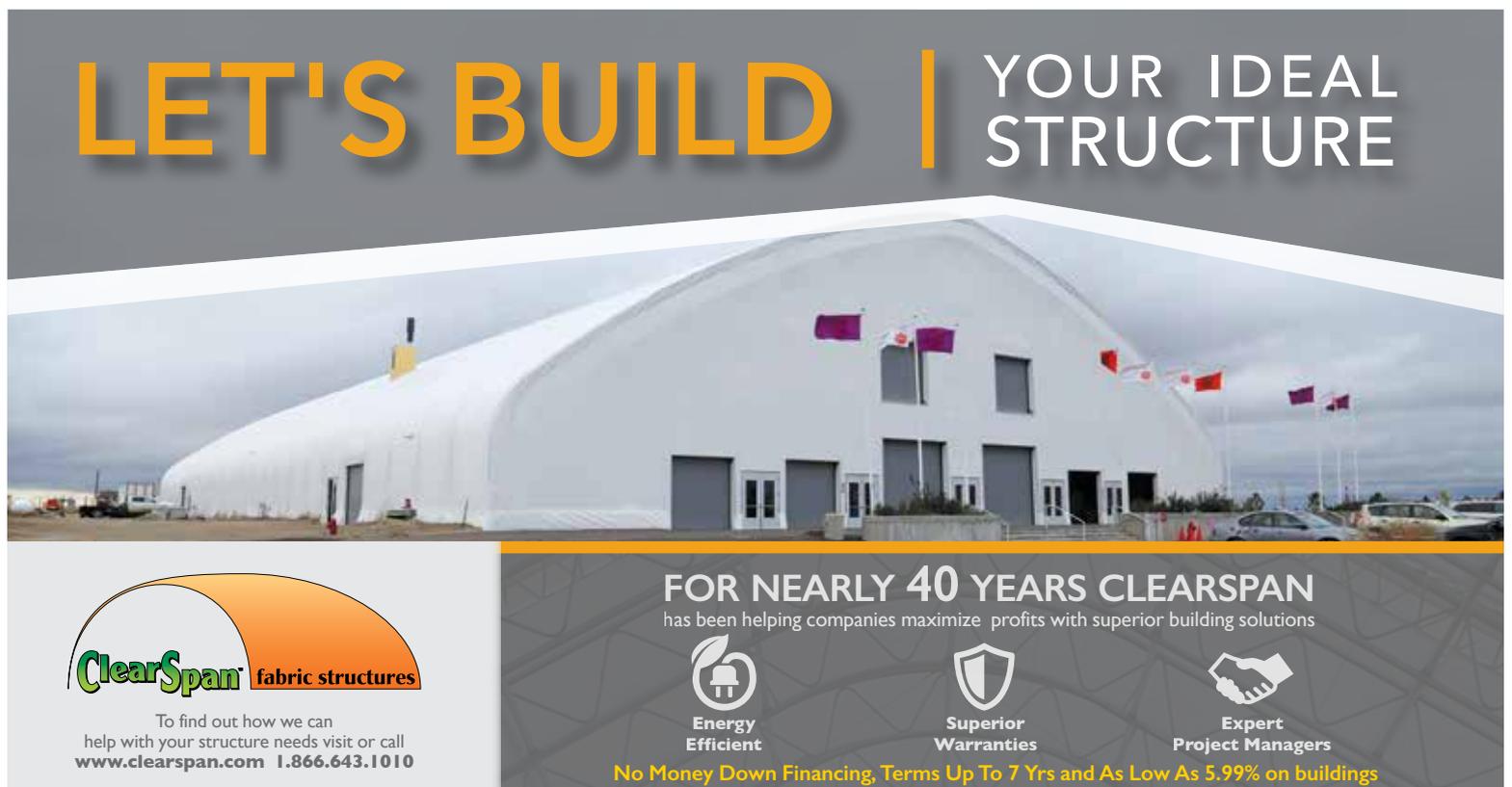
PROJECT PROFITABILITY: HOW TO BE AN EFFECTIVE PROJECT MANAGER

By Howard Birnberg, Association for Project Managers

Why did you become an engineer? This is a fundamental question many engineers can readily answer. Typically, they say they became engineers because they were interested in construction, liked to solve problems, or enjoyed seeing their work turned into a reality. Rarely would they say they became an engineer because they wanted to be a project manager!

Those who are managing projects typically ended up in the role because of management skills they acquired (often by accident; not because of a plan). A rare few have the most important skill of all: They are good communicators.

Read the entire article at <http://tinyurl.com/projectprofit-dec18>.



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CELEBRATING THE ENGINEERING PROFESSION

TAKE CELEBRATING TO A NEW LEVEL
TO SPOTLIGHT THE INDUSTRY'S
SUCCESS AND REWARDS.

WE RECENTLY WRAPPED UP the 2018 Hot Firm and A/E Industry Awards Conference, the AEC industry's largest awards conference. At the event, we unveiled our new mission to "elevate the industry." One of the five tenants of this new mission is to celebrate. We need to celebrate our accomplishments and the industry to bring more positive exposure to the important things this industry does for the world.

The truth is, we always have something to celebrate. We are the designers of the world. The development of communities, quality of life, and economic growth depend on the engineering profession. Here are some other reasons that celebrating is so important to the success of your firm and to the industry:

Celebrating creates momentum — The reality is that teams and firms that celebrate success attract more success. As the momentum grows, the team or firm develops an increasingly positive energy that is critical to further growth and evolution. Celebrating the accomplishments of individuals and of organizations can have profound impacts on both culture and operations.

Celebrating is physically good for you — Celebrating brings the mind, body, and spirit into harmony, releasing endorphins that make you feel good. This conditions you to seek the rewards of success more in your daily work and life. If we fail to celebrate, we are robbing ourselves of important reinforcing benefits.

Celebrating is a learning opportunity — Celebrating helps us understand what is working. It tells the culture what is good and educates us on what we should focus on. Celebrating enhances the educational value exponentially as we learn what we or others are doing that is working.

Engineers at all levels need to look for opportunities to celebrate success, from celebrating individuals, the team, and the firm as a whole. The benefits are numerous, in addition to those listed above. We need to take celebrating to a new level, working hard to get greater exposure for the success and rewards that can be enjoyed in our industry. This helps not only elevate our firms, but the industry as a whole, enabling us to attract much needed talent to fill the increasing demand of infrastructure.

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

AWARDS, PROMOTIONS, AND NEW HIRES

ON THE RISE



Steve Kuntz, P.E.,
DBIA



Joann Papageorgis



Josh Baxley, P.E.



Morgan Hurst, P.E.



Patrick Domres



Jennifer Carrier, P.E.



Anthony Bond



Kane Cuddy



Ali Tali, P.E.



Luke Olson, P.E.



Amanda Ludlow



Nicole Boulay



Greg Marconnet



Jeff Mason, P.E.



Brian Young



Mays Boyd, P.E.



Garrett Phelps, P.E.



William Knapp, P.E.

Brady L. Flaharty, P.E., was named president and COO of ARRO Consulting, Inc. He has 24 years of experience in management, planning, engineering, and construction of large-scale infrastructure improvement projects.

Dewberry promoted **Steve Kuntz, P.E., DBIA**, to transportation business unit manager in the firm's Fairfax, Va., office. With 20 years of experience in civil engineering, Kuntz has served as a project manager or roadway design manager on numerous projects. **Joann Papageorgis** joined Dewberry's Northeast environmental team in its Parsippany, N.J., office. She has more than 30 years of project management experience on complex, multidisciplinary highway and transit infrastructure projects, including as program director of the \$1.5 billion Bayonne Bridge Navigational Clearance Program. **Josh Baxley, P.E.**, and **Morgan Hurst, P.E.**, joined Dewberry's north Florida offices. Baxley will provide added leadership to the Tallahassee team and serve clients in various markets, including water, utilities, and site/civil engineering. Hurst joins the firm's Panama City office as a senior project manager responsible for client and agency relationships, managing staff in project development, and providing site/civil engineering design expertise. **Patrick Domres** joined the firm as a senior environmental scientist in the Long Beach, Calif., office. He will be responsible for working with the Environmental Management System ISO 14001:2015, which includes auditing, gap assessments, and project management.

Jennifer Carrier, P.E., joined HNTB Corporation as Connecticut office leader and associate vice president. Before joining HNTB, Carrier served as director of transportation planning for the Capitol Region Council of Governments, working extensively with the Connecticut Department of Transportation.

BOND promoted **Anthony Bond** as president and **Kane Cuddy** as COO for the firm's Civil & Utility Division. In their new roles, they will spearhead BOND's long-range strategic plan developing integrated solutions to align BOND's services and capabilities with clients' needs. They will also play an important role to continue developing business as BOND expands capabilities across the Northeast.

TranSystems Corp. welcomed **Ali Tali, P.E.**, as vice president and Northeast Region bridge design practice leader. He will work out of the company's Boston office. He has more than 35 years of experience in the design and management of bridge projects.

Luke Olson, P.E., joined EXP as vice president, Transit, overseeing the transit sector globally. With almost 20 years of transit engineering experience, he has served in lead project roles for various modes of transit, including light rail, commuter, bus and bus rapid transit, and streetcars.

The Illinois Section of the American Society of Civil Engineers selected Illinois Tollway Deputy Chief of Program Implementation **Clarita Lao** for the 2018 Government Civil Engineer of the Year Award. Lao was recognized for her engineering career accomplishments spanning more than three decades, her leadership and management skills, and dedication to engineering excellence.

Amanda Ludlow joined Stantec's Transportation practice in its South Burlington, Vt., office as a principal focused on guiding development of the local stormwater planning and design group. Ludlow has nearly 25 years of experience in engineered natural systems, low impact development, and ecological services. Stantec's Water practice welcomed **Nicole Boulay** as sector leader for water in Virginia, bringing nearly 20 years of experience in water and wastewater treatment plant planning, design, and construction across the Washington, D.C., metro area.

Greg Marconnet and **Jeff Mason, P.E.**, were promoted to group leaders for Mead & Hunt. These corporate vice president roles will lead the marketing, sales, and operations teams of two high-growth markets. Marconnet was selected to be the group leader for the newly created Food & Beverage Group. Mason will be taking the helm as group leader for the Architecture & Building Engineering Group.

Pennoni hired **Brian Young** to serve the firm's Baltimore location as office director. He joins the firm with more than 20 years of experience in all elements of highway operations, design, construction, and traffic engineering. Young previously served as district engineer for the Maryland Department of Transportation State Highway Administration and led the SHA's District 3 office.

Mays Boyd, P.E., joined the Richmond Hill, Ga.-based Pittman Engineering team as a project engineer. Boyd has worked on several large projects in the coastal region, including Sun City Hilton Head, the May River Road improvements in Bluffton, and the Turner's Pointe development in Chatham County.

Garrett Phelps, P.E., will serve as regional director for Thomas & Hutton's Atlanta region. He has 20 years of experience in planning, design, and management of a broad range of land development and civil engineering projects throughout the southeastern U.S.

William Knapp, P.E., joined STV as vice president and design-build director in the firm's Western Region. He will be based in STV's Oakland, Calif., office and manage design-build efforts in the western half of the U.S. for the firm's Transportation & Infrastructure Division.

DECEMBER 2018

CAPITAL IDEAS 2018

DEC. 5-6 — ATLANTA

Interactive curriculum of model state legislation, campaign tactics, innovative policies, and peer-to-peer collaboration to help participants advance successful proposals to raise new funding for transportation.

<http://t4america.org/capital-ideas>

IDENTIFICATION OF WETLAND PLANTS IN WINTER

DEC. 13-14 — BASKING RIDGE, N.J.

Through a combination of classroom and field training, nationally recognized wetland expert Ralph Tiner provides tools to gain a competitive edge in the field of wetland delineation all year long.

www.cpe.rutgers.edu/courses/current/eh0205ca.html

JANUARY 2019

BUILDING INNOVATION 2019 CONFERENCE & EXPO

JAN. 7-10 — WASHINGTON, D.C.

Examine processes, communities, workforces, structures, resources, practices, communications, and collaboration aimed at “Optimizing for Tomorrow.”

www.nibs.org/page/Conference2019

2019 TRB ANNUAL MEETING

JAN. 13-17 — WASHINGTON, D.C.

Meeting program will cover all transportation modes, with more than 5,000 presentations in nearly 800 sessions and workshops.

www.trb.org/AnnualMeeting/AnnualMeeting.aspx

INTERNATIONAL LIDAR MAPPING FORUM

JAN. 28-30 — DENVER

Technical conference and exhibition showcasing the latest airborne, terrestrial, and underwater LiDAR as well as emerging remote-sensing and data-collection tools and technologies.

www.lidarmap.org

FEBRUARY 2019

GEOSYNTHETICS CONFERENCE

FEB. 10-13 — HOUSTON

More than 1,300 geotechnical practitioners, designers, regulators, contractors, and installers gather to learn the latest research, materials, applications, and case studies.

<https://geosyntheticsconference.com>

ASCE WEEK INTERNATIONAL

FEB. 11-15 — PANAMA CITY, PANAMA

A continuing education event with seminars and a technical tour providing as many as 35 PDHs.

www.asceweekinternational.org

IECA ANNUAL CONFERENCE

FEB. 19-22 — DENVER

Learn the latest updates and advancements in the erosion and sediment control and stormwater industry and gain insight to critical issues facing the profession.

http://www.ieca.org/IECA/IECA_Events/2019_Annual_Conference.aspx

PCI CONVENTION

FEB. 26-MARCH 2 — LOUISVILLE, KY.

Precast/Prestressed Concrete Institute 2019 Convention includes education sessions, committee and council meetings, and The Precast Show exhibition. National Bridge Conference and all peer-reviewed paper presentations are moved to the PCI fall conference.

www.pci.org

MARCH 2019

SUCCESSFUL SUCCESSOR SEMINAR

MARCH 13-15 — NEW ORLEANS

Discuss issues facing newcomers to the c-suite and individuals who are preparing to take on a high-level management role in today's AEC firm.

www.zweiggroup.com/seminars/successful-successor-seminar

EXCELLENCE IN PROJECT MANAGEMENT

MARCH 27 — KANSAS CITY, MO.

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

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

APRIL 2019

NASCC: THE STEEL CONFERENCE

APRIL 3-5 — ST. LOUIS

Educational and networking event for the structural steel industry, bringing together structural engineers, structural steel fabricators, erectors, detailers, and architects.

www.aisc.org/nascc

DESIGN-BUILD FOR TRANSPORTATION

APRIL 8-10 — CINCINNATI

Only U.S. event targeted to the rapidly growing design-build transportation industry.

<https://dbia.org/conferences/design-build-for-transportation-conference>

DESIGN-BUILD FOR WATER/WASTEWATER

APRIL 10-12 — CINCINNATI

Targeted conference for owners and design-build practitioners in the water and wastewater sectors.

www.dbwater.com

THE PRINCIPALS ACADEMY

APRIL 24-25 — DALLAS

Intensive course in all aspects of managing a professional service firm, including business planning, marketing/business development, accounting, financial management, project management, leadership, mergers and acquisitions, ownership transition planning, and recruitment and retention.

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

STRUCTURES CONGRESS 2019

APRIL 24-27 — ORLANDO, FLA.

Learn the latest from the experts who develop SEI/ASCE standards and earn PDHs from 12 tracks of technical sessions — Buildings, Bridges, Natural Disasters, Professional Practice, Risk Management, Blast, Materials, Seismic, Forensics, and more.

www.structurescongress.org

AEC BUILDTECH

APRIL 30-MAY 2 — ROSEMONT, ILL.

Inaugural event intended for architects, engineers, and contractors to learn about new building technologies and processes and how to apply them. Offers continuing education credits.

www.aecbuildtech.com

MAY 2019

WEF STORMWATER AND GREEN INFRASTRUCTURE SYMPOSIUM

MAY 8-10 — FORT LAUDERDALE, FLA.

Inaugural symposium crafted to deepen the technical knowledge of professionals involved with stormwater management and provide forums to discuss leading issues.

<https://wef.org/events/conferences/upcoming-conferences/stormwater-and-green-infrastructure-symposium-2019>

P3CONNECT

MAY 15-16 — DENVER

National Conference for Public-Private Partnerships offers this event for public-sector officials and private-sector innovators focused on advancing public-private partnerships (P3s) nationwide.

<https://thep3connect.org>

INTRODUCTION TO STRUCTURAL DESIGN OF WOOD BUILDINGS PER THE 2018 NDS

MAY 21-22 — BLACKSBURG, VA.

Course is designed for individuals who never had the opportunity to learn wood design basics in a university-level course, but are involved in the design, construction, and inspection of wood buildings.

www.cpe.vt.edu/sdwnds/index.html

SPAR 3D AND AEC NEXT TECHNOLOGY EXPO + CONFERENCE

MAY 21-23 — ANAHEIM, CALIF.

Co-located conferences feature 3D technologies from input to output, from 3D sensing to 3D processing to 3D visualization tools, plus the latest trends and best practices to help design, construct and manage AEC projects.

www.spar3d.com/events/spar-3d-expo-conference

www.aecnext.com

LEADERSHIP SKILLS FOR AEC PROFESSIONALS

MAY 22-23 — SAN DIEGO, CALIF.

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

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

JUNE 2019

SECOND INTERNATIONAL INTERACTIVE SYMPOSIUM ON ULTRA-HIGH PERFORMANCE CONCRETE

JUNE 2-5 — ALBANY, N.Y.

Innovation Awards and a platform to present recent Ultra-High Performance Concrete activities, research, and breakthroughs, as well as an opportunity to participate in hot topic panel discussions.

www.uhpcsymposium.com

THE PRINCIPALS ACADEMY

JUNE 5-6 — SEATTLE

Intensive course in all aspects of managing a professional service firm, including business planning, marketing/business development, accounting, financial management, project management, leadership, mergers and acquisitions, ownership transition planning, and recruitment and retention.

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

INTERNATIONAL BRIDGE CONFERENCE

JUNE 10-13 — NATIONAL HARBOR, MD.

Presented by the Engineers' Society of Western Pennsylvania, the IBC annually attracts more than 1,200 bridge owners and engineers, senior policy makers, government officials, bridge designers, construction executives, and suppliers from throughout the U.S. and abroad.

<https://eswp.com/bridge/bridge-home>

REAL MARKETING AND BRANDING FOR AEC FIRMS

JUNE 20 — CHICAGO

Designed to bring clarity and distinction between marketing and sales (business development), this course will aid all levels of staff to understand how to market the firm and build the brand in their respective roles.

<https://zweiggroup.com/seminars/real-marketing-and-branding-for-aec-firms>

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INSURANCE MARKET OUTLOOK

INSURANCE INDUSTRY ECONOMICS PROVIDE SOME PERSPECTIVE ON WHERE INSURANCE RATES ARE GOING IN 2019.

By Jeff Cavignac, CPCU, RPLU, ARM, MLIS; Jase Hamilton, CPCU, AFSB; and Patrick Casinelli, RHU, REBC, CHRS

INSURANCE IS NOT A UNIQUE CONCEPT. Although the sharing of risk has been going on for thousands of years, “modern” insurance only traces its roots back about 300 years. That is, if you consider a bunch of boat owners sitting around a coffee shop (Lloyds) agreeing to share the cost if one of their boats went down as the beginning of modern insurance.

Insurance, however, is a unique product. Businesses pay a lot of money — sometimes hundreds of thousands or millions of dollars — for something they hope they never use. If they use it, the cost will go up; and if they use it a lot, they may not be able to get it. And if they can’t get it, in most cases, they can’t stay in business.

While some forms of insurance are either required by law (workers compensation and auto liability, for example) or mandated by contract, other coverages are purchased because it makes financial sense to transfer the risk of a significant exposure to an insurance company in exchange for a relatively modest premium. (Note the use of the term “modest”; some people think any money spent on insurance is too much.) Regardless of whether insurance is mandated by law or contract or simply purchased because it makes sense, the cost of insurance is a major expense for most businesses.

Insurance is only one component of the cost of risk (sometimes less than half), and the cost of risk can be one of a company’s largest expenses, sometimes exceeding 5 percent of total income. Because of this, managing risk effectively and budgeting for the cost of risk are critical to both short- and long-term success.

Economics of the insurance industry

Insurance companies, like any other for-profit enterprise, are in business to make money for their shareholders. Insurance companies make money in one of two ways: underwriting profits and investment income.

An underwriting profit is achieved when losses plus all expenses are less than premiums. Dividing the former by the latter equals the combined ratio. A combined ratio of less than 100 percent means there is an underwriting profit, and a combined ratio of more than 100 percent means there is an underwriting loss. The industry has generated an underwriting profit in only three out of the last 10 years (see Table 1). The average of all 10 years in Table 1 equals 101.5 percent. Most insurance company executives will tell you they would like to see their combined ratio under 95 percent and, ideally, at 92.5 percent or lower. So, if most insurance companies are losing money on underwriting, how can they actually make money?

Insurance companies collect premiums and set aside reserves to pay future claims. These funds, known as surplus, generate investment income. In 2017, the industry lost 3.7 percent on underwriting (2017 was a terrible year for property-driven catastrophic losses) but earned an overall return of 5 percent. The difference is attributable to investments. During periods of substantial investment returns, insurance companies are willing to tolerate inferior underwriting results because they make it up on investments.

Since the insurance industry’s surplus is currently at an all-time high, prices should go down since supply is up. On the other hand, insurance company returns have been mediocre, so they need to increase rates to improve those returns. Rates have been relatively flat during the last three years (see Figure 1), so efforts to increase premiums do not appear to be working. While most underwriters are seeking single-digit increases where they can get it, rates are still predicted to be flat and some lines will see minor decreases.

\$ in Billions

Description	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Net Written Premium	\$434.90	\$418.40	\$423.80	\$438.0	\$456.90	\$477.7	\$487.6	\$505.8	\$523.5	\$552.6
Combined Ratio	105	101	102.4	108.1	103.2	96.1	97.0	97.8	100.7	103.7
Investment Income	\$51.5	\$47.1	\$47.6	\$49.1	\$48.0	\$47.4	\$46.2	47.2	46.3	49.0
Operating Income	\$30.6	\$45.0	\$38.2	\$15.4	\$33.3	\$64.3	\$55.6	57.3	42.6	20.3
Policyholder Surplus	\$457.30	\$511.50	\$556.90	\$553.70	\$586.8	\$653.3	\$674.7	\$673.7	700.9	752.5
Return on Avg. Net Worth	0.1%	5.0%	5.6%	3.0%	5.1%	10.3%	8.4%	8.4%	6.2%	5.0%

Source: Insurance Information Institute (iii.org)

Table 1: Insurance industry economics, 2008-2018



Figure 1: Commercial lines rate changes, 2008-2018

Rate outlooks

Property, general liability, auto, and umbrella (aka allied lines)

— As expected, preferred property risks are receiving the largest decreases, but even challenging accounts benefit from somewhat relaxed underwriting and increased competition. While property rates in general should be flat, two notable exceptions are property in high-risk locations, such as the Southeast (2017 was one of the worst years ever for insured catastrophes) and risk of residential wood frames, both completed and under construction.

General liability is also stable and 2019 should bring flat renewal pricing, with preferred accounts seeing single-digit decreases. Not surprisingly, the companies that have the best risk management programs and positive loss histories are experiencing the most favorable renewals.

On the other hand, automobile rates are going up across the country. This is caused by increased frequency due to distracted driving, as well as severity. Poor profitability in this line is increasing the average premiums anywhere from 5 percent to 25 percent. Differences among insurers is also greater in this line, which means this coverage is being shopped more frequently than other lines. Increased focus on fleet safety is critical to managing auto insurance premiums.

Excess liability (umbrella) remains reasonably competitive. Pricing is usually based on underlying policies, so excess liability pricing will increase if the underlying auto premiums increase.

Professional and pollution liability insurance — These lines remain competitive and there are a number of new players looking for business. Coverage and risk control services, however, differ dramatically, as does the quality of the claims teams for each insurance company. While price is important, the best value in this line is rarely the least expensive.

Executive risk — which includes directors and officers liability, employment practices, and fiduciary liability — remains stable, but is being carefully underwritten. This coverage also varies significantly by industry. Adverse loss experience or poor internal controls will also impact pricing. As much or more than most exposures, these areas lend themselves to being proactively managed. It is also important to understand the coverage you are purchasing, as every policy is unique and coverage differences can be significant.

Cyber coverage continues to be the fastest growing insurance product, yet it is still under purchased. Every business has cyber risk. Managing these exposures goes beyond having data backups. Cyber extortion and social engineering (aka cyber deceit), among other types of crimes, continue to grow. Every business owner should consider this coverage. The application process, even if you don't buy the insurance, will serve as a self-audit for your exposures and alert you to areas that can be improved.

Workers compensation rates continue to improve across the country, as well as in California. Rates in California reached an all-time high in 2003, when the "average charged rate per \$100 of payroll" was \$6.29. Rates dropped nearly 67 percent to \$2.10 in 2009. Unfortunately, this was well under what was needed for profitability and combined ratios inflated to 130 percent in the same year (see Figure 2).

From 2009 to June 2014, average charged rates increased 41 percent to \$2.97 — still less than half of the \$6.10 charged in 2003. This increased pricing generated an underwriting profit in 2012, the first time since 2007. As this line turned profitable, more insurance companies became interested in writing workers compensation and, since 2014, rates have dropped approximately 20 percent. Although the combined ratio is creeping up, workers compensation rates are still anticipated to drop 5 to 10 percent. Note that this can differ, in some cases dramatically, by classification. In addition, there are other factors such as your experience modification and schedule credits, which will directly affect net rate.

Best practices

The current insurance marketplace is relatively stable. While profits haven't been great, they have been decent, and the industry's surplus is keeping pricing competitive. Most businesses will be able to negotiate flat rates, and some preferred risks with solid risk management programs and favorable loss histories will be able to negotiate rate reductions.

Insurance premiums, however, need to be kept in perspective. They are only one component in the total cost of risk. OSHA estimated, among others, that the indirect cost of risk actually exceeds premiums paid. This includes money spent managing risk, training employees to be safe, dealing with claims, funding uncovered claims, and a number of other costs.

While it is important to understand the economics of the insurance industry and how this can affect your costs, there is nothing you can do about it. The market is the market. What you can control is how your company manages risk. Risk management needs to be front and center all the time. In the long run, the only way to reduce the cost of risk is to reduce the frequency and severity of claims that drive that cost. An effective risk management program, coupled with a proactive insurance brokerage firm and the right insurance company, is the key to lowering your total cost of risk. Investment in risk management will produce great returns and directly impact your bottom line.

Surety bonding: The peak of the cycle

As we close on 2018, the construction and surety industry remain in

fairly good shape. For most contractors, backlogs are as strong as they have been in over a decade, margins are returning to pre-recession highs, and work is abundant. For surety companies, profits are at an all-time high, loss margins remain low, and demand for bonding — along with total spending in the building industry — continues to grow across the nation.

According to the U.S. Census Bureau, total construction spending in 2017 was \$1.24 trillion and is expected to grow to more than \$1.35 trillion in 2018. Along with construction spending, the surety industries historic results have continued to improve. Since 2012, the direct written premium for the industry has grown from \$5 billion to more than \$6.2 billion at the end of 2017 — an increase of more than 23 percent. And the industry does not appear to be slowing down any time soon, with projected direct written premiums of more than \$6.5 billion in 2018.

The continued results and positive forecast for both underwriters and contractors have many wondering when the market is going to reach its boiling point and how to prepare for the inevitable decline. Rather than speculate, surety underwriters are depending even more on their clients and agents to proactively manage their operations and associated risks to grow in an expanding economy. Best-in-class contractors are using the market's positive growth and outlook to focus on what they do best and intelligently grow their backlogs, rather than over extending themselves by taking on work far outside their abilities and capacity. As growth continues, three main questions continue to be at the top of all contractors' and underwriters' minds — labor shortage, material costs, and fiscal policy.

Health insurance outlook

The Affordable Care Act (ACA) is still the law, but the individual mandate ends in 2019, which means that individuals will no longer have to carry medical insurance or prove that they have coverage. We are not sure how this will affect employer group plans, but it may have a negative impact on rates if the pool of insureds sees higher claims and less premiums.

One of the last provisions of the ACA law is the Cadillac Tax, which may or may not be implemented in 2020. The Cadillac Tax is intended to help fund benefits to the uninsured. Employers were supposed to begin paying a 40 percent tax on costs of health plans that were above \$10,200 per individual and \$27,500 for family coverage.

Throughout 2018, rates remained flat with only minor increases. The ACA allowed teenage rate bands to change (0-14, 15, 16, 17, 18, 19, and 20), which resulted in higher increases for employees with dependents on the group plan.

For 2019, we expect low single-digit rate increases and minimal plan changes. Rates for all small employers (2 to 99 eligible employees) will be based on the employee and their dependents' individual ages, plan design, and company location. For example, a family of five will pay for each family member based on each individual's age and the plan they select. Some younger employees or families with one child may realize lower premiums.

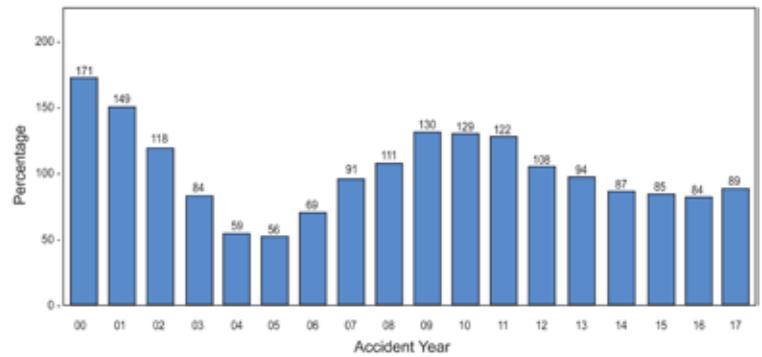


Figure 2: Workers compensation projected accident year combined loss and expense ratio, 2000-2017

We forecast additional plan changes in 2019 that will remain compliant with ACA guidelines. All of the major insurance companies have determined that, in order to stay in compliance with the ACA's metallic tier guidelines, they must change plan benefits every year. The ACA guidelines gave a percentage requirement for each tier: 90 percent = Platinum, 80 percent = Gold, 70 percent = Silver, and 60 percent = Bronze. As costs increase, the value of the percentage changes and therefore the plan benefits change.

Using the Platinum plan as an example, if the actuarial value of a plan this year was \$1,000, then the Platinum plan has to cover 90 percent (\$900) and pass 10 percent (\$100) to the plan member. In the second year, if the actuarial value goes up to \$1,100, 10 percent (\$110) can be passed to the plan member and the benefits will change. This will always be a moving target until the values are fixed or the law is changed.

For insurance carriers to be competitive in 2019, we will continue to see plans that offer Skinny Network choices, which offer a smaller number of providers. Skinny Network plans might offer an attractive price, but employees will have very few choices of doctors. Be sure to run a report to compare current providers to those associated with any programs you are considering.

Insurance carriers continue to seek greater discounts from hospitals, medical groups, and doctors and are offering patient exclusivity in return. Some insurance carriers will allow Skinny Networks to be offered side-by-side with full networks, with the price and contribution being set by the employer to favor one or the other.

Employee satisfaction increases with choice of medical plans and networks, so the more choices offered, the better the employees feel about their benefits package. Also, ancillary (dental, life, disability, and vision) and supplemental (accident, cancer, hospital, etc.) benefits have shown to greatly improve employee satisfaction, which will help organizations hire and retain the best employees.

Trust Plans, or Association Plans, are being formed for industry-specific companies so they can band together to lower their cost. Captives, self-funding, and partially self-funded plans continue to be popular and could be a viable option for companies with more than 50 employees. Additional ways to reduce cost include buying a Bronze level plan and

supplementing it with cancer, hospital, accident, and critical illness plans.

Conclusion

The construction market is cyclical in nature, and it's impossible that the current upswing will last forever. Yet, in spite of the market experiencing the longest expansion in history, there remains little to suggest the end is near. The last year (2018) continued to yield good growth in construction despite a weakening labor pool, increasing material costs, and uncertainty surrounding fiscal policy.

As these factors continue to burden the construction industry in 2019, contractors must continue to hold the line and not only maintain the profits they've worked so hard to get back, but also retain those profits, take advantage of the low interest rates, reduce debt, liquidate surplus equipment, and build cash reserves to guarantee future sustainability and success, both professionally and personally.

JEFF CAVIGNAC, CPCU, RPLU, ARM, MLIS, is president and principal of Cavnac & Associates (www.cavnac.com); and **JASE HAMILTON, CPCU, AFSB**, and **PATRICK CASINELLI, RHU, REBC, CHRS**, are principals. Cavnac & Associates, a San Diego-based risk management and commercial insurance brokerage firm, provides a broad range of insurance and expertise to design and construction firms, as well as to law firms, real estate-related entities, manufacturing companies, and the general business community.

What does risk really cost a company?

For many companies, the cost of risk is one of their largest expenses, but you won't find it on their income statement. The cost of risk includes factors such as:

- time spent analyzing risk;
- money spent on risk control, including salaries for safety, human resources, and claims management;
- the cost of educating employees on safe practices;
- the cost of complying with all the various laws imposed by OSHA, the Department of Labor, and other governmental organizations;
- money spent paying uncovered losses or funding deductibles;
- time spent dealing with losses;
- productivity costs due to time lost by injured workers and the cost of training new workers; and
- the cost of insurance (less than 50 percent of the cost of risk in many cases).

LEADERSHIP MUST MAKE DIVERSITY AND INCLUSION WORK

SET PERFORMANCE METRICS AND KEEP TEAMS ACCOUNTABLE TO CONFRONT INSTITUTIONAL PARADIGMS AND BIASES THAT PERPETUATE THE STATUS QUO.

By Mike Carragher

IF YOU'RE A 60 MINUTES FAN, you may remember a recent episode featuring Salesforce's Chairman and CEO Marc Benioff discussing his company's commitment to gender equality. Except there was a twist to this story: A salary audit showed that some female employees actually made less than their male counterparts. Benioff was stunned by the numbers. After all, his company had a reputation for fairness and inclusion, and it had been ranked No. 1 on Fortune's 2017 list of Best Companies to Work For.



VHB decided a few years ago that the firm would need a broader array of perspectives, opinions, and life experiences to meet future challenges in the AEC industry.



Mike Carragher, president and CEO of VHB

But Benioff did what I could imagine many CEOs and leadership teams would be reluctant to do — he admitted before millions that his company hadn't lived up to its promise to employees. Not only that, he corrected the salary imbalances to the tune of \$6 million. It was the right thing to do, he said.

Call it a great PR move, but what I saw in Benioff's actions and candor was a leader who's living out the company's core values.

Progressive leadership like Benioff's reflects a refreshing dynamic in corporate America. Industries from tech to transportation to financial and AEC are recognizing that workforce diversity and inclusion are fundamental to their growth and long-term sustainability.

A mountain of research supports this view. McKinsey & Company's 2015 report, *Why Diversity Matters* (www.mckinsey.com/~media/mckinsey/business%20functions/organization/our%20insights/why%20diversity%20matters/diversity%20matters.ashx), and Deloitte's *Diversity and inclusion: The reality gap 2017 Global Human Capital Trends* (www2.deloitte.com/insights/us/en/focus/human-capital-trends/2017/diversity-and-inclusion-at-the-workplace.html), highlight data that underscore the positives of diversity and inclusion as a corporate culture.

While the two research papers offer noteworthy perspectives, it's this key point found in the Deloitte study that says it all: "Companies with inclusive talent practices in hiring, promotion, development, leadership, and team management generate up to 30 percent higher revenue per employee and greater profitability than their competitors."

And then there's the perspective of the newest generation of professionals who in 2025 will make up 75 percent of the U.S. workforce. The Deloitte report observed that this generation sees inclusion as a mandatory part of corporate culture, defining how the company listens to them at work.

So, it stands to reason that employers whose cultures reflect these expectations hold competitive advantages when it comes to recruitment, retention, and performance.

The writing is clearly on the wall: Companies either move forward with diversity and inclusion or fall behind without them.

Based on my own experience as president and CEO of VHB, I know that it takes unwavering commitment from leadership to instill and maintain an inclusive culture.

That's how VHB has approached its diversity and inclusion ambitions since deciding a few years ago that our company would need a broader array of perspectives, opinions, and life experiences to meet future challenges in the AEC industry. Even with VHB's solid record on diversity and gender equality, we saw a need to do more to expand recruitment efforts and inspire greater collaboration among our 1,400 employees from diverse backgrounds.

With that thought in mind, last year we created the People and Culture Department. It's led by a chief people officer who is part of our C-suite and reports directly to me. The department concentrates on employee engagement and enhancing the full employee experience so VHB can provide an environment that encourages each person to fulfill their potential and help our team grow stronger in the process. From employee recruitment and onboarding to career development and ownership opportunities, we're fostering a healthy, diverse, engaged team. More recently, an employee-led resource group began to hold sessions that raise awareness of diversity and inclusion at VHB.

Advancing a diversity and inclusion agenda takes resolve from the very top because such an undertaking likely will confront institutional paradigms and biases that perpetuate the status quo. Training alone won't yield a lasting impact on prejudices and practices. For diversity and inclusion to have their desired effects, leadership must set performance metrics and keep teams accountable.

But, as Salesforce's Benioff proved, the full measurement of a company's commitment to diversity and inclusion is in leadership's actions. We need to set an example by living our core values and acting with integrity and respect for everyone. It's the right thing to do.

MIKE CARRAGHER is the president and CEO of VHB, an engineering, science, planning, and design firm with 1,400 employees in 30 East Coast locations. VHB was named one of the 2017 Best Firms to Work For by Zweig Group and the 2018 Employer of the Year by Women's Transportation Seminar (WTS).

MASTER PLANNING IN MALAWI

ENGINEERS AND ARCHITECTS EXTEND HOPE THROUGH DESIGN.

By Robert Donahue, AIA, LEED AP

SEASONED WITH SKELETAL REMINDERS of our architectural and engineering history, our cultural world savors residual remnants of our past that echo in cathedrals, pyramids, and aqueducts. Previously reverberating acoustics, some ruins now simply resonate craftsmanship of stone masonry, structural stone rib vaults, or graceful architectural proportions.

Devoid of those skeletal ancient ruins, Malawi is a country whose past becomes synonymous with the present. Simple sunbaked clay brick homes topped with shaggy grass-thatched roofs slowly melt in the rain, eventually returning to the earth from whence they came. Villages organically develop along shop-laden roads backed by homes with neatly swept bare dirt yards and goats milling around central maize granaries. The Malawian landscape looks virtually the same as the British explorer Dr. Livingstone encountered in the late 1800s when exploring interior Africa and discovering the lake now bearing the country's name.

Beit Cure International Hospital

Beit Cure International Hospital (BCIH), a teaching hospital specializing in the orthopedic treatment of children and adults, was established in Blantyre, Malawi, in 2002 by The Beit Trust, a UK-based charity, as a gift to the people of Malawi. BCIH is part of an international non-denominational Christian network of eight surgical hospitals and other clinics serving in 26 developing countries.

Specializing in pediatric orthopedic total hip and knee replacement surgeries, club foot, and bowleg deformities, BCIH offers free medical services to the poorest of the poor. Portable clinics travel throughout Malawi and adjacent countries offering medical consultation and selecting children in the most need for services, developing schedules and travel arrangements for children and their families. The existing hospital campus includes a 50-bed children's ward and an adult ward with eight private rooms. While adult patients pay for services, all medical surgeries and procedures for children are free of charge.

BCIH also serves the local medical community, the adjacent College of Medicine, and other neighboring hospitals in Blantyre through partnerships, training, and other shared educational opportunities. Visiting expat surgeons offer training and clinicals to help educate Malawian medical students and professionals. Partnerships are also fostered by medical referrals to/from neighboring hospitals and collaborative sharing of equipment when needed. In developing countries, hospitals often struggle to provide even minimal care, let alone specialize in multiple facets of medical services.

Hope through design

I eagerly joined a diverse 10-person team recruited by Engineering Ministries International (eMi; <https://emiworld.org>) to provide design



Having particular interest to our civil and structural engineers, the existing water tower provided about one day of storage capacity for the hospital campus. With a defunct borehole pump, the hospital is completely dependent on city water with no redundant supply.

services for BCIH. eMi is a nondenominational Christian development organization with offices in 10 countries whose vision is to foster God-inspired restoration and hope through design, discipleship, and diversity. eMi partners with indigenous and expat ministries to analyze, design, and improve their facilities, helping them become better stewards of natural resources and improve the livelihood of people on their ministry campuses. eMi's tagline is "Designing a World of Hope."

On Aug. 31, 2018, our design team assembled at the Blantyre International Airport. Most of us were mentally and physically exhausted, with some enduring a 48-hour plane trip. Despite having never met

Malawi design team

- Trevis Smith, eMi project leader (civil engineer), North Africa
- Meg Longman, eMi associate staff (architectural), UK
- Martina Nasser, eMi associate staff (architectural), North Africa
- Nathan Geier, architect, The Woodlands, Texas
- John Cooksey, health care architect, Denver
- Robert Donahue, architect/planner, Round Rock, Texas
- Eric Lehmkuhl, structural engineer, San Diego
- Robin Osborne, civil engineer, San Diego
- Joe Ross, mechanical engineer, San Diego
- Cassandra Rounds, electrical engineer, Phoenix

one another, our team quickly joined together in a common purpose of serving alongside BCIH.

Several weeks before our primary team assembled, two Ugandan surveyors traveled to the site to survey the entire hospital campus in addition to three other satellite properties with support housing. Our primary team, led from a field office in North Africa, included three architects, two architectural interns, two civil engineers, a structural engineer, mechanical engineer, and electrical engineer (see “Malawi design team”). Our diverse design team included two from North Africa, another from the UK, and the remaining from San Diego, Phoenix, Denver, Houston, and Austin, Texas.

Understanding the hospital vision

During our first full day, we met with Mark Deysher, the executive director of BCIH, learning about local culture, the vision and history of the hospital, and touring the main campus facilities. We heard several amazing stories of physical healing, struggling families, and the tremendous impact of children returning to their villages with prior deformities removed. Many families tend to hide children with deformities out of shame or an unwritten sense of the “sins of the father.” Spiritual pastors accompany village reuniting experiences to explain and minister to returning families now unashamed of previously hidden and outcast children.

After enjoying a worship service at a local church and touring some of downtown Blantyre, our team spent most of our second day sketching and measuring buildings on multiple sites to create accurate as-built drawings.

Throughout our time in Malawi, we shared how each of us felt compelled to volunteer for this project, focusing on our common purpose of serving the people of Malawi, and enjoying our week and a half of divinely intertwined life paths.

Our third day in Malawi coincided with the weekly arrival of incoming patients. After a relatively quiet weekend, the hospital suddenly became a beehive of activity. Some children were admitted while others were prepped for life-changing surgeries. Day clinics, x-ray, ultrasound, pharmacy, and other hospital services provided care to out-patients.

Unique to Malawi, BCIH provides three meals per day for all patients and one family guardian. Some children require supplemental nourishment to physically withstand surgery. The hospital kitchen was abuzz with meal preparation throughout the day while spiritual leaders offered counseling to patients and families, many having traveled great distances from all over Malawi and even some neighboring countries. Our team enjoyed traditional Malawian dishes cooked in the hospital kitchen.

Most of our core project days involved our architectural team meeting with ministry leadership and hospital staff to learn the hospital’s history, vision, function, challenges, and future direction. Gleanings from



The in-country rendered site master plan, illustrating existing buildings without color, future demolished buildings as dashed with red inner lines, and proposed new buildings/additions as solid red.



An initial conceptual elevation sketch shows a potential two-story addition with connecting balcony to provide accessibility to the upper floor in the existing building.



Team at the edge of the plateau before heading into the Shire River Valley on the way to a wildlife preserve. Scottish missionaries in the late 1800s, unable to continue beyond a section of waterfalls and donned with wool clothing, found the more mild temperatures of the plateau a welcome respite. Their settlement became the present-day city of Blantyre.

these meetings developed the framework for designing a “master plan of hope.”

Developing the master plan

Through the process of talking to nurses, surgeons, cooks, administration, and spiritual staff, we developed a greater understanding and clearer picture of current functions, challenges, and future needs of the hospital. Simultaneously, our engineering team explored existing structural, civil, mechanical, and electrical systems to gain an understanding of current challenges and potential future improvements.

Our team also assessed the existing hospital facilities from the standpoint of building code, accessibility, structural, civil, and electrical conditions to create recommendations for critical improvements.

From a civil engineering perspective, the existing water supply system was inspected and mapped. With primary storage in a large water tower, water supply included several smaller tanks scattered around the campus. With a nonfunctional existing borehole pump, the hospital is currently fully dependent on city water, with no backup or alternate

supply. Our civil engineers developed a water demand analysis illustrating the current storage capacity providing only a day’s supply of water.

Our civil engineers also analyzed site runoff concerns, measured wastewater/storm inverts, and mapped existing pipe layouts. Civil recommendations included swale diversion of runoff from an adjacent site, addition of another water tower of comparable size (affording two days of capacity), rehabilitation of the existing borehole/drilling a new borehole for redundant supply, and installation of a grease interceptor along the waste line beyond the kitchen.

Our structural engineer analyzed the existing water tower structure, finding it sufficiently braced to support the large dead load of water. Additionally, the engineer examined attics to analyze existing roof trusses, looked at some minor wall cracking as requested by the hospital, made recommendations for column spacing in proposed new buildings, and explored potential solutions for bracing a proposed tall flue stack for a new incinerator.



Our architectural team created a 3D SketchUp model of the existing hospital campus and a potential outpatient and administration addition.

Exploring surgical theaters and other medical spaces, our mechanical engineer made recommendations to improve air supply, filtration, and conditioning, exhaust, and surgical sterilization. Our electrical engineer looked at panel boxes, switchgear, and a diesel generator, mapped existing wiring, and connected load demand instruments during several of our project days.

Hospital staff expressed a desire to lessen the use of expensive diesel generator fuel, detach from the sporadic national power supply, and pursue either solar supply or battery storage to bridge the gap in power drops. To meet this concern, our electrical engineer analyzed existing power demands, future demands, solar panel capacity/sizes, and battery sizes/capacities.

At the end of the week, our team shared a presentation of a schematic hospital floor plan, overall architectural site master plan, civil infrastructure plan, structural analysis of existing water tower and future water tower improvements, electrical system analysis and infrastructure improvements, and schematic architectural building designs for potential future hospital expansions.

Conclusion

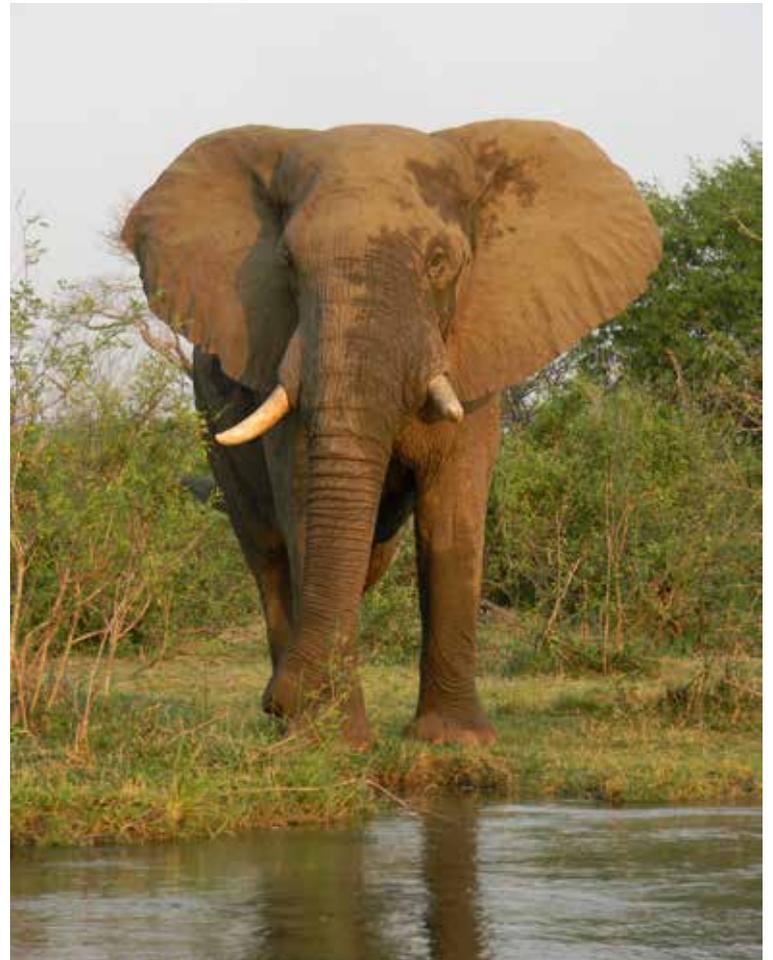
After an intense design charrette week, our team enjoyed a couple of days at a Malawian Wildlife Preserve, meeting some of the locals, including lions, elephants, crocodiles, hippos, and warthogs, among others.

Our team continued to serve BCIH this fall as we refined and further developed the hospital master plan. By the end of the year, we will release a design report to BCIH for use as a fundraising tool and strategy mapping for campus improvements.

eMi recently served CURE International with similar master planning projects at other hospital campuses in Niger and Uganda and is scheduling future projects at other CURE hospital campuses. Upcoming projects, along with more information about eMi and how you can serve, can be found at www.emiworld.org.

If design professionals think of nations as involved in a journey along a development ladder rather than being subservient in a first to third grading hierarchy, we can more easily show compassion and see developing countries as having tremendous opportunity to nurture and grow. Having lived overseas, visiting more than 70 countries, and enjoying the blessing of serving on more than 40 projects like this, I see the developing world as having amazing potential while equally mired in a quixsand of challenges.

Serving the developing world as a westerner (especially in an indirect communication culture like Malawi) requires patience, humility, cultural sensitivity, and remembering that we don't know as much as we think we know — not necessarily an easy task for us architects and engineers!



This 45-year-old bull elephant expressed his disdain for our boat encroaching on his turf. There are few things that can get your heart racing more than sitting in a boat 15 feet from shore and having a much larger elephant charge you to confirm his larger size.

ROBERT DONAHUE, AIA, LEED AP, is a project architect at Lockwood, Andrews & Newnam, Inc. (LAN), a planning, engineering, and program management firm. He can be reached at radonahue@lan-inc.com.

2018 BIM AWARDS

TRIMBLE RECOGNIZES NORTH AMERICAN PROJECTS THAT HIGHLIGHT EFFECTIVE USE OF MODELING FOR DESIGN AND CONSTRUCTION.

THE TEKLA NORTH AMERICA BIM AWARDS CELEBRATE the success of projects in North America modeled using Trimble's Tekla software. The awards welcome project entries of all sizes and complexity, with judging based on collaboration between multiple participants and use of Industry Foundation Classes (IFC) and open BIM; challenges solved with Tekla; multi-material aspects or complex geometries; and the "cool factor" — uniqueness of the project and creativity in project execution.

Following are the 2018 Tekla North America BIM Award winners in six categories — Cast-in-place concrete, Precast concrete, Steel, Multi-material, Small project, and Tekla Structural Designer.

Cast-in-place concrete: 727 West Madison

727 West Madison is a 46-story, cylindrical apartment tower in Chicago's West Loop neighborhood and will be Chicago's tallest building west of the Kennedy expressway. Located on Madison Street and Halsted Street, this iconic building with street-level retail spaces will incorporate banquet halls, a business center, pool, and health club to be shared with the adjacent 400-room hotel.

Pepper Construction's Self Perform Group served as the concrete subcontractor on this project, placing more than 27,000 cubic yards of concrete from May 2017 through May 2018. Project completion was scheduled for fall 2018.

Due to site logistics and schedule, the concrete structure was built in three phases — the tower proceeding ahead on the critical path and the parking garage/podium split into two phases.

Early in the project, the concrete superintendent and project engineer were flying through the model when the superintendent realized that the current schedule would not work because of the atypical size of the detention tank. The depth and length divided the site, cutting off pumping accessibility to the tower once parking garage construction began.

With the concrete Tekla model, the field team was able to detect this early enough to work with the general contractor, design team, and client to provide an alternate size and location, saving the project time and money.

Tekla BIMsight also helped identify a condition in which the construction fence and property line did not allow proper shoring of an upper floor cantilever. Because the shoring was laid out and overlaid early, the issue was identified with enough time to submit and obtain approval to install the construction fence outside the property line for temporary shoring without negatively impacting the schedule.

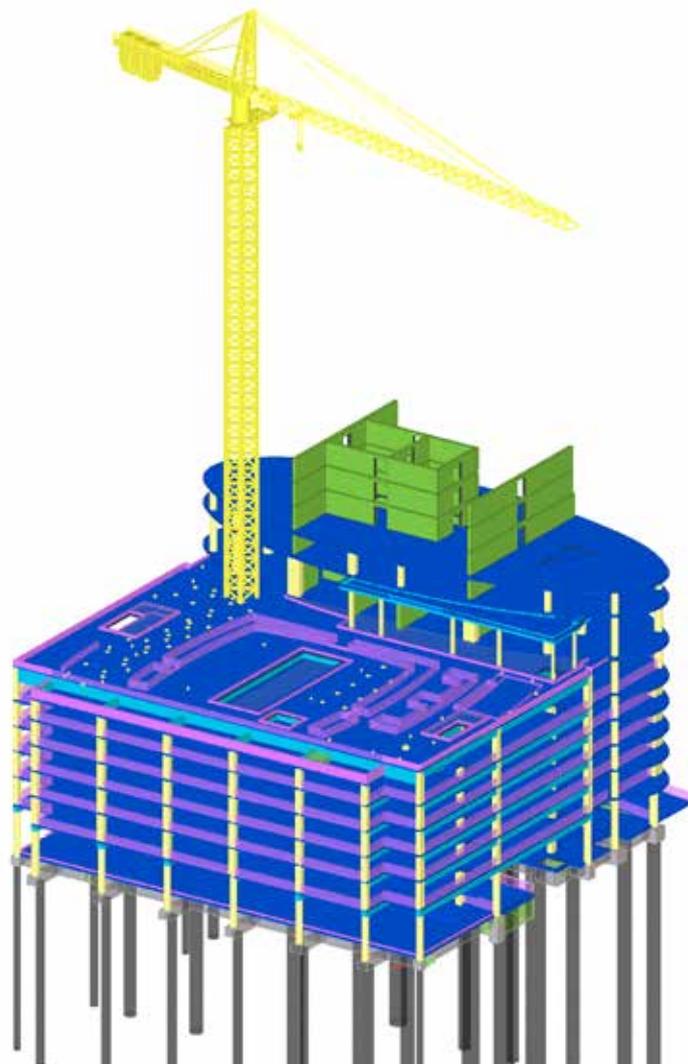
Tekla Structures was used throughout the project for concrete quantities and model-based estimation. The model was updated for a variety

of value engineering options and design changes through several rounds of budgeting before contract award.

Milestone IFC was used with the change management tool in Tekla Structures to quickly locate changes, output spreadsheets to quantify changes, and model snapshots or meeting fly throughs of the model to communicate change order requests.

Once concrete placement started onsite, project engineers and superintendents used the model to accurately order and track quantities for concrete deliveries. On one of the pours, the accurate model quantities saved concrete from two trucks compared with the original hand take-off.

From breaking ground through topping out, the model was used for all concrete layout. Layout points were populated, managed, and exported from Tekla using text files that were fed directly into total stations. Field technicians and project engineers coordinated hands-on in the field using Tekla BIMsight.



Tekla 3D model of 727 West Madison



Rendered model of the Statue of Liberty Museum

Precast winner: Statue of Liberty Museum

High Concrete Group, LLC is a family-owned company that has delivered precast concrete structures for nearly 50 years. The company provides structure and enclosure systems, components, and accessories for virtually every kind of project from residential to warehouse and retail structures and sports stadiums, including several exceptionally complex buildings.

High Concrete creates constructible models for 95 percent of its projects to Level of Development (LOD) 400, for which it relies on Tekla Structures software.

The Statue of Liberty Museum is a new museum on Liberty Island that features precast concrete panels around the perimeter, with the exception of a glass façade that faces Lady Liberty and gives patrons of the museum a view of the statue from every angle. The structure also features a large staircase that leads to a green roof for a unique vantage point of the statue.

High Concrete was responsible for the large insulated precast concrete panels around the outside. The panels have a distinct vertical rib pattern and the concrete mix and finish were created to give the appearance that the panels rose up out of the stone around the island. The precast panels were designed to withstand flood waters and also interface with the steel structure. The precast concrete was modeled in Tekla Structures to LOD 400, which means the concrete parts are modeled accurately and in their correct location; all hardware, including lifting devices, are modeled and all reinforcing added to the pieces.

There were many challenges to this project. For example, it was on an island and required special shipping parameters. High Concrete had to ensure all panels were able to be shipped on a barge to the site. The project also has a lot of steel interface, so High Concrete relied heavily on reference models from the steel supplier to ensure the steel structure and precast panels aligned perfectly. The complex shape and design elements of the project made it difficult to visualize the final project, so they created rendered augmented reality models of the project and offered the customer a unique experience to visualize the project using Microsoft HoloLens.

One benefit High Concrete gained from the use of Tekla Structures is

a database of information that can then be used to feed other systems such as their ERP system, SAP. They populate the cast unit information, bill of materials, and other data from the data from the model. For this project, coordination was very important with the interface of concrete panels and the steel structure, so they used Tekla's ability to bring in the steel vendor's model as a reference model, as well as creating IFC files of their model to share with the customer. Finally, they used Tekla's ability to create layout points that could be exported and loaded into a total station that the layout team used to layout the panels, as well as check location of site-cast hardware.

They also used Trimble's Sketchup to create a textured rendered model. They exported the Tekla model into Sketchup, added photo-realistic textures, and inserted it into a model of Liberty Island found in Sketchup's 3D warehouse, and then put that Sketchup model onto the Microsoft HoloLens using the Sketchup Viewer app.

Steel Winner: New Mexico City International Airport

The design of the original New Mexico City International Airport has a surface area of almost 8 million square feet and will be modeled entirely in Tekla Structures and represent the largest Tekla model ever created on a global scale. The entire terminal building will be covered by a continuous light Space Frame that will unify walls and roof in a fluid design that represents the fluid movement of flight.

With spans as great as 328 feet, or three times conventional airport spans, this monumental scale was inspired by Mexican architecture as well as symbolism. The largest interior span is 558 feet.

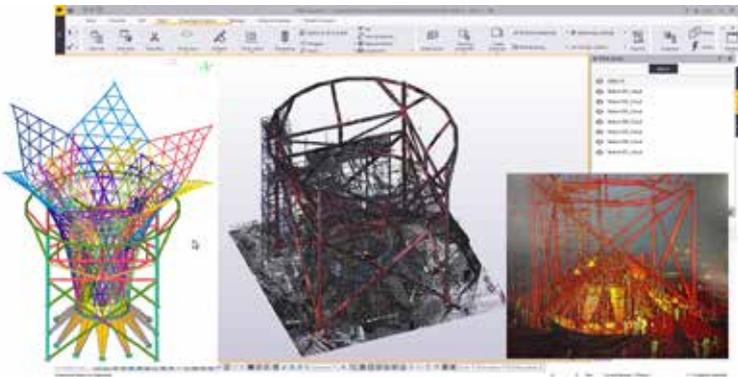
The size of the project would demand thousands of manhours with a manual approach, which, combined with the desire to prevent errors, led to using Tekla Structures to create a 3D model. The more automation the team could incorporate into the process, the fewer mistakes. Geometrically, they needed a method that would allow for physical markings on the elements that could be accurately identified on the model. The surveying team required a list with these elements and their coordinates so that they could easily verify the positioning of the bars.

The project is defined by two database tables with more than 600,000 elements. Moving from a table format into a 3D model was easy in Trimble's Tekla Structures. With a "raw" model with every bar of the

funnels in place, the team needed to assign the connections between them. Tekla Structures offers compatible connections to the HGG software used by the pipe-cutting machine. The team developed a macro via the Tekla API that would read the metadata on each bar, compare it with the database, and assign the proper connection. All cuts were made directly from the 3D model.

Speaking about the size of the project, there are not many modeling tools on the market that can manage so many elements in a single model. Constructora Terminal Valle de Mexico tried modeling the structure in other programs, but the files were too large and could not be operated without tremendous lag.

Using the latest version of Tekla Structures allowed the team to superimpose point cloud data from Trimble RealWorks, point cloud processing and analysis software for 3D laser scanning professionals obtained with a Trimble 3D scanner. Combining the Tekla model, API, point cloud, and layout points allowed creation of a totally constructible model.



Tekla Structures was used to create a 3D model of the planned New Mexico City International Airport.

Multi-material winner: University of Wisconsin Music Performance Center

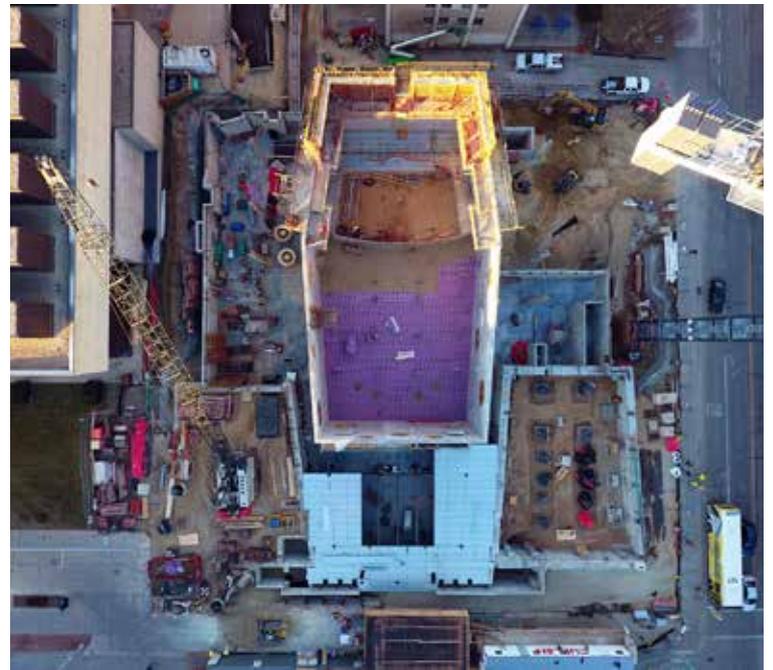
Entered by JMT Consultants, The University of Wisconsin Music Performance Center is a 75,000-gross-square-foot building designed to be a marquee musical performance center for University of Wisconsin - Madison students, faculty, and special guests. The building will host a 650-seat main concert hall, a 320-seat recital hall, a rehearsal room for the full orchestra, and assorted spaces for public and private administrative use.

The structure of the building is a hybrid of steel, concrete walls, and a few glulam beams. Steel framing and decking rises from the basement and supports all floors and roof areas. However, the Concert Hall is framed by 80-foot-tall walls poured with self-consolidating concrete and braces steel on all sides. Large concrete acoustical chambers also rise more than 30 feet from a supported concrete slab on the second-floor level. The roof of the Recital Hall is framed by glulam beams and wooden decking. The exterior will consist of curtainwall window systems, V-shaped precast panels, metal panels, and stone veneer.

Tight schedules and complex architectural features integrated with the structural design of multiple materials presented an issue that would not have been as successful without the use of BIM. Having steel, concrete, and rebar accurately detailed within one model, with the use of Tekla Structures, made coordination simple and easy. Throughout the course of the project, design obstacles were overcome by performing model reviews containing all building components of the structure, allowing clashes and design issues to be found and solutions to be applied quickly, which was key to keeping the project on schedule.

Utilizing Tekla Structures to work from one intelligent model with steel, concrete rebar and allowing construction data to be easily extracted was key to the success of this project. Trimble Sketchup was used for complex shapes such as decorative precast panels, to be easily modeled and brought into the Tekla model, saving time and increasing the accuracy of these components.

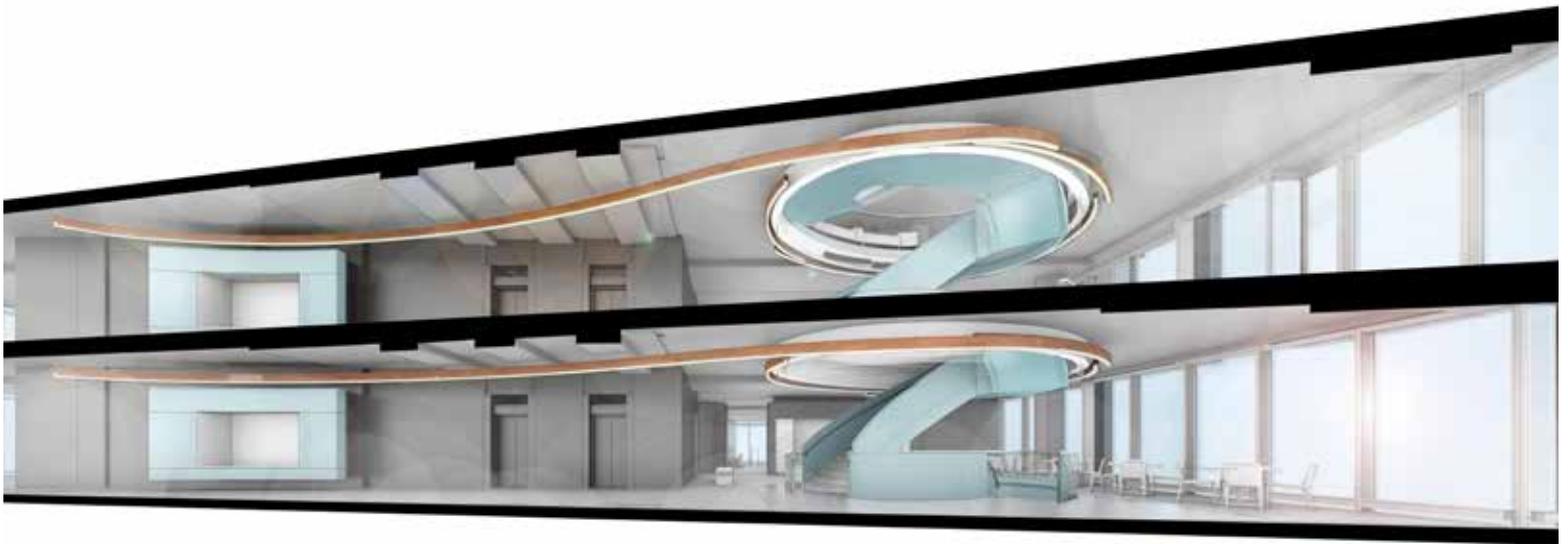
Multiple disciplines working on the same Tekla model simultaneously was essential to keeping the project on schedule and ensuring all components would fit together as designed when assembled onsite. Accurately modeling and detailing decorative precast panels, cast-in-place concrete, rebar, embedded steel, structural steel, miscellaneous steel, and acoustical elements in one model made coordination much easier.



Aerial view of construction of the University of Wisconsin Music Performance Center

Small Project winner: Nestle USA Headquarters Monumental Stair

Nestle USA Headquarters Monumental Stair is a small, yet very complex project. This project contains a challenging compound curve shape (oval staircase) with lighted plate railings covering the entire stair frame.



Architect's rendering of Nestle USA Headquarters monumental stair

The unique nature of the inner guarding on the stair as it slopes to the vertical, as well as being curved in plan to follow the helical shape, presented challenges. The painted 14GA carbon steel cladding ribbed with 3/16-inch-thick laser-cut steel cladding and rail support paired with illuminated handrails and stair underside cladding that follows the bottom slope of the stringer makes it even more interesting, if not daunting.

Crystal Steel provided full shop drawings and machine data to its workshop to provide all stringers, treads, glass and stainless-steel guarding, cladding, grab rails, and brackets, all fully modeled in Tekla and verified by BIM interface with the client.

The unique nature of the inner guarding on the stair, as it slopes to the vertical, as well as being curved in plan to follow the helical shape, added to the complexity of the project, but with the use of Tekla Structures, it was never impossible.

The project comprised 25 tons of steel, 1,863 square feet of glass in 233 panels, and 3,637 square feet of stainless-steel cladding.



Project contains a challenging compound curve shape with lighted plate railings.

Tekla Structural Designer winner: Cincinnati Tennis Center Court South

Located at The Lindner Family Tennis Center in Mason, Ohio, the new 40,000-square-foot South Building stands 104 feet tall. BDMD Architects planned and designed the building and Lawson Elser (LEI) provided structural engineering services on the project.

The multi-material building stands atop 70 drilled-shaft foundations that are 30 feet deep in the soil. The building rises from the ground on 22 cast-in-place concrete columns. The precast seating facing the center court is supported by four cast-in-place concrete raker beams. To handle the gravity load from the seating, these raker beams were supported by prestressed concrete beams at the top and bottom. These prestressed beams span 95 feet, allowing for an unobstructed view for the 252 air-conditioned box seats below.

The building has slabs on metal deck typically at every floor supported by a beam girder system. Level four and five are supported by steel structure. The building has two steel trusses that span 95 feet, giving a clear floor span at the fourth and the fifth floors. The canopy on the building comprises five steel trusses that cantilever over the box seats by 30 feet and gives the building its height of 104 feet above ground. The building is primarily supported against lateral wind and seismic loads by three concrete elevator shafts.

This project had a strict schedule for construction — between the end of the 2017 tournament and the start of the 2018 tournament. The complexities in the geometry and a plethora of materials and construction techniques used in the construction only added to the challenge. With a thorough comparison of analysis and design tools, LEI chose Trimble's Tekla Structural Designer for its capability of integration with Revit and the ability to design both concrete and steel together.

Use of BIM and Tekla Structural Designer allowed the team to efficiently visualize, create information-rich models, and design a building of this complex nature. Existing conditions altered the geometry of the building, which caused challenges during construction. However, LEI

was able to easily modify the BIM and Tekla models to re-analyze and compare the impact on the original design intent.

LEI engineers used Tekla Structural Designer to efficiently manage the project and save time by not having to switch between multiple software programs to design steel and concrete separately. The software's ability to compute wind and seismic loads were crucial time-saving tools. The software had the ability to perform FEM analysis along with grillage chase-down, which gave LEI a great deal of control over design and analysis of the model. The capability to perform analysis by floor is a great tool, especially when a model has multiple levels.

Tekla Structural Designer offered collaboration between involved parties, including architects, technicians, and fabricators. Its integration with Revit helped LEI import the geometry from the architect's model and, after analysis and design, import the information back into Revit. This prevented the loss of vital design data while going back and forth between programs.

Tekla Structural Designer's user interface was intuitive, user friendly, and easy to pick up; this was LEI's first project working with the program.

The \$25 million project included 420 tons of steel, 111,744 cubic feet of concrete, and 15 pieces of precast concrete tiered seating.

Information provided by Trimble (www.trimble.com), producer of Tekla software (www.tekla.com). View all of the 2018 Tekla North America BIM Award entries at www.tekla.com/us/bim-awards/projects.



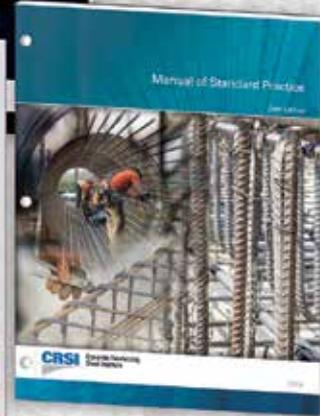
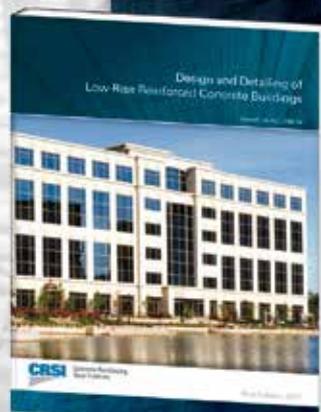
Lindner Family Tennis Center's new 40,000-square-foot South Building

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Atos and Bentley will offer a complete solution to create and operate digital twins for industry and infrastructure asset owners.

STILL ‘GOING DIGITAL’

DIGITAL TWINS AND CONNECTED DIGITAL WORKFLOWS TAKE CENTER STAGE AT BENTLEY’S 2018 YEAR IN INFRASTRUCTURE.

BENTLEY SYSTEMS’ ANNUAL YEAR IN INFRASTRUCTURE CONFERENCE provides an international stage for the company to reveal its latest developments and highlight recent acquisitions, as well as honor the finalists and winners of its Year in Infrastructure Awards. Keeping with the same general theme from 2017 — Going Digital — the 2018 conference, Oct. 15-18 in London, expanded on that concept with emphasis on digital twins and Bentley’s Open portfolio of applications that connect digital workflows across disciplines and share digital components in a Connected Data Environment (CDE).

iTwin Services

Bentley announced its iTwin Services (available early in 2019) digital twin cloud services for infrastructure projects (project digital twins) and assets (performance digital twins). iTwin Services can be transparently provisioned within Bentley’s CDE for ProjectWise and AssetWise users.

Infrastructure asset owners and their teams have recognized the potential for leveraging digital twins for many uses, including application of analytics, artificial intelligence (AI), and machine learning in

simulations and decision support throughout the life cycle of design, construction, and operations. To realize this potential, digital representations of assets must be synchronized to changing conditions in the real world. According to Bentley, just capturing and representing physical conditions, including IoT inputs, can never be sufficient to understand, analyze, or model intended improvements, without also comprehending the “digital DNA” captured in the project or asset’s engineering specifications.

A representation of any infrastructure asset’s physical reality can now be reliably captured and maintained through increasingly continuous surveys and Bentley’s reality modeling software, providing digital context in the form of “reality meshes.” Overlapping photographs and (as needed) supplemental laser scans, largely from drones and ground-level imagery, are processed to generate spatially classified and engineering-ready reality meshes at any desired level of accuracy — within which each digital component can be automatically recognized and/or geospatially referenced. The reality mesh can provide an efficient and immersive visual “twin” to intuitively navigate for finding, viewing, and querying the associated information within, or related to, the asset’s digital engineering models.

The challenge in comparably capturing and maintaining these engineering counterparts of the physical asset — its digital components — is the opacity of their existing representations, compounded by continuous changes. Bentley’s iModelHub, introduced in 2017, provides automated digital alignment and synchronization, based on change



OpenCities Planner takes advantage of city-scale reality modeling to span GIS and BIM.

ledgers, corresponding to the CDE's project workflows (ProjectWise) or configuration management (AssetWise).

Once populated and synchronized by way of digital context and digital components, iTwin Services deliver their benefits through Bentley's new open-source iModel.js library for web-based immersive visualization. Infrastructure teams can develop custom applications that connect their digital twin for specific use cases by leveraging a vast open source ecosystem. In addition, a geospatially immersive environment for city-scale digital twins is now available through Bentley's new OpenCities Planner services.

ProjectWiseCONNECT Edition users of Bentley's CDE can instantiate cloud-provisioned iTwin Services for any project without disruption to their existing ProjectWise workflows. iModelHub will then create and maintain the project's iModel — a distributed database, with its intrinsic change ledger updated at each deliverable-in-progress check-in state. For each such update to engineering information, application-specific "information bridge" processing produces digital alignment of the iModel's digital components.

To the extent of available reality modeling for the physical site, the CDE's corresponding ContextShare service maintains updated digital context. The iModel's digital components and ContextShare digital context are merged through Navigator Web and iModel.js visualization, as authorized and secured by iModelHub.

Accordingly, iTwin Services enable comprehensive project status reviews to be continuously available, synchronized to any requested project state on the iModel change ledger timeline, and/or for visualization and analytics visibility into changes between any project timeline states. iTwin Services will also integrate Bentley's SYNCHRO 4D construction modeling.

iModel.js

Bentley also announced the initial release of its iModel.js library, an open-source initiative to improve the accessibility of infrastructure digital twins for both visualization and analysis. iModel.js can be used

by developers and IT professionals to create immersive applications that connect their infrastructure digital twins with the rest of their digital world.

The iModel.js library is a comprehensive collection of JavaScript packages that build on the most open, popular, and flexible standards for modern cloud and web development. It is written in TypeScript, and leverages open technologies including SQLite, Node.js, NPM, WebGL, Electron, Docker, Kubernetes, and HTML5 and CSS. The same codebase can produce cloud services and web, mobile, and desktop applications. The source code is hosted on GitHub and is distributed under the MIT license.

With iModel.js, users can create a web-based experience that shows interactive "nD" views (1D, 2D, 3D, 4D, etc.) of iModels that are assembled and synchronized from BIM files and other digital engineering models, and from data created directly with iModel.js. Those same views can also include digital (reality) context, real-time sensor data, and other data from enterprise sources and analytics.

Since the iModel is synchronized by iModelHub, it always reflects the most recent updates from all project participants, who are thus able to visualize and analyze changes between points in time or between versions. Only users and applications authorized by the iModel owner, through iModelHub, are granted access through iModel.js.

According to Johan Palm, program manager, Digital Project Delivery at Hatch, "iModel.js gives Hatch the ability to implement a stakeholder engagement technology that extends the iModelHub visionary technology. We can expose complex project information to a level that is accessible, consumable, and extendable via the cloud and in context to the 3D model. Most importantly, we can do so in a manner that embraces change as the project progresses."

Keith Bentley, Bentley Systems' founder and CTO, said, "We firmly believe that iModel.js, and of course the foundation upon which it is built, is the most open, productive, intuitive, and powerful development environment for capital projects and infrastructure assets, ever. We're excited to work with user organizations, strategic partners, and third-party developers to build an open ecosystem around iModels to tap the vast potential of infrastructure digital twins."

Learn more about iModel.js at <https://imodeljs.github.io/iModelJs-docs-output> and iModels and iModelHub at www.iModelHub.com.

Open applications

Bentley launched several applications as part of its Open portfolio:

- OpenSite Designer for design and construction of civil site projects;
- OpenBuildings, bringing together its AECOSim building design and Speedikon factory and industrial design applications;
- OpenBuildings Station Designer, a specialized application for designing rail and metro stations;
- OpenBridge Designer, which combines Bentley's bridge modeling, analysis, and design capabilities into one package; and
- OpenFlows FLOOD, a flood analysis and early warning system.



OpenBridge Designer integrates modeling capabilities and analysis and design features to meet the design and construction needs of both concrete and steel bridges.

Bhupinder Singh, chief product officer, Bentley Systems, said, “Open has three meanings. First, it signifies open to multiple disciplines. Second, it means open to analysis and simulation. Using different applications, two different disciplines — for example, a geotechnical engineer and a structural engineer — can iterate on the same dataset in our comprehensive modeling environment, providing a ‘digital feedback loop’ and enhancing their collaboration across BIM workflows. And third, because MicroStation technology underpins Open applications, users can produce multidiscipline deliverables and accomplish multidiscipline clash resolution from any Open application.”

OpenSite Designer provides a comprehensive site design workflow, including reality modeling, geotechnical, underground utilities, storm-water drainage, terrain modeling, detailed drawing production, and visualization. Interoperating with PLAXIS, Bentley’s newly acquired geotechnical engineering solution, site plans can be enhanced with new information about the active properties of soil, including bearing capacity, stresses, and displacement.

OpenBuildings Designer incorporates all of the capabilities of AECOsim Building Designer as well as Components Center and a range of new capabilities and standards including EnergyPlus, a building energy model to help users comply with ASHRAE standards in the U.S., and UK energy requirements; support of international standards including IFC 2x3, IFC4 Reference View, COBie, and Singapore’s Building and Construction Authority; new capabilities to design curtain wall systems; and OpenBuildings Speedikon, an application for industrialized design and construction.

OpenBridge Designer integrates the modeling capabilities of OpenBridge Modeler and the analysis and design features of RM Bridge, LEAP Bridge Concrete, and LEAP Bridge Steel to meet the design and construction needs of both concrete and steel bridges. OpenBridge Designer enables bridge designers to create an intelligent, parametric bridge model, fully integrated with analysis and design, as well as drawings. It enables seamless synchronization of various disciplines for analysis, design, detailing, documentation, construction engineering, and load-rating.

Bentley rebranded its Haestad water modeling and ACTION Modellers flood analysis product lines to form OpenFlows for water districts, sewer utilities, and flood plain managers. OpenFlows extends smart water networks capabilities with GIS-based asset-centric information for water loss reduction, water operations, flood prediction, and prevention. OpenFlows FLOOD continuously monitors watersheds, integrating data from real-time monitoring stations and numerical models to calculate risk levels. OpenFlows FLOOD mitigates flood risk, improving understanding of the processes involved in flood generation, and transmitting early alerts to reduce the impact caused by floods.

Connecting digital workflows across disciplines

Collaborative digital workflows are characterized by data captured or created for one purpose being accessed and used by other applications for other purposes, thereby saving time, minimizing rework, and improving data quality over the asset life cycle. For example, OpenFlows can use ContextCapture to create a 3D reality mesh, feeding into OpenFlows FLOOD modeling and using the terrain as input to

various analyses in a single review environment for visualization and presentation to stakeholders using LumenRT.

Connecting analysis with modeling in another Open collaborative digital workflow involves the layout of road geometry, and hydraulic analysis and design using storm analysis tools including the determination of the size of storm inlets, pipes, depth of pipes, and manholes. The collaborative nature of the workflow enables clash detection in the subsurface environment, and iteration and adjustment as needed, to confirm functional and physical characteristics.

Completing its announcement about Open applications, Bentley said that Bentley Map will be rebranded as OpenCities Map; and OpenComms, aimed primarily at multisystem operators, will incorporate Bentley Fiber and Bentley Coax.

ProjectWise integration with Microsoft 365

Bentley announced the general availability of integration between ProjectWise 365 Services and Microsoft 365. The collaboration capabilities of Microsoft Teams and Microsoft Flow, alongside analytics from Microsoft SharePoint and Microsoft Power BI, can now be applied to mainstream automated digital workflows within ProjectWise.

Neil Lee, IT director - Applications, Mott MacDonald, said, “Our evaluation of the integration capability against the typical demands of our project teams demonstrated that Bentley and Microsoft are fulfilling the vision of enabling more seamless and automated digital workflows for project teams to access project information residing in either Office 365 or ProjectWise. Our project teams will be enabled to drive improved project outcomes with more streamlined collaboration that enables faster and more informed decisions.”

ProjectWise 365 Services also embrace every project stakeholder, connected through Microsoft’s Azure cloud service and Bentley’s new integrated web-based PDF review and markup in ProjectWise that enables reviewers to submit and respond to comments and markups in near real-time as well as submit issues for resolution.

ProjectWise 365 Services include ProjectWise Project Insights with automated project status dashboards that help identify trends and potential issues early to mitigate risks. And leveraging Microsoft Power BI, users can combine design status with financial, schedule, and other project information for a comprehensive view of project performance.

Acquisitions and partnerships

Bentley announced the acquisition of Agency9, based in Stockholm. Agency9 (www.agency9.com) has provided nearly half of Sweden’s larger municipalities with city-scale digital twin cloud services for city planning and related web-based 3D visualization. Since 2012, Agency9 has taken advantage of reality meshes created by Bentley’s ContextCapture reality modeling software as the digital context for visualizing urban infrastructure assets represented in GIS data, terrain surveys, and BIM models. Bentley’s new iTwin cloud services will enable OpenCities Planner (formerly Agency9 CityPlanner) to serve urban planning requirements at fuller levels of detail.



LEGION’s pedestrian simulation applications offer modeling for scenarios such as interaction of pedestrians with each other and with physical obstacles, circulation and evacuations within public spaces like railway stations, airports, sports arenas, and tall buildings, and pedestrian and vehicle interactions.

Bentley also acquired pedestrian simulation software provider LEGION, based in London and supporting more than half of the world’s 40 largest transit agencies. LEGION’s pedestrian simulation application offers modeling capabilities of people’s interactions with each other and physical obstacles and activities, including circulation and evacuations, within public spaces such as railway stations, airports, sports arenas, tall buildings, and street level with vehicle interactions.

Using LEGION simulation tools in collaborative digital workflows with Bentley’s OpenBuildings Designer, architects, engineers, and owners can consider pedestrian traffic in their design alternatives. The newly announced OpenBuildings Station Designer will enable collaborative digital workflows to fully model pedestrian activities and journeys to and from trains, platforms, and through stations.

Atos and Bentley announced a strategic partnership through which they will offer a complete solution to create and operate digital twins on behalf of industry and infrastructure asset owners. Atos’ global experience and expertise in digital transformation together with Bentley’s infrastructure, engineering, reality modeling, and asset performance software portfolio will enable businesses to take advantage of fully integrated and managed digital twins as a cloud-based service.

This partnership offers owner-operators the following features and benefits:

- full immersive visibility of assets with up-to-date 3D models of assets via drone-enabled scans;
- real-time monitoring to predict asset performance and avoid failures;
- performance analysis to maximize asset availability, increase productivity, ensure optimum performance, and ultimately extend the life of assets in the field;
- remote operation of assets in the case of dangerous or inaccessible assets;
- operational training for immersive virtual reality environments; and
- decision-making support for asset operational strategies.

Information provided by Bentley Systems (www.bentley.com).



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River Road Bridge Replacement, Uxbridge, Mass. Photo: The Reinforced Earth Company

Modular Gravity Retaining Wall System Facilitates Fast Construction

In 2018, The T-WALL® Retaining Wall System, formerly of The Neel Company, was added to The Reinforced Earth Company's (RECo) list of proven retaining wall solutions.

The T-WALL modular gravity retaining wall system has been a staple in the highway and railroad construction industries for three decades. An ideal solution for bridge abutments, approach embankments, accelerated bridge construction, and other bridge applications, the system uses modular precast concrete units and select backfill, which reduces as the wall rises—and there are no mechanical connections needed. The simple stacking and compacting procedure allows for fast construction. T-WALL is particularly economical in areas that have a narrow base width.

T-WALL units come in three sizes to accommodate application, wall size and other unique site criteria including varying stem lengths, as well as extended-height and sloped tops for the uppermost wall course. A wide range of standard and custom architectural treatments can also be applied to the front face.

For more information on the T-WALL system, please visit reinforcedearth.com or contact RECo's headquarters in Reston, Va.



Figure 1: Moisture content range. Source: RDH Building Science Inc.

ACCOMMODATING SHRINKAGE IN MULTI-STORY WOOD-FRAME STRUCTURES

PROCEDURES FOR ESTIMATING WOOD SHRINKAGE AND DETAILING OPTIONS MINIMIZE EFFECTS ON BUILDING PERFORMANCE.

By Richard McLain, P.E., S.E., and Doug Steimle, P.E.

IN WOOD-FRAME BUILDINGS of three or more stories, cumulative shrinkage can be significant and has an impact on the function and performance of finishes, openings, mechanical/electrical/plumbing (MEP) systems, and structural connections. However, as more designers look to wood-frame construction to improve the cost and sustainability of their mid-rise projects, many have learned that accommodating wood shrinkage is actually very straightforward.

This excerpt of a WoodWorks technical paper describes procedures for estimating wood shrinkage and provides detailing options that minimize its effects on building performance. For a more detailed discussion of this topic, read the full paper at www.woodworks.org/shrinkage-wood-frame-structures.

Moisture content

Wood moisture content (MC) is the weight of water in wood as a percentage of the completely dry wood weight. During the life of a tree, its MC can exceed 200 percent, meaning the total water weight in a given volume of wood makes up two thirds or more of the total weight.

The fiber saturation point (FSP) is the point at which wood has no free water and yet the cell walls are saturated. The FSP of different species of wood varies, but for most common softwoods is around 28 to 30 percent. The MC of lumber in-service is typically 7 to 14 percent, much lower than the FSP. Wood remains dimensionally stable above the FSP; i.e., it doesn't change in dimension with an increase or decrease of moisture as long as it remains above the FSP at all times.

Table 4-2. Moisture content of wood in equilibrium with stated temperature and relative humidity

Temperature (°C (°F))	Moisture content (%) at various relative humidity values																		
	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
-1.1 (30)	1.4	2.6	3.7	4.6	5.5	6.3	7.1	7.9	8.7	9.5	10.4	11.3	12.4	13.5	14.9	16.5	18.5	21.0	24.3
4.4 (40)	1.4	2.6	3.7	4.6	5.5	6.3	7.1	7.9	8.7	9.5	10.4	11.3	12.3	13.5	14.9	16.5	18.5	21.0	24.3
10.0 (50)	1.4	2.6	3.6	4.6	5.5	6.3	7.1	7.9	8.7	9.5	10.3	11.2	12.3	13.4	14.8	16.4	18.4	20.9	24.3
15.6 (60)	1.3	2.5	3.6	4.6	5.4	6.2	7.0	7.8	8.6	9.4	10.2	11.1	12.1	13.3	14.6	16.2	18.2	20.7	24.1
21.1 (70)	1.3	2.5	3.5	4.5	5.4	6.2	6.9	7.7	8.5	9.2	10.1	11.0	12.0	13.1	14.4	16.0	17.9	20.5	23.9
26.7 (80)	1.3	2.4	3.5	4.4	5.3	6.1	6.8	7.6	8.3	9.1	9.9	10.8	11.7	12.9	14.2	15.7	17.7	20.2	23.6
32.2 (90)	1.2	2.3	3.4	4.3	5.1	5.9	6.7	7.4	8.1	8.9	9.7	10.5	11.5	12.6	13.9	15.4	17.3	19.8	23.3
37.8 (100)	1.2	2.3	3.3	4.2	5.0	5.8	6.5	7.2	7.9	8.7	9.5	10.3	11.2	12.3	13.6	15.1	17.0	19.5	22.9
43.3 (110)	1.1	2.2	3.2	4.0	4.9	5.6	6.3	7.0	7.7	8.4	9.2	10.0	11.0	12.0	13.2	14.7	16.6	19.1	22.4
48.9 (120)	1.1	2.1	3.0	3.9	4.7	5.4	6.1	6.8	7.5	8.2	8.9	9.7	10.6	11.7	12.9	14.4	16.2	18.6	22.0
54.4 (130)	1.0	2.0	2.9	3.7	4.5	5.2	5.9	6.6	7.2	7.9	8.7	9.4	10.3	11.3	12.5	14.0	15.8	18.2	21.5
60.0 (140)	0.9	1.9	2.8	3.6	4.3	5.0	5.7	6.3	7.0	7.7	8.4	9.1	10.0	11.0	12.1	13.6	15.3	17.7	21.0
65.6 (150)	0.9	1.8	2.6	3.4	4.1	4.8	5.5	6.1	6.7	7.4	8.1	8.8	9.7	10.6	11.8	13.1	14.9	17.2	20.4
71.1 (160)	0.8	1.6	2.4	3.2	3.9	4.6	5.2	5.8	6.4	7.1	7.8	8.5	9.3	10.3	11.4	12.7	14.4	16.7	19.9
76.7 (170)	0.7	1.5	2.3	3.0	3.7	4.3	4.9	5.6	6.2	6.8	7.4	8.2	9.0	9.9	11.0	12.3	14.0	16.2	19.3
82.2 (180)	0.7	1.4	2.1	2.8	3.5	4.1	4.7	5.3	5.9	6.5	7.1	7.8	8.6	9.5	10.5	11.8	13.5	15.7	18.7
87.8 (190)	0.6	1.3	1.9	2.6	3.2	3.8	4.4	5.0	5.5	6.1	6.8	7.5	8.2	9.1	10.1	11.4	13.0	15.1	18.1
93.3 (200)	0.5	1.1	1.7	2.4	3.0	3.5	4.1	4.6	5.2	5.8	6.4	7.1	7.8	8.7	9.7	10.9	12.5	14.6	17.5
98.9 (210)	0.5	1.0	1.6	2.1	2.7	3.2	3.8	4.3	4.9	5.4	6.0	6.7	7.4	8.3	9.2	10.4	12.0	14.0	16.9
104.4 (220)	0.4	0.9	1.4	1.9	2.4	2.9	3.4	3.9	4.5	5.0	5.6	6.3	7.0	7.8	8.8	9.9			
110.0 (230)	0.3	0.8	1.2	1.6	2.1	2.6	3.1	3.6	4.2	4.7	5.3	6.0	6.7						
115.6 (240)	0.3	0.6	0.9	1.3	1.7	2.1	2.6	3.1	3.5	4.1	4.6								
121.1 (250)	0.2	0.4	0.7	1.0	1.3	1.7	2.1	2.5	2.9										
126.7 (260)	0.2	0.3	0.5	0.7	0.9	1.1	1.4												
132.2 (270)	0.1	0.1	0.2	0.3	0.4	0.4													

Figure 2: Equilibrium moisture content — relative humidity vs. temperature. Source: Wood Handbook, USDA Forest Products Laboratory

This is because the water being absorbed or released is largely free water in the cells, not bound water (which is bound to the cell walls). Once the moisture content drops below the FSP (i.e., bound water is being removed), the wood starts to change dimensionally. Since water is now being released from cell walls, both the walls and surrounding structure shrink, causing the overall cross-section of wood to shrink.

In wood-frame construction, the three variables influencing the magnitude of shrinkage are:

- installed MC;
- in-service MC, or equilibrium moisture content (EMC); and
- cumulative thickness of cross-grain wood elements.

Initial MC, or MC at the time of manufacture, is typically specified on a project's structural drawings. In many parts of the country, the specification would read "a maximum MC of 19 percent." In order to achieve this, lumber is generally kiln dried. Engineered wood products, including wood structural panels such as plywood and oriented strand board (OSB), glued-laminated timber (glulam) and structural composite lumber (SCL), are manufactured with lower moisture contents, in the range of 2 to 15 percent. Engineered wood manufacturers generally provide initial moisture contents for their products.

After close-in, the framing in a conditioned building eventually reaches its in-service MC, or EMC, in the range of 7 to 15 percent. Until that point, the wood framing is subject to inevitable shrinkage. EMC is a function of temperature and relative humidity as shown in Figure 1. It is worth noting that EMC is a dynamic equilibrium, meaning it can change throughout the year with climate changes. It also varies across the country based on local climatic conditions (see Figure 2). Generally, for wood exposed to exterior (non-conditioned) atmospheric conditions, variations in EMC of 1 to 3 percent exist between the driest months and wettest months. The EMC of wood within a conditioned building follows the same trends but varies with interior conditions. Typically, the average annual EMC for a given project's climate is used for shrinkage estimation purposes.

Table 13-1. Equilibrium moisture content for outside conditions in several U.S. locations prior to 1997

State	City	Equilibrium moisture content ^a (%)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
AK	Juneau	16.5	16.0	15.1	13.9	13.6	13.9	15.1	16.5	18.1	18.0	17.7	18.1
AL	Mobile	13.8	13.1	13.3	13.3	13.4	13.3	14.2	14.4	13.9	13.0	13.7	14.0
AZ	Flagstaff	11.8	11.4	10.8	9.3	8.8	7.5	9.7	11.1	10.3	10.1	10.8	11.8
AZ	Phoenix	9.4	8.4	7.9	6.1	5.1	4.6	6.2	6.9	6.9	7.0	8.2	9.5
AR	Little Rock	13.8	13.2	12.8	13.1	13.7	13.1	13.3	13.5	13.9	13.1	13.5	13.9
CA	Fresno	16.4	14.1	12.6	10.6	9.1	8.2	7.8	8.4	9.2	10.3	13.4	16.6
CA	Los Angeles	12.2	13.0	13.8	13.8	14.4	14.8	15.0	15.1	14.5	13.8	12.4	12.1
CO	Denver	10.7	10.5	10.2	9.6	10.2	9.6	9.4	9.6	9.5	9.5	11.0	11.0
DC	Washington	11.8	11.5	11.3	11.1	11.6	11.7	11.7	12.3	12.6	12.5	12.2	12.2
FL	Miami	13.5	13.1	12.8	12.3	12.7	14.0	13.7	14.1	14.5	13.5	13.9	13.4
GA	Atlanta	13.3	12.3	12.0	11.8	12.5	13.0	13.8	14.2	13.9	13.0	12.9	13.2
HI	Honolulu	13.3	12.8	11.9	11.3	10.8	10.6	10.6	10.7	10.8	11.3	12.1	12.9
ID	Boise	15.2	13.5	11.1	10.0	9.7	9.0	7.3	7.3	8.4	10.0	13.3	15.2
IL	Chicago	14.2	13.7	13.4	12.5	12.2	12.4	12.8	13.3	13.3	12.9	14.0	14.9
IN	Indianapolis	15.1	14.6	13.8	12.8	13.0	12.8	13.9	14.5	14.2	13.7	14.8	15.7
IA	Des Moines	14.0	13.9	13.3	12.6	12.4	12.6	13.1	13.4	13.7	12.7	13.9	14.9

Figure 3: Equilibrium moisture content for a sample of regional cities. For a complete list, see the Wood Handbook. Source: Wood Handbook, USDA Forest Products Laboratory

Shrinkage code requirements

Section 2304.3.3 of the 2015 International Building Code stipulates when shrinkage consideration is required in wood-frame building design.

Wood walls and bearing partitions shall not support more than two floors and a roof unless an analysis satisfactory to the building official shows that shrinkage of the wood framing will not have adverse effects on the structure or any MEP systems, or other equipment installed therein, due to excessive shrinkage or differential movements caused by shrinkage. The analysis shall also show that the roof drainage system and the foregoing systems or equipment will not be adversely affected or, as an alternative, such systems shall be designed to accommodate the differential shrinkage or movements.

Calculating shrinkage

Although there are several ways to calculate the amount of shrinkage in wood members, it is important to remember that, regardless of the equations used, they are simple calculations. With proper planning, the amount of wood shrinkage can be accurately predicted with relative ease.

One simple calculation is to assume a dimensional change of 0.0025 inch per inch of cross-sectional dimension for every 1 percent change in MC. For example, the anticipated shrinkage in a platform-framed, solid sawn lumber floor-to-wall detail that includes a 13.75-inch shrinkage zone (see Figure 4), starting at an MC of 19 percent with an EMC of 12 percent, would be:

$$\text{Shrinkage} = (0.0025)(13.75 \text{ inches})(19 - 12) = -0.24 \text{ inch}$$

When utilizing other types of floor joists such as I-Joists and parallel chord trusses, a degree of engineering judgement is required to determine what to include in the shrinkage zone. For example, floor sheathing is often manufactured with a low moisture content that could be near or even below the EMC. The same could be true for I-Joists. There is also a possibility that these materials slightly expand as they take on moisture during construction, only to shrink again after the building is closed in. Although the final determination should take into account how well the framing materials are protected from the weather during construction, some engineers choose not to include these members in the shrinkage zone — i.e., they expect no shrinkage contribution from

them. For parallel chord trusses in a platform-framed condition, only the top and bottom chords are typically included in the shrinkage zone. This is because a vertically oriented member usually exists at the end of the truss, separating the top and bottom chords, and no longitudinal shrinkage is assumed in this member.

Minimizing shrinkage

Of the significant variables affecting shrinkage, EMC is the only one largely out of the designer's control. It is heavily influenced by the building's conditioning, including temperature, relative humidity, and local climatic conditions. However, a project's design and construction team can influence the two remaining variables — initial moisture content and combined thickness of the wood in cross-grain orientation.

While the initial MC of wood can be specified by the design team, it is subject to change before, during, and after construction. The amount of change depends to a large degree on the protective measures taken by the contractor. To minimize moisture accumulation onsite:

- avoid storing material where it is exposed to rain or standing water;
- keep unused framing materials covered;
- inspect building enclosure layers such as weather-resistive barriers for proper installation;
- “dry-in” the structure as quickly as possible; and
- immediately remove any standing water from floor framing after rain showers.

Because cross-grain wood members contribute to shrinkage, reducing the total thickness of cross-grain wood members in the vertical load path is one way to minimize shrinkage and its effects. Traditionally, wood-frame construction has been platform-frame, where floor fram-

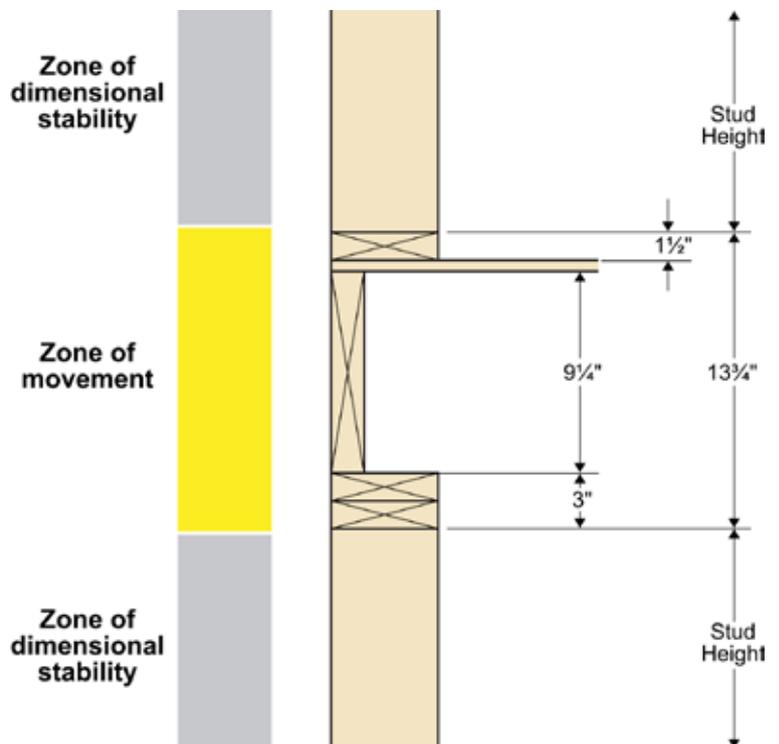


Figure 4: Shrinkage Zone in Platform-Framed Detail

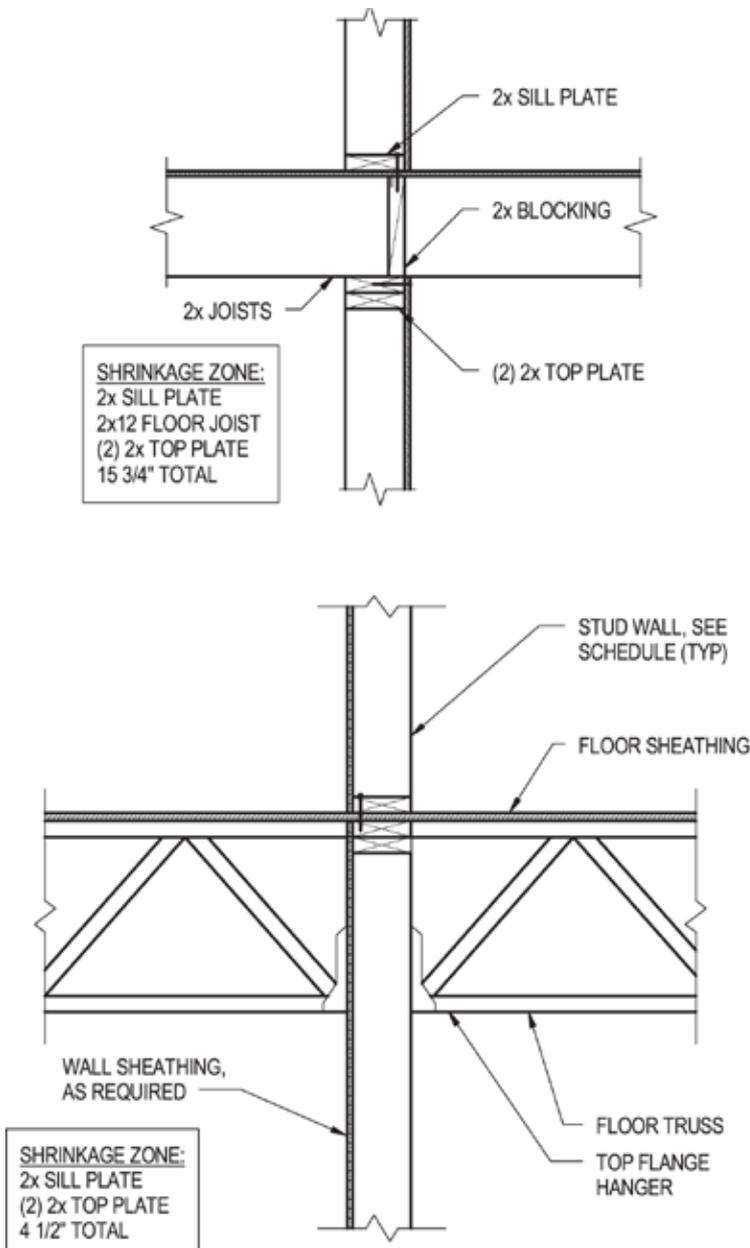


Figure 5: Typical platform-framed detail (top) and semi-balloon-frame detail (bottom).
Source: Schaefer

ing and rim or band joists bear on the top plates of supporting walls. However, switching to a semi-balloon-frame system, where only the floor sheathing bears on the lower walls and floor joists are hung from the walls, can significantly reduce per-floor and cumulative building shrinkage. Figure 5 illustrates the difference. The upper platform detail has a shrinkage zone of 15.75 inches per floor, resulting in shrinkage per floor of 0.28 inches, or approximately 1.4 inches for a five-story building. The lower semi-balloon frame detail has a shrinkage zone of 4.5 inches per floor, resulting in shrinkage per floor of 0.08 inches, or approximately 0.4 inches for a five-story building. These values are based on an initial MC of 19 percent and an EMC of 12 percent.

Conclusion

Shrinkage in multi-story wood-frame buildings is not a new phenomenon, nor is it overly complex to address. It requires an awareness of how and why wood shrinks, close attention when selecting and specifying materials and details, proper material care on the jobsite, and installation that closely adheres to the construction drawings.

For more information on this topic, including details on wood science and shrinkage, rate of shrinkage, accommodating the expansion of wood products and differential movement (e.g., brick veneer and openings, architectural finishes, MEP, and balconies/decks), the complete paper, *Accommodating Shrinkage in Mid-Rise Wood-Frame Structures*, is available at www.woodworks.org/shrinkage-wood-frame-structures.

RICHARD MCLAIN, P.E., S.E., is senior technical director with WoodWorks (www.woodworks.org).

DOUG STEIMLE, P.E., is a principal, with Schaefer (<https://schaefer-inc.com>).

A WALK ABOVE

PEDESTRIAN BRIDGES COMBINE AESTHETICS AND FUNCTION WITH DIVERSE DESIGNS.

THREE PEDESTRIAN BRIDGES highlighted in recent press releases — one under construction, one winning numerous awards, and one celebrating 25 years of service — reflect the creative and sometimes complex architectural and structural engineering involved in these signature

structures that, according to LMN Architects, “elevate the pedestrian experience.

Grand Avenue Park Pedestrian Bridge, Everett, Wash.

Elevating utilitarian infrastructure to a thoughtfully designed community asset, the Grand Avenue Park Pedestrian Bridge highlights the value of rethinking public realm design. The bridge will transform the Everett waterfront, establishing a new connection between the uplands Grand Avenue Park and the developing waterfront district. The project will fulfill a decades-long goal for a convenient, non-motorized passage to the waterfront, which has grown to feature a 66-acre mixed-



The Grand Avenue Park Pedestrian Bridge, which is establishing a new connection between the uplands Grand Avenue Park and the developing Everett, Wash., waterfront district, integrates accessible pathways into a sloped truss, eliminating the need for an uphill elevator and saving significant costs.

use development, the Everett Farmer's Market, and the largest public marina on the West Coast.

The challenge for this project was how to resolve essential engineering infrastructure and transportation functions as seamlessly as possible. By deconstructing the elements of the project — functional, aesthetic, and environmental — and reimagining the parts, the design team developed a solution that preserved the view while greatly minimizing the intervention into the steep, 75-foot-high hillside. The new design integrates accessible pathways into a sloped truss, eliminating the need for the uphill elevator and saving significant costs.

Two ramps act as switchbacks to reduce the grade change and frame a series of dramatic views to Whidbey Island, the waterfront, and the Olympic Mountains. The ramps bring pedestrians through a varied sequence of spaces that interact with the structure, beginning above, then cantilevered outboard over the highway, and finally bringing them within the truss itself.

Along the pathway, a sequence of viewing platforms offers multiple experiences of the surrounding landscape. Resembling a railroad overpass, the weathered steel trusses of the bridge's frame have been strategically positioned to echo the ramp volumes and sectioned over the active railway to allow for ease of installation during construction. Stormwater overflow piping — the initial impetus for the project — all but disappears beneath the pathway, reinforcing the bridge's ability to elegantly solve simultaneous challenges. Hillside stormwater and sewer lines will also be replaced as part of the project, and the potential for a future water main crossing is incorporated into the bridge design.

While the project is driven by performance and practicality, the design affords opportunities for artful intervention. Custom-designed aluminum panels serve triple duty as safety rails, lighting reflectors, and visual elements. The panels feature a waterjet-cut geometric pattern that is as minimal as possible at eye level to facilitate views, while becoming denser in proximity to pathway lighting where it serves as a reflector. The geometric pattern is repeated on the base of the tower where it is sandblasted into the concrete to further animate the structure. By embracing a creative pragmatist approach, the solution addresses both functional and aesthetic demands, weaving urban infrastructure into the life of the city and becoming a catalyst for continued community revitalization. The \$19.3 million project is anticipating completion in 2019.

The project team includes LMN Architects (design architecture), Interwest Construction, Inc. (general contractor), KPFF (prime consultant, structural engineering, civil engineering, construction support), McMillen Jacobs Associates (civil engineering), Tres West Engineers, Inc. (mechanical engineering), Stantec (electrical engineering), HWA GeoSciences, Inc. (geotechnical engineering), The Greenbusch Group, Inc. (vertical transportation), Landau Associates, Inc. (environmental engineering), Ott Consultants (constructability review and construction scheduling), KBA (construction management services), and City of Everett Parks & Recreation (landscape).

Idaho Ave. Pedestrian Overcrossing, Santa Monica, Calif.

TRC Companies Inc. announced that the Idaho Avenue Pedestrian Overcrossing Bridge was named California's Outstanding Bikeway and Trails Project for 2017. The award for the spiraling footbridge, which takes people from the cliffs of Palisades Park down to the Pacific



The spiraling Idaho Avenue Pedestrian Overcrossing Bridge, named California's Outstanding Bikeway and Trails Project for 2017, takes people from the cliffs of Palisades Park down to the Pacific Ocean.

Ocean, was given by the American Society of Civil Engineers. TRC served as construction manager on the project.

The new overcrossing replaced the original 1957 structure, which was starting to deteriorate. The project included construction of a 1.2-mile bike path and jogging trail. The work was part of a larger \$20 million project in which TRC assisted the City of Santa Monica in rebuilding the California Incline Bridge, which connects Santa Monica to the Pacific Coast Highway. The original 750-foot bridge was constructed in the 1930s and needed to be brought up to current seismic standards.

For motorists driving up the California Incline, the V-shaped pier of the overcrossing frames stunning views of the Santa Monica Pier, the beach, and the Pacific Ocean.

The Idaho Avenue Pedestrian Overcrossing has received numerous awards, including a 2018 Engineering Excellence Honor Award from the American Council of Engineering Companies of California and the 2017 International Bridge Conference Arthur G. Hayden Medal.

Denver International Airport Passenger Bridge

In June, the Denver International Airport celebrated the 25th anniversary of construction of its Pedestrian Bridge, one of only two of its kind in the world today. The bridge connects the main terminal with concourse A, with a security portal on its lower deck and international customs accessed on its upper level. Constructed in 1993 to offer a pedestrian alternative to the airport's inter-terminal train system, the bridge was a widely acclaimed design feat for its time.

"This project was incredibly sophisticated. This was the first time a passenger structure had been built in the world large enough to allow for planes to travel underneath. And at a length of 365 feet, we designed it so two planes could pass under it side-by-side," said Luis O. Acosta, the architect of record who led the project's design.

Built as a freestanding structure, the 40-foot-wide, 365-foot-long passenger bridge was designed by LOA Architecture (previously Luis O. Acosta Architects). Other design team members included the structural

engineer and prime consultant LONCO (now operating as Benesch), mechanical engineer Behrent Engineering, and electrical engineer Roos/Szynskie. The bridge was built by M.A. Mortenson Company. The project's construction took less than 12 months; it is currently the longest free-span airport bridge in the U.S.

The bridge, not originally included in the airport's master plan, was added after the main terminal and concourse A had already been constructed. Since the two buildings did not align at the same height, and were not designed to connect, the architects were tasked with the further challenge of creating an arc that would be both structurally sound and visually appealing. A further challenge to the project was FAA restrictions that required clearance distances from the top of the runway to the underside of the bridge as well as consideration for the bridge's deflection under various loading conditions.

Further challenges the team had to address included creating a structure that did not allow icicles to form, which could cause damage to planes passing underneath, and supporting the two-level bridge when the underground passenger train ran directly underneath causing regular vibrations.

An all-glass curtain wall system encloses the bridge, providing a panoramic view of Colorado's diverse environments with the Rocky Mountains visible to the west and the plains to the east.

"This team did a wonderful job of creating something never before built, in a condensed timeframe to support Denver's globally renowned airport. That the project has remained virtually untouched since its construction is a real testament to the talent that brought this project to life," said Brian Holland, with Mortenson Construction.



Denver International Airport's Pedestrian Bridge, constructed in 1993, is a freestanding 40-foot-wide, 365-foot-long structure with enough clearance to allow two planes to travel underneath side-by-side.

Information provided by LMN Architects (<https://lmnarchitects.com>); TRC (www.trcsolutions.com); and LOA Architecture (www.loaarchitecture.com).



Figure 1: Gerber Girders were initially used in bridges.

GERBER GIRDERS: FROM FORENSIC INVESTIGATION TO REPAIRS

UPDATED PROVISIONS AND STANDARDS ENSURE SAFETY OF CANTILEVER GIRDER STRUCTURES.

By Lakshmi M. Vemuri, EIT; and Alfredo E. Bustamante, P.E., CDT

GERBER GIRDERS, OR CANTILEVER GIRDERS, have been one of the most widely used structural framing systems throughout the world, primarily during the 19th and 20th centuries. Initially, they were used in bridges (Figure 1), but owing to the simplicity in analysis and design, they were soon adopted into building structures as primary or secondary framing.

However, since the 1980s there have been numerous failures of structures with Gerber Girder framing. Investigations of these failures shed light on the fact that the building codes and design standards prior to 1989 were not adequate. Consequently, it is important for forensic engineers now to be able to identify this framing system in any structure

and provide restoration solutions based on updated codes, if required by the findings.

This article provides an overview of the structural steel Gerber Girder System, examples of well-documented failures of this system, structural issues that resulted in these failures, and updated provisions in building codes and standards issued to ensure safety of cantilever girder structures as an outcome of these failures.

Overview

Gottfried Heinrich Gerber invented the Gerber Girder System in the 19th century. It is also referred to as the cantilever-suspended span girder and primarily consists of two members — the cantilever girder and the suspended girder. This system is designed in such a way that the cantilever girder “cantilevers” over the column supports, connected to the girder through a base plate, with the ends supporting the suspended spans through shear connections.

The basic idea behind this system is to create a statically determinate structure by introducing hinges in a continuous beam, which are strategically placed in the beams at locations that produce a structurally stable configuration as well as an even distribution of girder design moments under uniform loading (Figure 2).

Popularity of the Gerber Girder System can be attributed to its economy,

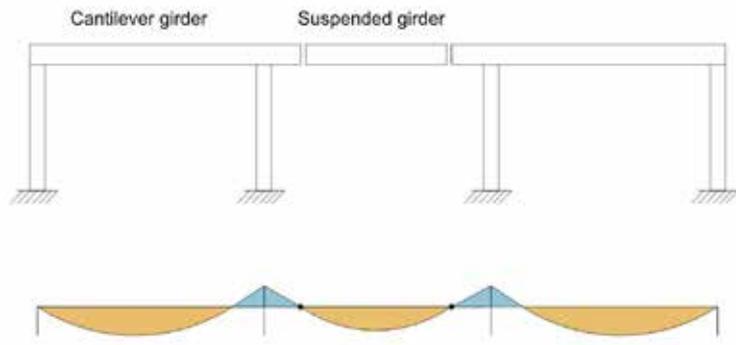


Figure 2: Strategically placed hinges produce an even distribution of girder design moments under uniform loading.

as it involves simple and repeated framing for relatively uniform loading. This system also includes the advantage of both simply supported beams and continuous beams, making it relatively easy to analytically determine the bending moments by hand calculations. The maximum positive and negative moments get distributed over mid-spans and supports, thus producing lower total stresses than that in similar structural framing configurations with simply supported beams.

Though this system is still currently being used for the new design of bridge structures, it has become a lapsed system for building framing. The reason for this is the development of structural analysis software making the design of structurally indeterminate structures easy and economical.

Failures and structural issues

Since the early 1980s, there have been several failures of steel frame buildings that have the Gerber Girder System with open web steel joist (OWSJ) framing. Two examples of this failure are the Station Square collapse in Burnaby, Canada (Figure 3) and a more recent warehouse partial roof framing collapse in Texas.



Figure 3: The Station Square collapse in 1988 involved four bays of a supermarket and roof parking facility.

The Station Square collapse in 1988 is one of the most well-documented failures relating to the Gerber Girder System. Four bays of a supermarket and roof parking facility collapsed causing property damage. The failure was attributed to the roof Gerber Girder System's inability to hold the weight of the parking deck and the automobiles above.

The modes of failure, as reported by the Project Commissioner Inquiry, were caused by buckling of the girder-column assembly and lateral torsional buckling of the girder at the location above the support, causing one of the girders to rotate. It was found also that the girder-column assemblies lacked essential lateral supports, which led to the failure.

In 2011, three bays of a warehouse in Texas collapsed; the failure was similar to the one at the Station Square. The partial roof collapse was primarily due to structural instability of the girders and columns of the girder-column joint assembly (Figure 4). This structural instability was caused by deficient roof framing design of the warehouse. The failures included localized girder web and flange deformation at the support, rotation of girder about the longitudinal axis, and out-of-plumb columns.

Through thorough investigations of these collapses, it was found that most of the failures occurred due to the lack of lateral support at the top of the column and lateral torsional support to the girders. This points out that a critical design factor that needs to be satisfied in a Gerber Girder configuration is stability of the girder-column connection. Because of the structural instability of these Gerber Girders used with OWSJ in buildings, their behavior is highly unpredictable, and failure can occur even in the absence of any significant loading.

Codes and standards

These and other documented structural failures triggered professional technical societies and other organizations to identify specific structural concerns and update the provisions and specifications accordingly. Following are the industry standards that were modified as a result of the Gerber Girder failure prior to 1989.

Canadian Institute of Steel Construction (CISC) — Subsequent to various collapses of floor and roof framing systems utilizing the cantilever girder system in the 1980s, CISC published Roof Framing with Cantilever (Gerber) Girders & Open Web Steel Joists in 1989 that identifies specific structural concerns regarding this framing system. This standard defines the instability condition in a Gerber System as absence of girder web stiffeners and lateral bracing at the top of the column in the column-girder joint.

This publication requires the girder-column joint assembly to be well examined to ensure girder cross sectional stability, as well as girder and column lateral stability. It also provides design solutions for achieving the stability of the system by providing girder web stiffeners over the supports to prevent local instabilities (web crippling, web buckling, etc.) and joist bottom chord extension to ensure lateral support to the column as well as lateral torsional support to the girder. This was the first publication that addressed the Gerber Girder structural instability condition.



Figure 4: Failed girder-column connection, girder lateral torsional buckling, and local failure at a warehouse in Texas.

Structural Stability Research Council — This professional organization described the instability condition in girder-column joint assembly in its Fifth Edition of Guide to Stability Design for Metal Structures. Section 12.11 advised that a brace needs to be provided at the bottom flange of the girder, bottom chord extension at the top of the column, and that use of web stiffeners in the girder at the column location may also be effective under certain conditions.

American Institute of Steel Construction (AISC) — Specification for Structural Steel Buildings AISC 360 Standard includes provisions that apply to the cantilever girder systems in 2016, Fifteenth Edition. The provisions for stability bracing are given in Part 2 General Design Considerations. AISC suggests that the girder-column joint should be considered as a brace point for both cantilever beam and the column top for stability purposes. It offers the use of joist bottom chord extensions to the top of the column to ensure stability. In case the use of bottom chord extensions cannot be accommodated, it advises the use of diagonal bracing, whose strength and stiffness requirements are satisfied according to AISC Specification Appendix 6.

Another alternative to provide required stability to the system is by providing stiffeners in the beam web along with moment connection between the column top and beam bottom. This also ensures proper alignment of the girder-column assembly. In any case, AISC requires that the assembly must meet the requirements of AISC Specification J10, which ensures local stability like web local yielding, flange local bending, etc.

Repairs

As mentioned above, changes in the code to correct the Gerber Girder design deficiencies did not take effect until 1989. However, there are still steel structures in service built prior to 1989 that have this lateral instability condition that needs to be identified and corrected before any additional damages occur. Based on lessons learned from these failures, it is evident that the key to the Gerber Girder System working

properly is to have appropriate rotational restraint at the girder-column connections.

The structural instability condition can be accomplished in two ways:

Option 1 — Use of plate stiffeners in the girder webs at the column support locations. These stiffener plates are required to prevent girder web instabilities, such as web sideways, web crippling, and web compression buckling.

Option 2 — Add a bottom chord extension to the OWSJ unless the girder is “torsionally restrained” about its longitudinal axis at vertical supports. In other words, the girder should be restrained from rotating or twisting about its longitudinal axis at the column support locations (Figure 5).

Conclusions

It is important for structural forensic engineers to be aware of the Gerber Girder deficiencies and be able to identify these defective structures. A structural forensic investigation should be performed to evaluate a structure’s stability, and required repair design and documentation should be provided according to current code provisions.

Current and future owners of structural steel buildings should engage the services of qualified structural engineers to evaluate their properties for OWSJ framing and determine if the Gerber Girder structural instability condition is present.

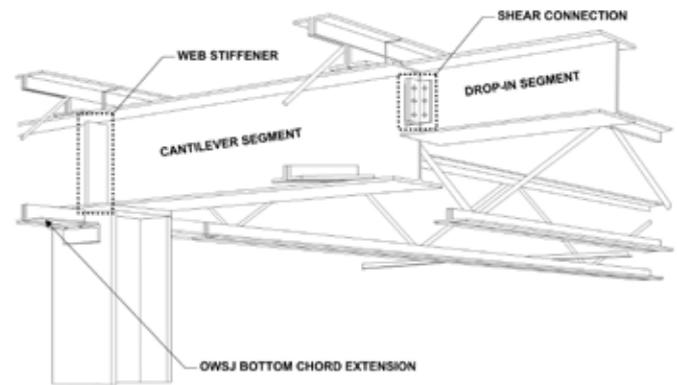


Figure 5: A Gerber Girder should be restrained from rotating or twisting about its longitudinal axis at the column support locations.

LAKSHMI M. VEMURI, EIT, is a structural engineer II at Walker Consultants specializing in restoration of structures. She has successfully worked on many concrete- and steel-related building restoration projects.

ALFREDO E. BUSTAMANTE, P.E., CDT, a principal and director of Forensic Restoration at Walker Consultants, has more than 17 years of experience as a project manager in a variety of structural, architectural, and material distress-related projects. His experience includes evaluation, design, and construction phase services of many building exterior wall repair projects.

WHEN TO INVEST IN WATER

AN ENGINEER'S PERSPECTIVE ON PRIORITIZING WATER INFRASTRUCTURE NEEDS

By Jim Barbato, P.E.

WHEN IT COMES TO OUR NATION'S INFRASTRUCTURE, Americans expect reliable highways, bridges, and water systems. To keep up with that expectation, we are at a point where major infrastructure investments are required. According to the 2017 American Society of Civil Engineers (ASCE) Infrastructure Report Card, it will cost roughly \$4.6 trillion — more than the federal government spends in an entire year — to address critical infrastructure needs across the country.

An important part of that investment revolves around fragmented and inefficient water and wastewater infrastructure systems. More than 150,000 water systems in the United States serve nearly 320 million Americans, and most households receive drinking water from one of roughly 51,000 community water systems managed by local municipalities.

For these local governments, investing in their water systems is just one priority in their long list of budgetary considerations, which include critical decisions regarding roadways, bridges, schools, and first responders. It's difficult to prioritize those needs, and it can be easy to overlook the state of the buried infrastructure.

Unfortunately, this has resulted in water infrastructure that has been overlooked for far too long in many communities across the country. Many of the 1 million miles of water main in America were laid in the early 20th century and have a lifespan of roughly 100 years. With utilities averaging a pipe replacement rate of 0.5 percent per year, according to the ASCE, it will take an estimated 200 years to replace the systems — essentially double the useful life of the pipe.

In specifically evaluating the water and wastewater infrastructure in the 2017 Infrastructure Report Card, the ASCE gave U.S. water infrastructure a "D" and wastewater infrastructure a "D+." The issue is serious, and the price tag is large: The American Water Works Association estimates \$1 trillion is needed to maintain and expand drinking water service to meet demands over the next 15 years.

In addition to the significant capital investment necessary, municipalities must also meet increasing regulatory compliance from federal and state regulatory agencies, which require enhanced engineering and technical expertise.

A viable solution: Publicly regulated water utilities

The situation is a dire one, which is causing increased interest from municipalities in partnering with publicly regulated utilities to help improve local water and wastewater systems. By leveraging compliance expertise, purchasing power, and operational efficiencies, publicly

regulated water utilities can often provide the resources required to rehabilitate systems struggling with aging infrastructure and accompanying operations issues.

A partnership between a municipality and a publicly regulated water company can take several forms to help the system's water quality and distribution system. In many cases, a company such as Aqua acquiring the system from a municipality proves to be the best option for all involved, as proceeds netted from the sale of a water system can offer the local government additional budgetary resources while providing a guarantee that the system's water infrastructure will receive necessary capital investment and maintenance, without draining resources from other vital municipal services.

There are many important considerations that go into an agreement to sell a water system, on both the part of the seller and the publicly regulated purchaser. For both parties, the current state of the water system's infrastructure is one of the most important factors in determining the value of the system, infrastructure investments the purchaser will need to make, as well as any possible rate impact for customers.

As a part of this process, the publicly regulated company will typically conduct a thorough analysis of the system and its history. This analysis typically includes:

- evaluating the system's monthly operating reports;
- reviewing water quality test results;



Jim Barbato, P.E., vice president of corporate engineering, Aqua America

- understanding any investments made by the municipality in the past five years; and
- assessing the municipality's compliance track record for both primary and secondary Environmental Protection Agency standards.

The fact-finding process also requires a general understanding of the municipality, including the number of customers and households served; miles of water main; the number of wells, tanks, and pumps in the service area; and other infrastructure considerations.

Reconstructing and rehabilitating water systems

Upon successful completion of an acquisition, a team of engineers uses this initial review to inform plans to invest in infrastructure to improve the system, both in the short and long term. These plans are developed by taking into careful consideration the quality of the water that is being delivered to customers, the prudence of any infrastructure investments for the long-term viability of the system, and any costs that might be passed onto customers.

Of course, the one priority for a publicly regulated utility such as Aqua is to ensure that the water it delivers meets all federal and local drinking water standards. In some cases, massive rehabilitation and reconstruction is required to ensure that customers receive safe and reliable water. Reconstructions often include:

- reviewing the water source supply and constructing or drilling new wells;
- building new well stations with updated water treatment such as improved chlorination and pH controls to monitor the water quality resulting from the treatment process and provide auto-alerts to employees; and
- improving the security around water treatment facilities.

Distressed systems also often require construction of new storage facilities, distribution system upgrades, and replacement of legacy metering systems with newer remote-read meters. In cases where water quality issues are impacting taste or causing odor, improvements might be required to the system's water treatment and storage facilities. Even systems that do not require major reconstruction may require other

upgrades or maintenance, such as cleaning and painting storage tanks or well station modifications.

Various issues can complicate the process of rehabilitating an acquired water system. For example, Aqua has acquired systems that had such poor water quality that the EPA had issued "boil water advisories" notifying customers to boil their water to ensure its safety before consuming. In these cases, the first priority is installing new filtration and treatment systems before addressing other issues. The challenge in reconstructing municipal systems with severe water quality issues is the need to operate the system while executing improvement plans on parallel paths — addressing the immediate need for providing clean drinking water while also initiating long-term infrastructure improvements.

The timelines for capital improvements for acquired systems vary greatly based on need. Aside from addressing immediate water quality issues, the primary focus when acquiring a system is to ensure that safe and reliable water is provided to all customers.

Rehabilitation efforts for newly acquired systems and Aqua's long-standing commitment to investing in our existing systems continues to drive our capital investment program. Aqua spends roughly \$1.5 billion every three years to improve water and wastewater infrastructure in communities across the country. This investment, coupled with investments of other publicly regulated water companies, provides a viable solution for municipalities across the country struggling to maintain their own water systems, and in a larger sense, plays a critical role in addressing our nation's dire infrastructure needs.

JIM BARBATO, P.E., is vice president of corporate engineering at Aqua America (www.aquaamerica.com), a publicly traded water and wastewater utility serving nearly 3 million people in Pennsylvania, Ohio, North Carolina, Illinois, Texas, New Jersey, Indiana, and Virginia.

READY FOR STORMS

PENNONI DEVELOPS PLAN TO UPGRADE AND FLOODPROOF STORMWATER PUMPS TO ALLEVIATE CITY'S FLOOD RISK.

By Kenneth Shine, Assoc. DBIA, CFM

BURLINGTON CITY, N.J., IS A PROACTIVE COMMUNITY that sits on the banks of the Delaware River between Philadelphia, and Trenton, N.J. Having most of its land located within the Federal Emergency Management

Agency (FEMA) 100-year flood zone, good planning and design play key roles in helping the city fund the projects that will have the greatest impact to deal with the reality of climate change and sea level rise projections.

Being ready for a storm event is always on the minds of the staff and Office of Emergency Management (OEM) in Burlington City, and particularly within the Sewer & Drainage Division. The city's staff pays constant attention to weather forecasts, and they are quick to act when storms are coming by inspecting and clearing critical drainage features and taking action to lower Kennedy Lake for the little additional storage it provides. The additional storage delivers valuable



To meet federal funding requirements for floodproofing standards to the 500-year flood elevation, Pennoni designed a structural platform using the existing underground concrete well pump pit as a base.

minutes to emergency responders when people need help. The existing 60-HP pump (installed in the mid-1950s) is taken to full throttle, and for storms like Hurricane Irene, which blew through in August 2011, the backup 100-HP pump (also installed in the mid-1950s) is brought online to help carry the load and prevent the city from flooding.

Pennoni was ready for the challenge when the city asked us to develop a plan to increase storage at Kennedy Lake to alleviate nuisance flooding and threats to properties that backed up to the six-acre, two-lake system along West Broad Street and West Federal Street. The initial review revealed that the invert elevation of the lake discharge pipe was higher than the lake bottom, so dredging Kennedy Lake to increase depth would not increase storage capacity. Pennoni looked to enlarge the lake instead. Due to existing residences and commercial properties that surround the lake, an expansion would only allow for enough additional storage to handle a one-year rain event.

The engineers at Pennoni looked slightly further downstream from the lake system and identified the existing stormwater pumps, located at the city's wastewater treatment plant. The existing stormwater pumps consisted of one 60-HP pump and one 100-HP pump. They had been installed in the mid-1950s and one of the manufacturers was no longer in business. Repair parts were no longer available for either pump, so whenever the pumps required maintenance, new parts needed to be machined and fabricated, which was costly and time-consuming.

The drainage area terminating at the pumps is almost 1,200 acres and includes the discharge from the Sylvan Lake system in Burlington Township. Under normal weather conditions, the runoff enters the Kennedy Lake system in Burlington City where it is piped to the well pump pit located at the city's wastewater treatment plant. The aging 60-HP pump kicks on to move the water through a 54-inch force main that is 2,500 feet long, passes under the New Jersey Light Rail line (which moves commuters between Camden and Trenton all day and carries freight at night), and discharges to the Delaware River near the Burlington-Bristol Bridge.

Pennoni analyzed the existing stormwater pump components and well



Existing 100-HP and 60-HP pumps over a well pump pit, installed in the mid-1950s, lacked sufficient capacity and were susceptible to flooding.

pump pit. In July 2012, Pennoni provided the city with a comprehensive report that recommended replacing the two existing pumps with two new state-of-the-art 150-HP pumps. The project was put on the Sewer & Drainage Department's Capital Improvement Project list and the city began investigating how to fund the improvements.

In the wake of Hurricane Sandy, monies became available through the FEMA Hazard Mitigation Grant Program (HMGP). In 2013 the city again enlisted Pennoni, this time to assist with the grant application process. Pennoni coordinated closely with the New Jersey OEM, which was administering the grant; provided data to show the effects of the 50-, 100-, 200-, and 500-year storm events; and provided cost-benefit analysis information to demonstrate that upgrading the stormwater pumps would benefit more than 1,000 residences, commercial/retail properties, schools, and public buildings at savings from flood damage estimated for the 50- to the 500-year storms of \$65 million to \$81 million.

Applying for FEMA HMGP money is an on-going process, with multiple submissions that are made on an as-needed basis for FEMA to adequately assess the project. The city was notified in December 2015 that the project was approved for FEMA HMGP participation and Pennoni was authorized to proceed with the design.

The funding requirements included a caveat that all improvements connected with the stormwater pump upgrades must comply with floodproofing standards to the 500-year flood elevation. This element required that the new pump motors be installed 10-feet higher than the existing pumps. In addition, all electrical improvements leading back to the Power Building (located about 75-feet from the well pit) and within the Power Building needed to be flood-proofed to the 500-year flood level.

Again, Pennoni was up to the challenge and designed a structural platform using the existing underground concrete well pump pit as a base, saving on the costs of providing a new foundation. The electrical improvements included feeder conductors that were capable of immersion in water. The Power Building, which had a first-floor elevation to



All electrical improvements leading back to the Power Building (located about 75-feet from the well pit) and within the Power Building also needed to be floodproofed to the 500-year flood level.

meet the 100-year flood level, was to be flood protected by sealing all cracks and seams in the basement, coating walls and floors with waterproofing paint to the 500-year flood elevation (2.8 feet above first-floor grade) and installing flood barriers at both doors and on the mechanical vent wall protrusion.

The design for the new pumps included monitoring equipment and failsafe backup systems. The available space within the existing well pump pit would not allow for two check valves, and the lag pump was designed instead with a hydraulically actuated knife valve. The two new 150-HP pumps would have variable-speed motors and be used alternately to increase their lifespans. The existing pumping capacity for the 60-HP and 100-HP pumps was 31,000 gallons per minute (gpm). One of the new 150-HP pumps could move as much as 58,000 gpm of water. The city would increase pumping capacity for current and future storm events and have a redundant system in place in case one pump went down. The engineer's estimate for the final bid project was just under \$1.5 million.

The project was bid in May 2017, with two bidders providing the exact same low-bid price of \$1,289,000! The city followed New Jersey Local Public Contracts Law and awarded the project at their regular June meeting.

The preconstruction meeting was held in August 2017 and the pumps, motors, and controls were released for fabrication within a month. Structural platform components required a lengthier review period and were released for fabrication in February 2018. The temporary bypass system, which included bypassing the sanitary sewer effluent

from both the Burlington City and Burlington Township wastewater treatment plants, went into operation in June 2018. Within two weeks, the old pumps had been removed, the structural platform was set, the control panels were installed, and the first new 150-HP pump was set and put into operation.

The flood mitigation project was a success at this point, with the city now having the ability to pump more water faster than they ever had! Two weeks later, installation and start-up of the second pump had been completed and the city now has a redundant system in place to protect its inhabitants and their property.

The project only required one change order for unforeseen issues, when spare conduits between the Pump Building and Power Building were found to be crushed and needed to be replaced and encased in concrete.

The Burlington City Stormwater Pump Upgrades project is a FEMA HMGP-funded project that will benefit the community for years to come by mitigating potentially catastrophic flooding that would have been caused if the aging, pre-existing pumps had failed. This project also helped the city improve its Community Rating System designation from Class 8 to Class 7, allowing flood insurance rates to be discounted by 15 percent through the National Flood Insurance Program.

KENNETH SHINE, ASSOC. DBIA, CFM, is project manager at Pennoni (www.pennoni.com). He can be contacted at kshine@pennoni.com.



Hampton Roads Sanitation District's eight-step process includes flocculation and sedimentation, ozone contact, biologically active filtration, granular activated carbon contractors, ultraviolet disinfection, chlorine contact, chemical addition, and aquifer recharge. *Photo: Hampton Roads Sanitation District*

A SUSTAINABLE SOURCE OF WATER

VIRGINIA PROJECT FINDS INNOVATIVE REUSE OF WASTEWATER.

By Thomas Renner

A recently opened research center could be the centerpiece toward solving vexing and critical water issues facing Virginia's Hampton Roads region. The innovative water treatment program — Sustainable Water Initiative for Tomorrow (SWIFT) — is a critical first step in that it is designed to ensure a sustainable source of groundwater while addressing environmental challenges.

The \$25 million research center, located on the grounds of Nansemond Treatment Plant in Suffolk, is capable of producing 1 million gallons of SWIFT Water (water treated to meet drinking quality standards) daily. The SWIFT Water is treated to match existing groundwater and used to charge the Potomac Aquifer.

The eventual goal is to build five facilities by 2030 to recharge the Potomac aquifer with more than 100 million gallons of SWIFT water daily by 2030. The project aims to have the first full-scale SWIFT facility built by 2020, and four more added by 2030. The total output from each facility will range from 9 to 45 million gallons per day.

“This is a great project because 90 percent of what we currently discharge will no longer go into the Chesapeake Bay,” said Ted Henifin, general manager of the Hampton Roads Sanitation District (HRSD), the Virginia agency that is managing the project. “It will be treated, purified, and put into the ground where it can provide other benefits.”

An eight-step process

The system to clean wastewater revolves around an eight-step process that completes three primary objectives. “One goal of this project is to treat without the large environmental footprint of membrane systems,” Henifin said. “The SWIFT Recharge is a first of its kind treatment, recharge, research, and public education facility.”

The eight-step process includes flocculation and sedimentation, ozone contact, biologically active filtration, granular activated carbon contractors, ultraviolet disinfection, chlorine contact, chemical addition, and aquifer recharge.

When wastewater enters an HRSD treatment plant, it first flows through a bar screen that removes large floating objects such as trash, sticks, and rags. The captured material is properly disposed of in a landfill and the wastewater flows to a grit chamber and a sedimentation tank. These devices slow the flow of the water and allow sand, grit, human waste solids and other small particles to settle to the bottom. These solids are then removed along with any scum or grease floating on top.

The wastewater then travels to secondary treatment facilities that speed up the processes of nature, allowing microorganisms (bacteria and other organisms) to consume 80 to 90 percent of the organic matter — human, animal, and plant waste.

The most commonly used secondary treatment technique in HRSD plants is the activated sludge process. The process speeds up the work of the microorganisms by pumping oxygen-rich air and sludge into close contact with the wastewater in an aeration tank. Over several hours, the organic matter is broken down into harmless by-products.

The wastewater is then sent to a final clarifier, where the microorganisms that grow during the activated sludge process sink to the bottom and are recycled back to the aeration tanks, and the remaining water moves on to the final treatment process.

Advanced treatment systems remove additional pollutants such as nutrients, heavy metals, and chemical compounds. These systems may use microorganisms that differ from those in secondary treatment, additional chemicals, or an effluent filtration system. This significantly increases plant construction and operation costs but improves the final quality of HRSD's highly treated water.

Finally, the water is disinfected. Some wastewater treatment plants use chlorine, while others expose the water to high levels of ultraviolet light. HRSD facilities remove excess chlorine before discharging the cleaned water to local rivers. These processes kill 99 percent of disease-causing pathogens such as bacteria and viruses. That step allows the water to support the intended use of the area waterway and can be released back into the environment.

Cost-effective pump stations

Two underground pump stations and several vaults are key parts of the process. "Building the pump station was the most cost-effective option, both from a capital perspective and operations and maintenance, allowing gravity to feed to the stations," Henifin said. "Additionally, building the pump station underground allows for site circulation above the pump station, which was important to conserve land and minimize footprint."

The vaults and pumps are protected by channel frame doors manufactured by The BILCO Company of Connecticut that prevent water and other liquids from entering the access opening. There are seven doors protecting the valves and pumps in the sophisticated system, along with three LadderUP Safety Posts, also manufactured by BILCO. The posts provide easier, safer access through floor doors, roof vents and manholes. Two BILCO roof hatches were also used in the project. Marcor Associates of Midlothian, Va., delivered the doors, hatches, and safety posts. Crowder Construction and Hazen and Sawyer served as general contractors on the project.

In improving its infrastructure for SWIFT, HRSD built a new \$12.4 million pump station designed to pump as much as 16.6 million gallons per day (mgd) of wastewater. The Bridge Street Pump station, which replaces a station that had been in operation for longer than 70 years, will be resistant to tidal flooding as well as the effects of long-term sea level rise.

The station includes walls that extend more than 300 feet into the ground, five pumps at the bottom of the pump station, pipes that range from 8 to 48 inches in diameter, and 14 concrete walls, each of them 3 feet thick. The station includes the latest in technology and will be able to handle the wastewater of a growing population in Hampton, one of the largest cities within the HRSD.

Fighting subsidence

There are many benefits associated with SWIFT, but among the most crucial are replenishing the area's dwindling groundwater supply, fighting sea level rise, and protecting groundwater from saltwater intrusion due to a shrinking aquifer.



The Hampton Roads Sanitation District's Sustainable Water Initiative for Tomorrow (SWIFT) is designed to ensure a sustainable source of groundwater while addressing environmental challenges. Photo: Scott Lau, Marcor Associates

“Once we were seriously considering treating to drinking water standards, we needed to find a beneficial use for the valuable water we would be producing,” Henifin said. “That led to the idea that we should put it back into the already stressed groundwater aquifer. Using the aquifer to redistribute the water to anyone in Eastern Virginia would eliminate the need to build expensive pipelines to move water to specific areas or customers. We see this as a ‘wireless’ solution to water distribution.”

Land subsidence has been observed in the Chesapeake Bay region at rates of 1.1 to 4.8 millimeters per year since the 1940s, according to a government report (<https://pubs.usgs.gov/circ/1392/pdf/circ1392.pdf>). The aquifer system in the region has been compacted by extensive groundwater pumping, accounting for more than half of observed land subsidence. The report said, “Glacial isostatic adjustment, or the flexing of Earth’s crust in response to glacier formation and melting, also likely contributes to land subsidence in the region.”

Increased water use in the region is a direct result of its surge in population. The Hampton Roads region population swelled from slightly less than 600,000 residents in 1960 to more than 1.7 million in 2016, ac-

ording to estimates. In Virginia Beach alone, the population increased from about 8,000 in 1960 to more than 450,000 in 2016.

The SWIFT project is critical in many respects and could be a template for many areas of the country to follow to fight similar issues with wastewater and land subsidence. “There are many elements that can be applied in other areas, but for the most part, SWIFT requires some geological features to be fully successful that are location specific — a confined thirsty aquifer being the primary requirement,” Henifin said. “But large-scale success with a carbon-based process — eliminating the need to deal with a waste brine stream — opens the possibility of recycling wastewater throughout the country.”

THOMAS RENNER writes frequently on construction, manufacturing, building, and other topics for trade publications in the United States and Canada.

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Example of the existing conditions and urban solution toward slope and runoff prior to introduction of green infrastructure. Photo: used with permission from the Philadelphia Water Department



Detail of stilling well application in upper terrace area with level trough to distribute water evenly and infiltrate with plantings. Photo: used with permission from the Philadelphia Water Department

GREEN INFRASTRUCTURE: TAMING THE ASPHALT JUNGLE

DESIGNS THAT MOVE TOWARD MORE NATURALIZED STORMWATER MANAGEMENT CAN HELP COUNTERBALANCE IMPERVIOUS URBAN DEVELOPMENT.

By Gerald DeFelicis, Jr., LLA, RLA, PP, with Maraliese Beveridge

MANAGING SURFACE RUNOFF IS A CHALLENGE that is addressed using many different approaches depending on the setting. Whether the environment is natural terrain, paved cityscape, or one that runs along another body of water, each situation needs to be addressed uniquely. Two things you can count on are that water always finds its way to the lowest point, and nature doesn't always put it where we'd like it, when we want it.

A little history

In the wake of the last 100 years of build-out, redevelopment, and overdevelopment, installation of impervious products has dominated the base plane, making stormwater management all the more challenging. Asphalt mixed with any number of elements, including crushed brick, stone, sand, gravel, shells, cement, slag, geosynthetic, and other composite aggregates, consistently prevent water penetration. While projects requiring these surfaces have a drainage component designed into them, they are only required to manage normal rainfall amounts and don't always calculate the advantages of green methods to dispose of their water overages. The mission of green infrastructure is to channel water back into the ground more directly to prevent flooding rather than having it run off and dealt with in a series of retention and detention scenarios.

Eighty percent of all rain events in the Northeast yield 1 inch of rain or

less per hour. In most instances, any rainfall above that becomes problematic. Since the success of managing stormwater has traditionally been based on how quickly we can drain runoff, using this equation we are left with a giant problem handling excess volume. It has been the intent of most green stormwater systems to evaluate the possibility of intercepting the initial 1 inch to 1-1/2 inches of rainfall and divert it to an alternative drainage system that can infiltrate or store the potential runoff. In a perfect world — if green means alone could handle that amount — there would be a drastic reduction to the potential problems.

100-year flood

Unfortunately, the term 100-year-flood doesn't mean it has the potential to occur once every 100 years. Rather, it's a flood that statistically has a 1 percent chance of occurring in any given year (USGS). Superstorm Sandy was the hurricane that broke the camel's back. According to the National Weather Service, "In more than 100 years, there is not a single storm that came up the East Coast and turned west." Instead of heading out to sea, she caused \$50 billion in damages in the U.S., second only to Hurricane Katrina (NOAA).

Sandy was the exception to all the rules and catalyst to changes in building codes designed to protect structures and shorelines by making them more resilient. She also shed a light on the types of damage that could occur further inland that had never been experienced before, causing public-sector entities to take a closer look at local infrastructure that was formerly considered safe from this type of severe weather event.

To complicate matters, stormwater runoff mixes with man-made contaminants in all of these settings during a storm event, so the very least we can do is provide systems that can mitigate and separate it within our environment as efficiently as possible. Since the notion of global warming has increasingly been accepted and extreme weather events kicked-off by Sandy have illustrated how devastating water can be, corporate, public, and private agencies have become more receptive to



After view of terrace slope with storage yard set behind green and shade trees being fed by stormwater runoff. Photo: used with permission from the Philadelphia Water Department

the notion of going green, or at least adding green components, to help offset existing hard infrastructure systems.

Of course, urban settings have been the most problematic, since many of them over the years have evolved into asphalt jungles. Myriad methods have been devised to channel runoff from pavement on roadways, walkways, and parking lots through a system of drainage basins, bioretention ponds, and pipelines.

Some cities have another problem to deal with using underground combined sewer overflow (CSO) systems that collect rainwater runoff, domestic sewage, and industrial wastewater into one pipe. Combined sewer systems were originally designed along the eastern seaboard as a means of successfully flushing waste, which under normal conditions is transported to a sewage treatment plant without incident. However, during heavy rainfall or snow melt, when this volume exceeds the treatment plant capacity, untreated water discharges directly to nearby streams, rivers, and other water bodies.

Green streets

Green street has become a term synonymous with the introduction pervious surfaces, use of native vegetation, and adaptation of substrate to facilitate absorption of stormwater. The definition of green streets has expanded over time to recognize the adaptability of various urban spaces, and in an aesthetically pleasing manner.

Many urban areas do not have the luxury of having large spaces of land that could be used for traditional drainage basin structures, so other means to manage runoff have been developed. In the early 2000s, many older Northeast cities that have combined sewer systems led the way

to development of new, innovative methods of green infrastructure. In one instance, runoff was redirected in the higher ends of drainage sheds, thereby reducing the overall volume flowing into the combined sewer system. Other methods introduced included stormwater trenches combined with raingardens and other planted areas.

One raingarden we designed was constructed to divert two city blocks of stormwater into a storage and infiltration bed with native plantings. Some combined sewer systems have been retrofitted with green inlets where trees take in water directly to the root zone and porous piping combined with stone trenches. Depending on soil conditions, these systems enable storage of stormwater volumes to be slow-released back into combined sewer systems at non-peak times or when able systems can serve as infiltrate beds to return water directly into the ground.

There are other urban situations that address stormwater runoff in areas where it may not previously have been anticipated to be a problem. In one example, a water utility's staging and storage yard was the subject of a green makeover. Previously, when an excessive grade or slope was confronted, or an area was difficult to maintain, the practice was to pave the area to prevent erosion. While this offered a short-term solution, it only contributed to the problem of runoff. The storage yard sat above the surrounding street grade, therefore, the logical green solution was to remove the concrete from the slopes and, through a system of double weir inlets, collect the initial runoff and direct it to stilling wells in level trenches to provide infiltration and to water native plant materials surrounding and greening the entire area.

Tree power

Trees do more than just provide shade. They soak up gallons of water, reducing stormwater runoff, act as a filtration system for pollutants in soil and water, help regulate water flow, recharge groundwater, improve soil microbiology, produce oxygen, and reduce erosion, to name a few!



View of entry to completed Fish Hatchery with the introduction of stabilized earth as the pervious material along center aisle and porous concrete with Shad Fish image in foreground. Photo: used with permission from Philadelphia Parks & Recreation

According to Vincent Cotrone, urban forester, Penn State Extension, Northeast Region, “In urban and suburban settings, a single deciduous tree can intercept from 500 to 760 gallons per year; and a mature evergreen can intercept more than 4,000 gallons per year. Even young, small trees help. In a recent Forest Service study, a single small tree that was only nine years old was able to intercept 58 gallons of stormwater from a 1/2-inch rain event — 67 percent of the rain that fell within the canopy.” (<https://extension.psu.edu/the-role-of-trees-and-forests-in-healthy-watersheds>).

Introducing trees as part of green infrastructure design can be a formidable solution for helping to manage stormwater in some situations. The cost of the complete replacement of the existing subsurface infrastructure system is not a likely solution. But in some cases, integrating trees into key areas within an existing system can substantially help reduce runoff volume before it enters the treatment plant. Trees can also be useful installed in areas that don’t normally flood by acting as a preventative measure.

A perfect project

The Pleasant Hill Fish Hatchery in Philadelphia is an exemplary project illustrating a complete transition of an existing park with impervious surfaces and invasive vegetation species to a green space designed to manage stormwater runoff naturally while reflecting the environment along the Delaware River. The site has hatchery ponds that are fed from secondarily treated water and act as filtration prior to release into the river further downstream.

Redesign of the park was intended to disconnect a majority of the existing hard surfaces by installation of pervious pavement, porous concrete, and stabilized earth walkways that direct stormwater runoff over an equivalent flow length of pervious area.

The hatchery ponds were dredged, deepened, and stabilized with a rock base lining, and the water edges were planted with terraces of native wetland species adapted to this environment. The surrounding uplands have been re-naturalized with species found within the area and the entire park has become reintegrated to the natural riverfront of the Delaware River.

The native plant materials that have been reintroduced around the grounds are more appropriate for the weather, soils, and USDA Plant Hardiness Zone. These plants readily adapt to the environment and, once established, allow natural processes of green infrastructure that doesn’t require false or artificial maintenance such as irrigation and reestablish soil profiles in areas that have been harmed or scarified.

Some areas that were formerly mowed were reintroduced to trees and other native species, creating open areas in which birds will naturally redistribute seed, encouraging additional native flora and fauna habitats. This newly created environment more accurately reflects nature for this region and historic seasonal changes. In colonial times, during the second week of April each year, the native Shadblow serviceberry (*Amelanchier canadensis*), bloomed along the Delaware River when the Shad fish came in. This was how the community was signaled that it was time to fish.



Pervious surfacing within a floodplain area along the Delaware River in the Borough of Palmyra, Burlington County, N.J., uses a combination of pervious asphalt in the lower area, stone and epoxy-bound material on the ADA sloped walks, and precast porous concrete slabs on the level rest areas.



Typical use of a curb infiltration unit located upstream of a combined sewer inlet to redirect rainwater to a shade tree and curb strip area. This is an example of many green stormwater infrastructure practices highlighted by the Philadelphia Water Department. *Photo: used with permission of the Philadelphia Water Department*

Shorelines and wetlands

Perhaps the area in which green infrastructure has advanced the most is along shorelines and wetlands, integrating more natural ways to protect our coastal areas using increasingly innovative protectants. The green infrastructure measures for shore communities include both means of mitigating potential flooding through introduction of good planning and design practices, and an encouragement of the use of native materials (particularly plants).

Wetlands are an important resource that cannot be overlooked. They help protect and improve water quality, store flood waters, maintain surface water flow, provide a habitat for fish and wildlife, suppress tidal forces, and improve marshland health. Loss of wetlands is a result of a combination of encroaching development, constriction of the flow of water, rising water levels, weather-related circumstances, and associated landfills and dredge spoil sites. Wetland health can be checked through aerial imagery and mapping, while pollution can be monitored through scientific testing and visual assessment. Either way, regular monitoring and associated repair or replacement is vital to a healthy ecosystem.

Tidal marshes are marine landscapes that contain wetlands along the coasts of tidal basins, including estuaries, which are frequently inundated by flooding from the daily tidal flow of the adjacent ocean or major water body. Living Shorelines provide an infiltration buffer between the water and land and can be designed in many ways to mimic the natural process while helping to control flooding. Many have a breakwater of rocks, a strand of coastal wetlands and beach, then a bank and an upland buffer. When properly maintained, shorelines and

wetlands with soft edges, marsh, and natural structures are better at absorbing the impact of floodwater and more resilient than water edges created with rip rap and bulkheads, particularly as a long-term solution.

Conclusion

We must face that we, and those before us, have done almost everything possible to prevent terrestrial hydrology from occurring naturally. Flooding, of any amount, in cities, parks, and shorelines has been a long-time problem that has only gotten worse as we continue to develop land — which is why it is essential to continue to create alternate and proactive methods of dealing with flood protection.

Water is our most precious resource, and although we predictably can't stop every flood from affecting the built environment, as we move forward, our approach needs to migrate through design and planning toward more naturalized stormwater management. Ongoing research is constantly finding green solutions, such as living roofs that mitigate water at the top of the chain before it becomes runoff, and aquatic mosses that can quickly remove contaminants from water (www.innovatorsmag.com/magic-moss-fixes-contaminated-water).

Green infrastructure is not a fix-all solution in every situation, but it can be very effective when integrated as a component within an overall system. Green systems are not sustainable by themselves; however, the maintenance required and their ability to work in tandem with other hardscape systems to help prevent flooding, filtrate contaminants, and facilitate groundwater recharge is a long-term benefit. While we can't completely tame the asphalt jungle, we can counterbalance future installations by integrating design that creates an equilibrium through a combination of viable, natural working solutions that are more in sync with nature to achieve the best results.

GERALD DEFELICIS, JR., LLA, RLA, PP, senior project manager at Maser Consulting PA (www.maserconsulting.com), has more than 30 years of varied experience within the fields of landscape architecture and planning. His expertise lies in educational and recreational design, and he is fully versed in the management and design of projects, including site analysis, conceptual and final design, design development, construction document preparation, and project site supervision. DeFelicis' current responsibilities include coordination, design, and overall management of recreation facility projects and the provision of landscape architectural services in the Philadelphia and southern New Jersey region. He has been instrumental in creation and development of several stormwater management design initiatives within the City of Philadelphia.

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

ADVANCED SURFACE TECHNOLOGIES FOR CITIES

SMART SURFACES COALITION LAUNCHED TO HELP CITIES REDUCE URBAN HEAT, BETTER FIGHT AND ADAPT TO CLIMATE CHANGE.

IN AUGUST, 22 sustainability and urban organizations, including the U.S. Green Building Council (USGBC), formed the Smart Surfaces Coalition (www.staycoolsavecash.com) to help cities rapidly adopt cost-effective solutions to cut excess heat radiation from buildings and surfaces; reduce flood risk; and improve livability, health, and equity while saving billions of dollars and creating hundreds of thousands of new jobs.

“The Smart Surfaces Coalition shows cities how to use advanced surface technologies to reduce heat and prevent flooding,” said Greg Kats, Smart Surfaces Coalition founder. “These solutions deliver enormous health and financial benefits, slowing global warming, enhancing quality of life, and saving taxpayers billions of dollars in energy costs.”

Excessive summer heat waves are the new norm in the U.S., with scientists finding that most American cities will experience a huge jump, up to five or even 10 times as many excessively hot (90°+F) days, within just a few decades. The five hottest years on record globally have all occurred since 2010. In the U.S., May 2018 was the hottest on record, and June 2018 was the third hottest in the 124-year temperature record. Rapidly rising temperatures are already costing consumers and companies billions in higher energy and health care costs and making American communities less livable and healthy.

Smart surface technologies allow cities to better manage sun radiation and runoff through:

- cool roofs and pavements that reflect (instead of absorbing) sunlight, cutting temperatures and smog;
- green roofs and trees that provide shade and reduce flood risk;
- solar PV that converts sunshine into electricity and provides shade; and
- porous pavements, sidewalks, and roads that reduce water runoff, flooding, and cut the cost of managing stormwater.

The Smart Surfaces Coalition is already working with a dozen cities to develop tools and training to support mayors, city managers, and other key officials around the U.S. to understand and adopt these new opportunities to improve quality of life, health and fiscal bottom line. The coalition’s goal is to partner with more than 250 cities to adopt and begin implementing smart surfaces as standard city-wide policy by 2023.

The coalition released a new eight-page whitepaper, Stay Cool/Save Cash (<https://www.staycoolsavecash.com/analysis/stay-cool-save-cash-whitepaper>). Its recommendations and findings are based on a 300-page report, Delivering Urban Resilience (<https://www.staycoolsavecash.com/analysis/delivering-urban-resilience-full-report>), which



Smart surface technologies such as green roofs produce savings in the form of lower energy and water bills, lower health costs, reduced water treatment, and infrastructure costs.

is built on four years of data collection and research on greening the cities of El Paso, Texas; Philadelphia; and Washington, D.C.

Fifteen organizations, including USGBC, the American Institute of Architects, the National League of Cities, the National Housing Trust, the Chesapeake Bay Foundation, and The JPB Foundation collaborated on the report, which found that smart surface adoption would save El Paso \$540 million, Philadelphia \$3.6 billion, and Washington, D.C., \$1.8 billion, not including large additional financial benefits from avoiding lost tourism revenue.

Smart surface technologies produce savings in the form of lower energy and water bills, lower health costs, reduced water treatment, and infrastructure costs. New jobs would result from manufacture, installation, and maintenance of smart surfaces, many of which are labor-intensive.

Low-income urban areas are generally more vulnerable to extreme heat, as they have fewer green spaces and more impervious surfaces, resulting in hotter temperatures and poor environmental air quality. This leads to higher energy bills and greater health risks. Smart surfaces help solve all these structural inequalities.

“Cities are increasingly at risk from severe summer heat,” said Kats. “This coalition will support adoption of smart surface technologies to save billions of dollars and cut greenhouse gasses while making cities cooler, more resilient, healthier, and equitable.”

Information provided by the U.S. Green Building Council (www.usgbc.org).

MEGA-SPANS

RESEARCHERS PROPOSE NEW BRIDGE FORMS THAT CAN SPAN FURTHER.

NEWLY IDENTIFIED BRIDGE FORMS could enable significantly longer bridge spans to be achieved in the future, potentially making a crossing over the Strait of Gibraltar, from the Iberian Peninsula to Morocco, feasible. The new bridge forms — identified by a team of researchers from the University of Sheffield and Brunel University London, working with long-span bridge expert Ian Firth of engineering consultants COWI — use a new mathematical modeling technique to identify optimal forms for very long-span bridges. The research was published on Sept. 19, 2018 in the Proceedings of the Royal Society.

The current world record bridge span — the distance of suspended roadway between towers — stands at just under 2 kilometers. The most popular form for long spans is the suspension bridge form, as used for the Humber Bridge, though the cable-stayed bridge form, where cables directly connect the tower to the roadway — such as used in the recently constructed Queensferry Crossing in Scotland — is becoming increasingly popular.

As bridge spans become longer, a rapidly growing proportion of the structure is needed just to carry the bridge's own weight, rather than the traffic crossing it. This can create a vicious cycle: A relatively small increase in span requires use of significantly more material, leading to a heavier structure that requires yet more material to support it. This also sets a limit on how long a bridge span can be; beyond this limit a bridge simply cannot carry its own weight.

One option is to use stronger, lighter materials. However, steel remains the preferred choice because it is tough, readily available, and relatively cheap. So the only other way to increase span is change the bridge's design.

"The suspension bridge has been around for hundreds of years, and while we've been able to build longer spans through incremental improvements, we've never stopped to look to see if it's actually the best form to use," said Professor Matthew Gilbert from the University of Sheffield, who led the research. "Our research has shown that more structurally efficient forms do exist, which might open the door to significantly longer bridge spans in the future."

The technique devised by the team draws on theory developed by Gilbert's namesake, Davies Gilbert, who in the early 19th Century used mathematical theory to persuade Thomas Telford that the suspension cables in his original design for the Menai Strait bridge in North Wales followed too shallow a curve. He also proposed a "catenary of equal stress" showing the optimal shape of a cable accounting for the presence of gravity loads.

By incorporating this early 19th century theory into a modern mathematical optimization model, the team identified bridge concepts that



Split towers comprising just two or three "spokes" retain most of the benefit of the optimal designs while being a little easier to construct.

require the minimum possible volume of material, potentially making significantly longer spans feasible.

The mathematically optimal designs contain regions that resemble a bicycle wheel, with multiple "spokes" in place of a single tower. But these would be difficult to build in practice at large scale. The team therefore replaced these with split towers comprising just two or three "spokes" as a compromise that retains most of the benefit of the optimal designs while being a little easier to construct.

For a 5-kilometer span, which is likely to be required to build the 14-kilometer Strait of Gibraltar crossing, a traditional suspension bridge design would require far more material, making it at least 73 percent heavier than the optimal design. In contrast, the proposed two- and three-spoke designs would be just 12 and 6 percent heavier, respectively, making them potentially much more economical to build.

The new bridge forms require less material principally because the forces from the deck are transmitted more efficiently through the bridge superstructure to the foundations. This is achieved by keeping the load paths short and avoiding sharp corners between tensile and compressive elements.

The team emphasized that its research is just the first step, and that the ideas cannot be developed immediately for construction of a mega-span bridge. The current model considers only gravity loads and does not yet consider dynamic forces arising from traffic or wind loading. Further work is also required to address construction and maintenance issues.

Co-author, Ian Firth, from COWI, said, "This is an interesting development in the search for greater material efficiency in the design of super-long-span bridges. There is much more work to do, notably in devising effective and economic construction methods, but maybe one day we will see these new forms taking shape across some wide estuary or sea crossing."

The research, funded by the Engineering and Physical Sciences Research Council, was also presented at Tomorrow's Megastructures, a symposium organized by the International Association for Bridge and Structural Engineering.

Information provided by the University of Sheffield (www.sheffield.ac.uk).

AMERICA'S TRANSPORTATION AWARDS ANNOUNCED

ILLINOIS AND GEORGIA EARN TOP AWARDS IN THE NATIONAL TRANSPORTATION COMPETITION.

AN INNOVATIVE FIX for a congestion-plagued interchange connecting people to some of Chicago's most popular destinations and a bikeable and walkable greenway that connects neighborhoods in Atlanta's north side were honored as the winners in the 2018 America's Transportation Awards competition.

The Illinois Department of Transportation's (IDOT) \$135 million Interstate 55 and Lake Shore Drive Interchange project earned the Grand Prize, while the Georgia Department of Transportation's (GDOT) \$9.3 million 400 Trail (PATH 400) project was voted the Socrata People's Choice Award winner in the 11th annual competition sponsored by the American Association of State Highway and Transportation Officials (AASHTO), AAA, the U.S. Chamber of Commerce, and Socrata, part of Tyler Technologies.

IDOT's Interstate 55 and Lake Shore Drive Interchange project increased safety, reduced congestion, and cut drive times. The new interchange now connects a major interstate and an urban expressway near some of Chicago's most popular recreational and educational destinations. Several creative solutions were used during construction, such as building a temporary bridge to accommodate interstate traffic to avoid closures and detours.

"We are proud to bring this award home to Illinois for the first time," said Illinois Transportation Secretary Randy Blakenhorn. "The innovation that made this project stand out represents IDOT's enthusiasm and commitment for creating and maintaining a safe and efficient transportation system for travelers statewide. Our employees strive to find creative solutions each and every day in everything they do to keep Illinois moving."

GDOT's 400 Trail project earned the highest number of online votes



The new \$135 million interchange has improved a critical connecting point in Chicago and greatly improved traffic flow.



The path was built on the right-of-way of GA 400 and public land adjacent to Metro Atlanta Regional Transit Authority, reclaiming what was previously a highway-only corridor and creating a multimodal trail by turning underutilized gray infrastructure into useable green space.

cast in the Socrata People's Choice Award competition. The multimodal pathway, built on the right-of-way of GA 400 and the public land adjacent to Metro Atlanta Regional Transit Authority, reclaimed what was previously a highway-only corridor. PATH400 connects neighborhoods, offices and retail locations and provides users with an easy way to explore, exercise, commute and engage. The pathway brings together 8,000 residents within a walking distance of 10 minutes.

"This is truly a proud moment for Georgia. The project was built through local funding only – no state or federal funds were used," said GDOT Commissioner Russell R. McMurry, P.E. "The partnership between the PATH Foundation, Livable Buckhead, the Buckhead CID and Georgia DOT resulted in unused right-of-way property being transformed into a beautiful and functional pedestrian-friendly path. You may not even realize that you are right next to a major highway."

The 2018 competition attracted 79 project nominations from state departments of transportation in 35 states. Four regional competitions were held and the three projects from each region receiving the highest ratings competed for the final two awards. An independent panel of industry judges selected the Grand Prize winner; the project receiving the highest number of online votes earned the Socrata People's Choice Award.

Presented at the AASHTO Annual Meeting in Atlanta, the Grand Prize and Socrata People's Choice awards each came with \$10,000 cash prizes to be used to support a charity or transportation-related scholarship program. IDOT said its prize money will be given to the Special Olympics, which debuted 50 years ago at Chicago's Soldier Field, just north of the I-55 and Lake Shore Drive Interchange. GDOT said it will donate its prize money to Livable Buckhead to help complete the trail. Livable Buckhead is a nonprofit organization that is spearheading construction of PATH400 in Buckhead.

Learn more about the America's Transportation Awards and this year's entries at www.americastransportationawards.org.

Information provided by the American Association of State Highway and Transportation Officials (www.transportation.org), the Georgia Department of Transportation (www.dot.ga.gov), and the Illinois Department of Transportation (www.idot.illinois.gov).

3D DESIGN AND CONSTRUCTION ANALYSIS

BIM WORKFLOWS HELP ALABAMA DEPARTMENT OF TRANSPORTATION MAINTAIN SCHEDULE ON I-59/I-20 RECONSTRUCTION.

THE ALABAMA DEPARTMENT OF TRANSPORTATION (ALDOT) initiated an estimated \$750 million reconstruction project to replace structurally deficient and functionally obsolete interstate bridges through downtown Birmingham. The existing bridges are located along the only east-west interstate through the Birmingham Business District, which is primarily an elevated six-lane-divided highway through this 3.5-mile section of the city. The twin bridges include 189 bridge spans that require new girders and deck sections. The reconstruction project consisted of 23 new bridges, eight bridge widenings, five bridge replacements, and 16 retaining walls.

ALDOT understood that the construction process had to be precise and efficient with as few construction delays as possible. For these reasons, ALDOT used 3D design and construction analysis to identify potential issues and potential construction delays before the project broke ground. The visualization group of ALDOT's design bureau was tasked with providing a complete 3D model. To support precise cost estimation and lower bids for the project, it was critical that the digital engineering model include accurate and timely data to support multiple uses, including visualizations, design checks, construction analysis, clash detection, right-of-way negotiations, lawsuits, aesthetics, and construction bidding.

The project faced many challenges, including a fast-paced schedule, information coordination, utility coordination, public involvement, and changes in the overall design. Because of public and stakeholder concerns, the visualization group used MicroStation Luxology rendering capabilities and LumenRT to create visualizations that were instrumental in winning approval for the project.

To meet the objectives of replacing the structurally deficient and



Modeling provided visibility into the project and highlighted potential conflicts. *Image: courtesy of Bentley Systems*



Proposed highway design model shown in its real-world environment. *Image: courtesy of Bentley Systems*

functionally obsolete interstate bridges, ALDOT used 3D design technology to ensure efficient designs, and eliminate costly construction delays. Scheduling of the project was critical, and the design needed to be created quickly and information exchanged across teams to support the 14-month construction schedule.

A critical element in any construction project are utilities, and ALDOT invested millions into locating and relocating them, engaging the visualization group to ensure that there were no clashes in the model. The organization used MicroStation's clash detection capability to ensure that utilities were properly located in the design to minimize errors in construction. ALDOT saved more than \$10 million by implementing the BIM review methodology supported by Bentley's technology.

Bentley's applications also allowed ALDOT to reduce the environmental impact by minimizing noise levels in a developed urban area and eliminating dangerous and unnecessary access points along the interstate. OpenRoads was used to create the digital terrain models, and StormCAD, CulvertMaster, and FlowMaster were used to address drainage and utilities design. ALDOT used ProjectWise to allow designers, department heads, drafters, reviewers, and consulting teams to have access and ensured that everyone was working on the right data.

Using ProjectWise on the project, which is currently under construction, helped the consulting firms save thousands of dollars on time and delivery, and ALDOT to save tens of thousands of hours creating 3D models to meet the rigorous scheduling demands. ProjectWise enabled inspectors and contractors to access design files on tablets, saving hundreds of hours in meeting time and processes used on previous workflows.

"Using Bentley's integrated civil design and collaboration applications allowed us to quickly produce an accurate 3D model that included grade, terrain, signage, pave, striping, signals, lighting, bridges, drainage, and utilities, said Matt Taylor, P.E., state engineer, ALDOT. "It eliminated design errors, minimized construction change orders, and helped save waste in public money while building safer infrastructure."

Information provided by Bentley Systems (www.bentley.com).



The aptly named Black Rock Beach. “No one was looking forward to walking that beach with GPS,” said Andreas Garbe, AG Survey’s managing director.

COMING ASHORE

A UK COMPANY IS BUCKING TRADITION BY COMBINING UAS SURVEY AND SOFTWARE TECHNOLOGY TO MEASURE SANDY SHORES.

By Mary Jo Wagner

FOR EIGHT MONTHS IN 2017, life was literally a beach for the survey crews of Bristol-based AG Surveys. Not the beach towel, bucket, and spade kind of beach day, however. Instead, teams substituted the typical beach gear with stacks of control targets, GNSS receivers, and unmanned aerial system (UAS) technology and raced against the tides and weather to survey 80 beaches along England’s southwest coast. Someone may have brought a towel along for wishful thinking, but it was no day at the beach, really.

“Each tidal range was up to seven days and we tried to survey five to seven beaches within that tidal window,” said Andreas Garbe, AG Survey’s managing director. “Often we only had one hour in which to collect a significant amount of data — a point every 5 meters at a height accuracy of 3 cm — before the tide chased us away. And we needed robust, photogrammetric software to process and deliver the measurements within two weeks of each beach surveyed. It was a full-on, relentless cycle of time crunches, surveying, processing, and delivering data.”

The intense project was all part of a national coastal monitoring program funded by England’s Department of Environment, Food and

Rural Affairs and run through the Environment Agency (EA) to collect topographic beach surveys around the country.

Compounding the stressful nature of the project was AG Survey’s decision to use a UAS — an unproven technology for beach surveys — to measure a large percentage of those beaches.

“Historically, all of the topographic beach surveys for the program were done with GPS technology to measure points every 5 meters,” Garbe said. “We thought many of the designated beaches could be surveyed more efficiently and more comprehensively with the speed and data depth of a UAS. Together with specialized UAS processing software, we wanted to prove that a UAS-based approach could be a better solution for a number of challenging beaches.”

It was a successful gamble.

In acquiring a UAS for the project, AG Surveys became the first company in England to officially use a UAS to survey beaches and prove the viability of the technology for coastal monitoring. And, by pairing the aerial technology with an intelligent and rapid data-processing software, the new solution gave them the results and expertise to open up new business opportunities.

Sensing an opportunity

For decades, England’s roughly 5,670 kilometers of coastal frontline was assessed and monitored through regional and local programs. In 2011, the EA took six existing regional coastal monitoring programs and integrated them to form the National Network of Regional Coastal



A swath of Black Rock Beach from the UAS. At the tip of the red arrow is a ground control point in the shape of a white cross. The colored shapes to the lower left of the arrow are a pile of debris people had collected on the beach.

Monitoring Program (NNRCMP) designed to provide a national, homogenized umbrella for regional monitoring efforts.

Implemented in five-year phases, the NNRCMP uses a range of data-gathering sources such as aerial photography, LiDAR, GNSS, and wave buoys to develop beach and bathymetric profiles — metrics that can help determine the risks of coastal flooding and erosion and help coastal managers make sustainable shoreline management decisions. After implementing the first five-year phase of the NNRCMP in 2011, the EA issued tenders in 2016 for all six regions for the 2017-2021 campaign. One requirement of the tenders was for comprehensive, baseline topographic beach surveys based on a 5-meter grid and a data height accuracy of 3 centimeters.

“During the first monitoring program, we did all the beach surveys with GPS, which was quite labor intensive,” said Garbe. “In the southwest we have massive beaches, many of which are littered with cobbles and boulders, so walking them with GPS is challenging and requires a lot of manpower. In the north of the region we also have beaches in the Severn Tidal Range — the second highest tidal range in the world — with a tidal range of up to 15 meters, so timing is critical. Based on our previous experience, we believed a UAS-based system could provide the same height model as GPS but would enable us to cover larger areas faster and produce better data detail.”

Having successfully surveyed a number of beaches in North Cornwall for the debut monitoring program, AG Surveys was awarded three of the four designated regions in the program’s southwest region.

Forming a rough C-shape, the project area stretched from St Austell on the south coast, around the farthest, southwestern point at Land’s End, and up the coast to the small village of Aust, 16 kilometers north of Bristol — a footprint of about 200 kilometers. Within those boundaries were 80 beaches of varying sizes, shapes, and topography. Each required one baseline survey — a full boundary coverage from one side to the other and from the back of the beach to the lowest waterline at Mean Low Water (MLWS) tide — and a series of profile line surveys.

The profile surveys follow predefined lines set every 50 meters from the back of the beach to the MLWS line and GNSS measurements are taken within 10 centimeters of each side of the line.

An additional program requirement was that all beaches had to be surveyed during spring tide, an unusually high tide when a new moon or a full moon causes the greatest rise and fall in tidal level. As the spring tides only occur twice each lunar month, AG Surveys had to develop a tight survey and data-delivery schedule.

“As a complement to our GNSS-based beach surveys, we needed a UAS that could handle the varied coastal landscapes, the stringent data-accuracy specifications, and the notoriously windy conditions along the southwest coast,” Garbe said. “Equally important was having a software solution that could readily handle the volume, spectral richness, and spatial density of the UAS imagery. It needed to be fast and incredibly accurate.”

After researching options, AG Surveys chose Trimble’s UX5HP Multispectral UAS (now Delair) and Trimble Inpho UASMaster photogrammetry software for its aerial beach surveys. They conducted the surveys between January and September 2017.

Rocking it

To devise a survey plan, the company first consulted Google Earth to study each of the targeted beaches. They identified 22 beaches that would be too laborious to survey with GNSS or would pose health and safety risks to crews, some of which included Westward Ho, Saunton Sands, and Minehead.

In general, Garbe and his crew of three or four could cover 3 square kilometers a day, flying four to five UX5 flights at an altitude between 100 and 120 meters, speeds of 80 kilometers per hour, and a lateral overlap of 80 percent. To ensure the reliability and accuracy of the UAS data, they also used a minimum of 10 ground control points (GCPs) for each flight block and measured each target’s position with a GNSS receiver.



AG Survey’s Andreas Garbe sets up the UX5HP for their most northerly survey unit at Severn Beach. The M4 motorway is in the background.



Darina Barbova, a land surveyor/data handler with AG Surveys, checks the UAS data acquired over Porthscatho Beach before driving three hours back to the office.

“Although it’s more time consuming, we needed ground control to achieve the height accuracy and data redundancy,” Garbe said. “Sometimes we needed more than 10 GCPs, especially if we had a monotone, sandy beach without much distinction or a really rocky one that had sharp variations in the topography. With this methodology, we consistently achieved an accuracy between 2.7 and 3 centimeters.”

One particularly challenging beach they had to survey was aptly named Black Rock, a large, rocky beach about 3 miles south of Bude that’s twinned with Cornwall’s Widemouth Bay Beach. A wild beauty with prominent, rocky outcrops and extremely high tides, Black Rock will test a surveyor’s resolve.

“It’s nearly completely rock bed so trying to survey the shoreline means you’re constantly clambering up half a meter on seaweed covered rocks and then sliding down the other side,” said Garbe. “Doing that with GPS is not fun. Thankfully the UAS reduced most of the hassle.”

Since Widemouth Bay and Black Rock sit adjacent to each other, AG Survey’s crew surveyed both simultaneously.

Arriving in the early morning for low tide, they first located suitable positions for the 50 GCPs they would need for the 2.5 kilometer by 1 kilometer area of interest (AOI). To work around the rock-laden shore-

lines, they found flat spots on rocks and used biodegradable paint to mark them.

Considering the beach size, topography, and wind direction, Garbe used Trimble’s Aerial Imaging Flight Planning software to establish three flight paths — one at the back of the beach, one at the waterline, and one in the middle. Once the GCP locations were recorded with GNSS, Garbe flew the first, 30-minute aerial survey along the back of the beach at an altitude of 120 meters. As soon as the UAS landed, the ground crew laid GCPs for the next flight over the low-water shoreline and then repeated the process a third time for the last flight over the middle block. After a six-hour day, they collected a total of 1,745 images over the whole AOI at a ground sample distance (GSD) of 1.65 centimeter.

“The significant advantages of having the UAS for this are its efficiency, stability, and consistent accuracy,” Garbe said. “We had less than one hour to collect the data within the lowest tide window; later than that and the crew would have had to wade into knee- or hip-deep water to try to find the control points. With traditional GNSS, we would have had to climb over endless rocks and the points would have been all over the place. It would have taken much longer, risked our safety, and been impossible to achieve the same results.”

All of the imagery was downloaded into their integrated Trimble Business Center (TBC) and UASMaster processing chain — the workhorse of the system and the engine that created the data products needed to prove the viability of the UAS approach.

Digital proof

Similar to all of the UAS-derived beach surveys, Garbe and his team first imported into TBC the flight and GNSS data and the base station data from the combined Widemouth Bay and Black Rock survey. Using both the UX5's on-board GNSS positioning data and the ground control data, they processed precise, short baselines between the base station and each photo point — the shorter the baseline, the higher the accuracy. After ensuring the sharpness and brightness of each image, all 1,745 images were integrated into UASMaster to create a dense point cloud and a seamless orthophoto of the entire AOI.

“One of the reasons we use UASMaster is for its photogrammetry power,” said Garbe. “It’s incredibly good at automatic aerial triangulation and tie-point matching for point cloud creation and subsequent orthophotos. The matching capabilities are particularly important for beaches which are often homogenous and low-textured. And having the ability to seamlessly move between TBC and UASMaster makes the workflow much more efficient.”

Because the imagery was preprocessed in TBC, UASMaster already has a foundational geographic reference for the location of each photo in relation to its neighbors. To produce the point cloud, the program uses the coordinates from the ground control and each photo center to calculate the interior orientation — the relationship between the image plane and the projection center of the UAS’ camera — and the exterior orientation — the relationship between the ground and the image. It then analyzes image pixels and looks for pixels with the same or similar gray-scale values in neighboring images. When the software finds matches, it uses triangulation to calculate the 3D coordinate of those points, an artificial intelligence process that results in dense 3D height models. The program also automatically color codes each of the points to indicate what they are — sand, boulders, rocks.

Unique to UASMaster is the ability to produce seamless, georeferenced orthophotos directly from the point cloud. The program uses the height model of the point cloud, adjusts the 3D point sizes to fit the ortho pixel size, and stretches the images over the 3D model to orthorectify it. The entire project is then integrated back into TBC for final editing. This streamlined method is easier and requires much less processing, helping the AG Surveys team meet the tight delivery deadlines.

It took two days for UASMaster to produce both a 3-centimeter point cloud and orthophoto of Widemouth Bay and Black Rock, a process that would have taken over a week to complete with manual photogrammetric techniques. And, Garbe said, the UAS provides significantly more visual information than a traditional aerial photo or GNSS survey.



Surveying cobbled beaches like Westward Ho with GPS technology is challenging. That was a prime reason AG Surveys chose the UAS to survey this beach instead.

“The results from Black Rock are absolutely amazing,” Garbe said. “We produced a color-coded, 5-centimeter grid point cloud in which you can zoom around and view the entire beach, including cliff faces and edges, from different angles. It’s a ridiculous amount of 3D data and I don’t think you could get that kind of detail and visualization any other way.”

For each of the 22 UAS-derived beach surveys, AG Surveys delivered the point cloud, orthophoto, profile line survey, and a detailed comparison document that lists the measurement accuracy of the UX5 points and the nearest GNSS survey point to validate the precision of the UAS technology.

Since the baseline surveys are only performed once every five years, AG Surveys will need to wait to see if their UAS approach will be adopted for the next campaign. But their success has already led to other topographic beach surveys and Natural England has expressed interest in testing the UAS system for vegetation and habitat mapping along the coast.

At this rate, the crews at AG Surveys may be finding sand in their hair for quite some time.

MARY JO WAGNER is a freelance writer, editor, and media consultant based in Vancouver, B.C.

FIVE CHALLENGES DRONES FACE IN TERRAIN MAPPING

BATTERY MANAGEMENT, LOGISTICS, AND SCOUTING CAN OVERCOME MOST PROBLEMS.

By Mark Chesterman

Unmanned aerial vehicles, especially commercially available ones, have numerous applications, one of them being surveying or, to be more specific, terrain mapping. Traditional zone mapping is a time-consuming process, and it usually involves a lot of workforces. Quadcopters and fixed-wing drones can significantly decrease the time necessary to complete such an undertaking, but they too are faced with various challenges. This article discusses the major challenges faced by drone operators in the field and some solutions.

Major terrain mapping difficulties

Quadcopters and fixed-wing drones are not infallible terrain mapping tools. They are subjected to factors, both internal and external. For instance, as a surveyor, two challenges to overcome even before hitting the field are related to power and transportation. To simply put it — more area to cover requires more power. There's also the matter of transporting your drone from one place to another. Such an obstacle can be overcome with a carrying case or securing alternative means of transportation (car, train, plane, etc.).

These are only a couple of examples of challenges to circumvent in terrain mapping. Major issues to address during surveys include taking off/landing, an area's accessibility, weather conditions (rain, snow, wind), how much of the work zone can be mapped, and, of course, transportation.

Taking off and landing — One of the first adversities to overcome is related to taking off and landing your UAV. Bear in mind that in the case of a quadcopter, you will need a flat surface and an open space for both landings and taking off. Scouting the terrain should be a prerequisite, as an obstructed landing/taking off place (low branches, tall grass or another sort of vegetation) can deplete your UAV's batteries and leave you with little time to take readings or measurements.

Fixed-wing drones, much like the ones used in the military, need more space to be deployed than quadcopters. If you prefer fixed-wing crafts, be sure to find a long and straight path to launch and land it. Don't forget that successful take-off means you will have more battery available for your project.

Accessibility — When scouting an area for terrain mapping, determine if ground control points (GCPs) can be deployed. Look for anything that might make GCPs not feasible — swampy terrain, marshes, overgrown vegetation, or areas that are otherwise inaccessible. If the situation dictates, consider using a post-processed kinetic module instead of GCPs or a real-time kinetic model. This drone attachment allows you to add geotags to the photos taken by drones. Using these tags, you



Quadcopters can significantly decrease the time necessary to complete terrain mapping.

will be able to create powerful and highly accurate 2D models of the surveyed area.

Weather conditions — Of course, sunny and warm weather is the ideal choice for terrain mapping, but Mother Nature takes orders from no man. Really bad weather such as winds of more than 40 kilometers per hour, snowstorms, and heavy rain mean you have to pack up your surveying equipment and go. If you're dealing with only a light breeze, piloting the drone should not be too difficult. It doesn't matter if you're employing a quadcopter, fixed-wing, in-built wing, or hybrid drone because they all have an increased wind-resistance factor. If the wind picks up in speed, don't force the drone's controls to keep it on the path. Let it glide for a while before assuming control. Any extra commands will take a toll on the battery.

Area to map — The concept is easy enough to grasp: More space to cover means you'll be using more of that power reserve. At this point, you must figure out which type of drone you're going to use to cover the whole area. Quadcopters are inefficient at covering large areas, being more suitable for small-area mapping. If your project calls for surveying a large area, it's better to employ a hybrid, in-built wings, or fixed-wing drone. These models take advantage of the design to glide through the air, using very little power.

Transportation — The last challenge to overcome during terrain mapping is related to transportation. For instance, if you are put in a position to survey an island with a quadcopter, you must choose at least take-off and landing spots to cover the whole surface. In our experience, the best way to ensure that the drone reaches the next destination safely is to buy a carry case or a reinforced backpack. Additionally, it's easier to transport a drone to various take-off/landing spots with a car or other vehicle.

Conclusion

Terrain mapping with UAVs is an interesting undertaking but not without challenges. Most of them are related to battery management, logistics, and scouting. However, with a little planning, you can easily complete the task.

MARK CHESTERMAN is a drone aficionado and a technology enthusiast who provides comprehensive drone reviews on <http://droneista.com>.

COLD-FORMED STEEL FRAMING EDUCATIONAL OPPORTUNITIES

STEEL INDUSTRY OFFERS RESOURCES FOR BEGINNERS AND EXPERIENCED DESIGN PROFESSIONALS.

By Roger LaBoube, Ph.D., P.E.

HERE IS A FAMILIAR PROBLEM: You or one of your employees has recently graduated from an engineering college. You are excited and ready to design the most beautiful and efficient structures in the world and are pretty good at the design methodologies you were taught. But now you are confronted with a design problem using cold-formed steel framing. With no training and little design experience, what do you do?

Unfortunately, most college curricula, with too few hours and too many subjects to pack into an undergraduate or even a graduate program, do not teach cold-formed steel framing design. But thankfully, the industry has developed resources for both beginners and experienced designer engineers. Many of the educational resources provide professional development hour (PDH) credits for participants. Following are some of these educational opportunities.

Cold-Formed Steel Engineers Institute

The mission of the Cold-Formed Steel Engineers Institute (CFSEI) is “To enable and encourage the efficient design of safe and cost effective cold-formed steel framed structures.” To accomplish its mission, CFSEI provides state-of-the-art information regarding steel-framing design and construction that is developed by experts who are helping to shape cold-formed steel design techniques and practices.

CFSEI offers webinars, seminars at their annual CFSEI EXPO, and FAQ videos on their website, www.cfsei.org. Typically, a minimum of six webinars are offered annually and are archived at <https://cfsei.memberclicks.net/webinars>. The CFSEI Annual EXPO offers two days of face-to-face seminars. Additionally, CFSEI partners with structural engineers’ associations nationwide to meet the growing demand for instruction in cold-formed steel application and design. Formats for these educational programs range from one-hour sessions to multi-hour and full-day presentations for such organizations as Edu-Code and state structural engineering associations.

CFSEI Tech Notes are an invaluable resource to understanding the nuances of cold-formed steel design. More than 40 Tech Notes (<https://cfsei.memberclicks.net/technical-notes>) have been developed and address the range of issues encountered by a cold-formed steel engineer, including the following:

- durability and corrosion protection;
- fasteners and connection hardware;
- component assemblies (trusses and wall panels);



- general topics;
- floor and joist systems;
- wall systems;
- roof and ceiling systems;
- thermal, fire, and acoustics; and
- lateral systems.

Students from around the world have participated in CFSEI’s International Cold-Formed Steel Building Student Design Competition. The mission of the student competition is to promote higher education in cold-formed steel structural design and to encourage students to use creative thinking skills to solve engineering problems. The goal of this competition is to push the creative bounds of structural design with light-steel-framed buildings.

The design problem for the 2016-2017 competition was a three-story, cold-formed steel condominium building located in Las Vegas with 26,912 square feet (2,500 square meters) of useable floor space. The primary load bearing and lateral structural system were to be cold-formed steel framing, designed to IBC 2012 and governing American Iron and Steel Institute (AISI) specifications with load combinations taken from ASCE 7-10.

AISI Education Committee

The focus of the AISI Education Committee is to monitor the alignment of education products with the standards and to ensure adequate educational products are available to support each AISI standard and, where needs are not met, advocate for additional resources to support the standards. The primary effort of the AISI Education Committee has been development and maintenance of AISI design guides and manuals, which include:

- AISI D100 – CFS Design Manual
- AISI D110 – CFS Framing Design Guide
- AISI D111 – CFS Purlin Roof Framing Systems
- AISI D112 – Brick Veneer CFS Framing Design Guide
- AISI D113 – Design Guide for CFS Framed Shear Wall Assemblies (in development)

- AISI D310 – Design Examples for the Design of Profiled Steel Diaphragm Panels Based on AISI S310-16

These documents are available at <https://shop.steel.org>.

Center for Cold-Formed Steel Structures

The mission of the Wei-Wen Yu Center for Cold-Formed Steel Structures (www.ccfsonline.org) is to provide an integrated approach for handling research, teaching, engineering education, technical services, and professional activity. The center brings together the technical resources of interested parties such as university researchers, steel producers, product manufacturers, consultants, building officials, government agencies, and others with a common goal of continued improvement of cold-formed steel design and construction.

The center's Cold-Formed Steel for Students website (<http://ccfsonline.org/cold-formed-steel-for-students>) provides an introduction to cold-formed steel, the cross sections used for cold-formed steel framing, and the appropriate design specifications. Also, a list of design aids is provided for more in-depth study and for future career reference. To facilitate questions regarding material presented on this website or a question pertaining to cold-formed steel applications and design, the Ask the Professor tab is available.

A biennial three-day short course offered by the center is designed to benefit both engineers who are unfamiliar with cold-formed steel design and engineers experienced with cold-formed steel design. For engineers unfamiliar with cold-formed steel design, the course is structured to provide an introduction to the behavior of cold-formed steel members and connections and how that behavior is addressed by the AISI specification. For engineers experienced with cold-formed steel design, the course is intended to strengthen their understanding of the fundamental behavior of both members and connections, as well as provide a better understanding of cold-formed steel design. Both commercial and residential applications of cold-formed steel are discussed. The technical program is structured to discuss the many applications of cold-formed steel members, including wall studs, floor joists, purlins, girts, decks, and panels.

For engineers interested in delving into the research that serves as the basis for the design specification provisions, the center's online library (<http://scholarsmine.mst.edu/ccfss>) has a wealth of information. The online library also has design documents developed by AISI, Steel Deck Institute, and Rack Manufacturers Institute. The center's biennial international specialty conference offers a forum for dissemination of on-going and recently completed research. Proceedings of the past conferences are posted at the online library website.

Steel Framing Alliance

The mission of the Steel Framing Alliance is to enable and encourage the widespread, practical, and economical use and preference for cold-formed steel framing by identifying, maintaining, and promoting competitive advantages while identifying and pre-empting threats.

The Steel Framing Alliance works to expand market share in the commercial and residential construction markets with an emphasis on

growth potential of structural cold-formed steel framing in the mid-rise sector for offices, hotels, condos, apartments, and other multi-family housing, university housing, and similar buildings.

The "STEEL Doing It Right" seminar is organized by the Association of the Wall and Ceiling Industry and the Steel Framing Alliance. The seminar brings comprehensive education and training to those currently working in the steel framing industry and to those looking to expand their business. The content is based on industry-accepted standards and best practices. The seminar covers the essential knowledge and techniques for correct installation of cold-formed steel, as well as codes and standards affecting cold-formed steel; structural (load-bearing) wall assemblies; wind-bearing and curtain wall framing; interior systems; roof assemblies; estimating; project management; and more.

The Steel Framing Alliance also publishes design guides on such topics as thermal design, fire and acoustic design, as well as position papers such as durability and sustainability of cold-formed steel.

Other education opportunities

MBMA University/Industry Collaboration on Capstone Design Project — The Metal Building Manufacturers Association launched a collaborative program to match metal building manufacturers with university educators to help develop a capstone design experience. In the first two years of the program, MBMA has worked with more than a dozen universities to introduce students to metal building construction through a real-world design experience that also incorporates site visits as well as visits to the fabrication and design facility. Resources have been developed to assist faculty in this effort. Interested universities are invited to contact Dr. W. Lee Shoemaker at MBMA for more information on the program (mbma@mbma.com).

Manufacturers' associations, including the Steel Framing Industry Association (SFIA; www.steel framingassociation.org) and Steel Stud Manufacturers Association (SSMA; www.ssma.com) have span and load tables for basic conditions that can act as an initial check for architects and engineers for determining a size and thickness that may be required for a particular design application. In addition, SSMA has a set of typical details in both .dwg and .pdf format for free download. The SFIA has a series of free, previously recorded webinar presentations on topics ranging from specifying cold-formed steel to panelization and energy codes. All of this information and more are available from their respective websites.

In closing

If all else fails, an invaluable resource for obtaining cold-formed steel design information is the CFSEI Hotline, which can be accessed at 800-79Steel (800-797-8335) or at Ask an Expert at https://cfsei.memberclicks.net/index.php?option=com_mc&view=mc&Itemid=148.

ROGER LABOUBE, PH.D., P.E., is director of the Wei-Wen Yu Center for Cold-Formed Steel Structures (<http://ccfsonline.org>).



01. ACOUSTIC PANELS

ASI Architectural introduced StrandTec Wood Fiber Ceiling and Wall Panels, which reduce echo and reverberation while enhancing a room's overall aesthetics. These sustainable, high-performance, cost-effective acoustical solutions can be retrofitted into an existing facility or incorporated as part of a new build, the company said. StrandTec panels are made up of cementitious wood fiber, manufactured using only wood strands, portland cement, and water. Standard panel finishes are natural and white and are paintable with vivid SonoKote colors to fit with any décor. StrandTec panels are available in 1-inch, 1.375-inch, and 2-inch thicknesses, in various dimensions and edge options.

ASI ARCHITECTURAL
WWW.ASIARCHITECTURAL.COM



02. CABLE RAILING SYSTEM

Superior Aluminum Products introduced series 2000 cable railing system, which it said provides modern styling and a virtually unobstructed view. Stainless steel cables combined with aluminum posts and rail assemblies form a strong, durable, maintenance-free system that meets OSHA, ADA, and ICC safety criteria. Superior cable railing is available in any height, with standard heights of 42 inches for commercial and 36 inches for residential projects. The 3/16-inch 1x19 type 316 stainless steel cable is made from 19 strands for high tensile strength with no stretching. The 2-1/2-inch square aluminum posts can be surface mounted, side mounted, or embedded into concrete.

SUPERIOR ALUMINUM PRODUCTS
WWW.SUPERIORALUMINUM.COM



03. CONCRETE PAVERS

Tectura Designs' Quick Ship Collection of UltraFace pavers feature compressive strength averages of 9,500 psi; a price of \$3.90 per square foot; and guaranteed shipping within four business days or less. The Quick Ship Collection is available in a common size — 24 inches square — and in four of the most popular UltraFace colors, comprising versatile, on-trend neutrals, the company said. Tectura Designs also offers the Thin Paver, giving architects and designers the freedom of specifying a 1-inch-thick paver that boasts the strength of its 2- to 4-inch-thick counterparts; and the Quattro Series, which merges the look of porcelain with the strength of concrete.

TECTURA DESIGNS
WWW.TECTURADESIGNS.COM



04. HURRICANE TIE

Simpson Strong-Tie introduced the H1.81Z hurricane tie, designed to provide stronger connections between heavy engineered wood rafters and wall top plates. Developed and tested to provide lateral resistance during seismic events, the H1.81Z is also ideal for roofs with heavy snow loads or connections where there are higher load demands on the structure. The code-listed 1-3/4-inch-wide H1.81Z connector also installs with half the number of nails that would be needed for two single-sided twist straps, and it features a ZMAX zinc finish to increase resistance to corrosion. Installation on either the outside or the inside of the wall is acceptable according to all LVL manufacturers' installation instructions.

SIMPSON STRONG-TIE
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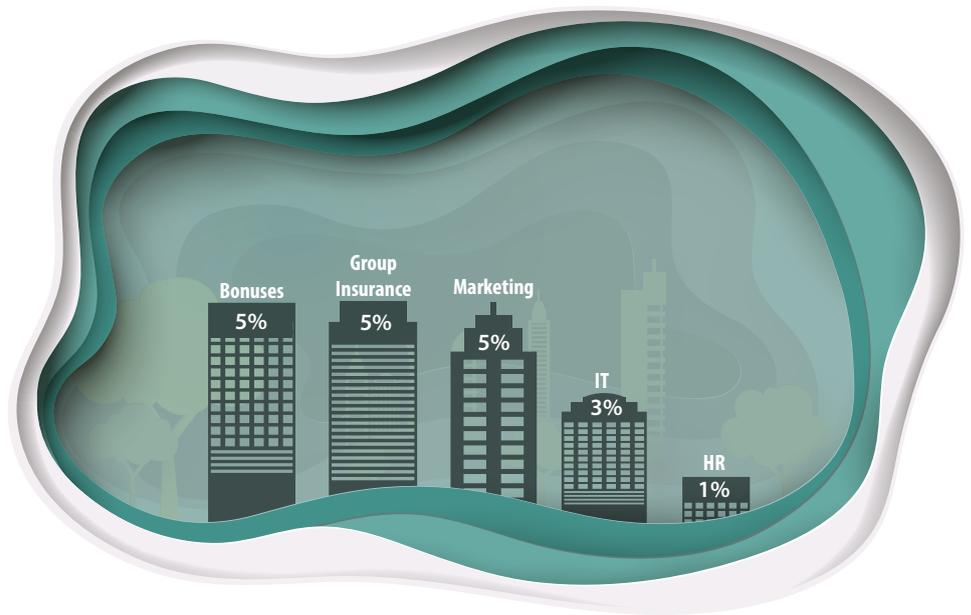
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Firm costs for each operating expense as a percentage of net service revenue.

OPERATING EXPENSES

By Tyler Thompson

ZWEIG GROUP RECENTLY ISSUED its 2018 Operating Expenses Survey of AEC Firms. This publication covers operating and overhead expenses of architecture, engineering, and environmental consulting firms that have a large impact on profitability.

The term “operating expenses” has different meanings across different businesses, but at Zweig Group, we break it down with one question: What non-production expenses are necessary for firms in the AEC industry to operate at an optimal rate? Even firms with the best production staff can falter without the right attention to detail in their overhead expenses. So, which expenditures fall into this bucket?

Common departments that aren’t lumped into the production staff are marketing, information technology (IT), and human resources (HR). The three departments combine, on average, for 10 percent of spending as a percentage of net service revenue (NSR). When looking at yearly trends, HR spending has remained about the same over the last few years. However, marketing expenses as a percentage of NSR have been trending up while IT spending has declined. Where does your firm stand when it comes to spending in these three departments?

Employee benefits outside of their base salary are also analyzed among AEC firms. Bonuses as a percentage of NSR have fluctuated between 5 percent and 8 percent during the last five years. The number itself isn’t important, but the fact that it’s changing so much every year tells us that

firms may not be proactive in setting their yearly bonus rates. Many more benefit costs such as group insurance, paid time off, and 401(k) plans are presented in this study and represent an opportunity for firms to compare their rates with the industry benchmark.

Liability insurance expenses are important to address when looking at firm projects and potential employee-related conflicts. Despite firms constantly hammering down the importance of onsite safety, things happen, and firms must be prepared. From high-risk to low-risk projects, project liability insurance per employee is important to monitor. Additionally, firms cover themselves from employment controversies with employment-practice liability insurance (EPLI). This study dives into the amount spent as a percent of NSR and as a static amount per full-time employee.

This publication gives firms a detailed look into the typical operating expenses of a firm in the AEC industry. Compiling data from five hard-hitting surveys from the 2018 season, this is sure to provide firms with all the data they need to keep the business running smoothly outside of their production staff.

The 2018 Operating Expenses Survey of AEC Firms is available for purchase (print or digital) at <https://zweiggroup.com>.

TYLER THOMPSON, is Zweig Group research manager. He can be contacted at research@zweiggroup.com.



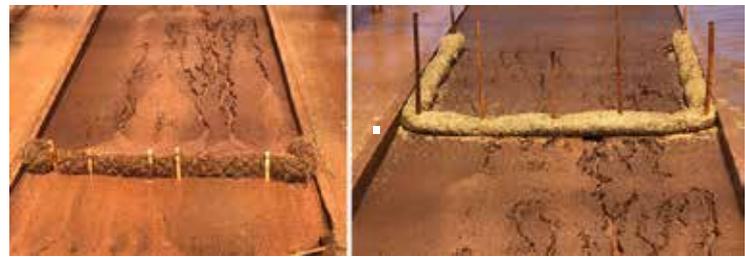
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